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Article

Solar photovoltaic adoption among landed residential property in Malaysia: Integration of sustainable energy security dimension

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Abstract: The Malaysian government's efforts to promote solar photovoltaic (PV) usage among households face a challenge due to its low adoption rate. This study delves into the factors influencing the exponential adoption of solar PV electricity generation among landed residential property owners in Malaysia. The research aims to comprehensively examine the predictors influencing the adoption of solar PV systems among Malaysian households. Hence, the study employs an enhanced Theory of Planned Behavior framework, integrating sustainable energy security dimensions such as availability, affordability, efficiency, acceptability, regulation, and governance. The sample comprised 556 Malaysian residents who owned and resided in the landed properties. The home locations where at least one solar PV installation existed within a residential street. Snowball sampling was employed through referrals, leveraging social and community networks. Collected data was analyzed using the partial least squares structural equation modeling. Attitude, affordability, and acceptability emerged as pivotal factors significantly impacting the intention to use solar PV systems among Malaysian households. This research not only enriches academic discourse but also offers practical implications for policymakers, guiding the formulation of targeted strategies to promote sustainable energy practices and facilitate the widespread adoption of solar PV systems in Malaysia.

Keywords: acceptability; affordability; attitude; photovoltaic; solar PV; sustainable energy security

1. Introduction

According to the World Bank, the net percentage of Malaysia's energy imports plummeted negatively, marking a disconcerting trajectory that has since grown below the average annual rate (CEIC, 2020). Although the Malaysian government has introduced policies aimed at accelerating solar photovoltaic (PV) adoption, these initiatives have yet to yield the desired results (Eenerdata, 2000). Several factors contribute to this gap, including an inadequate understanding of individual household behaviors, inefficiencies in policy implementation, and limited research on sustainable energy security (Nurwidiana et al., 2021). Existing literature has largely examined solar energy adoption from a technical or expert-driven perspective, often overlooking the importance of household behavior, psychological factors, and the effectiveness of policies (Lau et al., 2020; Narula and Reddy, 2016).

Previous studies exploring public and social attitudes toward solar energy in various Malaysian regions have underscored crucial barriers to solar energy adoption (Shafie et al., 2011; Solangi et al., 2015; Teoh et al., 2020). While technical aspects

of solar PV systems have been extensively explored, the sociopsychological dimensions, particularly how they interact with sustainable energy security frameworks, remain under-researched in the overall understanding of solar energy adoption. This can be explained by lack of commitment by consumers as insufficient knowledge for new technologies (Ho and Amin, 2023). However, a critical gap persists in understanding the impact of sustainable energy security (SES) practices on solar PV adoption, along with the direct and indirect factors influencing sustainable solar PV adoption, which is the aim of this study (Qazi et al., 2021).

While SES is acknowledged as a crucial parameter, it has predominantly been examined within the fields of energy policy and macroeconomics, with limited exploration of its social dimensions. The existing literature shows a significant gap in applying SES dimensions to solar energy (Narula et al., 2017; Rathore et al., 2018; Wang et al., 2018). This presents a critical opportunity for further exploration, as understanding the interplay between SES dimensions and individual will explore how regulatory frameworks and governance moderate these relationships among non-users of solar PV in landed residential properties in Malaysia.

This study aimed to answer the following three research questions. The first sought to identify the fundamental predictors influencing the intention to use solar PV systems among owners of landed residential properties. The second question examined the mediating role of intention to use in the relationship between the identified predictors and behavioral readiness to adopt solar PV systems. The third explored the moderating effect of regulation and governance on the relationship between the dimensions of sustainable energy security including availability, affordability, efficiency, and acceptability and the intention to adopt solar PV systems. This study seeks to address these gaps by investigating how intention to use mediates the relationship between key factors, i.e. attitudes, availability, affordability, and efficiency and behavioral readiness. It provides critical insights into how policy adjustments could accelerate solar PV adoption among Malaysian homeowners.

2. Literature review and hypothesis development

2.1. Solar photovoltaic system

Initially utilized to power space crafts and smaller gadgets like calculators and watches, the application of solar cells expanded exponentially. The promise of solar cell electricity has transformed into a reality and rendering it cost-competitive in diverse geographical locations. Large-scale photovoltaic (PV) systems now play a vital role in augmenting our electric grid, thereby reducing our reliance on conventional energy sources (Green, 2019). Utilities and governmental bodies grapple with the integration of solar PV installations into the existing electric grid, with concerns about potential disruptions to the delicate balance between power supply and demand (Green, 2019).

Renewable energy technologies are gaining prominence in Malaysia’s energy landscape, with solar PV systems experiencing a particularly rapid expansion due to recent technological advancements (Vaka et al., 2020). This growth signifies a vital

step toward Malaysia's sustainable energy future, offering the potential to mitigate environmental impacts and contribute to the global fight against climate change.

Situated in the tropical regions of Asia and the Pacific, Malaysia benefits from consistently hot and humid weather, offering an ideal environment for solar PV technology implementation (Alam et al., 2021). The country enjoys exceptional sun exposure throughout the year, with high solar irradiance translating into significant potential for solar power generation, estimated at 6500 MW (Abdullah et al., 2019). Large-scale solar and rooftop solar installations present excellent opportunities for solar deployment in Malaysia, capitalizing on the nation's abundant sunlight. Hence, the potential for solar energy is immense in Malaysia. Utilizing residential rooftops for PV solar systems has a positive impact on Malaysia's energy strategy. Therefore, this study focuses on the urban residential sector, where electricity demand is highest, rather than the industrial, commercial, or agricultural sectors.

2.2. Sustainable energy security dimensions

Sahid and Sin (2019) integrate renewable energy into the Energy Security (ES) index review, incorporating sustainability concepts. However, it is notable that even in this case, a comprehensive SES study is lacking. This scarcity of research highlights the underexplored terrain of SES, particularly within the realm of renewable energy, with a particular focus on solar energy. Past studies emphasize the need for robust indicators in evaluating energy security. Indicators should be measurable, achievable, relevant, and time-bound (Afgan et al., 2000; Kumar and Katoch, 2014; Morris and Therivel, 2009). In the context of Malaysia, Sharifuddin (2014) has developed a methodology for quantitatively assessing energy security tailored to the data limitations of Malaysia and other Southeast Asian nations. Comprehensive indicators are essential to gauge a country's energy security level.

2.3. Theory of planned behavior

Previous studies have identified key elements including pricing, technological advancements, and the financial stability of households, all of which play significant roles in shaping the behavioral intention to adopt solar PV systems. Researchers such as Lau et al. (2020); Lundheim et al. (2021); Palm and Lantz (2020) have explored adoption factors within the framework of the Theory of Planned Behavior (TPB). These determinants from TPB are aligned with our study and classified into sustainable energy security (SES) dimensions. By delving into these dimensions, this research aims to shed light on the complex dynamics of solar PV system adoption among residential property owners, ultimately contributing valuable insights to the field. The conceptual framework is depicted in **Figure 1**.

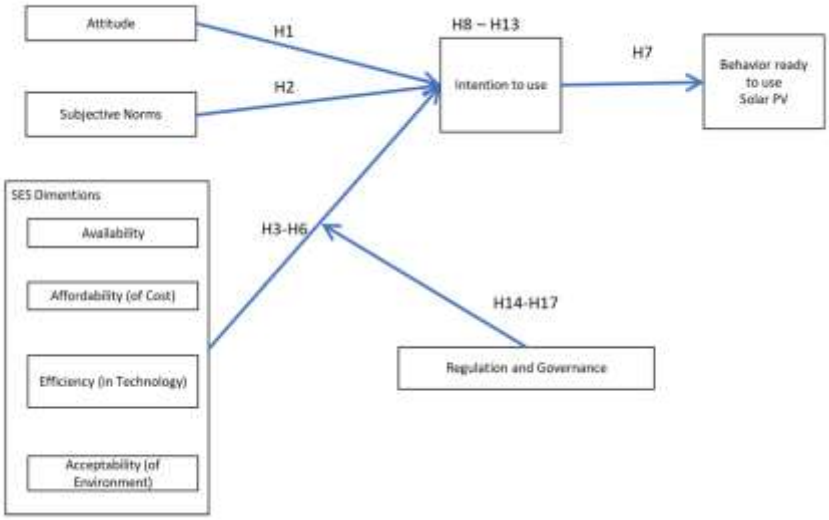

Figure 1. Conceptual framework.

2.4. Hypotheses development

2.4.1. Attitude, subjective norms and availability

Irfan et al. (2020) highlighted a positive correlation between consumers' intentions and their willingness to pay for renewable energy, driven by the belief that adopting RE can address pressing energy and environmental challenges, including reliance on fossil fuels, global warming, poor air quality, and climate change. Alam et al. (2021) reinforced these findings, demonstrating a strong positive relationship between attitudes and the intention to adopt solar PV technology in households. Lundheim et al. (2021) presented a more nuanced perspective, suggesting that in Nordic countries, attitudes have only a marginal influence on the intention to install solar panels in private homes. These findings indicate that the impact of attitudes on solar PV adoption may vary based on regional and socio-cultural contexts. Building on the findings of Lundheim et al. (2021), the following hypothesis recognizes that the influence of attitudes as context-dependent, with regional and cultural factors shaping the perceived value of solar PV technology in Malaysia.

H1: Attitude has significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

Awlam et al. (2021) report that subjective norms have a significant and strong effect on the intention to adopt PV solar technology among households in Malaysia. Qureshi et al. (2017) found that the availability of PV technology in the market positively influences its diffusion. According to the study, individuals increasingly influence one another to adopt solar technology by providing moral support. Similarly, Elahi et al. (2022) found a significant and positive impact of subjective norms on farmers' intentions to install a PV water pump in Pakistan. Abuzaid et al. (2022) found that the social dimension did not serve as a positively influential factor in the perception of residential PV solar projects in the UAE. On a broader scale, research examining solar system adoption patterns across several European markets

has illuminated the complex interplay between social norms and their impact on adoption rates. Hence, this study aimed to examine the following hypothesis:

H2: Subjective Norms have significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

Availability, within the realm of energy security, encompasses a multifaceted perspective. This signifies not just having ample supplies of energy but also attaining energy independence. It encompasses essential aspects such as the number of hours of electricity availability per day, the presence of trained repair personnel, and the accessibility of spare parts and supplies. In essence, it's about creating an environment where energy services are not just theoretically accessible but practically available to consumers (Narula et al., 2017). Availability, in this context, ensures that the energy system is not just a theoretical construct but a practical reality, accessible and reliable for those considering the adoption of solar PV systems (Qureshi et al., 2017). Understanding this dimension of availability is crucial for comprehending the factors that influence non-user's decisions regarding solar PV adoption. The availability of solar PV systems in local markets was identified as a key driver of adoption, as well as a reliable alternative source for a consistent electricity supply. Therefore, the following hypothesis is formed:

H3: Availability has significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

2.4.2. Affordability efficiency and acceptability

Affordability refers to the capacity to pay for a unit of energy for a specific service, determined by retail energy prices and consumers' financial capabilities (Bouhal et al., 2018). The social objective of equity as a core principle of SES is intrinsically linked to affordability, underscoring its importance in the adoption of solar PV systems (Egli, 2020). In the context of solar PV systems, affordability is measured by the monetary output (USD) per unit of energy generated from sunlight, a key parameter reflecting advancements in infrastructure, technology, processes, and management practices (Qazi et al., 2021). Financial resources allocated by the Malaysian government for renewable energy were limited to a predetermined portion of the utility's total income (Teoh et al., 2020). This created a pressing need for increased financial support to ensure adequate funding for renewable energy generators. Furthermore, the high installation costs associated with solar PV systems reduce affordability for individual homeowners (Solangi et al., 2015). Hence, this study would test the following hypothesis:

H4: Affordability of cost has significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

From the perspective of consumers, efficiency also includes factors such as the ease of installation, functionality, maintenance, and technical support related to solar PV systems (Sovacool et al., 2011). Their perceptions are often shaped by indirect experiences and reviews from existing users. This user-oriented view is essential in understanding how the ease of use, reliability, and technical efficiency of solar PV systems influence the decision-making process of potential adopters (Qureshi et al., 2017). In addition, users with high levels of self-efficacy are often competent and comfortable with technical support (Ho and Song 2021). Therefore, evaluating

efficiency from both a systemic and user experience perspective is essential for creating a comprehensive understanding of the energy adoption landscape. With that, we proposed the following hypothesis:

H5: Efficiency in technology has significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

Acceptability within the context of energy alternatives embodies multifaceted considerations, ranging from environmental concerns to social and cultural barriers prevalent within the population (Narula, 2014). Cheam et al. (2021) found that environmentalism significantly and positively influences the intention to adopt solar PV technology in Malaysia. Users' willingness to adopt new technology is often linked to their needs and preferences are considered by the businesses and service providers (Ho et al., 2025). In the UAE, a study by Abuzaid et al. (2022) showed that environmental dimensions play a major role in shaping customer perceptions of residential PV solar projects, further supporting the positive impact of environmental awareness on customer perceptions of such projects. Therefore, the following hypothesis is developed:

H6: Acceptability of the environment will have significant influence on Intention to use solar PV among landed residential property owners in Malaysia.

2.4.3. Behavioral intention

Behavioral intention, defined as the conscious anticipation of future behavior, serves as a precursor to actual behavior (Ajzen, 1985). It acts as a reliable indicator of whether consumers are likely to repeat a specific behavior, suggesting their likelihood of using a service or product again (Ho, 2019). Study by Lim et al. (2016) shows that online purchase intention significantly and positively influences online shopping behavior. Similarly, Kapoor and Dwivedi (2020) found that consumers' behavioral intentions toward green innovations significantly and positively influenced their adoption decisions. Therefore, we derived the following hypothesis:

H7: Intention to use has a significant influence on Behavior readiness to use solar PV among landed residential property owners in Malaysia.

2.4.4. Intention to use as mediator

Past studies have consistently demonstrated that intention plays a pivotal role in explaining untried behavior (Lundheim et al. 2021; Palm and Lantz 2020). In the context of individuals who have not yet adopted solar PV systems, their behavioral readiness to use such technology constitutes untried behavior. The transition for non-users from conventional electricity usage to adopting solar PV systems involves a significant shift in behavioral patterns (Triandis, 1980). This intention to use solar PV systems serves as the cognitive antecedent of behavior and reflects an individual's mental preparedness to embrace this change (Gollwitzer, 1996).

When faced with disruption due to high electricity bills and disconnected electricity supply, their perceived value for adopting solar PV becomes central to their core values. This revaluation process leads to a significant shift in their sense of self and compelling them to consider adopting solar PV systems (Qureshi et al., 2017).

Consequently, the intention to use precedes behavioral readiness to use in their decision-making process (Lau et al., 2020). Based on these premises, this study posits the following hypotheses:

H8: Intention to use mediates the relationship between Attitude and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

H9: Intention to use mediates the relationship between Subjective Norm and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

H10: Intention to use mediates the relationship between Availability and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

H11: Intention to use mediates the relationship between Affordability and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

H12: Intention to use mediates the relationship between Efficiency and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

H13: Intention to use mediates the relationship between Acceptability and Behavior readiness to use solar PV among landed residential property owners in Malaysia.

2.4.5. Regulation and governance as moderator

The significance of government incentives in encouraging renewable energy adoption is underscored in the study conducted by Bekti et al. (2021) in Indonesia, emphasizing the pivotal role these schemes play in motivating individuals to embrace sustainable technologies. Similarly, Kim et al. (2014) explored both monetary and non-monetary government strategies. They revealed that individuals, when presented with equivalent perceptions of the value of a green product, are more inclined to adopt it if they possess a comprehensive understanding of government incentives. Breetz et al. (2018) argue that regulatory frameworks play a critical role in shaping the availability of clean energy technologies, including solar PV systems. A study by Ai et al. (2021) reveals that regulations positively promote green technology innovation, primarily due to the crowding-out effect and resource effect associated with political connections. Therefore, we developed the following hypotheses:

H14: Regulation and Governance moderates the relationship between availability and intention to use solar PV among landed residential property owners in Malaysia.

H15: Regulation and Governance moderates the relationship between affordability of cost and Intention to use solar PV among landed residential property owners in Malaysia.

H16: Regulation and Governance moderates the relationship between efficiency in technology and Intention to use solar PV among landed residential property owners in Malaysia.

H17: Regulation and Governance moderates the relationship between acceptability of the environment and Intention to use solar PV among landed residential property owners in Malaysia.

3. Methodology

3.1. Research design

This study investigated the extent to which various determinants influence the adoption of solar PV systems among landed residential owners. The research design employed in this study delineates the meticulous framework for the collection, measurement, and analysis of data aligned with the study's research objectives footed in positivist paradigm.

The study selected individuals who own a landed residential property as the unit of analysis. In this study, the individual refers to the non-users of Solar PV systems who own landed residential property. There are about 7.1 million buildings in Malaysia and 4.2 million are landed residential (NAPIC 2023). Hence, these non-users who are landed residential owners have the option to use either the traditional electrical system or alternative systems, including solar PV systems. Therefore, these non-user house owners with landed properties are eligible respondents for the survey, and the data collected was generalized to represent the entire population of Malaysia.

3.2. Research population

The target population for this study comprises owners of landed houses and was chosen based on accessibility. The study focused on the Klang Valley region in Malaysia, which houses the largest population in Malaysia, with 9.3 million population. Klang Valley is an urban conglomeration encompassing Kuala Lumpur, including its neighboring cities and towns in the state of Selangor, Putrajaya, and Cyberjaya. This choice was made as Klang Valley boasts the largest residential buildings in Malaysia was 1.1 million units, making it a suitable representation of the country's diversity (NAPIC, 2023). These were the ready numbers of rooftops that can install solar PV systems on landed residential.

3.3. Sample and data collection

3.3.1. Sample description

The inclusion criteria outline the primary characteristics of the target population and guide the selection of the study sample. This study adhered to the inclusion criteria proposed by Winter and Dodou (2012) to identify eligible respondents. The respondents of the sample met the following criteria. First, the respondents must be Malaysian residents who owned and resided in the landed properties. Secondly, the covered areas were within a 50 km radius of the Kuala Lumpur City Centre (KLCC) as the centre point, extending north to Batu Caves, south to Sepang, east to Cheras, and west to Port Klang. Furthermore, the respondents were chosen from locations where at least one solar PV installation existed within a residential street. This

criterion ensured the respondents were knowledgeable about solar PV installations through their experiences as observers.

3.3.2. Data collection process

The study maintains transparency and consistency in the sample collection process. Therefore, snowball sampling was employed to enhance the respondent pool through referrals, leveraging social and community networks. Respondents were required to click on the Google Form link and submit their responses, which were then stored in the Google Form database. Ethical approval was obtained from the relevant department to address any potential ethical concerns associated with the questionnaire. By the end of the data collection period, 562 responses had been received.

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) program. Maximum likelihood exploratory factor analysis (EFA) is conducted for construct validation. Confirmatory factor analysis (CFA) was performed with the use of Partial Least Squares Structural Equation Modeling (PLS-SEM). These analytical techniques aid in interpreting the collected data and validating the research constructs.

4. Data analysis and results

4.1. Demographics of respondents

The results presented in **Table 1** reveal that the majority of the study's respondents, accounting for 63.7%, were male from a total of n = 556 respondents. This suggests that decision-making within households predominantly lies in the hands of males. A total of 250 respondents fell within the age bracket of 26 to 45 years (45%), followed by respondents aged between 46 and 65 years (38.8%). Additionally, 16.2% of the study's participants were aged 66 and above, indicating that the working class still predominantly owns majority of houses.

Table 1. Demographic characterization of the respondents.

		Frequency	Percent	Cumulative Percent
Gender	Female	202	36.3	36.3
	Male	354	63.7	100.0
Age	26–45 years	250	45.0	45.0
	46–65 years	216	38.8	83.8
	66 and above	90	16.2	100.0
Occupation Status:	Entrepreneur	124	22.3	22.3
	Private sector employee	432	77.7	100.0
Average monthly household income	Less than RM 2500	100	18.0	18.0
	RM 2501–RM 4849	50	9.0	27.0
	RM 4850–RM 7099	152	27.3	54.3
	RM 7110–RM 10,959	50	9.0	63.3

	RM 10,960–RM 15,039	102	18.3	81.7
	RM 15,040 and above	102	18.3	100.0

4.2. Structural model

The research model was tested using SmartPLS 3. This visual representation depicted the hypotheses and relationships between variables. Constructs, or variables, were denoted as circles, while indicators were represented as rectangles. These indicators, also known as measurement items, served as direct proxies for the raw data. The relationships between constructs and their respective indicators were illustrated through arrows.

Upon completion of the structural model, the PLS algorithm was executed to gather necessary data for evaluating the model. As depicted in **Figure 2**, arrows were drawn from constructs to indicators, indicating reflective measurement models. With the path model prepared, further evaluation ensued. Overall, sixteen reflective constructs within the path model were confirmed. These constructs encompassed attitude (AT), subjective norms (SN), availability (AVL), affordability (AFF), efficiency (EFF), acceptability (ACC), regulation and governance (RGP), intention to use (INT), and behavioral readiness to use (B).

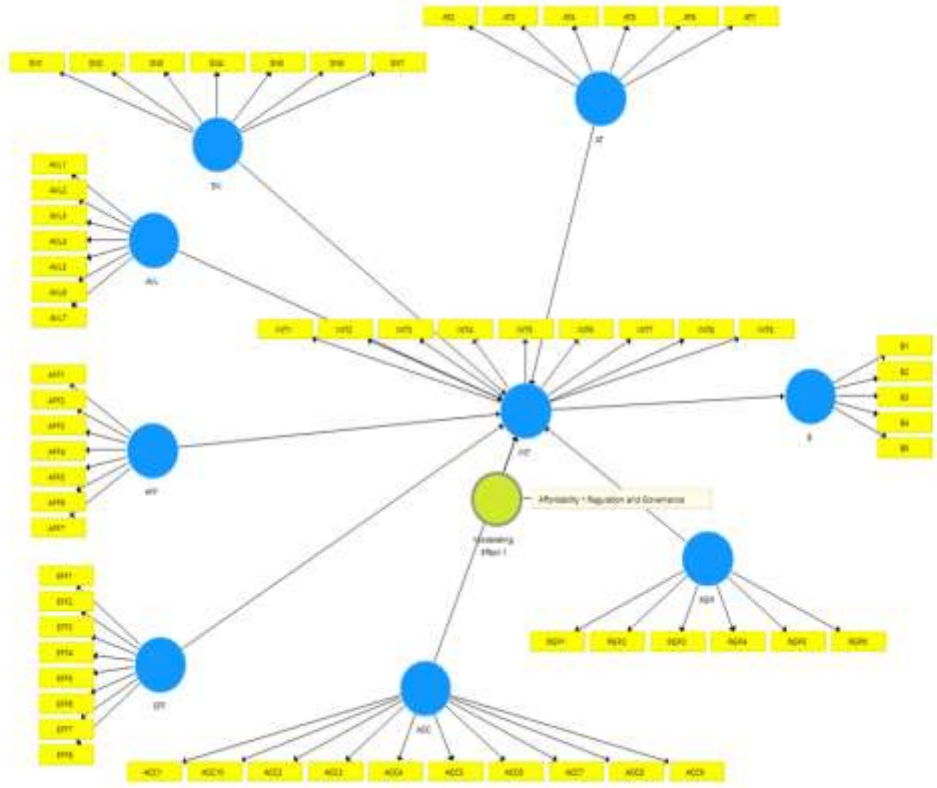

Figure 2. Structural Model: PLS path model.

With the application of the PLS-SEM model estimation, recommended scrutinizing the results of the measurement models. Once content with the

measurement model outcomes, the analysis could progress to the second stage, focusing on the structural paths. Evaluation of the reflective measurement models involved several tests, namely indicator reliability (outer loadings), internal consistency reliability (composite reliability), and convergent validity (average variance extracted). This study adhered to the criteria outlined by Hair et al. (2014, 2019) for assessing its reflective measurement models.

Firstly, outer loadings were examined, and those below 0.70 were considered for removal. If an outer loading fell between 0.40 and 0.70, it was retained unless its removal enhanced composite reliability (CR) and average variance extracted (AVE) of the construct (Hair et al., 2014). Secondly, CR values exceeding 0.70 were deemed significant. For exploratory studies, CR values between 0.60 and 0.70 were acceptable. Indicators with outer loadings below 0.40 were eliminated.

4.3. Validity and reliability

From PLS algorithm run report, the Confirmatory Factor Analysis (CFA) value was used to assess the measurement's validity and reliability. The CFA threshold score set at 0.60 was used (Hair et al., 2019). Elements with values exceeding 0.60 were retained for further analysis to establish their total influence on all indicators (see **Table 2**).

Table 2. Factor loading.

Constructs	Indicators	Loadings
Acceptability	ACC10	0.784
	ACC7	0.840
	ACC8	0.865
	ACC9	0.805
Affordability	AFF2	0.857
	AFF3	0.865
	AFF4	0.792
	AFF5	0.725
Attitude	AT1	0.742
	AT2	0.799
	AT3	0.735
	AT4	0.721
	AT5	0.834
	AT6	0.788
Availability	AVL3	0.701
	AVL5	0.731
	AVL6	0.655
Behavior	B2	0.805
	B3	0.730
	B4	0.731
Efficiency	EFF2	0.659
	EFF3	0.574

	EFF4	0.789
	EFF5	0.733
Intention	IN4	0.817
	IN5	0.819
	IN6	0.760
	IN7	0.707
Regulations and Governance	RGP1	0.934
	RGP2	0.902
	RGP6	0.180
Subjective Norms	SN1	0.885
	SN2	0.895
	SN6	0.678

Each construct exhibited a Cronbach's alpha greater than 0.60, indicating internal consistency (Hair et al., 2019). Additionally, the overall dependability ratings exceeded the 0.70 threshold (Hair et al., 2019). Composite reliability, considered a more rigorous measure of reliability, was evaluated, as recommended by researchers (Hair et al., 2019). The Average Variance Extracted (AVE) of each component exceeded 0.5, demonstrating convergent validity (Hair et al., 2019). Moreover, all Dijkstra-Henseler (Rho A) cutoff values exceeded 0.7, providing additional support for composite reliability. The summary of the validity and reliability tests is presented in **Table 3**.

Table 3. Test results for validity and reliability.

Constructs	**Cronbach's Alpha**	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Acceptability	0.842	0.844	0.894	0.679
Affordability	0.829	0.852	0.885	0.659
Attitude	0.863	0.872	0.898	0.594
Availability	0.824	0.799	0.738	0.785
Efficiency	0.639	0.657	0.785	0.781
Intention	0.784	0.801	0.859	0.804
Regulation and Governance	0.865	0.843	0.760	0.773
Subjective Norms	0.810	0.868	0.863	0.809
Behavior	0.840	0.836	0.800	0.772

4.4. Model fit assessment

4.4.1. R^2 and Q^2

In Partial Least Squares (PLS) analysis, the determination coefficient R^2 and path coefficients are instrumental in evaluating the structural model. The initial crucial criterion for assessing a structural model involves determining the coefficient of determination (R-squared) for each endogenous latent variable. A robust R^2 value

is 0.67, while 0.333 is deemed average, and values of 0.19 and below are considered inadequate. As indicated in **Table 4**, the adjusted R^2 score for behavior is provided, aiding in determining the extent of variance explained by intention and independent factors. The values exceeding 0.7 are considered acceptable. The final model has significantly enhanced both predictability and *R*-squared values.

Table 4. R^2 test.

	R^2	R^2 Adjusted
Intention	0.786	0.781
Behavior	0.757	0.755

Q^2, also known as predictive relevance, serves as a metric to determine a model's predictive capability (Hair et al., 2019). Additionally, Q^2 assesses the predictive value of endogenous components within the model. As illustrated in **Table 5**, the Q^2 test values in PLS analysis are greater than zero, indicating that the data has been faithfully replicated and the model possesses predictive power.

Table 5. Q^2 test.

	SSO	SSE	Q^2 (= 1 − SSE/SSO)
Acceptability	2288	2288	
Affordability	2288	2288	
Attitude	3432	3432	
Availability	1716	1716	
Efficiency	228	2288	
Intention	2288	1501	0.340
Regulation Governance	1716	171	
Subjective Norms	1716	1716	
Behavior	1716	1487	0.133

4.4.2. Model fit

Smart PLS provides bootstrap-based inference statistics based on SRMR criteria. Accurate model fit offers additional insights for interpreting SRMR bootstrap confidence interval results (Hair et al., 2019). SRMR signifies the variance between the observed and inferred model correlation matrices (Wong, 2013). A value lower than 0.10 is considered acceptable. In this SEM analysis, the SRMR is 0.082, which falls within the acceptable range (Wong, 2013). Refer to **Table 6** for the model-fitting indices.

Table 6. Model fit indices.

	Saturated Model	Estimated Model
SRMR	0.096	0.097
d_ULS	5.441	5.604
d_G	0.918	0.918
Chi-Square	17.543	17.543

NFI	0.887	0.887

4.5. Hypotheses testing

The next step involved testing the hypotheses derived from this study by analyzing the structural model using the bootstrap procedure to determine their significance. Bootstrapping, a nonparametric procedure, was applied to test the statistical significance of various PLS-SEM results, including path coefficients and HTMT values. Following the recommendations put forth by Hair et al. (2014, 2019), the bootstrap procedure was executed with two specific options: (i) no sign changes, and (ii) 5000 subsamples. This rigorous approach ensured a robust evaluation of the hypotheses and their underlying structural relationships.

4.5.1. Direct effects

The results of the PLS-SEM bootstrapping showed that the path coefficients, which represent standardized regression weights, range from −1 to +1. The findings (refer **Table 7**) revealed that attitude marginally influences the intention to use solar PV (β = 0.175, *p*-value = 0.048), thus supporting H1. While affordability significantly influences the intention to use solar PV (β = 0.194, *p*-value = 0.000), confirming the support for H4. Acceptability significantly affects the intention to use solar energy (β = 0.528, *p*-value = 0.000), thus supporting H6. Moreover, the impact of Intention to use solar energy on behavioral readiness to use (H7) was strong and significant (β = 0.507, *p*-value = 0.000).

Table 7. Path coefficients.

Hypothesis	Relationship	β	Std Dev	*T* Value	*P* Value
H1	Attitude → Intention	0.175	0.089	1.975	0.048
H2	Subjective Norms → Intention	−0.055	0.082	0.665	0.506
H3	Availability → Intention	−0.009	0.035	0.263	0.793
H4	Affordability → Intention	0.194	0.046	4.197	0.000
H5	Efficiency → Intention	0.039	0.032	1.199	0.231
H6	Acceptability → Intention	0.529	0.046	11.495	0.000
H7	Intention → Behavior	0.507	0.034	14.845	0.000

4.5.2. Indirect effects: Mediation

The results of the indirect effects (mediating effects) are presented in **Table 8**. It is evident that Intention to use solar PV significantly mediates the relationships between affordability (β = 0.098, *p*-value = 0.000), and acceptability (β = 0.268, *p*-value = 0.000) with behavioral readiness to use. Therefore, this supports hypotheses H11 and H13 related to the mediation effects.

Table 8. Indirect effect.

Hypothesis	Relationship	β	Std Dev	*T* Value	*P* Value
H8	Attitude → Intention → Behavior	0.089	0.047	1.908	0.056
H9	Subjective Norms → Intention → Behavior	−0.028	0.042	0.658	0.510

H10	Availability → Intention → Behavior	−0.005	0.018	0.261	0.794
H11	Affordability → Intention → Behavior	0.098	0.025	3.949	0.000
H12	Efficiency → Intention → Behavior	0.020	0.017	1.169	0.243
H13	Acceptability → Intention → Behavior	0.268	0.031	8.512	0.000

4.5.3. Moderation analysis

The moderating influence of regulations and governance refers to a scenario in which the relationship between two constructs depends on the values of regulations and governance, also termed as a moderator variable. This study aimed to test the hypothesis that the moderator variable (Regulations and Governance) affects the strength or direction of the relationship between two components in a model. The moderation analysis was conducted using SmartPLS and the result showed in **Table 9**. Interestingly, the data revealed that regulations and governance significantly moderate the relationship between Affordability and Intention to use solar PV (β = 0.152, *p*-value = 0.002), supporting H15.

Table 9. Moderation effect.

Hypothesis	**Relationship**	**β**	**Std Dev**	***T* Value**	***P* Value**
H14	Moderating AVL → Intention	−0.005	0.03	0.149	0.881
H15	Moderating AFF → Intention	−0.152	0.048	3.158	0.002
H16	Moderating Eff → Intention	0.025	0.037	0.665	0.506
H17	Moderating ACC → Intention	−0.005	0.034	0.149	0.881

Typical results of moderator analyses are represented using simple slope plots. SmartPLS generates these plots in the results report. **Figure 3a** illustrates the relationship between affordability and intention, moderated by regulations and governance. It is evident when regulations and governance are high (i.e., +1 standard deviation above the mean; green line), the relationship between affordability and intention to use is stronger than when regulations and governance are low (i.e., −1 standard deviation below the mean; red line). On the contrary, availability (refer **Figure 3b**) and intention to use do not moderate by regulations and governance with almost close to zero slope. While efficiency (refer **Figure 3c**) and intention to use do not moderate by regulations and governance as the slop of −1 SD is almost close to zero. Lastly, acceptability (refer **Figure 3d**) and intention to use do not moderate by regulations and governance when the slope is parallel with no relationship.

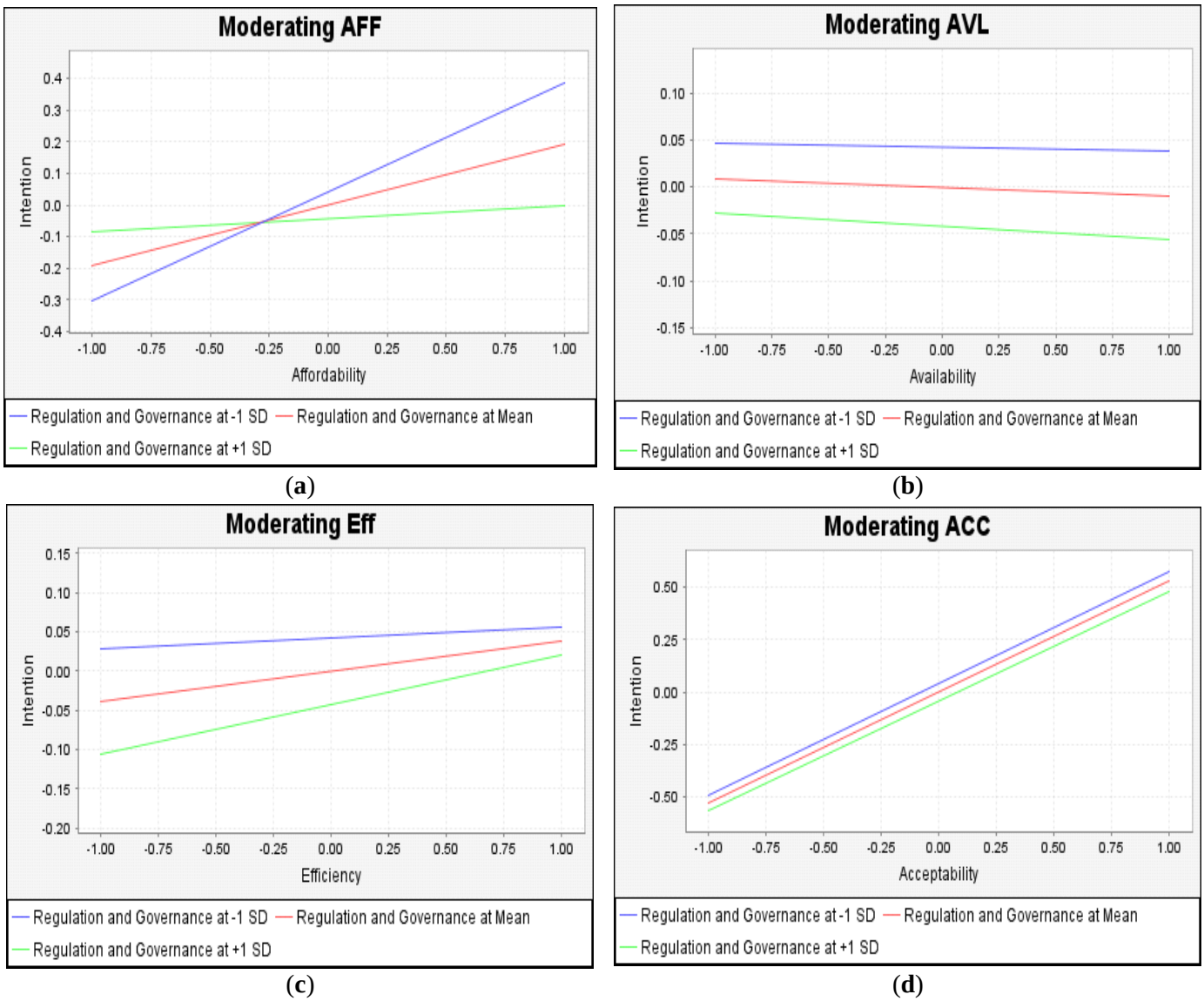

Figure 3. Simple slope analysis—moderating effect of regulation and governance on the link between affordability and intention, (**a**) moderating AFF; (**b**) moderating AVL; (**c**) moderating Eff; (**d**) moderating ACC.

5. Discussion and conclusion

This study examined non-user behavioral readiness to adopt solar PV systems for landed residential properties in Malaysia. It investigated a list of predictors, the mediating role of intention, and the moderating effects of governance and regulations in shaping non-user readiness to adopt solar PV systems. The data analysis statistically validated the list of SES factors for the adoption of solar PV among landed residential property owners to adopt solar PV systems. These SES factors include attitude, subjective norm, availability, affordability, efficiency, and acceptability. Each of these predictors plays a distinct role in shaping the overall intention to adopt solar PV technology. Hence, it explains how these predictors are interconnected and contribute to behavioral intentions.

The social aspect of SES has contributed to the understanding of how attitudes influence intentions regarding solar PV adoption. The findings suggest that social

and individual factors reduced the influence of subjective norms on decision-making in Malaysia. This finding aligns with Ang et al. (2020), where they found that individualistic individuals are more inclined to adopt clean energy. Therefore, this study challenges the assumption that social norms always play a decisive role in shaping individual intentions for new technologies (Ho and Song, 2023). Furthermore, this is consistent with Bawardi et al. (2022)'s study in urban settings, where individualism has a prevailing sense of independence and is less influenced by their neighbors' actions.

The examination extends to the mediating role of intention for molding behavioral readiness. Intention to use serves as a critical intermediary in the adoption process. It links the predictors with property owners' readiness to integrate solar PV systems. The mediating role of intention was confirmed in uncovering the mechanisms through which individual attitudes and perceptions are transformed into actual behavioral readiness. In addition, the moderating role of regulation and governance facilitates the relationship between SES dimensions and the intention to use solar PV systems. This exploration provides insight into how external regulatory frameworks influence the dynamics of intention. It added a contextual layer to further understanding of solar PV adoption.

6. Conclusion

This study research makes several contributions to academia, industry, and society, offering new insights into sustainable energy security and solar energy adoption. By extending the TPB with SES dimensions as predictors. It deepens the understanding of how SES factors act as critical determinants in solar energy adoption, lead to cost-effectiveness, and achieve grid parity, particularly within the Malaysian context. The findings offer novel remedial measures for the energy landscape, focusing on how Malaysia can leverage solar energy as a sustainable and economically viable alternative. This focus on SES provides a comprehensive understanding of the barriers and drivers influencing solar PV adoption, which is particularly beneficial for policymakers, industry stakeholders, and researchers aiming to foster sustainable energy practices.

6.1. Theoretical contribution

This study extended the TPB by integrating SES dimensions as industry-specific factors associated with solar energy adoption. It stands as a pioneering effort in the domain of sustainable energy security, particularly as it relates to household solar PV adoption in Malaysia. By merging TPB with SES, this study creates a new framework that captures the dynamics influencing solar energy usage, addressing a gap in the literature on policy strategies for promoting green technology.

Previous studies often relied on singular theoretical models, limiting their ability to fully explain solar energy adoption behaviors (Fayiah et al., 2020). In contrast, this study provides a more comprehensive analysis by combining the concept of SES in the theoretical framework. It sheds light on the relationships between various predictors of intention and behavioral readiness to adopt solar

energy, offering critical insights for targeted interventions to promote solar energy among non-users.

6.2. Managerial contribution

Practically, this study offers important implications for the renewable energy sector, particularly solar power. It highlights how sustainable energy practices and collaboration among landed property owners can enhance solar PV affordability, cost-effectiveness, and grid parity. These improvements can foster economic growth and energy independence in Malaysia, aligning with goals to reduce reliance on fossil fuels (Sulaima et al., 2019).

Energy insecurity has the potential to disrupt the social fabric, economic stability, and operational functionality of the nation (Ahmad and Abdul-Ghani, 2011). Malaysia must expedite the energy mix plans to meet growing demand. Hence, we can prevent energy insecurity incidents and ensure a continuous and reliable energy supply. Furthermore, the rate of energy demand outpaces supply, energy security has become a critical topic in policymaking (Seng and Mohd Fauzi, 2019). By addressing energy security concerns and adopting measures validated in this study to ensure consistent and reliable energy supplies, Malaysian policymakers can enhance resilience against potential energy disruptions.

As the rate of energy demand outpaces supply, energy security has become a critical topic in policymaking (Seng and Mohd Fauzi, 2019). By addressing energy security concerns and adopting measures validated in this study to ensure consistent and reliable energy supplies, Malaysian policymakers can enhance resilience against potential energy disruptions. Hence, the study also offers practical recommendations for developing policies related to energy transparency, public participation, and environmental considerations. It emphasizes the need for strong regulations and public-private partnerships to drive sustainable energy adoption. By empowering local stakeholders, including non-users, the study encourages a shift toward eco-friendly, renewable energy solutions. Policymakers and regulators are called to prioritize these sustainable practices, which are critical to securing Malaysia's energy future.

6.3. Limitations

This study acknowledges several limitations that must be considered. The theoretical framework employed may not have fully captured the range of hindrances and rejection factors influencing the adoption of solar PV systems in Malaysia. The study is limited to urban areas within the Klang Valley region of Malaysia, which constrains the generalizability of the findings. The distinct demographic factors, including culture, education, and socioeconomic status, in the selected region may not reflect the diversity across other geographical locations of Malaysia.

Additionally, this research was focused solely on solar energy, excluding other renewable energy sources such as hydropower, biomass, biogas, and hydrogen. Given the multifaceted nature of the renewable energy landscape, an analysis that includes a broader spectrum of electricity generation sources would enhance the study's comprehensiveness. Each renewable source comes with unique

characteristics and adoption challenges, and including these in future research would provide a more holistic view of the renewable energy sector.

6.4. Future direction

This study paves the way for identifying new variables that have yet to be explored in relation to the intention to adopt solar PV systems. Future studies could focus on community-based, ownership, and empowerment factors as influential variables. From a theoretical standpoint, expanding the scope to include barriers and rejection factors would provide valuable insights. It is crucial to explore low levels of acceptance, as they may offer critical perspectives for advancing solar PV initiatives and disseminating innovations. The study focused on the urban area in Malaysia. Hence, future studies should extend to include suburban and rural areas would provide a more comprehensive understanding of the factors affecting solar PV adoption across diverse settings.

In addition, this study could also be expanded to analyze solar PV adoption in the commercial and industrial sectors, alongside residential applications. Government initiatives often focus on these sectors due to their economic importance, making them relevant for studying factors that influence solar PV adoption. Understanding the economic benefits of solar energy in industrial and commercial settings would provide valuable data for policymakers and contribute to strategies that foster sustainable economic growth.

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References

Abdullah, W. S. W., Osman, M., Kadir, M. Z. A. A., & Verayiah, R. (2019). The potential and status of renewable energy development in Malaysia. Energies, 12(12), 2437. https://doi.org/10.3390/en12122437

Abuzaid, H., Moeilak, L. A., & Alzaatreh, A. (2022). Customers' perception of residential photovoltaic solar projects in the UAE: A structural equation modeling approach. Energy Strategy Reviews, 39(November 2021), 100778. https://doi.org/10.1016/j.esr.2021.100778

Abuzaid, H., Moeilak, L. A., & Alzaatreh, A. (2022). Customers' perception of residential photovoltaic solar projects in the UAE: A structural equation modeling approach. Energy Strategy Reviews, 39(November 2021), 100778. https://doi.org/10.1016/j.esr.2021.100778

Ahmad, N. A., & Abdul-Ghani, A. A. (2011). Towards sustainable development in Malaysia: In the perspective of energy security for buildings. Procedia Engineering, 20, 222–229. https://doi.org/10.1016/j.proeng.2011.11.159

Ai, Y. H., Peng, D. Y., & Xiong, H. H. (2021). Impact of environmental regulation intensity on green technology innovation: From the perspective of political and business connections. Sustainability (Switzerland), 13(9). https://doi.org/10.3390/su13094862

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In In J. Kuhl & J. Beckman (Ed.), Action-control: From cognition to behavior (pp. 11–39). Springer.

Alam, S. S., Ahmad, M., Othman, A. S., Shaari, Z. B. H., & Masukujjaman, M. (2021). Factors affecting photovoltaic solar technology usage intention among households in Malaysia: Model integration and empirical validation. Sustainability, 13(4), 1–20. https://doi.org/10.3390/su13041773

Alami, A. H., Ramadan, M., Abdelkareem, M. A., Alghawi, J. J., Alhattawi, N. T., Mohamad, H. A., & Olabi, A. G. (2022). Novel and practical photovoltaic applications. In Thermal Science and Engineering Progress (Vol. 29). Elsevier Ltd. https://doi.org/10.1016/j.tsep.2022.101208

Ang, J. B., Fredriksson, P. G., & Sharma, S. (2020). Individualism and the adoption of clean energy technology. Resource and Energy Economics, 61. https://doi.org/10.1016/j.reseneeco.2020.101180

Bawardi, H., Kaplan, S., & Feitelson, E. (2022). The role of individualistic versus collectivist values in shaping the residential choice of Palestinian knowledge-workers. Habitat International, 121. https://doi.org/10.1016/j.habitatint.2022.102516

Bekti, D. B. M., Prasetyo, Y. T., Redi, A. A. N. P., Budiman, A. S., Mandala, I. M. P. L., Putra, A. R., Persada, S. F., Nadlifatin, R., & Young, M. N. (2021). Determining Factors Affecting Customer Intention to Use Rooftop Solar Photovoltaics in Indonesia. Sustainability, 14(1), 280. https://doi.org/10.3390/su14010280

Bouhal, T., Fertahi, S. ed D., Agrouaz, Y., El Rhafiki, T., Kousksou, T., Zeraouli, Y., & Jamil, A. (2018). Technical assessment, economic viability and investment risk analysis of solar heating/cooling systems in residential buildings in Morocco. Solar Energy, 170, 1043–1062. https://doi.org/10.1016/j.solener.2018.06.032

Breetz, H., Mildenberger, M., & Stokes, L. (2018). The political logics of clean energy transitions. Business and Politics, 20(4), 492–522. https://doi.org/10.1017/bap.2018.14

CEIC. (2020). Malaysia: Energy Imports: Net: % of Energy Use | Economic Indicators. CEICData.Com.https://www.ceicdata.com/en/malaysia/energy-production-and-consumption/my-energy-imports-net--of-energy-use

Cheam, W., Lau, L., & Wei, C. (2021). Factors influencing the residence' s intention to adopt solar photovoltaic technology: a case study from Klang Valley, Malaysia. Clean Energy, 5(3), 464–473. https://doi.org/https://doi.org/10.1093/ce/zkab021

Egli, F. (2020). Renewable energy investment risk: An investigation of changes over time and the underlying drivers. Energy Policy, 140. https://doi.org/10.1016/j.enpol.2020.111428

Elahi, E., Khalid, Z., & Zhang, Z. (2022). Understanding farmers' intention and willingness to install renewable energy technology: A solution to reduce the environmental emissions of agriculture. Applied Energy, 309. https://doi.org/10.1016/j.apenergy.2021.118459

Fayiah, M., Dong, S., Singh, S., & Kwaku, E. A. (2020). A review of water–energy nexus trend, methods, challenges and future prospects. International Journal of Energy and Water Resources, 4(1), 91–107. https://doi.org/10.1007/s42108-020-00057-6

Enerdata. (2020). Total Energy Consumption 2018. Global Energy Statistical Yearbook 2019. https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html

Gollwitzer, P. M. (1996). The Volitional Benefits of Planning. The Psychology of Action: Linking Cognition and Motivation to Behavior, 287–312. http://www.ub.uni-konstanz.de/kops/volltexte/2008/5532/

Green, M. A. (2019). How Did Solar Cells Get So Cheap? In Joule (Vol. 3, Issue 3, pp. 631–633). Cell Press. doi.org/10.1016/j.joule.2019.02.010

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. European Business Review, 26(2), 106–121.

Ho, R.C., (2019). The outcome expectations of promocode in mobile shopping apps: an integrative behavioral and social cognitive perspective. In Proceedings of the 3rd International Conference on E-commerce, E-Business and E-Government (pp. 74-79).

Ho, R. C., & Amin, M. (2023). Exploring the role of commitment in potential absorptive capacity and its impact on new financial product knowledge: a social media banking perspective. Journal of Financial Services Marketing, 28(3), 585-598. doi.org/10.1057/s41264-022-00168-7

Ho, R. C., & Song, B. L. (2021). Immersive live streaming experience in satisfying the learners' need for self-directed learning. Interactive Technology and Smart Education, 19(2), 145–160. doi:10.1108/ITSE-12-2020-0242

Ho, R. C., & Song, B. L. (2023). User acceptance towards non-fungible token (NFT) as the FinTech for investment management in the metaverse. In Strategies and Opportunities for Technology in the Metaverse World (pp. 59-77). IGI Global, Hershey, PA. doi.org/10.4018/978-1-6684-5732-0.ch005

Ho, R.C., Song, B.L., & Tee, P.K. (2025). Managing Customer-Centric Strategies in The Digital Landscape, IGI Global, Hershey, PA. doi: 10.4018/979-8-3693-5668-5

Irfan, M., Zhao, Z., Li, H., & Rehman, A. (2020). The influence of consumers ' intention factors on willingness to pay for renewable energy : a structural equation modeling approach. Environmental Science and Pollution Research, April. https://doi.org/10.1007/s11356-020-08592-9

Kapoor, K. K., & Dwivedi, Y. K. (2020). Sustainable consumption from the consumer's perspective: Antecedents of solar innovation adoption. Resources, Conservation and Recycling, 152(May 2019), 104501. https://doi.org/10.1016/j.resconrec.2019.104501

Kim, H., Park, E., Kwon, S. J., Ohm, J. Y., & Chang, H. J. (2014). An integrated adoption model of solar energy technologies in South Korea. Renewable Energy, 66, 523–531. https://doi.org/10.1016/j.renene.2013.12.022

Lau, L. S., Choong, Y. O., Wei, C. Y., Seow, A. N., Choong, C. K., Senadjki, A., & Ching, S. L. (2020). Investigating nonusers' behavioural intention towards solar photovoltaic technology in Malaysia: The role of knowledge transmission and price value. Energy Policy, 144(April), 111651.https://doi.org/10.1016/j.enpol.2020.111651

Lim, Y. J., Osman, A., Salahuddin, S. N., Romle, A. R., & Abdullah, S. (2016). Factors Influencing Online Shopping Behavior: The Mediating Role of Purchase Intention. Procedia Economics and Finance, 35, 401–410. https://doi.org/10.1016/s2212-5671(16)00050-2

Lundheim, S. H., Vesely, S., Nayum, A., & Klöckner, C. A. (2021). From vague interest to strong intentions to install solar panels on private homes in the North – An analysis of psychological drivers. Renewable Energy, 165, 455–463. https://doi.org/10.1016/j.renene.2020.11.034

NAPIC. (2023). Malaysia Property Stock Report 2022. https://napic.jpph.gov.my/portal/web/guest/publication?p_p_id=ViewPublishings_WAR_ViewPublishingsportlet&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&_ViewPublishings_WAR_ViewPublishingsportlet_action= renderFileListingScreen&reportId = 22140&publishingId=13221&pageno=1&from=listing

Narula, K., Sudhakara Reddy, B., & Pachauri, S. (2017). Sustainable Energy Security for India: An assessment of energy demand sub-system. Applied Energy, 186, 126–139. https://doi.org/10.1016/j.apenergy.2016.02.142

Narula, K. (2014). Is sustainable energy security of India increasing or decreasing? International Journal of Sustainable Energy, 33(6), 1054–1075. https://doi.org/10.1080/14786451.2013.811411

Narula, K., & Reddy, B. S. (2016). A SES (sustainable energy security) index for developing countries. Energy, 94, 326–343. https://doi.org/10.1016/j.energy.2015.10.106

Nurwidiana, N., Sopha, B. M., & Widyaparaga, A. (2021, September). Behavioral factors underlying households' intention toward solar photovoltaic adoption. In Proceedings of th e Proceedings of the Second Asia Pacific International Conference on Industria l Engineering and Operations Management.

Palm, A., & Lantz, B. (2020). Information dissemination and residential solar PV adoption rates: The effect of an information campaign in Sweden. Energy Policy, 142(May). https://doi.org/10.1016/j.enpol.2020.111540

Qazi, A., Bhowmik, C., Hussain, F., Yang, S., Naseem, U., Adebayo, A. A., Gumaei, A., & Al-Rakhami, M. (2021). Analyzing the Public Opinion as a Guide for Renewable-Energy Status in Malaysia: A Case Study. IEEE Transactions on Engineering Management. https://doi.org/10.1109/TEM.2020.3046749

Qureshi, T. M., Ullah, K., & Arentsen, M. J. (2017). Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan. Renewable and Sustainable Energy Reviews, 78(December 2016), 754–763. https://doi.org/10.1016/j.rser.2017.04.020

Rathore, P. K. S., Chauhan, D. S., & Singh, R. P. (2018). Decentralized solar rooftop photovoltaic in India: On the path of sustainable energy security. Renewable Energy, 131, 297–307. https://doi.org/10.1016/j.renene.2018.07.049

REN21. (2019a). Renewables 2019 Global Status Report. In REN21 Secretariat. https://doi.org/10.3390/resources8030139

REN21. (2019b). What are the current trends in renewable energy? REN21 Secretariat. https://www.ren21.net/what-are-the-current-trends-in-renewable-energy/

Seng, K. K., & Mohd Fauzi, A. S. Bin. (2019). An Overview of Renewable and Non-Renewable Energy Demand as Well as Development Status in Malaysia. Chemical Science and Biomolecular Engineering, 1(1), 1–6. https://doi.org/10.31021/csbe.20171101

Shafie, S. M., Mahlia, T. M. I., Masjuki, H. H., & Andriyana, A. (2011). Current energy usage and sustainable energy in Malaysia: A review. Renewable and Sustainable Energy Reviews, 15(9), 4370–4377. https://doi.org/10.1016/j.rser.2011.07.113

Solangi, K. H., Saidur, R., Luhur, M. R., Aman, M. M., Badarudin, A., Kazi, S. N., Lwin, T. N. W., Rahim, N. A., & Islam, M. R. (2015). Social acceptance of solar energy in Malaysia: Users' perspective. Clean Technologies and Environmental Policy, 17(7), 1975–1986. https://doi.org/10.1007/s10098-015-0920-2

Sovacool, B. K., Mukherjee, I., Drupady, I. M., & Agostino, A. L. D. (2011). Evaluating energy security performance from 1990 to 2010 for eighteen countries. Energy, 36(10), 5846–5853. https://doi.org/10.1016/j.energy.2011.08.040

Sulaiman, J., Azman, A., & Saboori, B. (2014). Development of Solar Energy in Sabah Malaysia: The Case of Trudgill's perception. International Journal of Sustainable Energy and Environmental Research, 3(32), 90–99.

Teoh, A. N., Go, Y. I., & Yap, T. C. (2020). Psychosocial Implications of Large-Scale Implementations of Solar Power in Malaysia. Technologies, 8(2), 26. https://doi.org/10.3390/technologies8020026

Triandis, H. C. (1980). Reflections on trends in cross-cultural research. Journal of Cross-Cultural Psychology, 11(1), 35–58.

Vaka, M., Walvekar, R., Rasheed, A. K., & Khalid, M. (2020). A review on Malaysia's solar energy pathway towards carbon-neutral Malaysia beyond Covid'19 pandemic. In Journal of Cleaner Production, 273. https://doi.org/10.1016/j.jclepro.2020.122834

Wang, B., Wang, Q., Wei, Y. M., & Li, Z. P. (2018). Role of renewable energy in China's energy security and climate change mitigation: An index decomposition analysis. Renewable and Sustainable Energy Reviews, 90, 187–194. https://doi.org/10.1016/j.rser.2018.03.012

Winter, J. C. F. de, & Dodou, D. (2012). Five-Point Likert Items: t Test versus Mann-Whitney-Wilcoxon. Practical Assessment, Research & Evaluation, 15(11). https://www.researchgate.net/publication/266212127

Wong, K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. Marketing Bulletin, 24(1), 1–32.