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Determinants of Sustainable Energy Saving Behavior among University Students in Malaysia: A Case Study of Management & Science University (MSU)

*Kazeem Alasinrin Babatunde[1], Nur Fadzlunnisaa Wakimin[1], Siti Haslini Binti Zakaria[1], Miney Soman[1], Ken Charman[2]
[1]Faculty of Business, Management & Professional Studies, Management Science University, Malaysia
[2]Faculty of Business, CamEd Business School, Phnom Penh, Cambodia
*kazeem_alasinrin@msu.edu.my, nur_fadzlunnisaa@msu.edu.my, siti_haslini@msu.edu.my, miney_soman@msu.edu.my, kcharman@cam-ed.com

Abstract: The increasing energy demand and its impact on climate change pose serious challenges to environmental sustainability. University students, as future leaders and decision-makers, have the potential to adopt and promote sustainable energy-saving behavior in their communities. However, the factors influencing their energy-saving practices are poorly understood, especially in the Malaysian context. Using a cross-sectional survey design, this research examines the factors influencing energy-saving behavior among students of MSU. A self-administered questionnaire was distributed to MSU students, covering demographic details and variables related to energy-saving behavior and its determinants. The study employed stratified random sampling and used exploratory factor analysis (EFA) and structural equation modeling (SEM) for data analysis. The results show that social norms and perceived control over students' behaviors are the only significant factors affecting sustainable behavior to save energy among students. At the same time, environmental awareness, energy literacy, and personal attitudes have no significant effect. Social norms are the strongest driver of energy-saving behavior, followed by perceived behavioral control. The findings suggest that interventions and policies to foster sustainable energy-saving behavior among students should focus on enhancing social norms and perceived behavioral control. This research fills the knowledge gap by offering specific insight into sustainable energy-saving behavior among Malaysian university students.

Keywords: *Sustainable energy-saving behavior; Energy conservation; University Students;Structural equation modeling, Social Norms, Perceived behavioral control*

1. Introduction and Background

Reducing energy consumption is a crucial step toward achieving environmental sustainability and mitigating the adverse effects of climate change, which have become more evident and alarming in recent years (Ayeleru et al., 2023; Curto et al., 2021; Saudi et al., 2019). Energy-saving behaviors are essential not only in domestic and professional settings but also in academic institutions, especially universities (Leal Filho et al., 2022). University students are a key group in promoting energy conservation, as their involvement in energy-saving behaviors can influence their current and future energy consumption patterns (Leal Filho et al., 2022). This research examines factors affecting sustainable behavior to save energy among students at the Management & Science University (MSU) in Malaysia. Previous research has examined several factors determining energy-saving behavior, such as perceived behavioral control, energy literacy, personal attitudes, social norms, and environmental awareness (Cotton et al., 2018; Franco et al., 2022; Lee et al., 2022). However, there is a gap in understanding the specific dynamics of these factors in the Malaysian higher education context. Environmental awareness is a vital factor influencing individuals' knowledge of the environmental impacts of energy consumption and the importance of conservation (Dincă et al., 2022; Kuai et al., 2022). Studies from different regions of the world, such as Romania, China, and Europe, have highlighted the positive relationship between behavior to save energy and environmental awareness in various settings (Udalov et al., 2017). Using an integrated assessment mode in the Gulf Cooperation Council (GCC), Aldulaimi et al. (2022) revealed the necessity for member states to conserve energy and shift focus to renewable energy sources (Babatunde et al., 2023).

Another important factor that affects energy-saving behavior is energy literacy, which pertains to a person's comprehension of energy-efficient technologies and practices (Cotton et al., 2018, 2021). Research from various countries and cultures, such as Vietnam, Brazil, Belgium, and the United Kingdom, has investigated the complex relationship between behavior to save energy and student energy literacy (Franco et al., 2022; Lee et al., 2022). These studies have revealed the different factors, such as values, attitudes, and sustainability

intentions that mediate the link between energy-saving actions and energy knowledge. Personal attitudes, which include beliefs, values, and subjective norms, have also been identified as key determinants of energy-conserving behavior (Chen & Gou, 2022; Wang et al., 2023). Studies in this area emphasize that individuals who believe in energy conservation and feel responsible for reducing their energy consumption are more likely to exhibit energy conservation behaviors in their academic and non-academic domains. However, more studies are needed to investigate the intricate interaction between personal attitudes and other determinants within the specific socio-cultural context of Malaysian university students.

Another factor that shapes energy-saving behavior is social norms, which consist of descriptive norms (what others do) and injunctive norms (what others expect). Many studies in different contexts have shown how social norms affect individual choices related to energy consumption. Understanding the nuances of social norms and how they motivate energy-saving behaviors among Malaysian university students is important for creating a campus culture that supports environmental sustainability (Looi et al., 2022; Wee & Choong, 2019). Similarly, perceived behavioral control, which pertains to a person's understanding of their capacity to execute a particular action and overcome obstacles, has a significant impact (Boomsma et al., 2019; Canova & Manganelli, 2020). Findings indicate that people with higher perceived behavioral control are more inclined to participate in energy-saving activities. Information availability, resource access, and external stimuli enhance perceived behavioral control (Huang et al., 2020; Xuan et al., 2023). Exploring how the complex perceived behavioral control role among Malaysian university students can help design targeted interventions and strategies that empower them to adopt sustainable energy-saving behaviors.

This research fills the existing gaps in the academic literature by examining the relationship between environmental awareness, energy literacy, personal attitudes, social norms, perceived behavioral control, and sustainable energy-saving behavior among Malaysian university students. Focusing on MSU as a case study, this research seeks to enrich the knowledge base on the factors influencing energy-saving behavior. Moreover, the research aims to reveal how these factors can be leveraged to encourage sustainable energy practices within the campus environment. In a country facing energy consumption challenges (Babatunde et al., 2018) and climate change (Babatunde et al., 2021), understanding the drivers of energy-saving behavior among university students has profound implications. By identifying effective strategies to foster energy conservation and environmental responsibility among the younger generation, this research contributes significantly to broader efforts to achieve energy efficiency goals and cultivate a culture of sustainability in Malaysia and beyond.

2. Literature Review

Energy-saving behaviors are essential for achieving environmental sustainability, as they can help reduce energy consumption and mitigate the effects of climate change (Kasavan et al., 2021; Said et al., 2022). Various research has examined the factors that affect individual energy-conservation actions in different settings, such as households, workplaces, and universities. These factors include environmental awareness, social norms, and perceived behavioral control. Moreover, psychological theories, such as the Stimulus-Organism-Behavior-Consequences theory, the Norm Activation Model (NAM), and TPB, have provided useful frameworks for understanding these complex behaviors. This review aims to summarize the main findings from recent research on energy-saving behaviors, focusing on how these factors interact and identifying possible research gaps for further exploration.

Energy Saving Behavior and Environmental Awareness: Dincă et al. (2022) demonstrated that environmental awareness positively influenced energy-saving habits in Romania, alongside other factors such as perceived consumer effectiveness and collectivistic perspective. Kuai et al. (2022) found that increased environmental awareness significantly promoted household energy-saving behavior in China, especially among rural households, male household heads, and younger individuals. Udalov et al. (2017) revealed how motivations related to the environment positively impacted individual investment in energy efficiency and energy conservation actions in Belgium, the Netherlands, and Germany. While these studies provide valuable insights into the role of environmental awareness in promoting energy-saving behavior, they do not specifically focus on university students. Instead, the new study bridges this gap by investigating the determinants of sustainable energy-saving behavior among students in Malaysia, considering additional

factors such as perceived behavioral control, personal attitudes, energy literacy, and social norms. This approach provides a broader insight into energy conservation behavior within the context of higher education institutions.

Energy-Saving Behavior and Energy Literacy: Energy literacy and its relationship with energy-saving behavior have been examined in various contexts. Lee et al. (2022) discovered that high school students in Vietnam had low energy knowledge but high energy-saving behavior, indirectly influencing energy awareness on the intention and behavior to save energy mediated by values and attitude. Franco et al. (2022) explored students' sustainability attitudes and energy-saving intentions in higher education settings in Brazil and Belgium, identifying the main factors affecting student energy-saving, eco-friendly product use, and behavior motivated by financial considerations. Cotton et al. (2018) examined the connection between students' energy literacy and their universities' positions in a sustainability ranking, revealing significant differences in environmental attitudes among students at differently-ranked universities. Cotton et al. (2021) studied university students' energy literacy in China and the United Kingdom, highlighting cultural differences in energy knowledge, attitudes, and behaviors. These studies provide valuable insights into the role of energy literacy in promoting behavior that saves energy. However, there is a need to examine further the role of energy knowledge among university students in Malaysia, as the current study aims to do. By focusing on this specific context and including other determinants, such as personal attitudes, perceived control over behavior, and social norms, the study can contribute to a more comprehensive understanding of energy-saving behavior within higher education institutions.

Energy-Saving Behavior and Personal Attitudes: Several studies have investigated the factors influencing energy-saving behaviors and personal attitudes in recent years, focusing on various populations and settings. The relationship between these two aspects is crucial for understanding how individual choices and actions can contribute to a more sustainable future. For example, research has identified attitudes, personal norms, place attachment (Wang et al., 2023), perceived behavioral control, subjective norms, and moral norms (Chen & Gou, 2022) as significant predictors of intentions and actions related to energy conservation. Additionally, cultural values (Xuan et al., 2023) and visiting purposes (Wang et al., 2023) have been found to moderate these relationships. However, a salient research gap exists in understanding how these factors interact and how their effects may vary across different demographic groups and socio-cultural contexts. Furthermore, there is a need to explore the potential of tailored interventions that address specific populations' unique needs and preferences to promote energy-saving behaviors and attitudes effectively.

Energy-Saving Behaviors and Social Norms: Recent research has explored the connection between energy-saving behaviors and social norms in various contexts, demonstrating the key normative values' role in shaping individual actions. Tersia et al. (2021) and Xu et al. (2020) found that ascription of responsibility, descriptive norms, and injunctive norms influence behaviors to save energy differently in shared offices, while Ruokamo et al. (2022) showed that energy-saving tips, usage feedback, and online energy service platforms could lead to significant reductions in residential electricity consumption. Heib et al. (2023) identified personal norms and behavioral control as the strongest predictors of energy-saving intentions in a university setting. These findings highlight the importance of understanding the complex interplay between social norms and energy-saving behaviors and the need to explore further the role of additional factors, such as individual motivations, socio-cultural influences, and intervention design, to develop more effective strategies for promoting sustainable practices.

Energy-Saving Behaviors and Perceived Behavioral Control: Research on behaviors to save energy has explored various factors contributing to sustainable practices. Boomsma et al. (2019) discovered that heating-related energy-saving behaviors were more frequent in social housing residents experiencing condensation, dampness, and mold, with subjective norms playing a stronger role in energy-efficient homes. Canova & Manganelli (2020) extended the TPB to investigate workplace energy conservation determinants, finding that perceived behavioral control, subjective norm, cognitive attitude, and habit significantly affect intentions to save energy, with perceived behavioral control having the most impact. Huang et al. (2020) examined energy-saving among Chinese rural households, highlighting the positive influence of off-farm employment, democratic participation, literacy training or life skills, cooperative societies, and stable, clean energy usage. However, perceived behavioral control and ecological values only significantly affected energy-

saving behavior, not solar energy use. Xuan et al. (2023) combined SOBC, NAM, and TPB to study the impact of external and internal stimuli on the behavior of urban Vietnamese residents to save energy. The results opined that external factors positively affected energy-saving cultures, whereas internal factors activated personal norms. Furthermore, a positive moderating effect was observed by long-term orientation on the association between intention to save energy, behavior, and habit. At the same time, collectivism only moderated the connection between behavior to save energy and habit. Despite these insights, further research is required to study the role of individual differences in energy-saving behaviors across various contexts.

Energy-saving behaviors are complex phenomena influenced by multiple factors, including environmental awareness, social norms, perceived behavioral control, and contextual elements. While existing theories like the SOBC, the NAM, and the TPB theory have provided valuable insights into understanding these behaviors in various settings like workplaces and households, the specific determinants of university students' behaviors to save energy remain understudied. As the urgency of climate change intensifies, promoting energy conservation and consumption efficiency becomes paramount. Technological innovation in creating energy-efficient equipment is essential, but effective behavioral interventions must complement it to encourage sustainable energy practices. While awareness-raising campaigns are a starting point, they alone may not lead to significant and sustained behavioral change. Consequently, there is a pressing need for research focusing on behavioral interventions, considering the unique context of university students. Identifying the specific factors that influence energy-saving behaviors in this demographic and examining the impact of tailored interventions will provide crucial insights for developing effective strategies to foster energy conservation and environmental sustainability among university students in Malaysia. By addressing these research gaps, this paper advances knowledge on energy-saving behaviors and contributes to the efforts to combat climate change throughbehavioral change at the university level.

3. Methodology

Based on the extended TPB theory, this research employed a cross-sectional survey methodology to collect data and analyze the factors affecting sustainable behavior to save energy among university students. The study focused on the case of MSU and administered a survey questionnaire to the students. The questionnaire is made up of two main sections. The first section (Section A) asked for five demographic items: age, gender, year of study, faculty and type of accommodation. The second section (Section B) measured the participants' level of agreement on 25 items related to six variables: Social Norms, Environmental Awareness, Personal Attitudes, Energy Literacy, Perceived Behavioral Control and Sustainable Energy-Saving Behaviors. The responses for this section used a 5-point Likert scale from one (strongly disagree) to five (strongly agree). Table 1 shows the operationalization of each variable in the questionnaire.

Table 1: Number of Measurement Items

Construct	Number of Question	Per Variable
Environmental Awareness	4	Questions (1-4)
nergy Literacy	4	Questions (5-8)
ersonal Attitudes	4	Questions (9-12)
ocial Norms	4	Questions (13-16)
erceived Behavioral Control	4	Questions (17-20)
ustainable Energy Saving Behavior	5	Questions (21-25)

This study used an online survey created with Google Forms to collect data from the respondents. This method was chosen because of its advantages and suitability for this research. The benefits include a lower budget requirement, as the questionnaire can be emailed and distributed to many respondents simultaneously. Respondents can also complete the questionnaire at their convenience. The data collected is used to test the developed model and examine the relationships between the variables.

Sampling Method: This research employed a technique of stratified random sampling for participant selection. The target population was the university students enrolled at MSU in Malaysia. To ensure

representativeness and account for possible differences among faculties and programs, the population was stratified based on the academic faculties or departments within the university. A proportionate random sampling method was applied to each stratum to select the participants. This sampling method ensured that each stratum was adequately represented in the sample, allowing more accurate generalization of the findings to the target population.

Population and Sample Size: According to the school record, the population of MSU Shah Alam students was about 15,000. Based on Krejci & Morgan's (1975) table, the target sample size for this population size was 375. However, due to poor responses from the respondents, this study only obtained 307 samples. Considering the complexity of the proposed structural equation model and the desire for robust analysis, a sample size of 307 was deemed appropriate. This sample size allowed for sufficient statistical power to detect significant relationships between the variables and increased the reliability and generalizability of the findings.

4. Results and Discussion

Respondents' Profile: The respondents were 41.4% male and 58.6% female MSU students. Their average age was 21.31 years (SD = 2.240); most were year-one students. The respondents came from different faculties or departments within the university: 55.0% from FBMP, 16.9% from FHLS, 9.1% from IMS, 8.8% from FISE, 4.6% from SESS, 3.9% from SPH, and 1.6% from SHCA. Most respondents (54.1%) lived in off-campus private housing, 36.2% in off-campus shared housing and 9.8% in MSU residents.

Reliability Analysis: The reliability analysis of the scales utilized for measurement in the research was assessed using Cronbach's alpha or other appropriate measures. The measure of internal consistency for each construct must exceed a minimum value of 0.6. Sekaran & Bougie (2016) and Awang (2014) suggest that Cronbach's alpha value of more than 0.6 indicates reliable instruments for research. The reliability analysis verifies the instrument's reliability for Perceived Behavioral Control, Environmental Awareness (EA), Personal Attitudes (PA), Energy Literacy (EL), Social Norms (SN) and Sustainable Energy Saving Behavior (SESB). Table 2 shows that Cronbach's alpha value is more than 0.7 for all constructs, indicating high reliability.

Table 2: Assessment of Reliability for All Constructs

Construct	No of Items	Cronbach's Alpha
Environmental Awareness	4	0.774
Energy Literacy	4	0.830
Personal Attitudes	4	0.862
Social Norms	4	0.875
Perceived Behavioral Control	4	0.891
Sustainable Energy Saving Behavior	5	0.840

Normality Assessment: The normality of the data was assessed next. Table 3 displays the values of kurtosis and skewness for each construct. The data is normal if the absolute skewness and kurtosis values are 2.0 or lower (Hair et al., 2010). The results indicate that all constructs have skewness values between -0.401 and -0.043 and kurtosis values between -0.586 and -0.168, which are within the acceptable range. This implies that the data is normally distributed for all constructs.

Table 3: Normality Test

Construct	Skewness	Kurtosis
nvironmental Awareness	-0.062	-0.302
nergy Literacy	-0.043	-0.168
ersonal Attitudes	-0.319	-0.514
ocial Norms	-0.043	-0.394
erceived Behavioral Control	-0.058	-0.586
ustainable Energy Saving Behavior	-0.401	-0.401

Confirmatory Factor Analysis (CFA) Measurement Model: A measurement model combining all the constructs using CFA was established—the measurement model with the factor loadings for all items higher than 0.6, as shown in Figure 1. However, the fitness indexes failed to reach the necessary threshold despite all the factor loadings being within an acceptable range. This issue may be due to redundant items. Redundant items can be identified using Modification Indices (MI). When the MI value is greater than 15 (MI >15), it indicates that a pair of items is redundant. After deleting one item (SESB5) with an MI value greater than 15 and correlating each pair of redundant items, Table 4 shows that the fitness indexes met the level required for the validity of all constructs as recommended by Awang (2014), Awang et al. (2023) and (Zainudin et al. 2017).

Figure 1: The Pooled Measurement Model for Confirmatory Factor Analysis (CFA)

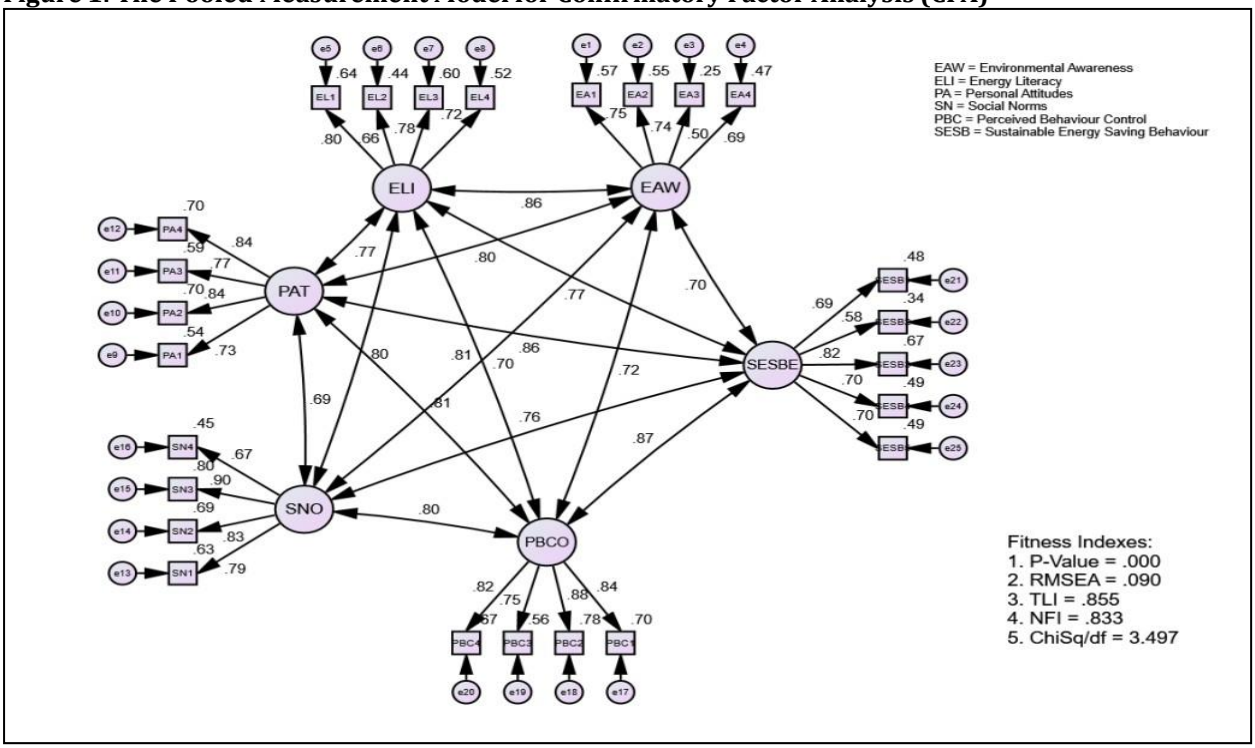


Table 4: Fitness Indexes Assessment for Final Measurement Model

Category	Index	Index Value	Comment
Absolute Fit	RMSEA	0.075	The level required is attained
Incremental Fit	TLI	0.903	The level required is attained
	NFI	0.877	The level required is attained
Parsimonious Fit	Chis/d	2.712	The level required is attained

The results in Table 5 and Table 6 show that the measurement model has good discriminant validity, convergent reliability and validity. Convergent validity refers to the degree to which the items of a construct measure the same concept. Reliability pertains to the degree to which the items of a construct are consistent and free of measurement errors. Discriminant validity means the degree to which the constructs are unique and do not overlap. These findings indicate that the measurement model meets the following criteria for these validity and reliability tests:

- The loadings of all factors for each item exceed 0.6, which indicates that they are significant and relevant for their respective constructs.
- Each construct with an average variance extracted (AVE) of more than 0.5 reveals that their respective constructs account for over fifty percent of the item variance.
- Each construct with a composite reliability (CR) of more than 0.7 reveals that each construct's items are reliable and internally consistent.

- Each construct with the square root of the AVE for each construct exceeds the correlations between constructs, indicating that each construct has a stronger association with its items than with other constructs.

These results suggest that the measurement model has a higher reliability and validity. The constructs and items are well-defined and measured (Hair et al., 2010).

Table 5: Composite Reliability and Convergent Validity

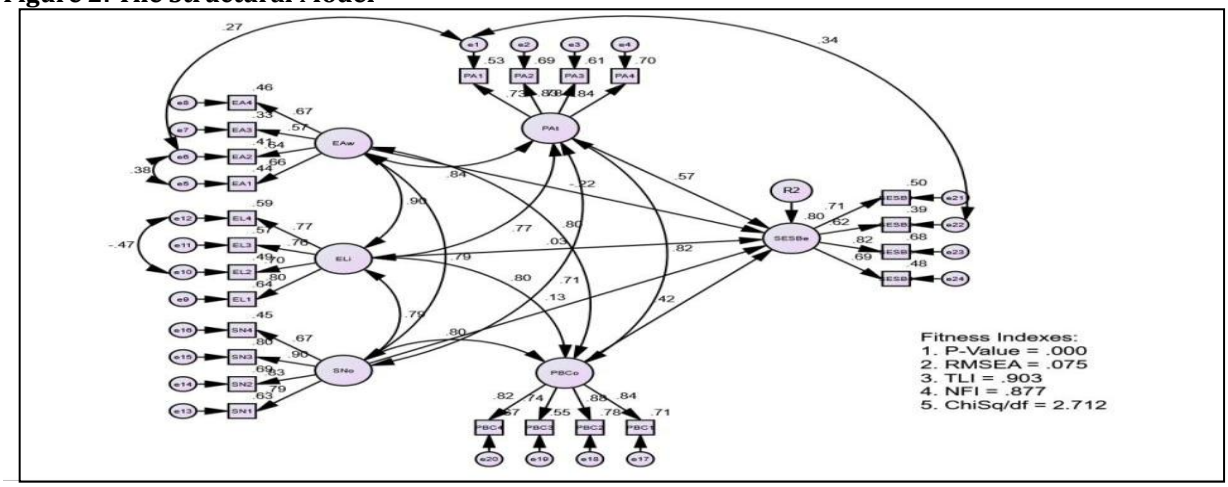
ONSTRUCT	ITEM	FACTOR LOADING	CR	AVE
Environmental Awareness	EA1	0.664	0.740	0.455
	EA2	0.640		
	EA3	0.600		
	EA4	0.675		
Energy Literacy	EL1	0.802	0.843	0.575
	EL2	0.698		
	EL3	0.758		
	EL4	0.770		
Personal Attitudes	PA1	0.726	0.872	0.632
	PA2	0.833		
	PA3	0.779		
	PA4	0.836		
Social Norms	SN1	0.793	0.877	0.643
	SN2	0.830		
	SN3	0.896		
	SN4	0.671		
Perceived Behavioral Control	PBC1	0.840	0.893	0.677
	PBC2	0.883		
	PBC3	0.744		
	PBC4	0.816		
Sustainable Energy Saving Behavior	SESB1	0.710	0.806	0.512
	SESB2	0.622		
	SESB3	0.823		
	SESB4	0.692		

Table 6: Discriminant Validity Index Summary

CONSTRUCT	EA	EL	PA	SN	PBC	SESB
Environmental Awareness	**0.675**					
Energy Literacy	0.420	**0.758**				
Personal Attitudes	0.310	0.360	**0.795**			
Social Norms	0.400	0.500	0.350	**0.802**		
Perceived Behavioral Control	0.390	0.480	0.390	0.520	**0.823**	
Sustainable Energy SavingBehavior	0.360	0.440	0.41	0.480	0.530	**0.716**

Structural Model: After establishing the measurement model's validity and reliability, a structural model was employed to examine the developed hypotheses. Figure 2 shows the results indicating the path coefficient from each exogenous construct to the endogenous construct. Table 7 summarizes the results of the hypothesis testing, showing that two hypotheses were supported and three hypotheses were not supported. The relationships between environmental awareness (β = -0.285, p = 0.359), energy literacy (β = 0.029, p = 0.870) and personal attitudes (β = 0.128, p = 0.160) and sustainable behavior to save energy were not significant. However, both social norms (β = 0.759, $p < 0.001$) and perceived control over behavior (β = 0.429, $p < 0.001$) had significant effects on sustainable behavior to save energy.

Figure 2: The Structural Model



The findings of this research showed that environmental awareness, energy literacy, and personal attitudes did not significantly affect the sustainable energy-saving behavior of students, while social norms and perceived behavioral control did. Different theoretical and empirical perspectives can explain these findings. First, according to the value-belief-norm theory, environmental awareness leads to pro-environmental behavior only when it activates personal norms, which are the sense of moral obligation to act environmentally friendly (Stern et al., 1999). Moreover, perceived behavioral control and social support can enhance or inhibit the influence of personal norms on behavior, depending on whether they facilitate or hinder the enactment of one's moral values. Therefore, environmental awareness may not directly affect students' sustainable energy-saving behavior but rather indirectly through personal norms.

Second, according to the TPB (Ajzen et al., 2005), individuals' behaviors are shaped by their intentions, which are, in turn, affected by their social norms, attitudes, and perceived control over their behavior. Attitude pertains to an individual's assessment of behavior as either positive or negative. Subjective norms involve an individual's perception of peer pressure to take part or refrain from taking part in an action, and perceived control over behavior relates to an individual's perception of the simplicity or complexity of executing a behavior. Therefore, energy literacy may not directly affect students' sustainable energy-saving behavior but rather has an indirect effect through perceived control over behavior, attitude, and norms. This conforms with the findings of Lee et al. (2022), who discovered that energy knowledge did not directly affect energy-saving intention or behavior but rather had an indirect effect through energy-related values and attitudes toward energy-saving.

Table 7: Fitness Indexes Assessment for Final Measurement Model

CONSTRUCT	PATH	CONSTRUCT	ESTIMATE	S.E.	C.R.	P	RESULT
SESBe	←	Environmental Awareness	0.285	0.311	0.917	0.359	Not Significant
SESBe	←	EnergyLiteracy	0.029	0.180	0.164	0.870	Not Significant
SESBe	←	PersonalAttitudes	0.128	0.091	1.405	0.160	Not Significant
SESBe	←	Social Norms	0.759	0.177	4.295	***	Significant
SESBe	←	Perceived BehavioralControl	0.429	0.117	3.678	***	Significant

Third, according to the attitude-behavior gap theory (Kollmus & Agyeman, 2002), there is often a discrepancy between what people say they will do and what they do concerning environmental issues. This gap can be explained by factors intervening between attitude and behavior, such as lack of knowledge, resources, time, skills, feedback, trust, social norms, habits, or incentives. Therefore, personal attitudes may not directly affect

students' sustainable energy-saving behavior but rather depend on the presence or absence of these intervening factors. This is supported by the findings of Users TCP and IEA (2020), who argued that personal attitudes are not stable or consistent predictors of behavior, especially when influenced by external factors such as situational constraints, habits, or incentives.

In contrast to these non-significant effects, social norms had a statistically significant impact on students' sustainable behavior to save energy. This reveals that students were more likely to save energy when they perceived that others were doing so or expected them to do so. This finding is consistent with previous studies highlighting social norms' influence on individual energy-saving choices and actions (e.g., Qin & Chen, 2022; Siqueira et al., 2022; Udalov et al., 2017). Social norms can act as a source of information, motivation, or pressure for individuals to adopt or avoid certain behaviors, depending on the perceived prevalence or desirability of the norm (Chen & Gou, 2022). In addition to social norms, perceived behavioral control significantly impacted students' sustainable behavior to conserve energy. This means that students were more likely to save energy when they felt confident performing the behavior and overcoming any barriers.

5. Conclusion

This research investigates the determinants of sustainable behavior to save energy among Malaysian university students, using the extended TPB as our theoretical framework. We collected data from 307 students at MSU through a survey method and analyzed it using SEM-Amos. Our results showed that only perceived behavioral control and social norms had statistically significant influences on sustainable energy-saving behavior among the students. Contrary to our expectations, environmental awareness, energy literacy, and personal attitudes did not significantly impact such behavior. These results pose practical and important theoretical implications.

Theoretically, our study adds to the literature on students' sustainable behaviors by providing empirical evidence for the applicability and extension of the TPB in the Malaysian university context. We confirmed the reliability of the theory's constructs, namely perceived behavioral control, social norms, and personal attitudes, and introduced additional factors such as environmental awareness and energy literacy. Moreover, our study highlighted the different levels of influence these factors had on sustainable energy-saving behavior among Malaysian university students, identifying social norms as the strongest predictor.

Practically, our findings have implications for policymakers, educators, and university administrators who want to foster sustainable energy-saving behavior among Malaysian university students. Our results suggest that enhancing students' perceived behavioral control and social norms can increase their intention and behavior to conserve energy. This insight could inform the development of strategies such as environmental education campaigns, supportive infrastructures, incentives and feedback mechanisms, and peer communication. Furthermore, we recommend fostering energy-saving habits among students through positive reinforcement, continuous practice, and barrier reduction.

Despite the contributions of our study, we acknowledge its limitations. First, the sample size was relatively small and was limited to one university in Malaysia, which could restrict the applicability of our results to a broader context. Future research could use a larger and more diverse sample of university students from different institutions and regions. Second, the paper used a cross-sectional design, which may not capture energy-saving behavior's dynamic and temporal aspects. Examining the causal relationships within a longitudinal or experimental design could provide deeper insights. Third, the study relied on self-reported measures, which may introduce biases such as social desirability or recall errors. Using objective measures, such as meter readings or observations, could improve the accuracy of the data. This study did not consider potential influences such as personality traits, emotions, values, and situational factors. Future research could explore these factors and their interactions with the existing constructs within the TPB model.

In conclusion, our study offers a comprehensive investigation into the factors affecting sustainable energy-saving behavior among Malaysian university students, employing the extended TPB as our guiding framework. The research emphasizes the key roles of social norms and perceived behavioral control in shaping such behavior. These findings are significant for theoretical advancement, practical interventions,

and policy formulation. While our research has limitations, it lays the groundwork for a further thorough study of the complex factors affecting energy-saving behavior. As we collectively strive for a sustainable future, further research could build upon these insights to devise effective strategies for promoting energy conservation among

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