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Consumers' Behavioral Intention on Rooftop PV Adoption to Promote Renewable Energy using Extended UTAUT Model in Indonesia

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ABSTRACT:

To address air pollution and reduce dependence on fossil fuels, the Indonesian government has set a target to achieve net-zero emissions by 2060 through the accelerated utilization of renewable energy. Among various technologies, rooftop photovoltaic (PV) systems are considered highly viable, particularly for the residential sector, which accounts for 43% of national electricity consumption. However, despite their potential, rooftop PV adoption in Indonesia remains underdeveloped, primarily due to a low adoption rate and negative public perception. This study aims to evaluate Indonesian consumer perspectives on rooftop PV adoption. An extended Unified Theory of Acceptance and Use of Technology (UTAUT) model is employed, incorporating Knowledge and Perceived Cost as additional factors. Spearman's correlation assesses the significance and relationships among key factors. The findings indicate that most respondents demonstrate a moderate to high intention to adopt rooftop PV. Perceived Cost emerges as the most significant factor influencing adoption, highlighting the substantial investment costs associated with renewable energy technology. Other influential factors include Facilitating Conditions, Social Influence, Effort Expectancy, Performance Expectancy, and Knowledge. These insights provide empirical guidance for policymakers and industry stakeholders in designing strategies to enhance the adoption of rooftop PV systems and support Indonesia's transition toward sustainable energy.

Keywords

Intention to adopt;
Rooftop PV;
Solar energy;
Spearman's correlation;
Extended UTAUT model

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1. Introduction

Indonesia has relied on fossil fuels, namely oil, gas, and coal, as its primary energy sources for electricity generation for many years. Although the availability of fossil fuels is still considered abundant, their usage is often associated with environmental issues. The combustion of fossil fuels emits greenhouse gases that contribute to air pollution and climate change [1]. To an extent, it can endanger human health and lives.

Indonesia aims to achieve net-zero emissions in 2060 or sooner by reducing its carbon footprint [2]. One of the main principles promoted by the Indonesian government is accelerating the use of renewable energy. To support this, Indonesia set targets to achieve a renewable energy share of 23% in the primary energy mix by 2025 and 31% by 2050 [3].

However, as of 2024, the share of renewable energy in the primary energy mix has only reached 13.93% [4]. Despite the low utilization, Indonesia possesses significant potential and development opportunities for renewable energy [5]. To meet the national target, approximately 24 Gigawatts of renewable energy capacity is required [6], which is relatively small compared to the country's estimated potential of 419 GW [7].

Indonesia has significant solar energy potential, estimated at 208 GW, supported by abundant sunlight averaging 4.8 kWh/m^2/day [7,8]. Research by Siregar et al. [9] reported that solar energy is the highest-ranked

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energy source among others; therefore is deemed suitable to be prioritized as an alternative energy source. Despite this, solar energy development remains limited, with only 0.3 GW installed by 2022, accounting for approximately 0.1% of its total potential [10]. Through the National Energy Policy, the Indonesian government targets 6.5 GW solar capacity by 2025 and 45 GW by 2050 [3].

Indonesia is focusing on three primary solar technologies: solar farm, rooftop PV, and floating solar [11]. Among these, rooftop PV systems are particularly attractive because they can be installed on existing building surfaces, avoiding the need for large open areas. The residential sector, which contributes approximately 43% of total national electricity consumption, offers significant potential for rooftop PV adoption [12].

In support of this, the government issued the Minister of Energy and Mineral Resources (MEMR) Regulation No. 49/2018 to facilitate and promote the use of rooftop PV [13]. The most recent update to this policy is MEMR Regulation No. 2/2024, which further encourages public participation in solar energy utilization [14]. Under this scheme, electricity generated from rooftop PV systems can either be fed into the grid managed by PLN using a feed-in-tariff (FIT) mechanism or consumed directly through net metering.

Despite regulatory support and its large potential, rooftop PV adoption in Indonesia remains relatively low. The number of users has increased from 351 in early 2018 to 7,472 by mid-2023 [15,16], showing a positive trend but still small compared to the peak electricity load [15]. Furthermore, when compared to other countries in Southeast Asia, Indonesia still lags behind Thailand, Vietnam, Malaysia, the Philippines, and Cambodia [17]. This highlights Indonesia's struggles in exploiting the potential of solar energy to meet the government targets.

Specific to the adoption of rooftop PV systems, the acceptance and preferences of Indonesian residents as consumers are considered a critical factor in promoting renewable energy, particularly during the initial stages of development [12,18,19]. Analyzing consumer behavior in product adoption is essential for assessing potential market acceptability and for forecasting the development of the industry [17,20].

Previous research related to this study has been conducted using various models. Bilal & Andajani used the Technology Acceptance Model-Diffusion of Innovation (TAM-DOI) model to examine the factors influencing the intention to adopt rooftop PV in Indonesia [21]. Anjum & Subhan used the integrated Theory of Planned Behavior-Diffusion of Innovation-Unified Theory of Acceptance and Use of Technology (TPB-DOI-UTAUT) to examine public intentions to adopt rooftop PV in India [22]. Bouaguel & Alsulimani used the TAM model to analyze factors influencing consumers' intention to utilize solar energy for residential purposes in Saudi Arabia [23].

The usage of TPB and TAM as models in technology adoption has been prevalent, particularly for rooftop PV adoption [24,25]. However, there is limited research applying the UTAUT model to evaluate consumers' intention to adopt rooftop PV, especially in Indonesia. Therefore, this study proposes an extended UTAUT model by combining the original UTAUT model [26] with additional constructs, namely Knowledge and Perceived Cost. This approach is taken due to the limited research that combines these factors with the UTAUT model to evaluate Indonesian consumers' intentions in adopting a rooftop PV system.

This study aims to focus on the perspective of prospective consumers for rooftop PV systems, whose participation is encouraged by the government to optimize the utilization of solar energy. The goal is to provide deeper insights into the development of rooftop PV in Indonesia. Additionally, the findings of this study seek to generate insights into market acceptance to enhance the adoption of rooftop PV in Indonesia, while also contributing to the broader understanding of sustainable energy planning in similar contexts. Two research questions will be addressed to evaluate Indonesian residents' perceptions and intentions regarding rooftop PV adoption:

RQ1: How do Indonesian residents perceive the adoption of rooftop PV?

RQ2: What are the key variables that influence their intention to install rooftop PV in Indonesia?

2. Literature Review and Research Model

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model developed to explain user intentions that lead to future technology usage, as illustrated in Figure 1 [27]. The model is derived from the integration of eight previous technology acceptance theories: Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behaviour, Combined TAM-TPB Model, Model of PC Utilization, Diffusion of Innovation Theory, and Social Cognitive Theory.

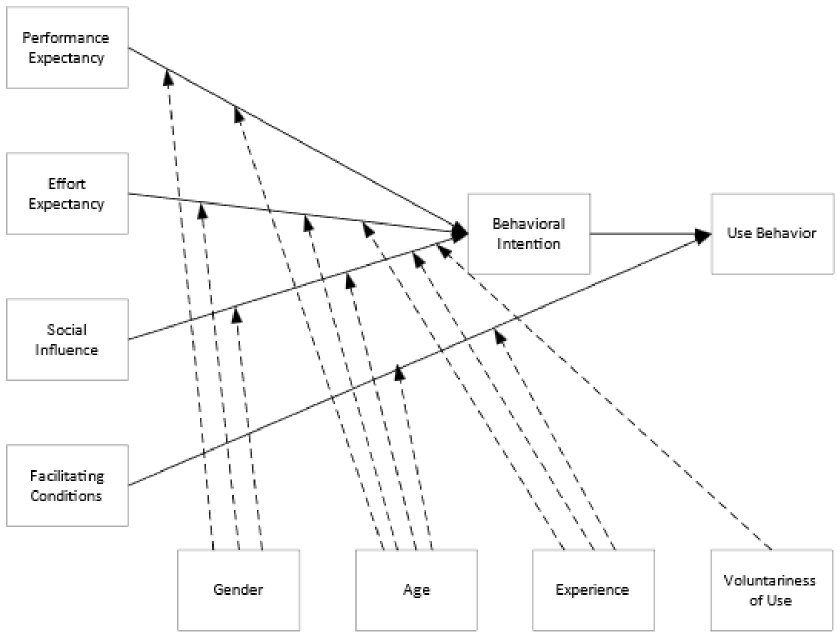

Figure 1: The UTAUT Model [26], depicting the relationships shaping users' intention towards technology adoption.

The UTAUT model consists of four significant constructs that determine users' intention and usage: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. These relationships are further moderated by Gender, Age, Experience, and Voluntariness of Use. By integrating these foundational theories, the UTAUT model achieves greater explanatory power, accounting for 70% of the variance in behavioral intention [26], compared to the 17% to 53% range explained by prior models [28].

Over the years, the robustness of UTAUT has been validated across diverse technological domains, such as Artificial Intelligence adoption [29], Fintech-based digital banking usage [30], acceptance of driver monitoring systems for automated vehicles [31], and data analytics techniques adoption in the healthcare industry [32]. In the context of renewable energy technologies, particularly rooftop PV systems, several studies have adapted the UTAUT model to explore adoption behaviors, including in India [19], Indonesia [33], Hungary [34], and Malaysia [35].

These applications demonstrate the model's flexibility and potential for meaningful adaptation to context-specific conditions, including those present in Indonesia's renewable energy landscape, where low public awareness and economic constraints play a critical role in shaping renewable technology acceptance [36,37]. Building on this foundation, the present study extends the original UTAUT model by introducing two additional constructs: Knowledge and Perceived Cost.

These extensions are grounded in prior research indicating that general public knowledge about the technology significantly impacts public interest towards rooftop PV adoption [38]. Additionally, the perceived cost of investing in rooftop PV has been identified as a significant barrier, primarily due to the high expenses involved. Furthermore, in Indonesian markets, incentives and subsidies are limited [37]. By integrating these constructs, this study aims to provide a more comprehensive understanding of Indonesian residents' behavioral intentions regarding rooftop PV adoption.

2.1. Performance Expectancy

Performance Expectancy is defined as the degree to which an individual believes that using the system will enhance their work performance [26]. This construct is associated with usefulness, outcome expectations, and the relative advantage of using the system [39,40]. This construct is a key determinant of technology adoption, as consumers often assess the system's expected performance before deciding to use it [41]. Venkatesh et al.

[26] further emphasized that among all UTAUT constructs, Performance Expectancy emerges as the strongest predictor of behavioral intention.

In the context of rooftop PV, users may expect improved energy efficiency, lower electricity costs, long-term usability, reduced reliance on centralized power, and its environmental benefits [42]. These anticipated outcomes align with the core of Performance Expectancy, as they represent perceived improvements in daily energy use and cost savings. The hypothesis is formulated as follows:

H1. Performance Expectancy is significantly correlated with adoption intention.

2.2. Effort Expectancy

Effort expectancy is defined as the ease with which the system can be used [26]. Effort expectancy is positively influenced when the utilization of a system is perceived as effortless [24]. The ease of use is said to foster positive attitudes toward adopting new technology. In the context of rooftop PV systems, users may be more inclined to adopt the technology if they perceive the process of installation and operation to be manageable [43]. Aggarwal et al. [19] highlighted that Effort Expectancy is a critical factor influencing consumers' purchase decisions, particularly when the technology involves complex or unfamiliar components, such as rooftop PV. The hypothesis is formulated as follows:

H2. Effort Expectancy is significantly correlated with adoption intention.

2.3. Social Influence

Social Influence is defined as the extent to which an individual perceives that significant others believe they should utilize a new system [26]. It is widely acknowledged that social factors can shape individual behavior, including in the adoption of rooftop PV [25,44]. In many cases, people are influenced by their social environment when considering new technologies [17].

In the context of Indonesian consumers, prior studies [33,45] have indicated that social influence has not significantly impacted their intention to adopt rooftop PV, possibly due to the technology's limited visibility and success in the region. Nevertheless, Aggarwal et al. [19] argue that as the solar market develops, social influence will emerge as a critical determinant in driving rooftop PV adoption. The hypothesis is formulated as follows:

H3. Social Influence is significantly correlated with adoption intention.

2.4. Facilitating Conditions

Facilitating Conditions are defined as the extent to which an individual believes that organizational and technical infrastructure exists to support the use of the system, including in terms of time, financial resources, and adaptability [26,46]. This construct plays a key role in supporting the long-term adoption of new technologies [24], as it helps build trust and encourages a positive attitude and intentions toward use [47]. It also involves creating an environment that removes barriers to use, such as providing accessible technical support, user training, and financial incentives [48].

While the original UTAUT model found that Facilitating Conditions influenced usage behavior but not behavioral intention, the extended UTAUT2 model [49] demonstrated its influence on both, particularly in consumer contexts. The shift in findings underscores the importance of context when evaluating the role of Facilitating Conditions. Various studies have confirmed the significance of this construct in shaping both intention and behavior in rooftop PV adoption [22,27,35]. The hypothesis is formulated as follows:

H4. Facilitating Conditions are significantly correlated with adoption intention.

2.5. Knowledge

Knowledge is considered a critical factor that can influence consumers' intention to adopt rooftop PV systems [50]. It encompasses both environmental awareness and an understanding of the benefits associated with adopting the technology. Environmental knowledge has been identified as a significant variable that enhances the intention to adopt rooftop PV [51]. Despite increasing awareness of environmental issues and renewable energy, consumers may still lack the necessary knowledge to support informed decision-making.

Accordingly, insufficient knowledge is often recognized as a key obstacle hindering the adoption of new technologies [52]. Prior studies have reported that the more consumers know about new technology, the better they recognize its benefits, which in turn increases their intention to adopt the system [25,53,54]. These findings highlight the significant influence of knowledge in driving the intention to adopt rooftop PV systems. The hypothesis is formulated as follows:

H5. Knowledge is significantly correlated with adoption intention.

2.6. Perceived Cost

Cost is recognized as a significant factor in the development and adoption of new technologies, particularly solar PV technology [22]. To achieve greater market penetration, the cost of rooftop PV must be comparable to the cost of conventional coal-based electricity generation [55]. For both adopters and non-adopters, cost is often perceived as the primary consideration influencing the decision to adopt rooftop PV [50]. Prior studies have highlighted that many consumers prioritize cost savings over environmental benefits when evaluating such technologies [56].

Perceived cost acts as a barrier to rooftop PV adoption, as the systems and renewable technologies in general are often associated with high upfront investment requirements [57], particularly in regions where conventional energy remains relatively inexpensive [58]. The financial burden includes installation and ongoing maintenance costs, which can discourage potential adopters. Therefore, perceived cost is considered a critical factor that may negatively influence consumers' intention to adopt solar energy technologies such as rooftop PV, as supported by a previous study [21]. The hypothesis is formulated as follows:

H6. Perceived Cost is significantly correlated with adoption intention.

The proposed framework of this study is presented in Figure 2.

3. Research Methodology

In this study, data will be collected using voluntary response sampling, in which the research questionnaire will be distributed online through social media platforms. Indonesia is a country with a population of over 200 million, and there is no available data indicating the number of individuals who intend to adopt rooftop PV. To process and analyze the collected data, a quantitative approach will be employed by applying Spearman's correlation to determine the significance and correlation between the predictors and Behavioral Intention.

3.1. Questionnaire Design and Data Collection

The data for this study were collected using a structured questionnaire distributed online. The target respondents were adult men and women residing in Indonesia who had not yet installed rooftop PV. The study specifically targeted individuals from the middle to upper socioeconomic status (SES) groups, assuming they possess the purchasing power required to adopt rooftop PV.

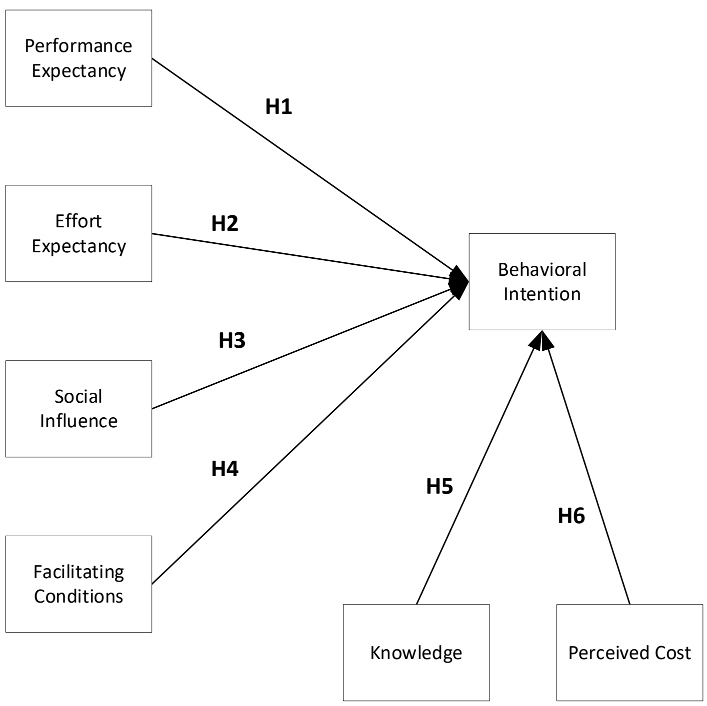

Figure 2: Conceptual Framework, adapted from the UTAUT model with additional constructs.

Voluntary response sampling was employed, in which respondents self-selected to participate by accessing the survey link shared through various social media platforms. This non-probability sampling method was considered suitable for reaching a broad and diverse audience across geographic regions.

To determine the minimum required sample size for correlation analysis, this study employed the two-stage sample size approximation method proposed by Bonett & Wright [59]. This method is specifically designed for non-parametric correlation coefficients such as Spearman's rho and is considered suitable when estimating sample sizes with desired levels of statistical power. In the first stage, an initial sample size is estimated using a predefined effect size, significance (alpha) level, and statistical power.

In the second stage, sample adequacy is assessed and adjusted if necessary. Bonett & Wright provide a set of lookup tables to determine the minimum sample size based on these parameters. Using this method, the required sample size was determined by setting an alpha () of 0.05, a statistical power () of 0.80, and a medium effect size (= 0.3). Based on these parameters, the minimum required sample size was calculated to be 72 participants [59].

The questionnaire consisted of two sections. The first section included demographic questions related to age, gender, income level, and education. The second section contained measurement items for each construct adopted in the research model. All measurement items were adapted from validated measures used in prior studies within the field of technology adoption and renewable energy. Each item was rated using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Details of the constructs and their respective measurement items are presented in Table 1.

Table 1: Construct and Measurement Items. Adapted from prior studies.

Constructs	**Items**	**Measurements**	**References**
Knowledge (KN)	KN1	I am familiar with rooftop PV.	[35]
	KN2	I am aware that rooftop PV is an environmentally friendly technology.	[35,60]
	KN3	I frequently read articles or news about rooftop PV.	[35]
Performance Expectancy (PE)	PE1	Rooftop PV is a technology that will be beneficial for me.	[33,34]
	PE2	Rooftop PV installation will reduce my electricity bills.	[34]
	PE3	Solar PV installation will reduce dependency on electricity supplier companies.	[19,34]
Effort Expectancy (EE)	EE1	It is easy for me to learn how to use rooftop PV.	[34]
	EE2	Rooftop PV can be installed easily in my house.	[19,33]
	EE3	Rooftop PV can be operated easily.	[43]
Social Influence (SI)	SI1	I will ask my family and friends about their experience in using an item before purchasing it.	[27,33]
	SI2	If my family and friends have good experiences with rooftop PV, I will consider using it.	[27,33]
	SI3	My family and friends will think that I should install rooftop PV.	[33,35]
Facilitating Conditions (FC)	FC1	I have the necessary knowledge regarding the usage and function of rooftop PV.	[34,35]
	FC2	I have resources (money, time, area) to install and use rooftop PV.	[34,35]
	FC3	I feel like I can get assistance from others if I have difficulties operating rooftop PV.	[33,35]
Perceived Cost (PC)	PC1	The cost incurred for rooftop PV installation is justified by the benefits provided.	[34]
	PC2	I think rooftop PV installation is a great investment for the future.	[35]
	PC3	Government incentives would motivate me to adopt rooftop PV.	[17,27]
	PC4	The cost to install and operate rooftop PV is affordable for me.	[34]
Behavioral Intention (BI)	BI1	I am interested in installing rooftop PV.	[23,33]
	BI2	I intend to install rooftop PV soon.	[17,35]
	BI3	I will support the development of rooftop PV in the future.	[34]

3.2. Constructs Validity & Reliability

To ensure the integrity and quality of a measurement instrument, it is essential to conduct both validity and reliability tests. Validity is defined as the degree to which an instrument accurately measures what it is designed to measure [61]. Meanwhile, reliability is defined as the extent to which an instrument produces stable, consistent, unbiased results across repeated trials [62].

The validity of the measurement items was assessed using Pearson's product-moment correlation, commonly denoted as "*r*", by comparing the obtained *p*-values to the critical *p*-value from the correlation table. Measurement items are considered valid if the $r_{count} > r_{table} = 0.361$ and the significance value (*p*-value) is less than 0.05 [63]. To determine the reliability, most researchers suggest that a Cronbach's alpha value of at least 0.7 indicates an acceptable level of internal consistency [64].

The results of the validity and reliability tests are presented in Table 2. All measurement items were found to be valid, as they satisfied both the *r* and significance value criteria. Most constructs had Cronbach's alpha values exceeding 0.7, indicating high reliability. However, the Cronbach's alpha for one construct, "Social Influence" was 0.607. Several researchers argue that a Cronbach's alpha value of 0.6 is considered moderate but still acceptable [65]. Therefore, the Social Influence construct is deemed reliable.

3.3. Data Processing

After data collection, the responses were analyzed using IBM SPSS Statistics version 26. Before correlation testing, the normality of the data was evaluated, and the results indicated that the data were not normally distributed. Therefore, Spearman's rank-order correlation was chosen to assess the relationships between variables, as it is suitable for non-normally distributed and ordinal data derived from Likert-scale responses [66]. This method has also been employed in prior research investigating the adoption behavior of emerging technologies, such as virtual reality gaming platforms for the elderly using the UTAUT model [67]. The analysis focuses on testing the strength and direction of associations between

Table 2: Validity and Reliability Test Results.

Measurement Items	**R (r_{table} = 0.361)**	**Significance**	**Cronbach's alpha**
KN1	0.881	<0.001	0.747
KN2	0.678	<0.001	
KN3	0.949	<0.001	
PE1	0.754	<0.001	0.812
PE2	0.85	<0.001	
PE3	0.824	<0.001	
EE1	0.853	<0.001	0.883
EE2	0.935	<0.001	
EE3	0.886	<0.001	
SI1	0.755	<0.001	0.634
SI2	0.726	<0.001	
SI3	0.719	<0.001	
FC1	0.791	<0.001	0.893
FC2	0.763	<0.001	
FC3	0.877	<0.001	
PC1	0.857	<0.001	0.833
PC2	0.810	<0.001	
PC3	0.832	<0.001	
PC4	0.803	<0.001	
BI1	0.745	<0.001	0.832
BI2	0.852	<0.001	
BI3	0.789	<0.001	

Table 3: Demographic Characteristics of the Respondents.

Characteristics	Category	Percentage (%)
Gender	Male	53.2
	Female	48.8
Age	25 – 35 years old	65.5
	35 – 45 years old	24.5
	45 – 55 years old	8.4
	>55 years old	1.6
Residence	Java	82.3
	Sumatera	11.3
	Kalimantan	3.5
	Sulawesi	1.9
	Bali	0.3
	Nusa Tenggara	0.6
Education	High School	36.8
	Bachelor	60.6
	Master	2.6
Income	Rp3,500,000 – Rp10,000,000	54.2
	>Rp10,000,000	45.8

each construct in the model to validate the proposed hypotheses derived from the extended UTAUT framework.

4. Results and Discussion

The questionnaire was distributed between November 2024 to April 2025, yielding a total of 310 responses. The first section of the questionnaire consisted of questions related to the respondent's demographics. The obtained demographic data are presented in Table 3. Most respondents were male (53.2%), aged between 25 and 35 (65.5%), and residing on Java Island (82.3%). Additionally, 76% of the respondents had completed a bachelor's degree, and 77% reported a monthly income of more than Rp10,000,000.

The descriptive analysis of the responses is presented in Table 4. Overall, most respondents showed moderate-to-positive responses across all seven constructs. Higher mean values were observed for Performance Expectancy, Behavioral Intention, Knowledge, Perceived Cost, and Social Influence, indicating a general awareness of rooftop PV benefits, willingness to adopt, and basic technological understanding. Additionally, the high mean value for Perceived Cost suggests that while cost is viewed as a major concern, it is also a factor that respondents actively consider, implying a conscious cost-benefit evaluation process. Social Influence also scored relatively high, reflecting the role of family and friends in shaping perceptions.

In contrast, lower mean values for Effort Expectancy and Facilitating Conditions suggest that many

Table 4: Descriptive Analysis.

Constructs	Minimum	Maximum	Mean	Std. Deviation
KN	1	5	4.24	0.725
PE	1	5	4.44	0.646
EE	1	5	4.05	0.826
SI	2	5	4.17	0.696
FC	2	5	3.99	0.885
PC	2	5	4.22	0.673
BI	2	5	4.31	0.645

Table 5: Significance of Hypothesis Testing.

Hypotheses	Significance (*P*-value)	Conclusion
H1: KN → BI	<0.01	Accepted
H2: PE → BI	<0.01	Accepted
H3: EE → BI	<0.01	Accepted
H4: SI → BI	<0.01	Accepted
H5: FC → BI	<0.01	Accepted
H6: PC → BI	<0.01	Accepted

Table 6: Spearman's rho for Each Correlation. Showing the strength and direction of relationships between constructs.

Construct	BI
KN	0.694**
PE	0.641**
EE	0.687**
SI	0.632**
FC	0.687**
PC	0.765**

**Correlation is significant at the 0.01 level (2-tailed)

respondents perceive the technology as somewhat complex or lacking in ease of use, and that adequate support systems or resources may not yet be sufficiently available. These lower values could act as potential barriers, even among individuals who recognize the benefits of rooftop PV or are already inclined to adopt it.

The results of the significance and correlation tests are presented in Table 5 and Table 6. As shown, all hypotheses have a *p*-value less than 0.05, indicating that each proposed relationship is statistically significant. Thus, all hypotheses are accepted. The strength and direction of the relationships were evaluated using Spearman's rho. All correlations are positive, with no negative values observed.

Among all constructs, Perceived Cost ($\rho = 0.765$, $p < 0.01$) showed the strongest positive correlation with Behavioral Intention, suggesting that cost remains a key determinant in the adoption decision. This finding aligns with previous research [23,43,68], which emphasizes the role of financial considerations in technology adoption, particularly for high-investment technology like rooftop PV. It is important to note that although many respondents reported a monthly income of more than Rp10,000,000, cost is still perceived as a major barrier influencing their decision to adopt new technologies such as rooftop PV. This highlights that perceived affordability, rather than absolute income, plays a more central role in influencing purchase decisions.

Moreover, literature suggests that one-time payments for rooftop PV, as opposed to instalment options, may further discourage adoption due to the upfront financial burden [23,57]. If the cost of adopting rooftop PV is perceived as affordable or financially supported through incentives or instalment plans, it is likely to positively influence individuals' intention to adopt the technology [69]. A study in India [70] shows that it is necessary to design a flexible and decentralized subsidy policy that accounts for the diverse socio-economic conditions across states, cities, and rural-urban areas, ensuring fair access to rooftop PV adoption. It is reported that the cost of solar PV technology has significantly declined in recent years, which is expected to encourage greater adoption among consumers [71].

Following Perceived Cost, Knowledge ($\rho = 0.694$, $p < 0.01$) is found to also have a strong and positive correlation with Behavioral Intention, suggesting that awareness and understanding of rooftop PV positively influence the willingness to adopt. This supports the idea that informed individuals are more likely to consider and pursue rooftop PV systems. This finding aligns with an existing study that emphasizes the importance of knowledge and awareness in shaping the intention to adopt rooftop PV [51,72] though others reported that knowledge did not significantly influence purchase and adoption behavior [73].

Facilitating Conditions ($\rho = 0.687$, $p < 0.01$) also exhibit a positive correlation with Behavioral Intention. This indicates that individuals are more inclined to adopt rooftop PV if they perceive that the necessary infrastructure, support, and resources (such as money, time, and area) are available. The availability of facilitating conditions not only removes technical and logistical barriers but also fosters consumer confidence in using the technology. This result is supported by previous studies [22,34,43,74].

Effort Expectancy ($\rho = 0.687$, $p < 0.01$) shares an equal strength of correlation with Facilitating Conditions, highlighting that ease of use and simplicity in operation significantly influence intention. Consumers tend to adopt rooftop PV when they perceive it as easy to understand, install, and maintain. This finding is consistent with prior studies [19], though some research, such as in the context of adoption in Hungary [34], found no significant relationship between effort expectancy and intention.

Performance Expectancy ($\rho = 0.641$, $p < 0.01$) also shows a positive correlation with Behavioral Intention.

Respondents who believe that rooftop PV will improve their energy efficiency and reduce long-term electricity costs are more inclined to adopt the system. While previous studies, including Venkatesh et al. [26], stated performance expectancy as the most dominant predictor in technology adoption, the relatively lower rho value here suggests that other factors, particularly cost, may have a stronger influence in this specific context. The study by Bekti et al. [33] reported that users' intention to adopt rooftop PV in Indonesia was not significantly correlated with performance expectancy.

Social Influence ($\rho = 0.632$, $p < 0.01$) also positively and significantly correlated with Behavioral Intention. This implies that social norms, opinions, and recommendations from family, friends, and the surrounding community play a substantial role in shaping adoption decisions. This finding is in line with previous research that highlighted the importance of social influence in adoption decisions [27,35,41]. Furthermore, even though some studies, such as those by Bekti et al. [33] found no significant relationship between Social Influence and Behavioral Intention, this study supports the view that it can contribute meaningfully to an individual's motivation, especially when social support is tied to facilitating conditions [35].

The integration of solar technology advancements requires the presence of supportive communities and the availability of reliable conditions to ensure successful and sustainable implementation in developing contexts [75]. A study in Portugal shows that by organizing as Renewable Energy Communities (RECs), households can lower individual investment costs, share risks collectively, and achieve a more balanced supply-demand of renewable energy through shared generation and storage [76].

5. Conclusions

The adoption and installation of rooftop PV systems can serve as a strategic step toward helping Indonesia achieve its renewable targets. It is essential to evaluate the level of public acceptance, particularly among Indonesian residents, before promoting the implementation of new technologies related to renewable energy, especially given that most residents are more accustomed to fossil-based energy sources. In addition to their relevance for Indonesia, the findings also provide valuable insights for the broader field of sustainable energy planning, particularly in understanding consumer adoption of rooftop PV.

This study aimed to evaluate the perceptions and intentions of Indonesian residents regarding the adoption of rooftop PV, a technology that converts solar energy into electricity. The theoretical framework used in this study is an extended version of the UTAUT model, with two additional constructs, Knowledge and Perceived Cost, integrated into the original model.

The findings revealed that most respondents demonstrated moderate-to-positive intentions to adopt rooftop PV. Among the factors analyzed, Perceived Cost emerged as the most influential determinant of consumer intention, reflecting the common perception of renewable energy technologies as a high-cost investment. This was followed in significance by Knowledge, Facilitating Conditions, Effort Expectancy, Performance Expectancy, and Social Influence. Overall, the constructs incorporated in the model were found to be positively significant in shaping adoption intention.

Several limitations are recognized in this study. First, additional relevant constructs not examined in this study may offer further explanatory power and should be considered in future research. Second, the use of a cross-sectional survey limits the ability to assess changes in perception or intention over time. Longitudinal studies could provide deeper insights into how attitudes evolve with increased public awareness and policy changes. Lastly, the analysis relied on Spearman's rank-order correlation, which primarily assesses the basic correlation between variables. Employing more advanced statistical techniques, such as Structural Equation Modelling (SEM), could provide deeper insights into the relationship among constructs.

This study holds strong social relevance, aligning with Indonesia's broader goals to accelerate renewable energy deployment and reduce dependence on fossil fuels. By identifying key factors influencing consumer intention, this study provides valuable insights for policymakers and stakeholders in designing targeted incentives, awareness campaigns, and infrastructure support for rooftop PV adoption.

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Conflict-of-Interest Statement

The authors declare that they have no conflict of interest

Author Contributions

N.E. (Master's student): Research conceptualization, research framework, data acquisition, data analysis and interpretation, manuscript writing. R.N. (Professor): Research conceptualization, research framework, supervision, reviewing, and editing. M.H. (Doctorate student): Research framework, supervision, reviewing, and editing. B.L. (Professor): Research framework, reviewing, and editing.

References

[1] C.G. Solomon, R.N. Salas, D. Malina, C.A. Sacks, C.C. Hardin, E. Prewitt, T.H. Lee, E.J. Rubin, Fossil-Fuel Pollution and Climate Change — A New NEJM Group Series, New England Journal of Medicine 386 (2022) 2328–2329. https://doi.org/10.1056/NEJMe2206300.

[2] Ministry of Energy and Mineral Resource, Berkenalan dengan Net Zero Emission, (2022).

[3] Peraturan Pemerintah Republik Indonesia No.79/2014 tentang Kebijakan Energi Nasional, 2014.

[4] F.D. Muliawati, Energi Terbarukan RI Masih di Bawah Target, Bahlil Ungkap Penyebabnya, CNBC Indonesia (2024).

[5] P.L. Vita, Ringkasan Permasalahan dan Tata Program Peningkatan Kontribusi Energi Baru dan Terbarukan dalam Bauran Energi Nasional , 2021.

[6] K. Hasjanah, U. Simanjuntak, Indonesia Needs a New Strategy to Achieve 23% Renewable Energy Mix by 2025, Institute for Essential Services Reform (2023).

[7] N.A. Pambudi, R.A. Firdaus, R. Rizkiana, D.K. Ulfa, M.S. Salsabila, Suharno, Sukatiman, Renewable Energy in Indonesia: Current Status, Potential, and Future Development, Sustainability 15 (2023) 2342. https://doi.org/10.3390/su15032342.

[8] H. Hardianto, Utilization of Solar Power Plant in Indonesia: A Review, International Journal of Environment, Engineering & Education 1 (2019). https://doi.org/10.55151/ijeedu.v1i3.21.

[9] Y.I. Siregar, Ranking of energy sources for sustainable electricity generation in Indonesia: A participatory multi-criteria analysis, International Journal of Sustainable Energy Planning and Management 35 (2022) 45–64. https://doi.org/10.54337/ijsepm.7241.

[10] A.P. Redaputri, C.B. Santoso, M.Y.S. Barusman, Photovoltaics rooftop regulations and their connection to pro-environment consumer behavior in Indonesia, Sustinere: Journal of Environment and Sustainability 8 (2024) 262–274. https://doi.org/10.22515/sustinere.jes.v8i2.399.

[11] I. Barran, E.A. Setiawan, PV Rooftop Repowering Potential In Indonesia: Study Case, IOP Conf Ser Earth Environ Sci 997 (2022) 012016. https://doi.org/10.1088/1755-1315/997/1/012016.

[12] J. Gunawan, T. Alifia, K. Fraser, Achieving renewable energy targets: The impact of residential solar PV prosumers in Indonesia, International Journal of Sustainable Energy Planning and Management 32 (2021) 111–124. https://doi.org/10.5278/ijsepm.6314.

[13] Menteri Energi dan Sumber Daya Mineral Republik Indonesia, Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia No.49/2018 tentang Penggunaan Sistem Pembangkit Listrik Tenaga Surya Atap oleh Konsumen PT Perusahaan Listrik Negara (PERSERO), 2018.

[14] Menteri Energi dan Sumber Daya Mineral Republik Indonesia, Pembangkit Listrik Tenaga Surya Atap yang Terhubung pada Jaringan Tenaga Listrik Pemegang Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Umum, 2024.

[15] F.N. Haryadi, D.F. Hakam, S.R. Ajija, A.A. Simaremare, I.A. Aditya, The Analysis of Residential Rooftop PV in Indonesia's Electricity Market, Economies 9 (2021) 192. https://doi.org/10.3390/economies9040192.

[16] Lavinda, Kementerian ESDM: Pengguna PLTS Atap Melonjak 26% per Juli 2023, (2023).

[17] P.A.A. Pramana, D.F. Hakam, H.B. Tambunan, K.M. Tofani, K.G.H. Mangunkusumo, How Are Consumer Perspectives of PV Rooftops and New Business Initiatives in Indonesia's Energy Transition?, Sustainability 16 (2024) 1590. https://doi.org/10.3390/su16041590.

[18] M. Chaikumbung, Institutions and consumer preferences for renewable energy: A meta-regression analysis, Renewable and Sustainable Energy Reviews 146 (2021) 111143. https://doi.org/10.1016/j.rser.2021.111143.

[19] A.K. Aggarwal, A.A. Syed, S. Garg, Factors driving Indian consumer's purchase intention of roof top solar, International Journal of Energy Sector Management 13 (2019) 539–555. https://doi.org/10.1108/IJESM-07-2018-0012.

[20] M.E. Porter, Competitive Strategy: Techniques for Analyzing Industries and Competitors, Free Press, New York, 1980.

[21] M. Bilal, E. Andajani, Factors Affecting the Intention to Use Roof Solar Panel in Households in Indonesia, ADI Journal on Recent Innovation (AJRI) 5 (2023) 25–33. https://doi.org/10.34306/ajri.v5i1.895.

[22] A. Anjum, M. Subhan, Examining public intentions and attitudes toward solar rooftop panel adoption in Indian residences: an integration of TPB, DOI and UTAUT, Kybernetes (2024). https://doi.org/10.1108/K-01-2024-0080.

[23] W. Bouaguel, T. Alsulimani, Understanding the Factors Influencing Consumers' Intention toward Shifting to Solar Energy Technology for Residential Use in Saudi Arabia Using

the Technology Acceptance Model, Sustainability 14 (2022) 11356. https://doi.org/10.3390/su141811356.

[24] D. Paramita, B. Hartono, D.S. Utomo, H.M. Arini, Y.P. Mulyani, A. Rizqiawan, K.M. Banjar Nahor, A. Spanellis, M. Beltran, H.N. Adrin, D.K. Baroroh, B. Tjahjono, Exploring factors influencing intention and actual usage in household solar PV adoption, Cleaner and Responsible Consumption 15 (2024) 100242. https://doi.org/10.1016/j.clrc.2024.100242.

[25] W. Li, J. Zhu, Y. Li, Y. Li, Z. Ding, Determinants of Solar Photovoltaic Adoption Intention among Households: A Meta-Analysis, Sustainability 16 (2024) 8204. https://doi.org/10.3390/su16188204.

[26] V. Venkatesh, Morris. Michael G., G.B. Davis, F.D. Davis, User Acceptance of Information Technology: Toward a Unified View, MIS Quarterly 27 (2003) 425–478. https://doi.org/10.2307/30036540.

[27] K.T. Tran, N. Le, P. V. Nguyen, Assessing the role of consumer innovativeness and government incentives in enhancing the intention to install solar photovoltaic panels in Vietnam, International Journal of Organizational Analysis (2024). https://doi.org/10.1108/IJOA-04-2024-4476.

[28] K. He, J. Zhang, Y. Zeng, Households' willingness to pay for energy utilization of crop straw in rural China: Based on an improved UTAUT model, Energy Policy 140 (2020) 111373. https://doi.org/10.1016/j.enpol.2020.111373.

[29] Md.M. Rana, M.S. Siddiqee, Md.N. Sakib, Md.R. Ahamed, Assessing AI adoption in developing country academia: A trust and privacy-augmented UTAUT framework, Heliyon 10 (2024) e37569. https://doi.org/10.1016/j.heliyon.2024.e37569.

[30] M. Tariq, S.Z. Maryam, W.A. Shaheen, Cognitive factors and actual usage of Fintech innovation: Exploring the UTAUT framework for digital banking, Heliyon 10 (2024) e35582. https://doi.org/10.1016/j.heliyon.2024.e35582.

[31] J. Smyth, H. Chen, V. Donzella, R. Woodman, Public acceptance of driver state monitoring for automated vehicles: Applying the UTAUT framework, Transp Res Part F Traffic Psychol Behav 83 (2021) 179–191. https://doi.org/10.1016/j.trf.2021.10.003.

[32] S. Abdalla, W. Al-Maamari, J. Al-Azki, Data analytics-driven innovation: UTAUT model perspectives for advancing healthcare social work, Journal of Open Innovation: Technology, Market, and Complexity 10 (2024) 100411. https://doi.org/10.1016/j.joitmc.2024.100411.

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

[34] L. Molnár, T. Szép, Technology acceptance of balcony solar systems in Hungary – exploring influencing factors in a late-adopter country, Management of Environmental Quality: An International Journal (2024). https://doi.org/10.1108/MEQ-06-2024-0242.

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

[36] M. Maulidia, P. Dargusch, P. Ashworth, F. Ardiansyah, Rethinking renewable energy targets and electricity sector reform in Indonesia: A private sector perspective, Renewable and Sustainable Energy Reviews 101 (2019) 231–247. https://doi.org/10.1016/j.rser.2018.11.005.

[37] M.S. Islami, T. Urmee, I.N.S. Kumara, Developing a framework to increase solar photovoltaic microgrid penetration in the tropical region: A case study in Indonesia, Sustainable Energy Technologies and Assessments 47 (2021) 101311. https://doi.org/10.1016/j.seta.2021.101311.

[38] D. Setyawati, Analysis of perceptions towards the rooftop photovoltaic solar system policy in Indonesia, Energy Policy 144 (2020) 111569. https://doi.org/10.1016/j.enpol.2020.111569.

[39] D.R. Compeau, C.A. Higgins, Computer Self-Efficacy: Development of a Measure and Initial Test, MIS Quarterly 19 (1995) 189. https://doi.org/10.2307/249688.

[40] F.D. Davis, Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, MIS Quarterly 13 (1989) 319. https://doi.org/10.2307/249008.

[41] A.K. Aggarwal, A.A. Syed, S. Garg, Diffusion of residential RT solar – is lack of funds the real issue?, International Journal of Energy Sector Management 14 (2019) 316–334. https://doi.org/10.1108/IJESM-02-2019-0004.

[42] M. Bošnjaković, A. Čikić, B. Zlatunić, Cost-Benefit Analysis of Small-Scale Rooftop PV Systems: The Case of Dragotin, Croatia, Applied Sciences 11 (2021) 9318. https://doi.org/10.3390/app11199318.

[43] P. Kaur, R.K. Ritu, A. Kaur, Unraveling consumer behavioral intentions to adopt solar water heaters in India using UTAUT model, Built Environment Project and Asset Management 14 (2024) 312–328. https://doi.org/10.1108/BEPAM-07-2023-0118.

[44] D.G. Myers, J.M. Twenge, Social Psychology, 13th ed., McGraw-Hill Education, 2019.

[45] A. Mathilda, G. Theodora, R.S. Tarigan, Examining Indonesian Consumer Willingness to Adopt Solar PV: The Effect of Green Consumption, Price Value, Social Influence, and Facilitating Conditions, International Journal of Social Service and Research 4 (2024) 783–791. https://doi.org/10.46799/ijssr.v4i03.740.

[46] J. Lu, C. Yu, C. Liu, J.E. Yao, Technology acceptance model for wireless Internet, Internet Research 13 (2003) 206–222. https://doi.org/10.1108/10662240310478222.

[47] A. Rahmani, A.B. Naeini, Predicting intention in applying solar energy technologies in agriculture industry: A moderated and mediated model, Cleaner and Responsible Consumption 8 (2023) 100102. https://doi.org/10.1016/j.clrc.2023.100102.

[48] K. Yang, J.C. Forney, The Moderating Role of Consumer Technology Anxiety in Mobile Shopping Adoption: Differential Effects of Facilitating Conditions and Social Influences, Journal of Electronic Commerce Research 14 (2013). https://doi.org/10.19333/JECR2013.v14i4.63.

[49] V. Venkatesh, J.Y.L. Thong, X. Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, MIS Quarterly 36 (2012) 157. https://doi.org/10.2307/41410412.

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

[51] T.D. Vu, H.V. Nguyen, T.M.N. Nguyen, Extend theory of planned behaviour model to explain rooftop solar energy adoption in emerging market. Moderating mechanism of personal innovativeness, Journal of Open Innovation: Technology, Market, and Complexity 9 (2023) 100078. https://doi.org/10.1016/j.joitmc.2023.100078.

[52] Y. Tanoto, Cost-reliability trade-offs for grid-connected rooftop PV in emerging economies: A case of Indonesia's urban residential households, Energy 285 (2023) 129388. https://doi.org/10.1016/j.energy.2023.129388.

[53] N.T.T. Le, K.T. Tran, Predicting the intention to install solar photovoltaic panels in emerging market: The role of consumer innovativeness, knowledge, and support for government incentives, Journal of Open Innovation: Technology, Market, and Complexity 10 (2024) 100423. https://doi.org/10.1016/j.joitmc.2024.100423.

[54] T.T. Lan, S. Jirakiattikul, L.D. Niem, K. Techato, The intention of households in the Daklak province to instal smart grid rooftop solar electricity systems, Energy Sustain Soc 11 (2021) 22. https://doi.org/10.1186/s13705-021-00297-2.

[55] A. Kumar, Sindhu M R, Vivek Mohan, Rekha Viswanathan, Akhil V S, An Adaptive Staggered Investment Strategy for promotion of residential rooftop solar PV installations in India, International Journal of Sustainable Energy Planning and Management 37 (2023) 75–94. https://doi.org/10.54337/ijsepm.7477.

[56] J. Palm, M. Tengvard, Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden, Sustainability: Science, Practice and Policy 7 (2011) 6–15. https://doi.org/10.1080/15487733.2011.11908061.

[57] E. Karakaya, P. Sriwannawit, Barriers to the adoption of photovoltaic systems: The state of the art, Renewable and Sustainable Energy Reviews 49 (2015) 60–66. https://doi.org/10.1016/j.rser.2015.04.058.

[58] N. Nurwidiana, Barriers to Adoption of Photovoltaic System: A case study from Indonesia, Journal of Industrial Engineering and Education 1 (2023) 80–89.

[59] D.G. Bonett, T.A. Wright, Sample Size Requirements for Estimating Pearson, Kendall and Spearman Correlations, Psychometrika 65 (2000) 23–28. https://doi.org/10.1007/BF02294183.

[60] Y. Sun, S. Wang, Understanding consumers' intentions to purchase green products in the social media marketing context, Asia Pacific Journal of Marketing and Logistics 32 (2019) 860–878. https://doi.org/10.1108/APJML-03-2019-0178.

[61] D.J. Karras, Statistical Methodology: 11. Reliability and Validity Assessment in Study Design, Part A , Academic Emergency Medicine 4 (1997). https://doi.org/10.1111/j.1553-2712.1997.tb03646.x.

[62] H.K. Mohajan, Two Criteria for Good Measurements in Research: Validity and Reliability, Annals of Spiru Haret University 17 (2017) 58–82. https://doi.org/10.26458/1746.

[63] M. Silvia, I. Irwansyah, Validity and Reliability Test of Content Creator Strategy Management, Jurnal Kajian Jurnalisme 6 (2023) 158. https://doi.org/10.24198/jkj.v6i2.43348.

[64] J.M. Cortina, What is coefficient alpha? An examination of theory and applications., Journal of Applied Psychology 78 (1993) 98–104. https://doi.org/10.1037/0021-9010.78.1.98.

[65] K.A.M. Daud, N.Z. Khidzir, A.R. Ismail, F.A. Abdullah, Validity and reliability of instrument to measure social media skills among small and medium entrepreneurs at Pengkalan Datu River, International Journal of Development and Sustainability 7 (2018) 1026–1037.

[66] P. Schober, C. Boer, L.A. Schwarte, Correlation Coefficients: Appropriate Use and Interpretation, Anesth Analg 126 (2018) 1763–1768. https://doi.org/10.1213/ANE.0000000000002864.

[67] C. Goumopoulos, E. Drakakis, D. Gklavakis, Feasibility and Acceptance of Augmented and Virtual Reality Exergames to Train Motor and Cognitive Skills of Elderly, Computers 12 (2023) 52. https://doi.org/10.3390/computers12030052.

[68] U.C. Bandara, T.S.M. Amarasena, Impact of Perceived Ease of Use, Awareness and Perceived Cost on Intention to Use Solar Energy Technology in Sri Lanka, Journal of International Business and Management (2020). https://doi.org/10.37227/jibm-2020-04-61.

[69] A. Akilesh, K. Damodaran, Accelerating Solar Power Generation to Achieve India's Net-Zero Goals: A Factor-Based Study, International Journal of Sustainable Energy Planning and Management 44 (2025) 47–58. https://doi.org/10.54337/ijsepm.9787.

[70] A. Kumar, Madassery R. Sindhu, Vivek Mohan, Vinu Thomas, Adaptive Decentralized Payback Normalization for Socio-Economic Rebalancing of RE subsidies - A Case Study, International Journal of Sustainable Energy Planning and Management 39 (2023) 37–55. https://doi.org/10.54337/ijsepm.7978.

[71] B. Limmeechokchai, B. Bahadur Pradhan, P. Chunark, A. Chaichaloempreecha, S. Rajbhandari, P. Pita, Energy system transformation for attainability of net zero emissions in Thailand, International Journal of Sustainable Energy Planning and Management 35 (2022) 27–44. https://doi.org/10.54337/ijsepm.7116.

[72] A.I. Ugulu, Barriers and motivations for solar photovoltaic (PV) adoption in urban Nigeria, International Journal of Sustainable Energy Planning and Management 21 (2019) 19–34. https://doi.org/https://doi.org/10.5278/ijsepm.2019.21.3.

[73] B. Chekima, S. Chekima, S.A.W. Syed Khalid Wafa, O.A. Igau, S.L. Sondoh, Sustainable consumption: the effects of knowledge, cultural values, environmental advertising, and demographics, International Journal of Sustainable Development & World Ecology 23 (2016) 210–220. https://doi.org/10.1080/13504509.2015.1114043.

[74] L. Ferreira, T. Oliveira, C. Neves, Consumer's intention to use and recommend smart home technologies: The role of environmental awareness, Energy 263 (2023) 125814. https://doi.org/10.1016/j.energy.2022.125814.

[75] J.J. Perez Gelves, G.A. Diaz Flores, Methodology to Assess the Implementation of Solar Power Projects in Rural Areas Using AHP: a Case Study of Colombia, International Journal of Sustainable Energy Planning and Management 29 (2020) 69–78. https://doi.org/https://doi.org/10.5278/ijsepm.3592.

[76] F. Barata, J. Sousa, C. Viveiros, S. Perinhas, Techno-economic Assessment of Battery Energy Storage Systems in Renewable Energy Communities, International Journal of Sustainable Energy Planning and Management (2025). https://doi.org/10.54337/ijsepm.9290.