Development of a Rooftop PV Acceptance Model Among the Public in Indonesia and Employees of PT PLN (Persero)

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Abstract.

The adoption of photovoltaic (PV) technology is vital for sustainable energy solutions, particularly in Indonesia's electricity sector. This study investigates the acceptance of rooftop PV systems among the general public and employees of PT PLN (Persero) using the Theory of Planned Behavior (TPB) framework. Data from 366 respondents (179 public, 187 employees) were analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM). Key findings reveal that the public's adoption intention is significantly influenced by Subjective Norm (β = 0.212, $p < 0.05$) and Attitude (β = 0.463, $p < 0.001$), with economic incentives (β = 0.279, $p < 0.001$) and perceived benefits (β = 0.266, $p < 0.001$) playing a major role. Conversely, employees' adoption intention is predominantly driven by Attitude (β = 0.689, $p < 0.001$), influenced by environmental benefits (β = 0.311, $p < 0.001$) and perceived incentives (β = 0.323, $p < 0.001$). The structural model explains 57.3% and 69.5% of the variance in adoption intention for public and employee groups, respectively. This study contributes to understanding adoption drivers and provides actionable recommendations for PT PLN, including targeted communication strategies, infrastructure enhancements, and cultural alignment initiatives to promote rooftop PV adoption.

Keywords: *Acceptance, PV rooftop, Renewable Energy.*

1 Introduction

The Paris Agreement, established at the 21st Conference of the Parties (COP21), requires all United Nations member states to address the dangers of climate change and limit global temperature increases to below 2°C. In Indonesia, this commitment was ratified under Law (Undang-Undang) Number 16 2016. PT PLN (Persero), as a state-owned enterprise contributing significantly to carbon emissions, has set a target to support the national goal of achieving Net Zero Emissions (NZE) by 2060.

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According to PT. PLN (Persero) 2021-2030 Electricity Supply Business Plan (RUPTL), the company aims to add 10.6 GW of new renewable energy capacity by 2025. This mix includes geothermal, hydro, solar, wind, and biomass power plants. In support of this, the government issued Regulation No. 49 of 2018, allowing consumers to install rooftop solar systems, which must not exceed 100% of their connected power. This presents both challenges and opportunities for PLN, as it navigates the potential financial impacts of this regulation.

PT PLN (Persero) has initiated a transformation strategy with four key aspirations: Green, Lean, Innovative, and Customer Focused. These initiatives aim to lead Indonesia's transition to large-scale renewable energy while maintaining low-cost, reliable electricity services. The company's transformation will continue with its 2023-2027 vision of global competitiveness through growth, digitalization, and NZE moonshots, with a particular focus on renewable energy development, such as through partnerships to produce and sell solar photovoltaics (PV).

Despite Indonesia's potential for solar PV development, adoption remains slow due to high costs and limited awareness[1]. While some communities are familiar with the technology, others are concerned about its risks, costs, and benefits. This resistance is driven by perceived barriers and safety risks, as well as concerns over the cost-benefit ratio [2]. Neglecting post-implementation factors can also hinder technology adoption, as noted by Setiawan and Singh in [3], who observed that failure in technology adoption often leads to future rejection in developing countries like Indonesia, further impeding the achievement of renewable energy targets.

2 Literature Review

The growing global emphasis on mitigating climate change has spurred interest in renewable energy, particularly solar photovoltaics (PV). Several studies across different countries have explored factors influencing the adoption and acceptance of solar energy, especially in the residential sector. A key theoretical framework commonly employed in these studies is the Theory of Planned Behavior (TPB), which evaluates attitudes, subjective norms, and perceived behavioral control as predictors of behavioral intentions. Studies highlight that attitudes toward renewable energy, environmental concerns, and the perceived benefits of PV systems are crucial determinants of adoption intention across various socio-economic contexts [4].

For instance, a study conducted in China focused on residential PV adoption using TPB and found that perceived rewards, such as financial incentives, played a more significant role than government guidance in shaping adoption intentions. Bungalow residents, in particular, exhibited a higher inclination to install PV systems compared to apartment dwellers, with economic policies significantly driving installation intentions [5]. In contrast, Alsulami et al. (2024) noted that in Saudi Arabia, despite favorable attitudes toward renewable energy, consumers' lack of knowledge about solar PV posed a significant barrier to adoption. Their research suggested that social influence and environmental beliefs alone were insufficient to trigger adoption, emphasizing the need for targeted educational initiatives [6].

The influence of environmental concerns on PV adoption is consistently emphasized. In a U.S. study, Wolske et al. [7] found that pro-environmental personal norms indirectly increased interest in solar PV through perceived personal benefits. Moreover, individuals who trusted solar installers and were drawn to novel technologies were more likely to consider installation, underscoring the importance of trusted social networks in promoting adoption. Similarly, research in Bangladesh demonstrated that environmental knowledge, adoption costs, and government initiatives significantly impacted the intention to adopt solar PV in rural households. The findings highlighted the role of environmental concern and awareness as primary predictors of usage intentions [8].

Interestingly, while the environmental benefits of solar PV are widely recognized, some studies question the overall impact on emissions when solar energy is added without phasing out conventional energy sources. For example, Okuyama et al. found that in Japan, residential solar PV adoption paradoxically led to a 1.75% increase in emissions because consumers used more electricity overall when they combined solar with conventional energy sources. This phenomenon suggests that adding renewable energy without eliminating traditional energy infrastructure may not result in the expected reductions in carbon emissions [9].

Other research extends beyond environmental and economic factors to explore personal characteristics, such as innovativeness. A study in Vietnam demonstrated that personal innovativeness moderated the relationship between perceived financial barriers and adoption intentions. While perceived monetary costs typically hinder PV adoption, individuals with higher levels of innovativeness were more likely to adopt the technology despite financial concerns [10]. This finding is echoed in research from India, where Agarwal et al. (2023) observed that purchasing intentions were heavily influenced by attitudes toward technology readiness and innovativeness. These personal traits significantly shaped the adoption of rooftop solar in the Agra region, with macroenvironmental factors such as government policies and incentives further bolstering adoption rates [11].

Similarly, Hasheem et al. explored the factors influencing the purchase intention of solar PV in Pakistan and found that technological optimism, perceived benefits, and product knowledge were significant predictors of consumer attitudes. Importantly, the study highlighted the role of perceived consumer effectiveness as a moderator, which amplified the impact of positive consumer attitudes on purchase intentions [12].

In the Indonesian context, research on renewable energy adoption echoes similar themes. Murtiningrum et al. examined electric motorcycles adoption intentions in Indonesia and found that factors such as perceived environmental benefits, government incentives, and subjective norms played a crucial role in shaping public perceptions and adoption intentions[13]. This study supports the applicability of the TPB framework in Indonesia for understanding the adoption of green technologies, such as solar PV, by revealing that perceived behavioral control and societal support significantly influence adoption behaviors. As Indonesia continues to push for higher renewable energy targets, such as the government's ambitious renewable energy roadmap, understanding the factors influencing adoption at the household level will be key to achieving these targets.

3 Research methodology

The study adopts the Theory of Planned Behavior (TPB) and employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze data. The research aims to explore factors influencing the acceptance of PV rooftop technology, such as attitudes, perceived behavioral control, subjective norms, and the benefits and risks associated with the adoption of PV rooftop.

This study adopts the Theory of Planned Behavior (TPB) framework with modifications inspired by Murtiningrum et al.'s model, which has been published in a Q1 journal. Murtiningrum's model, although focusing on the acceptance of a different object, provides a robust foundation for exploring renewable energy adoption in Indonesia. By integrating key constructs such as attitudes, subjective norms, and perceived behavioral control, along with additional variables like perceived risks and benefits, this study seeks to address the contextual nuances of rooftop PV system acceptance among the public and PLN employees.
Divided into three sections, the survey consists of 43 questions that include:

I. Participant demographics: gender, age, education, occupation, monthly average expenses.

II. SEM Variables: knowledge, environmental concern, perceptions of rooftop PV systems, perceived economic benefit, perceived risk, perceived environmental benefit, perceived cost, perceived incentive policies, attitude, subjective norm, perceived behavioral control, and rooftop PV adoption.

The model used in this research is an extension of TPB, with the inclusion of variables such as perceived economic benefits, perceived environmental benefits, and perceived risks[14]. The hypotheses generated from this model examine the impact of these variables on attitudes toward the adoption of PV rooftop and how these attitudes influence actual adoption behavior. Additionally, the study explores the moderating role of personal innovativeness in influencing perceived monetary barriers and adoption intention.

Before conducting the main survey, we conducted a pilot study to test the validity and reliability of the questionnaire items. A 6-point Likert scale was used in the instrument, ranging from 1 (Strongly disagree) to 6 (Strongly agree), with intermediate options including 2 (Disagree), 3 (Partially disagree), 4 (Partially agree), and 5 (Agree). The list below offers a summary of the questions used to build the SEM:

Table 1 Measurement Item and Definition in Research

No	Measurement items [13]	Definition	Reference
1	Knowledge	This study examines the influence of households' perceptions regarding the adequacy of product knowledge about solar PV technology on their attributions and evaluation criteria for gathering and processing information about solar PV systems.	[15] in [16]
2	Perception of Solar PV	Perception of Solar PV refers to the likelihood of adoption based on perceived advantages over current technologies, such as cost savings, protection against rising electricity costs and blackouts, and increasing home values [7].	[7]

No	Measurement items [13]	Definition	Reference
3	Perceived Environmental Benefit	Perceived Environmental Benefit refers to consumers' recognition of the advantages of Solar Energy Technologies (SETs) in terms of energy security, climate change mitigation, and energy efficiency. This includes an understanding of how SETs improve air quality, reduce CO_2 emissions, and the negative impacts of fossil fuel-based energy [17].	[17]
4	Perceived Risk	Perceived Risk refers to the extent to which technologies are seen as incompatible with existing practices, values, and needs, leading to a perception of higher risk due to the required changes or uncertain outcomes. In our survey, perceived riskiness was used as a proxy for this incompatibility [7].	[7]
5	Perceived Cost	Perceived Cost refers to the financial concerns residents associate with adopting solar energy, primarily due to the substantial initial capital required [4].	[4]
6	Perceived Incentive Policies	Perceived Incentive Policies refer to the political and financial initiatives by governments to support renewable energy adoption, such as financial support and preferential tax rates for households selling solar-based electricity.	[10]
7	Subjective Norm	Subjective norm is defined as the social influence that individuals experience with regard to the adoption of a specific behavior, based on the expectations and beliefs of those around them.	[10]
8	Perceived Behavioral Control	Perceived Behavioral Control (PBC) refers to the extent to which individuals feel capable and confident in their ability to engage in a specific behavior, such as adopting new technology.	[6]

No	Measurement items [13]	Definition	Reference
9	Attitude	Consumer's attitude towards solar photovoltaic technology refers to their favorable or unfavorable emotions and evaluations based on environmental perceptions and motivations [4].	[4]
10	PV Adoption	This study seeks to examine consumers' motivations and plans regarding the adoption of renewable energy technologies such as solar photovoltaic systems.	[15] in [16]

Figure 1 depicts the research framework employed in this study. The variables of attitude and rooftop PV adoption are considered endogenous, meaning that they are influenced by exogenous (independent) variables or other variables. The remaining variables in Figure 1 represent the exogenous variables. In accordance with the Theory of Planned Behavior (TPB) framework, as illustrated in Figure 1, it is postulated that attitude serves as a mediator between the perception of attributes (e.g., perception of rooftop PV, perceived environmental and economic benefits, perceived cost and risk, perceived incentive policies) and rooftop PV systems adoption.

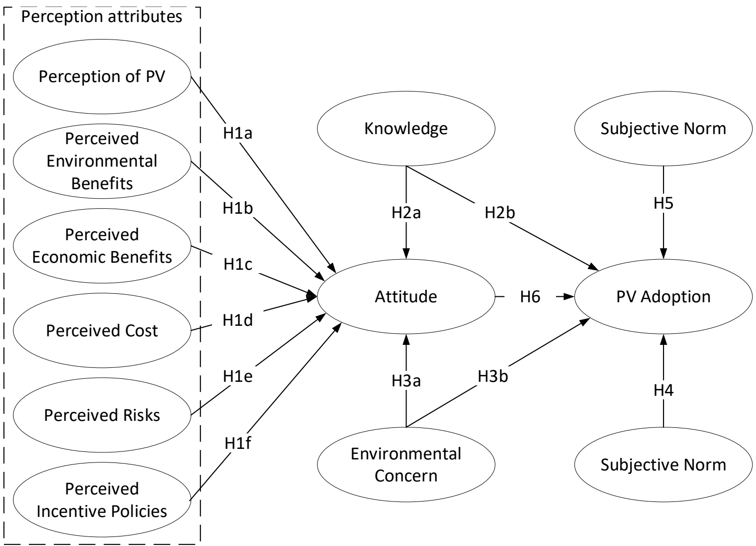

Figure 1 The research framework adopted from [3].

A pilot study was conducted with 18 participants prior to the main survey. The data was analyzed using SPSS software to assess the validity and reliability of the questionnaire. The results demonstrated that the questionnaire items were both valid and reliable, as evidenced by Spearman's correlation coefficients exceeding 0.47 and Cronbach's alpha values exceeding 0.7. Table 1 presents the values of Spearman's correlation coefficients and Cronbach's alpha coefficients for each construct.

Survey invitations were distributed via email and posted on social media platforms, including Facebook, LinkedIn, Instagram, and WhatsApp. Participants were directed to a Google Form, which is an online survey platform. Following the elimination of incomplete responses, a total of 179 public participants and 187 PLN employees were subjected to further analysis.

The research design is quantitative, using a cross-sectional survey method to collect data. The collected data was then processed and analyzed using PLS-SEM, which allows for the analysis of complex relationships between latent variables. The validity of the model was evaluated using reliability tests, convergent validity, and discriminant validity.

Table 2 Validity and Reliability Test Result

Code Item	Public		PLN employee	
	Spearman's correlation coefficients	Cronbach's Alpha	Spearman's correlation coefficients	Cronbach's Alpha
Knowledge		.886		.850
KN1	.531*		.470*	
KN2	.500*		.550*	
KN3	.536*		.469*	
KN4	.581*		.495*	
Environmental Awareness		.810		.741
EC1	.582*		.541*	
EC2	.468		.479*	
EC3	.471*		.512*	
EC4	.557*		.520*	
Perception of PV rooftop		.759		.819
PPV1	.475*		.583*	
PPV2	.553*		.609**	
PPV3	.503*		.505*	
PPV4	.692**		.486*	
Perceived Economic Benefits		.792		.767
PEB1	.628**		.679**	

Code Item	Public: Spearman's correlation coefficients	Public: Cronbach's Alpha	PLN employee: Spearman's correlation coefficients	PLN employee: Cronbach's Alpha
PEB2	.627**		.566*	
PEB3	.697**		.479*	
PEB4	.783**		.498*	
Perceived Environmental Benefits		.964		.869
PE1	.646**		.633**	
PE2	.581*		.604**	
PE3	.682**		.587*	
Perceived Risk		.639		.607
PR1	.561*		.560*	
PR2	.657**		.544*	
Perceived Costs		.648		.851
PC1	.476*		.483*	
PC2	.527*		.476*	
Perceived Incentive Policies		.909		.834
PIP1	.554*		.682**	
PIP2	.647**		.637**	
PIP3	.637**		.516*	
PIP4	.631**		.518*	
PIP5	.652**		.690**	
Subjective Norm		.847		.695
SN1	.495*		.497*	
SN2	.474*		.563*	
SN3	.670**		.596**	
SN4	.671**		.614**	
Perceived Behavioral Control		.792		.789
PBC1	.824**		.695**	
PBC2	.673**		.533*	
PBC3	.707**		.527*	
PBC4	.724**		.514*	
Attitude		.976		.727
AT1	.784**		.596**	
AT2	.722**		.604**	
AT3	.711**		.668**	
AT4	.671**		.580*	
PV Rooftop Adoption		.712		.640
PVA1	.824**		.750**	
PVA2	.647**		.566*	
PVA3	.744**		.629**	

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

4 Results and discussions

This study presents the average variance extracted (AVE) and composite reliability (CR) to confirm the convergent validity and reliability of the constructs. As illustrated in table 3, the factor loadings, AVE, and CR are all above the respective recommended 0.6, 0.5, and 0.7 levels.

Table 3 below shows responses and mean values across various constructs related to Knowledge, Environmental Awareness, Perception of PV Rooftop, and PV Rooftop Adoption for a total sample of 365 respondents, comprising 179 public respondents and 186 PLN employees.

Table 3 Respondent's Mean Scores on Constructs Related to PV Rooftop Adoption

Construct	Respond	Total N = 365		Public n = 179		PLN n = 186	
		Respond	mean	Respond	mean	Respond	mean
Knowledge	agree	236	4,13	133	3,89	103	4,37
	disagree	129		46		83	
Environmental Awareness	agree	355	5,44	176	5,48	179	5,40
	disagree	10		3		7	
Perception of PV rooftop	agree	294	4,58	149	4,56	145	4,60
	disagree	71		30		41	
Perceived Economic Benefits	agree	268	4,33	128	4,34	140	4,32
	disagree	97		51		46	
Perceived Environmental Benefits	agree	336	5,02	166	5,07	170	4,98
	disagree	29		13		16	
Perceived Risk	agree	221	3,98	122	3,78	99	4,18
	disagree	144		57		87	
Perceived Costs	agree	270	4,33	137	4,27	133	4,39
	disagree	95		42		53	
Perceived Incentive Policies	agree	285	4,57	134	4,70	151	4,44
	disagree	80		45		35	
Subjective Norm	agree	277	4,38	145	4,33	132	4,43
	disagree	88		34		54	
Perceived Behavioral Control	agree	289	4,52	139	4,52	150	4,52
	disagree	76		40		36	
Attitude	agree	298	4,60	140	4,64	158	4,57
	disagree	67		39		28	
PV Rooftop Adoption	agree	280	4,40	139	4,36	141	4,44
	disagree	85		40		45	

The table shows that PLN employees report slightly higher knowledge (mean = 4.37) compared to the public (mean = 3.89). Environmental Awareness scores are high across both groups, with a total mean of 5.44, indicating strong concern for environmental issues.

Perception of PV Rooftop is positive for both groups, with mean scores around 4.58 to 4.60. Perceived Economic Benefits and Perceived Environmental Benefits also rate highly, especially environmental benefits among employees (mean = 4.98). Perceived Risk and Costs show moderate levels (mean around 4.0–4.4), indicating they are recognized but not major deterrents.

Perceived Incentive Policies receive strong agreement, valued slightly more by the public (mean = 4.70) than employees (mean = 4.44). Both Subjective Norm and Perceived Behavioral Control score around 4.4–4.5. High scores in Attitude (mean = 4.60) and PV Rooftop Adoption Intention (mean around 4.4) suggest a favorable outlook toward PV adoption across groups

4.1 Structural model evaluation

The preceding section presented the constructs of validity and reliability. Subsequently, the structural model is evaluated using the coefficient of determination (R^2). The R^2 value for PV rooftop adoption in the model is 0.573, indicating that the constructs can explain 57.3% of the variance in the adoption of PV rooftop. While for PLN respondents value of R^2 in the model is 0.695, indicating that the constructs can explain 57.3% of the variance. In the literature, an R^2 value of 0.573 and 0.695 or greater (≥0.35) is considered substantial, whereas an R^2 value of less than 0.35 is considered moderate.

Table 4 Measurement items with convergent validity and reliability

Measurement Item	Public		PLN Employee	
	Composite Reliability	Average Variance Extracted (AVE)	Composite Reliability	Average Variance Extracted (AVE)
ATT	0.932	0.775	0.928	0.764
EC	0.911	0.720	0.881	0.653
KN	0.925	0.755	0.896	0.685
PBC	0.869	0.626	0.910	0.718
PC	0.871	0.772	0.832	0.716
PE	0.956	0.880	0.928	0.811
PEB	0.871	0.629	0.927	0.761
PIP	0.931	0.731	0.942	0.764
PPV	0.934	0.781	0.948	0.821
PR	0.787	0.656	0.748	0.609

Measurement Item	Public		PLN Employee	
	Composite Reliability	Average Variance Extracted (AVE)	Composite Reliability	Average Variance Extracted (AVE)
PVA	0.821	0.612	0.876	0.702
SN	0.861	0.610	0.898	0.688

As demonstrated in table 1, factor loadings, AVE, and CR exceed the respective recommended 0.6, 0.5, and 0.7 levels [18]. Table 2 Illustrates the results of the SEM. Factor loadings quantify the bivariate correlation coefficient between latent variables and their measurement items. This study presents the average variance extracted (AVE) and composite reliability (CR) to establish convergent validity and reliability of the constructs.

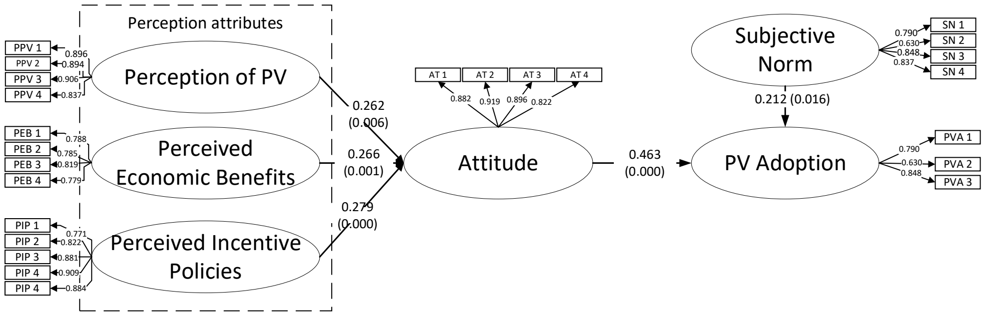

Figure 2 The result of structural equation modelling for public respondents

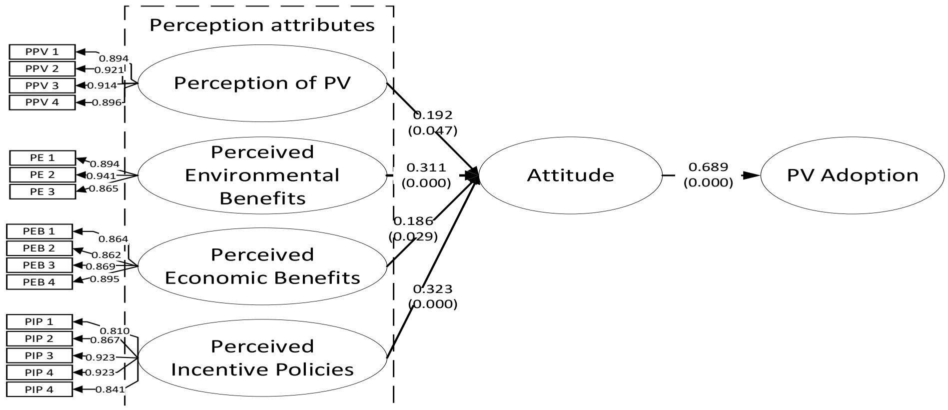

Figure 3 The result of structural equation modelling for PLN employee respondents

The analysis of the SEM presented in Figures 2 and 3, as well as the path coefficients in Table 2, highlights the factors influencing the adoption of PV rooftop among two distinct groups: public respondents and PLN employees.

For public respondents, the model highlights Attitude (AT) as a critical factor impacting PV Adoption Intention (PVA), with a path coefficient of 0.463 ($p = 0.000$). Attitude is significantly shaped by Perception of PV (PPV) with a coefficient of 0.262 ($p = 0.026$), Perceived Economic Benefits (PEB) at 0.266 ($p = 0.003$), and Perceived Incentive Policies (PIP) with the strongest effect of 0.279 ($p = 0.000$). This indicates that favorable perceptions, economic benefits, and incentives are instrumental in fostering a positive attitude toward PV adoption. Additionally, Subjective Norm (SN) has a significant direct effect on PV adoption intention (coefficient = 0.212, $p = 0.011$), suggesting that social influences moderately impact the public's decision to adopt PV technology.

In the PLN employee model, similar constructs are present, though there are notable differences. Attitude remains a key driver of PV adoption intention, with a stronger path coefficient of 0.689 ($p = 0.000$), underscoring its influence. Attitude formation is significantly influenced by Perception of PV (PPV) with a coefficient of 0.192 ($p = 0.047$), Perceived Environmental Benefits (PE) at 0.311 ($p = 0.000$), and Perceived Incentive Policies (PIP) with the highest impact at 0.323 ($p = 0.000$). These findings suggest that PLN employees are particularly motivated by incentives and environmental benefits when considering PV adoption. Interestingly, Perceived Economic Benefits (PEB) has a lower influence in this model (coefficient = 0.188, $p = 0.029$), though it remains significant. Unlike the public respondents, Subjective Norm (SN) does not appear to affect PV adoption intention for employees, indicating that PLN employees may rely more on internal motivations rather than social influences.

In conclusion, both models underline Attitude (AT) as the primary determinant of PV Adoption Intention (PVA), with public respondents displaying a coefficient of 0.463 and PLN employees 0.689. For both groups, Perceived Incentive Policies (PIP) and Perceived Economic Benefits (PEB) are crucial in shaping attitudes. However, Subjective Norm (SN) is only relevant for public respondents, suggesting that social factors are more influential for the general public, whereas PLN employees are more responsive to environmental and economic benefits. These insights suggest that tailored approaches promoting PV adoption should emphasize incentives, economic benefits, and, where applicable, environmental concerns and social influences.

5 References

[1] Sumarsono, N., Wahyuni, S., & Sudhartio, L. A paradigm shift of energy sources: Critical review on competitive dynamics of solar PV industry in Indonesia. Renewable Energy Focus, 41, 236–245, (2022).

[2] Huijts, N. M. A., Molin, E. J. E., & Steg, L. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renewable and Sustainable Energy Reviews, 16(1), 525–531, (2012).

[3] Setiawan, A. D., & Singh, R. Responsible Innovation in Practice: The Adoption of Solar PV in Telecom Towers in Indonesia. In Springer eBooks (pp. 225–243), (2015).

[4] Vibrans, L., Schulte, E., Morrissey, K., Bruckner, T., & Scheller, F. Same same, but different: Explaining heterogeneity among potential photovoltaic adopters in Germany using milieu segmentation. Energy Research and Social Science, 103(October 2022), 103212, (2023).

[5] Wu, J., Wang, S., Meng, Z., & Zhang, R., Public acceptance of residential photovoltaic installation: A case study in China. Heliyon, 9(10), e20891, (2023).

[6] Alsulami, A., Fairbrass, J., Botelho, T., & Assadinia, S. (2024). Technological Forecasting & Social Change Renewable energy and innovation in Saudi Arabia : An exploration of factors affecting consumers ' intention to adopt Solar PV. Technological Forecasting & Social Change, 204(May), 123430. https://doi.org/10.1016/j.techfore.2024.123430.

[7] Wolske, K. S., Stern, P. C., & Dietz, T. (2017). Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioral theories. Energy Research and Social Science, 25, 134–151. https://doi.org/10.1016/j.erss.2016.12.023.

[8] Alam, S. S., Masukujjaman, M., Lin, C. Y., Omar, N. A., Na, M., & Othman, A. S. (2022). Factors Affecting Photo Voltaic Solar Energy Usage Intention in Rural Households in Bangladesh: A Structural Equation Modelling Approach. Environmental and Climate Technologies, 26(1), 276–293. https://doi.org/10.2478/rtuect-2022-0021.

[9] Okuyama, A., Yoo, S., Kumagai, J., Keeley, A. R., & Managi, S. (2022). Questioning the Sun: Unexpected emissions implications from residential solar photovoltaic systems. Resources, Conservation and Recycling, 176(April 2021), 105924. https://doi.org/10.1016/j.resconrec.2021.105924.

[10] Vu, T. D., Nguyen, H. V., & Nguyen, T. M. N. (2023). 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(2), 100078. https://doi.org/10.1016/j.joitmc.2023.100078.

[11] Agarwal, R., Bhadauria, A., Swami, S., & Rajwnashi, R. (2023). Factors influence or inhibit the purchase intention towards rooftop solar: Using structural equation modeling and importance performance map analysis approach. Journal of Cleaner Production, 410(February), 137109. https://doi.org/10.1016/j.jclepro.2023.137109.

[12] Hasheem, M. J., Wang, S., Ye, N., Farooq, M. Z., & Shahid, H. M. (2022). Factors influencing purchase intention of solar photovoltaic technology: An extended perspective of technology readiness index and theory of planned behaviour. Cleaner and Responsible Consumption, 7(September), 100079. https://doi.org/10.1016/j.clrc.2022.100079.

[13] Murtiningrum, A. D., Darmawan, A., & Wong, H. (2022). The adoption of electric motorcycles: A survey of public perception in Indonesia. *Journal of Cleaner Production*, *379*(P2), 134737. https://doi.org/10.1016/j.jclepro.2022.134737.

[14] Ajzen, I. The Theory of Planned Behaviour. Organ. Behav. Hum. Decis. Process, 1991.

[15] Sun, Y., Wang, S., 2019. Understanding consumers' intentions to purchase green products in the social media marketing context. Asia Pac. J. Market. Logist. 32 (4).

[16] Hasheem, M. J., Wang, S., Ye, N., Farooq, M. Z., & Shahid, H. M. (2022). Factors influencing purchase intention of solar photovoltaic technology: An extended perspective of technology readiness index and theory of planned behaviour. Cleaner and Responsible Consumption, 7(September).

[17] Irfan, M., Elavarasan, R. M., Hao, Y., Feng, M., & Sailan, D. (2021). An assessment of consumers' willingness to utilize solar energy in China: End-users' perspective. *Journal of Cleaner Production*, *292*, 126008.

[18] Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2013. Multivariate Data Analysis. Pearson, Upper Saddle River, NJ.