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Harnessing Group-Level Influence to Boost Energy-Savings Behavior in the Office Building

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ABSTRACT

Using energy saving and effectively is one of the measures to ensure energy security in urban areas. Research on energy-saving behavior in buildings is one of the approaches to improving energy usage efficiency. This study explores the mechanisms that influence the energy-saving intention (EI) and energy-saving behavior (EB) of individuals in shared spaces, including the Self-transcendence group Values (SV), Descriptive Norm (DN), Group Interaction (GI), and Energy management board (MB). The research model proposed ten hypotheses based on the theory of Dynamic group, and data was collected through a direct survey questionnaire from 295 samples and analyzed using Structural Equation Modeling (SEM). The results show that descriptive norms, i.e., the actions of other members in the group, have the highest impact on the energy-saving behavior of individuals in shared spaces. Group interaction helps to increase the likelihood of acting and, therefore, reinforces the intention to save energy. The Energy management board indirectly influences the energy-saving behavior of individuals through their intention to save energy. These findings can contribute to the development of energy-saving strategies in shared spaces, focusing on descriptive norms, rather than the current approach based on instructions. Furthermore, the experimental research results can provide guidance for policymakers in developing strategies to change energy-saving behavior in buildings in urban areas in Vietnam.

Keywords: Energy-Saving Intention, Energy-Saving Behavior, Energy Management Board
JEL Classifications: Q4, Q43

1. INTRODUCTION

Energy plays an important role in Vietnam's socioeconomic development. Using energy helps to operate daily life more efficiently, participate in producing goods and supply services to meet human needs. In Vietnam, energy demand has significantly increased in recent years. From 2007 to 2017, Vietnam's total final energy consumption increased nearly 1.63 times from 36.24 million TOE to 59.17 million TOE, with an average annual growth rate of 5.08%. According to the Vietnam Energy Statistics, Vietnam's total primary energy supply in 2019 was 89,792 KTOE, an increase of 11.0% compared to 2018. From 2011 to 2019, the fastest growth rate was in coal, which increased by 13.2% per year, followed by renewable energy, which increased by 10.5% annually.

According to data published by the World Bank, Vietnam's primary energy intensity (EUI) in terms of MJ/USD in 2019 was approximately 5.94, lower than China (6.69) but significantly higher than other ASEAN countries (Malaysia: 4.68; Indonesia: 3.53; Philippines: 3.12), India (4.73), and modern economies. Currently, electricity consumption is mainly distributed across sectors, including industry, commerce-service, agriculture-forestry-fisheries, transportation, and civil. Statistics show that buildings and construction sectors account for about 76% of electricity usage, over one-third of the total final energy consumption globally, and nearly 40% of total direct and indirect CO_2 emissions (Copenhagen Centre on Energy Efficiency, October 2018) CO_2 emissions related to energy from buildings have been increasing since 2016 until recent years, specifically in 2019, it rose to 10 $GtCO_2$, the highest level ever recorded globally (IEA, 2020). In the United States, commercial buildings account for over 76% of electricity usage in the total consumption structure and over 40% of total greenhouse gas emissions (America, 2015). Buildings in the European Union (EU) play a significant role in energy consumption and greenhouse gas emissions within the region. According to statistics, they account for approximately 40% of total energy consumption and 36% of greenhouse gas emissions, primarily stemming from the processes of construction, use, renovation, and demolition. Construction projects in the EU require a substantial amount of energy for cooling, heating, lighting, and providing amenities to users. Furthermore, the use of inefficient energy sources and outdated technologies also contribute to the increase in greenhouse gas emissions (European commission, 2020). The energy usage rate in high-rise buildings in Vietnam has been very high in recent years, accounting for about 35-40% of the total energy consumption of the country. An estimated 54% of total energy consumption for commercial buildings is for the ventilation and air conditioning (HVAC) system, 10% for lighting, 19% for plug-in devices, and 17% for elevators (Dat, 30/08/2018). Based on research findings, a scientifically and reasonably designed high-rise building, when implementing efficient and energy-saving measures, not only saves 30% of electricity consumption, 30-50% of water usage, but also reduces 35% of CO_2 emissions and 50-90% of other types of waste. Identifying potential opportunities for energy-efficient and energy-saving use in commercial buildings can help minimize the adverse effects of greenhouse gases on the environment.

The simple and effective measures for energy saving in buildings include changing consumer behavior, encouraging and motivating consumers to achieve set goals (Lopes et al., 2019). A study by Wayes et al. (2017) indicated that installing new technology devices in shared spaces can help achieve energy-saving goals. However, Zhang and Peng (2017) argued that installing many new technology and energy-saving devices may increase the demand for energy, leading to higher energy consumption. Therefore, it is important to understand and explore the factors that drive users to perform energy-saving behaviors in shared spaces of buildings. According to the study by Scherbaum and Popovic (2008), an individual's environmental standard strongly influences their behavior and intention to save energy. Chatura et al. (2017) found that personal competence plays an important role in shaping individuals' energy-saving behavior in shared spaces. Lo et al. (2014) used an extended TPB model to examine the influence of social cognition factors and habits on energy-saving behaviors in offices with multiple occupants. Habit was found to be the most influential factor on turning off lights and computer screens. Although some studies have investigated the determinants behind individuals' decisions to apply energy-saving behaviors in shared spaces, they mainly focus on the VBN or TPB perspective. These theories are essentially based on rational propositions. Therefore, the explanatory value of the studies is limited because they only consider rational factors. As we know, the application of energy-saving behaviors cannot be understood solely as an individual decision but may be influenced by the social environment."

Some studies have shown that when living in public spaces, many individuals are not aware of their energy consumption responsibilities, leading to energy waste (Chen et al., 2016). Hong et al. (2019) suggest that wasteful work styles are a cause of increased energy consumption in offices. From another perspective, in modern workplaces, there are many devices such as printers, fax machines, photocopiers, and computers that are constantly on standby. While many devices are equipped with energy-saving technology, some are still using outdated technology, resulting in energy waste (Kavulya and Becerik-Gerber, 2012). The energy-saving behavior of residents plays a crucial role in improving the energy efficiency of buildings (Alam et al., 2017). Previous studies have shown that effective behavior practices can reduce energy consumption by up to 20% (Azar and Al Ansari, 2017). Therefore, changing people's behavior towards conscious and efficient energy use in public spaces is essential to reduce energy waste.

In typical office buildings, energy consumption systems are pre-designed, and the placement of devices such as printers and computers can significantly influence employees' energy-saving behavior (Lo et al., 2012). One challenge when implementing energy-saving behaviors in shared spaces is the constraints of regulations, high-level leadership commitment, and financial incentives to promote energy savings (Lo et al., 2012). Elie et al. (2014) argue that individuals are influenced by the actions of a group or community, a finding also supported by Mulville et al. (2016) and Testa et al. (2016). Colleagues who engage in energy-saving behavior serve as role models for others to follow, with even greater impact when company leaders or managers engage in such behavior (Midden et al., 2011). While studies have emphasized the importance of groups and their processes for energy-saving behavior (Hong et al., 2017; Sovacool et al., 2015). We still lack a clear understanding of how group influence in shared spaces affects the energy-saving behavior of individual occupants. Therefore, this study develops a new research model to better understand the underlying relationships and reciprocal effects between these factors. To achieve these objectives, this study applies group dynamics theory to investigate the influence of group-level factors on individual energy-saving behavior in shared spaces. A survey of work groups in office buildings in Hanoi was conducted, with data collected through a questionnaire and factor interactions tested using a structural equation model.

This study differs from previous research in several ways. First, it was conducted in Hanoi, the capital city of Vietnam. Vietnam is one of the developing countries, and cultural differences and organizational structures are likely to have a greater impact on individuals' energy-saving behavior compared to Western countries. Second, this study examines behavioral changes of individuals within social relationships. Finally, the experimental findings may assist policy makers, businesses, and companies in designing behavior change strategies to improve energy-use efficiency.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Theoretical Background

The Theory of Group Dynamics is a fundamental concept in the study of human behavior, particularly related to how individuals interact and relate with each other in a group setting. Proposed by Kurt Lewin in 1951, the Theory of Group Dynamics is based on the assumption that individual behavior is determined by their individual characteristics (Lewin, 1951). This theory has been applied in various areas, such as business, communication, and industry, as it can explain individual's behavior in relation to their peers in a group setting.

The Theory of Group Dynamics is based on the formula of interactional theory B = f (P, E), where individual behavior (B) is a function (f) of both individual characteristics (P) and social environmental factors (E). By understanding how the different elements interact and affect each other, the theory can be used to explain why people respond and behave the way they do in each situation. Factors such as trust, action and interaction, and leadership or management can all influence individual behavior and the success of a group.

It is important to note that the Theory of Group Dynamics is not only applicable to work groups and organizations, but also to other social groups, like families, classes, and communities (Forsyth, 2018). The study of group dynamics can help to better understand the behavior, perceptions, and emotions of an individual in a group setting, as well as the impact of norms on their behavior.

2.2. Self-transcendence Group Values (SV)

The belief of group members plays an important role in encouraging individuals to participate in energy-saving behaviors within a shared space. This is due to the fact that humans tend to feel more motivated in a group setting in which they are supported and accepted. When people feel accepted and supported, they are more likely to act in a way that is beneficial for the group and for the environment (Jans et al., 2018; Song et al., 2019). Studies have shown that group members who share similar values and beliefs are more likely to engage in energy-saving behaviors than those who do not. This is because individuals who share similar values and beliefs are more likely to understand the importance of energy conservation and are more likely to be motivated to participate (Zhang et al., 2018; Testa et al., 2016). Furthermore, group members who have a positive attitude towards the environment are more likely to take part in energy-saving behaviors. This is because such individuals recognize the importance of energy conservation and are more likely to be motivated to take part in the group's energy-saving initiatives. Therefore, the following hypothesis:

H_1: The belief of group members has a positive impact on individuals' intention to participate in energy-saving behaviors within a shared space.

2.3. Descriptive Norms

Descriptive norm is a type of norm that describes a social standard in which people evaluate their own behavior based on observations of others' behavior. In other words, descriptive norm is social information about how a behavior is typically performed in each situation. It can influence an individual's behavior and decision-making in a specific situation. Descriptive norm can be applied to promote energy conservation. If a community or a specific area tends to use energy-efficient devices, such as LED lights instead of fluorescent lights, this will create a positive descriptive norm regarding energy use. Others in the community will tend to conform and follow the behavior of others to fit in with the social environment. This can be promoted by creating education and energy-saving promotion programs in the community to build a positive descriptive norm, thereby helping to save energy and protect the environment (Zhu et al., 2021).

The hypotheses are set out as follows:

H_2: The self-trancendence has a positive effect on the descriptive norm.

H_3: The Descriptive norms have a positive effect on energy-saving intention.

H_4: The descriptive norms have a positive effect on individuals' energy-saving behavior.

2.4. Group Interaction

In social psychology, group interaction plays a crucial role in studying and understanding how people interact with each other in different social situations. It is an extremely important aspect of social psychology because group interactions can influence the behavior, thoughts, and emotions of each individual in the group. Hori et al. (2013) found that social interaction shows different effects on energy-saving behavior due to different contexts that people are in (Hori et al., 2013). Studies on group interaction also help people understand how groups can influence the behavior and thoughts of individuals in the group, and vice versa, how the behavior and thoughts of everyone can influence the group. This can help social psychologists come up with solutions and strategies to manage groups and resolve issues in group interaction situations (Baddeley, 2016; Testa et al., 2016; Zhu et al., 2021). We propose the following hypotheses:

H_5: The descriptive norms have a positive effect on group interaction

H_6: The group interaction has a positive effect on energy-saving intention

H_7: The group interaction has a positive effect on energy-saving behavior.

2.5. Energy-saving Intention

Behavioral intention is an important factor in understanding individual behavior. It reflects the extent to which an individual is willing to perform a specific behavior and is usually seen as the most direct precursor variable to behavior. Cognitive processes allow members to gather information and understand its meaning, which affects their intention and, ultimately, their behavior. Studies have consistently shown a positive and mediating effect of intention on behavior, especially in the field of psychology and sociology. Researchers have found that the level of willingness to engage in green consumption has a direct and significant indirect effect on actual green consumption behavior (Zhang et al., 2019). Similarly, the intention to save energy directly affects people's energy-saving behavior, acting as a mediator between individual subjective factors and external influencing factors (Zhang, 2018). For this reason, understanding the influence of intention on behavior is essential in order to encourage individuals to take part in energy-saving activities. Creating an environment that encourages and motivates people to save energy can help to make a real difference in terms of energy conservation. Therefore, the hypothesis is as follows:

H_8: Individuals' actual energy-saving behavior is positively influenced by their energy-saving intention.

2.6. Energy Management Board

The role of managers in managing employees' energy conservation practices is essential to create a more sustainable work environment. Managers can implement policies and regulations to ensure that employees engage in energy conservation practices, such as turning off lights when leaving a room, using computers and electronic devices efficiently, switching to LED light bulbs instead of traditional bulbs, and using energy-saving devices. Additionally, managers can organize training sessions and educate employees on the importance of energy conservation and effective device usage. These activities will help to raise employees' awareness of the importance of energy conservation and motivate them to engage in energy-saving actions in the office. Not only will this help to protect the environment, but it will also reduce costs for the office. Therefore, the hypotheses are as follows:

H_9: The energy management board has a positive influence on individuals' intention to save energy in a shared space.

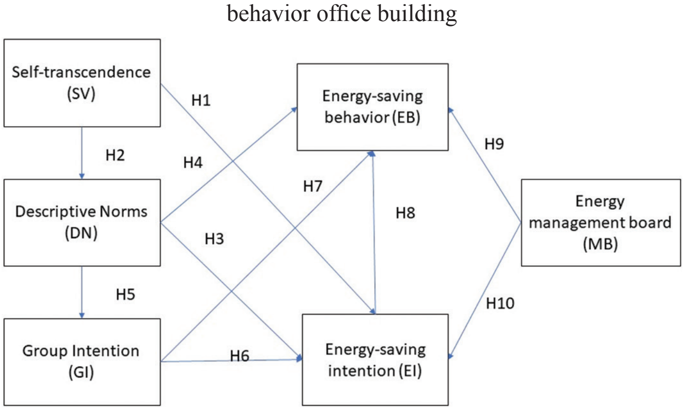
H_{10}: The energy management board has a positive influence on individuals' energy-saving behavior in a shared space (Figure 1).

3. METHODOLOGY

3.1. Methods

This study investigates the impact of group factors on energy-saving behavior of individuals in shared workplaces in buildings located in the capital city of Hanoi, Vietnam. The research utilized a qualitative and quantitative research methods. In-depth interviews and expert interviews were used to identify the basic characteristics of the proposed factors. Using the Structural Equation Modeling (SEM) equation, the proposed hypotheses in the theoretical model were evaluated, and the results were discussed, followed by recommendations for organizations, agencies, or businesses to use energy-saving and efficient measures. This helps businesses save costs and enhance their competitive capabilities (Reisinger and Turner, 1999).

Figure 1: Conceptual model the groufactors influencing energy-saving behavior office building



3.2. Data Collection and Sampling

We conducted multiple experimental surveys in office buildings in Hanoi city to collect data for our empirical survey model. From May 2021 to May 2022, we collected 295 survey questionnaires in offices located in buildings where office workers work in groups together. The sample size of 295 completed survey questionnaires provided sufficient data for analysis using the data analysis method [17], and we simulated the analytical data for this study using Smart PLS 3.0 software (Tabachnick et al., 2007). The descriptive statistical results are presented in Table 1.

3.3. Measurement

Data collection for this research and analysis was conducted in the building office in the Hanoi capital via survey questionnaires. A 5-level Likert scale was used to evaluate the variables, with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The measurement items used in the questionnaire are based on previous studies but adjusted to suit the culture in Vietnam. The details of the survey questionnaire and scales are presented in the Appendix 1.

Individual energy-saving behaviors are measured by questions such as "You will use curtains to reduce room temperature"; "When you do not use the device for a long time, you will turn off the device to reduce power consumption"; "I take my computer power off when not in use"; "I switch off the lights when leaving an unoccupied room". This is a highly effective way to understand the level of action taken by respondents regarding simple energy-saving measures for lights, air conditioning, and computers commonly used in offices. The behavioral intentions towards energy-saving are measured by four items. Two items were adapted from Testa et al. (2016), requiring respondents to indicate their level of daily energy-saving behaviors. Additionally, whether respondents would like to participate in energy-saving organizations and activities may reflect their willingness to implement energy-saving measures. In shared spaces, group-level factors can be addressed through the synthesis of users' thoughts and behaviors in the shared space. The self-transcendent values of the group are measured by asking an individual about their perceptions of their roommates' beliefs about usefulness, respect for nature, and environmental protection. Furthermore, the measurement of energy-saving indicators is referenced from Tang et al. (2019) literature (Tang et al., 2019). In shared spaces, residents are likely to imitate their roommates' behaviors due to close interaction. The five items were then designed from the perspective of the respondent's roommates' behavior. The habitual performance of energy use behaviors of their roommates is evaluated by the respondents. Regarding group interaction, it is measured by four items that draw from Bales (1970), (Bales, 1970), Forsyth, (2017), and (Forsyth, 2018) research, including reminding roommates, sharing energy-saving experiences, making or asking for energy-saving suggestions within the group.

3.4. Data Analysis

To ensure reliability and validity of the measurement model, confirmatory factor analysis (CFA) was conducted with 295 samples. The composite reliabilities (CR) and average variance extracted (AVE) values needed to exceed 0.5 and 50%

Table 1: Descriptive statistics of social demographic variables (n=295)

Demographic variables	Frequency (%)
Gender	
Male	68.5
Female	31.5
Total	100
Age	
From 20 to 25	15.9
From 26 to 35	50.8
From 36 to 45	23.05
From 46 to 55	10.25
Total	100
Income (million VND)	
From 3 to 5 million	8.8
From 5 to 10 million	32.20
From 10 million to 15 million	27.11
From 15 million to 20 million	31.89
Total	100
High education	
High school graduation	7.45
College graduation	7.32
Undergraduate degree	73.55
Master's degree	11.68
Total	100

AVE: Average variance extracted

respectively. Additionally, the factor load factor needed to be >0.5 to ensure convergent validity, while the square roots of the AVE values needed to be larger than the correlation coefficients between the variables to ensure discriminant validity.

Finally, the research hypotheses were tested using partial least squares structural equation modelling (PLS-SEM), which has been widely used in research fields of psychology and sociology (Safriel and Lavee, 1988). Recently, it has also been used to consider the influence of factors on energy-saving behavior, such as attitudes and intentions.

4. RESULTS

4.1. Verify the Reliability of the Scale

Structural equation modeling (SEM) is a complex data analysis method used to model the relationships between variables based on a theoretical model and collected data. This study used SEM to analyze the level of influence of groups on individual behavior in energy-saving usage in office buildings in Hanoi. To evaluate a factor's reliability, two criteria were used: Cronbach's alpha coefficient and the correlation coefficient between variables (item-total), which needed to be >0.6 and 0.3 respectively. Variables with a total correlation coefficient less than 0.3 were eliminated from the factor and considered as "junk variables". The results of reliability and variance analysis indicated that factors with loading coefficients >0.5 had reached convergence values and the overall reliability of the factors was above 0.7, with an average extracted variance (AVE) greater than 0,50. This demonstrates that the factor measurement tools in the formal sample had achieved the necessary reliability (Hair Jr et al., 2014). This shows that the factor scales in the formal sample have achieved the necessary reliability (Table 2).

Table 2: Scale's evaluation

Constructs	Cronbach's alpha	Composite reliability	Convergent validity	AVE
DN	0.831	0.888	0.836	0.664
			0.814	
			0.763	
			0.845	
EB	0.803	0.87	0.818	0.627
			0.76	
			0.792	
			0.796	
MB	0.809	0.887	0.811	0.723
			0.894	
			0.844	
SV	0.847	0.897	0.816	0.685
			0.822	
			0.841	
			0.831	
GI	0.889	0.931	0.879	0.818
			0.919	
			0.916	
EI	0.872	0.913	0.87	0.724
			0.786	
			0.847	
			0.896	

AVE: Average variance extracted, DN: Descriptive norms, EB: Energy-saving behavior, MB: Energy management board, SV: Self-transcendence group values, GI: Group interaction, EI: Energy-saving intention

Table 3: Discriminant validity

Factors	DN	EB	MB	SV	GI	EI
DN	**0.815**					
EB	0.575	**0.792**				
MB	0.533	0.456	**0.85**			
SV	0.625	0.585	0.555	**0.828**		
GI	0.609	0.53	0.566	0.647	**0.905**	
EI	0.585	0.636	0.572	0.66	0.732	**0.851**

1st value=Correlation among variables (two-tailed t-test); Square root of AVE (bold diagonal); N/A: Square root of AVE is not applicable for formative constructs.
DN: Descriptive Norms, GI: Group Interactions, EB: Energy-saving behavior, EI: Energy-saving intention, MB: Energy management board, SV: Self-transcendence group values

To ensure that the factor measurement tools in the formal sample had achieved the necessary reliability, the considered load factors needed to be greater than 0.5 to achieve convergence validity. Additionally, the square root of the variance needed to be larger than the correlation between the variables to ensure discriminant validity (Table 3).

4.2. Analysis Result Structural Model

- Perform CFA analysis on the structural model based on the hypotheses mentioned above. We used Smart-PLS software to analyze the model. The results show that from Table 4, the hypotheses DN-EI (P-value = 0.196), MB-EB (P = 0.765), and GI-EB (P = 0.743) were all removed from the model because they did not meet the condition of $P < 0.05$. The other hypotheses all achieved $P < 0.05$.
- The results indicate that individuals' energy-saving behavior is mainly influenced by the activities and characteristics of the group. EI is the factor that has the greatest impact on EB ($P = 0.000$; $\beta_{(EI-EB)} = 0.377$), which is consistent with the TPB theoretical model and the study by Zhang et al. (2018), Zhang et al. (2018).

Table 4: Path analysis-partial least squares structural equation modelling results

Path	Original sample (O)	Sample mean (M)	STDEV	T statistics (|O/STDEV|)	P
DN - > EB	0.24	0.238	0.075	3.185	0.002
DN - > GI	0.609	0.61	0.036	16.715	0
DN - > EI	0.092	0.091	0.071	1.295	0.196
MB - > EB	0.021	0.025	0.07	0.299	0.765
MB - > EI	0.141	0.137	0.06	2.359	0.019
SV - > DN	0.625	0.627	0.044	14.318	0
SV - > EB	0.194	0.191	0.086	2.251	0.025
SV - > EI	0.238	0.24	0.065	3.653	0
GI - > EB	−0.029	−0.036	0.088	0.328	0.743
GI - > EI	0.442	0.445	0.064	6.883	0
EI - > EB	0.377	0.384	0.087	4.335	0

1st value=standard beta coefficient, cSignificance at 1% respectively (two-tailed T-test) SV: Self-transcendence group values, DN: Descriptive norms, GI: Group Interactions, EB: Energy-saving behavior, EI: Energy-saving intention, MB: Energy management board, STDEV: Standard deviation

- We did not find a correlation between MB and EB, but MB indirectly affects EB through EI. Similarly, GI does not have a direct impact on EB but has an indirect impact on it.
- This study found interesting results when analyzing the role of the Energy Management Board (MB). MB indirectly influences the energy-saving behavior (EB) of individuals. In office buildings or shared spaces, a large amount of electricity is consumed for activities such as lighting and air conditioning. The energy management team is responsible for monitoring and supervising energy consumption activities, issuing regulations on energy use, and requiring everyone to comply. This explains why the energy-saving behavior of individuals is mainly compliant with regulations, and the spirit of voluntary energy-saving is not high. However, the MB indirectly influences the EB, helping individuals form energy-saving habits.
- The self-transcendence group values (SV) directly and indirectly impact energy-saving behavior. This indicates that the more an individual is aware of the values of the self-transcendence group, the more willing they are to apply energy-saving actions. However, this result differs from Hong et al.'s (2019) study, where the authors found that non-material values have little impact on residents' energy-saving behavior (Hong et al., 2019).
- Group interaction indirectly influences the energy-saving behavior of individuals in shared spaces. Group interaction plays an important role in increasing energy-saving intention and thereby enhancing the ability to implement EB, and this result is like the findings of Chen and Knight (2014). Sharing energy-saving experiences within the group will help members increase their awareness of energy-saving. The interaction between members in the group on enhancing energy-saving intention is higher than the influence of MB ($\beta_{(GI\text{-}EI)}$ = 0,442 > $\beta_{(MB\text{-}EI)}$ = 0.141) and sharing among members is the best way to help individuals increase their energy-saving intention.

Additionally, descriptive norms (DN) significantly influence group interaction ($\beta_{(DN\text{-}GI)}$ = 0.609), indicating that individuals with higher norm awareness are more likely to activate group interactions. They will try to communicate and persuade others to pursue the group's collective interests, which can reinforce individuals' energy conservation intentions and thus lead them to comply with the transmitted behavior. This result is consistent with Zhu et al.'s (2021), (Zhu et al., 2021) study. Therefore, descriptive norms only influence individuals' behavioral intentions when the norms are internalized in people's minds. Since attention is malleable and not sustainable, group interaction helps increase the visibility of descriptive norms and promote the behavioral intentions of everyone, thereby promoting their energy-saving activities.

5. CONCLUSION AND POLICY IMPLICATIONS

This study aims to clarify the relationship between group-level influences and energy-saving behaviors of individuals in shared spaces of office buildings. The study is based on the Theory of Group Dynamics, which explains the mechanisms related to group levels and obtained some results as follows:

The study selected group-level factors such as Self-transcendence group Values, Descriptive Norm, Group Interaction, and Energy Management Board to examine their impact on the intention and behavior of individuals towards energy-saving in shared spaces. Among these factors, Descriptive Norm has the strongest direct impact on individual energy-saving behavior. The normative actions of the group are always aimed at and adhered to by individuals. Moreover, Descriptive Norm indirectly influences the intention to save energy through group interactions. This shows that group interaction is beneficial to increase the display of descriptive norms and thus reinforce the intention of individuals to save energy. However, group interaction does not have a direct impact on energy-saving behaviors, meaning that individuals cannot be directly persuaded to engage in energy-saving behavior through advocacy.

Individuals with higher awareness of normative behavior are more likely to encourage others to participate in energy-saving actions. In addition, the values of the self-transcendence group have a direct and indirect impact on energy-saving behaviors by mediating the intention of behavior related to energy-saving. It implies that the beliefs of group members have a subtle influence on the energy-saving behaviors of individuals in shared spaces. The behavior of group members is directly affected by the beliefs of group members. The Energy Management Board does not have a direct impact on energy-saving behavior but indirectly influences it through the intention to save energy. This implies that when individuals comply with regulations, their behavior may not be based on awareness but only on compliance. However, in the case of individuals following long-term strategies, an energy-saving culture is formed, leading to an increase in energy-saving behaviors in the future.

The results obtained from this study affirm that individuals participating in a shared environment are influenced by the words and actions of other members of the group, whether directly or indirectly. The practical actions of the group serve as a norm that strongly promotes energy-saving behaviors of individuals. The findings from this study help unit, management agencies, organizations, or businesses identify factors that influence individuals' energy-saving behavior, and thereby implement activities and measures to improve energy efficiency in buildings.

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APPENDIX 1

Constructs	Questionnaire items	References
Self-transcendence group values (SV)		
SV1	My roommates emphasize the importance of respecting nature and protecting the environment.	(Zhu et al., 2021;
SV2	My roommates remind others to save energy and to protect the environment.	Hiratsuka et al., 2018)
SV3	My roommates are considerate of the needs and welfare of other people.	
SV4	My roommates assert that reducing pollution is a pivotal necessity for humanity.	
Descriptive norm (DN)		
DN1	My roommates switch off lights when leaving unoccupied room	(Tang et al., 2019)
DN2	My roommates shut doors and windows before turning on air conditioner.	
DN3	My roommates shut doors and windows before turning on air conditioner.	
DN4	My roommates select energy efficient mode of washing machine when in use.	
Group Interaction (GI)		
GI1	My roommates remind me of saving energy	(Zhu et al., 2021;
GI2	My roommates share their academic knowledge regarding energy-saving with me.	(Forsyth, 2018;
GI3	My roommates solicit my expertise regarding energy conservation.	Bales, 1970)
Energy management board (MB)		
SN1	The energy management board regularly reminds individuals to turn off their electrical devices when not in use	
SN2	The energy management board regularly promotes and provides guidance on energy-saving practices	
SN3	The energy management board has notifications and records of handling cases of wasteful use of energy-consuming equipment in the building	
Energy-saving intention (EI)		
EI1	I will choose to purchase energy-labeled equipment firstly.	(Tang et al., 2019;
EI2	I shall make every scholarly endeavor to assist my roommates in conserving energy.	Zhu et al., 2021)
EI3	I am prepared to modify my daily routine to promote energy efficiency.	
EI4	You would like to join in relevant energy-saving organizations or departments	
Energy-saving behavior (EB)		
EB1	When you do not use the device for a long time, you will turn off the device to reduce power consumption.	(Zhu et al., 2021)
EB2	You will use curtains to reduce room temperature.	
EB3	I take my computer power off when not in use	
EB4	I switch off the lights when leaving unoccupied room	