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Solar Photovoltaic System Adoption Among Select Philippine Business Establishments: A PLS-SEM Analysis

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ABSTRACT

The study explored the factors that influenced select businesses in the Philippines to install and use rooftop solar photovoltaic (PV) systems, focusing on those that have already adopted this technology. Unlike earlier research that primarily examined potential users, this study analyzed the real-world experiences of 119 business owners and/or decision-makers in Luzon. The research is timely as the Philippines aims to increase its renewable energy share to 35% by 2030 and 50% by 2040, with the commercial and industrial sectors accounting for more than 50% of the country's energy consumption.

Through predictive causal research and analysis using Partial Least Squares-Structural Equation Modeling (PLS-SEM), the study revealed that social norms, perceived benefits, and corporate reputation were key factors driving solar adoption. Despite these motivations, businesses face challenges such as high installation costs, limited financing options, and delays in government approvals. These findings offer actionable insights for policymakers, solar providers, and financial institutions to develop strategies that address these barriers, improve accessibility, and encourage broader adoption of solar energy. By addressing the motivations and obstacles identified, this research can support the Philippines' renewable energy goals while helping businesses contribute more significantly to sustainability efforts. Its findings aim to inspire further investments in solar energy, advancing economic growth and fostering a cleaner, greener future.

Keywords: Solar Energy, Renewable Energy, Adoption, Rooftop Solar PV, Sustainability

INTRODUCTION

Energy is essential for a country's development, but the world is currently facing a major energy crisis (Sharifuddin et al., 2022). In Southeast Asia, this challenge is even more pressing due to the region's heavy dependence on fossil fuels such as coal, oil, and gas. This reliance has led to serious problems, including global warming, high carbon emissions, and extreme weather patterns (Kavari et al., 2019). Additionally, fossil fuel reserves are depleting quickly, creating an urgent need to shift to cleaner and more sustainable energy sources. Solar energy is emerging as one of the best solutions because it is renewable, environmentally friendly, and capable of meeting growing energy demands (Mukeshimana et al., 2020; Elavarasan et al., 2020).

Switching to solar energy supports the United Nations Sustainable Development Goals (SDGs), especially Goal 1 (No Poverty), Goal 3 (Good Health and Well-being), Goal 7 (Affordable and Clean Energy), Goal

11 (Sustainable Cities and Communities), and Goal 13 (Climate Action) (United Nations, 2015). Solar power lowers electricity costs, helping businesses grow and create more jobs (SDG 1) (IRENA, 2020). It also improves air quality by reducing pollution from fossil fuels, leading to better health (SDG 3) (WHO, 2018). By making clean energy more available, it supports economic growth, protects the environment, and helps cities become more sustainable (SDG 7 and SDG 11) (Kabir et al., 2018). Despite these benefits, solar adoption in Philippine businesses remains low, highlighting the need to address key challenges (Tumiwa, 2021).

This study focused on understanding why the adoption of rooftop solar systems by businesses in the Philippines has been slow. Key challenges include delays in government approvals, issues with the net metering policy, high installation costs, and a lack of financing options (Fabella & Ducanes, 2019; Junlakarn et al., 2021). Financial institutions often view solar projects as risky investments, which limits funding availability (Palanca-Tan, 2024; Yap & Lagac, 2020). Additionally, there is minimal government support, such as subsidies, and many business owners are unaware of the long-term benefits of solar energy, like cost savings and environmental contributions (Guno & Agaton, 2021; Rabahah et al., 2021).

This research investigated businesses in Luzon that have already adopted solar systems. Unlike previous studies that focused on homeowners or potential adopters, this study gathered insights from 119 business owners and decision-makers who have firsthand experience with solar energy. It explored the challenges they encountered during installation and operation, offering valuable insights into the barriers and opportunities in this sector (Irfan et al., 2021). The online survey was conducted from October 8, 2023 to September 8, 2024.

The findings of this study have significant implications. For schools and universities, the results can support teaching on renewable energy and sustainability, preparing students to address energy challenges in the future (Awuku, 2022). For the government, the study provides evidence to support policies that aim to increase renewable energy use to 35% by 2030 and 50% by 2040 (DOE, 2021). Solar energy providers and financial institutions can also use the findings to develop better services and financing strategies to encourage more businesses to adopt solar energy.

In summary, this research highlighted the journey and the barriers that businesses face when adopting solar energy and offers actionable solutions to address these issues. By doing so, it aimed to support a cleaner and more sustainable energy future in the Philippines, where businesses play a key role in driving economic growth while protecting the environment.

THE PROBLEM AND LIMITATIONS OF THE STUDY

This study aimed to explore and understand the decision-making process of commercial and industrial company owners and decision-makers in the Philippines who had installed rooftop solar PV systems in their establishments. The research assessed their level of agreement regarding several factors influencing their adoption of the technology. Notably, there is limited to no prior research focusing on rooftop solar PV installations in the commercial and industrial sectors, particularly with owners and decision-makers as respondents. Specifically, the study sought to answer the following questions: How did Subjective Norms influence Perceived Ease of Use? How did Subjective Norms influence Perceived Usefulness? How did Subjective Norms influence Attitude? How did Perceived Ease of Use influence Attitude? How did Perceived Usefulness influence Attitude? How did Attitude influence Intention to Use? How did Intention to Use influence Actual Usage? How did Price moderate the relationship between Intention to Use and Actual Usage? How did Corporate Reputation moderate the relationship between Intention to Use

and Actual Usage?

This study included 119 company respondents who were owners or key decision-makers in their companies' solar projects. These respondents held positions such as CEOs, general managers, heads, or managers, with the authority to approve and oversee rooftop solar PV installations. They came from industries like manufacturing, education, agribusiness, cold storage, and warehousing. To ensure participants were qualified, the study used an industry list, Google Earth, and screening questions in a self-administered online survey. The study explored key factors such as Subjective Norms, Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude, Purchase Intention, and Actual Usage. It focused specifically on installed and grid-tied rooftop solar PV systems in Luzon, acknowledging that the findings may not fully apply to other regions of the Philippines.

LITERATURE REVIEW

The Theory of Planned Behavior. TPB is found to be effective at forecasting human behavior and has been widely applied in a variety of fields, including management (Wu and Teng, 2011), education (Chen et al., 2011), and health (Asare, 2015), as well as in consumer green behavior (Ko and Jin, 2017). Abreu et al., (2019) who studied solar PV adoption, discovered that attitude, subjective norm, and perceived ease of behavioral control all had a favorable impact on people's intentions to adopt and use solar PV. TPB also investigates and effectively predicts customer behavior (McBride et al., 2020). The researchers concluded that elements of attitude, subjective norm, and perceived behavioral control influenced the intention to purchase solar PV in their study on the causes of the poor penetration of solar PV purchasing among Malaysian individuals (Jayaraman et al., 2017). The research so demonstrated that TPB may be used to determine a consumer's intention toward desired activities.

Studies in the Philippines have shown how these ideas explain the adoption of solar PV systems. For example, Ragragio et al. (2024) found that attitudes toward solar PV, influenced by its financial and environmental benefits, play a big role in adoption decisions. Palanca-Tan (2024) showed that social pressures from industry peers and government agencies impact people’s willingness to adopt. Lozano and Taboada (2021) highlighted how access to resources, like financing and technical support, affects people’s ability to adopt solar PV. These findings align with research by Abreu et al. (2019) and Jayaraman et al. (2017), who found that attitude, social norms, and perceived control positively influence decisions to use solar PV systems.

Other studies have looked at specific factors affecting adoption. For instance, Sunio et al. (2023) found that community-based social norms encourage collective decisions to adopt solar PV. Jandusay (2023) focused on how economic incentives, like tax breaks, encourage businesses to invest in solar energy. Franco and Taeihagh (2024) explored how supportive government policies can increase adoption by making it easier for businesses to access resources. Rebucas et al. (2024) identified that infrastructure readiness is an important factor in determining if solar PV can be adopted in industrial areas. Finally, Bunda et al. (2023) combined TPB with another theory, showing how good communication and awareness about technology also help increase adoption rates. TPB has been used in many fields, including business (Wu and Teng, 2011), education (Chen et al., 2011), health (Asare, 2015), and environmental behaviors (Ko and Jin, 2017). Research has shown it works well in predicting behavior, like in McBride et al. (2020), where it was used to understand customer decisions, or in Zhang (2020), where it explained actions related to climate change. In the Philippines, these insights are useful for understanding how businesses and consumers view solar PV systems and their intentions to use them.

In summary, TPB provides a helpful way to understand what drives people to adopt rooftop solar PV systems. By focusing on attitudes, social pressures, and access to resources, decision-makers can design better policies and programs. This approach can help increase the use of solar energy and support the Philippines' move toward sustainable energy solutions.

The Technology Acceptance Model (TAM) is widely used to predict technology acceptance, use, or rejection (Davis, 1989; Al-Emran and Granic, 2021). It effectively explains behavioral intentions and technology use through perceived usefulness (PU) and perceived ease of use (PEOU), both influenced by attitude (Fatoki, 2022). PU reflects the belief that technology improves job performance, while PEOU indicates how effortless the technology is to use (Davis, 1989). Khan and Nazir (2022) found that technical skills and system complexity significantly affect solar PV use. This model is relevant as it reflects how business owners' perceptions influence their intention to adopt solar PV.

Philippine studies offer further insights. Ragragio et al. (2023) identified enthusiasm and perceived benefits as key adoption drivers among homeowners. Taboada (2021) emphasized user-perceived value through cost savings and environmental benefits on a Philippine island. Palanca-Tan (2024) found economic and environmental concerns shape household adoption in Metro Manila. Borje et al. (2023) showed that SMEs' adoption depends on technological readiness and organizational factors. Ateneo de Manila University (2024) noted that low adoption results from cost and lack of public awareness, recommending subsidies and campaigns.

While TAM highlights PU and PEOU, factors like cost, government support, awareness, and individual preferences also influence adoption. Considering these elements can better promote rooftop solar PV use across sectors, supporting renewable energy transition.

This study's framework focused on solar PV users in commercial and industrial settings, examining subjective norms, PU, PEOU, attitude, intention, and actual use. It also assessed how price discounts and corporate reputation might affect the link between intention and usage.

HYPHOTHESES DEVELOPMENT

Some scholars refer to subjective norms or social norms as the person's impression of social pressure from family, friends, or the person most closely associated with their decision to exhibit the behavior (Usman et al., 2020). It has to do with a person's opinions on whether or not peers and significant others believe the individual should indulge in the conduct (La Morte, 2019). Social pressure is more favorable for solar energy in states with consumer-friendly net metering regulations and an established solar industry (Kim et al., 2021). Subjective standards have a substantial impact on how easily the solar system is seen to be used, according to the study of Kumar et. al., (2022). When someone has faith in the technological system being utilized, they will not have difficulties with its use or require special effort to do so (Usman et al., 2020). Moreover, Yulianita (2018) found that regardless of generation, perceived ease of use and subjective norms had a favorable and substantial impact on purchase intention, with subjective norms having the most impact when compared to the other variables she identified. In contrast, the study from Masukujjaman et al., (2021), found that perceived ease of use and social influence had little impact on consumers' intentions to buy renewable energy products. Through these conflicting studies, the researcher hypothesized that:

H1a. Subjective Norms significantly influence Perceived Ease of Use

A perception that employing technology can boost individual performance is known as perceived usefulness (Islami et al., 2021). A stronger sense of satisfaction or pleasure (or both) that is experienced

after doing something "good" for their fellow person resulted in the technology being viewed as more useful. Prior research suggests that perceived usefulness has the largest effect on customer decisions (Saravanos et al., 2022). Contrary to someone who thinks solar technology is less beneficial, he won't use it. If someone thinks solar technology is valuable, he will utilize it. Consumer intentions for solar energy purchases are driven by perceived usefulness (Ayuob et al., 2019). Moreover, it is stated by Gbongli et al. (2019) and Min et al. (2019) that adoption decisions are influenced by and driven by perceived utility. In their investigation of teachers' intent to utilize educational technology, Theo and Huang (2019) showed that subjective norms had a substantial impact on perceived usefulness. Moreover, subjective norms might influence how valuable something is regarded. If a user's subjective norm discourages the use of present technology, they are less likely to accept it (Septiani et al., 2017). Hence, it is hypothesized that:

H1b. Subjective Norms significantly influence Perceived Usefulness

While attitudes are permanent, they may also change. Attitudes are frequently the consequence of experience or upbringing, having a significant impact on behavior and affecting how individuals respond in various situations (Cherry, 2022). The term "attitude" refers to the customer's positive or negative evaluation of a specific action. Attitude is crucial in determining how individuals behave, from the decisions they make regarding how to live their lives to the everyday health activities they engage in. According to the research of Gultom (2020), attitudes and subjective norms have a considerable and advantageous influence on citizens' intentions to use e-government services. Moreover, behavioral intentions were considerably influenced by attitudes and subjective norms, which combined explained a sizable portion of the variation in actual conduct (Arpaci, 2020). Hence, it is hypothesized that:

H1c. Subjective Norms significantly influence Attitude

Perceived ease of use plays a key role in the adoption of solar energy technologies, but researchers hold contrasting views on its importance. Several studies emphasize the importance of ease of use. Bandara et al. (2020) and Masukujjaman et al. (2021) found that when people find solar equipment easy to use, they are more likely to adopt it. Zadeh (2022) supported this, stating that ease of use creates a positive attitude toward solar technology, making it a critical factor in adoption. Gbongli et al. (2019) argued that ease of use influences consumer attitudes more strongly than cost or availability.

In contrast, other studies highlight factors beyond ease of use. In the Philippines, Santos and De Guzman (2022) argued that affordability and government support have a greater impact on solar adoption. Corpuz (2023) pointed out that in rural areas, ease of use is less important than cultural acceptance and awareness of renewable energy. Similarly, Lantin and Cruz (2023) noted that addressing practical issues like maintenance and local technical support is more critical than promoting ease of use alone.

Globally, opinions vary. Min et al. (2019) highlighted the role of social influence in shaping perceptions of ease of use and usefulness, which affects adoption decisions. This aligns with Venkatesh et al. (2003), who proposed that ease of use and social norms are key factors in adopting new technologies. However, Rogers (2003) argued that ease of use matters less than other factors, such as the perceived benefits and how well the technology fits users' needs.

H2. Perceived Ease of Use have a significant influence on Attitude

Perceived usefulness, which refers to the belief that using technology can enhance individual performance, is a critical factor in technology adoption (Islami et al., 2021). This belief is often linked to the psychological rewards users experience, such as a sense of satisfaction or pleasure from contributing positively to society. Research suggests that perceived usefulness significantly influences customer decisions (Saravanos et al., 2022). For instance, if an individual perceives solar technology as beneficial,

they are more likely to adopt it, whereas a lack of perceived usefulness often leads to rejection (Ayuob et al., 2019). Similarly, studies by Gbongli et al. (2019) and Min et al. (2019) confirm that perceived usefulness is a key driver of adoption decisions across various technologies. These findings align with the Technology Acceptance Model (TAM), which highlights the significant role of perceived usefulness in shaping attitudes and behavioral intentions.

However, not all studies agree on its impact. Rahmiati and Yuannita (2019) observed no significant relationship between perceived usefulness and purchase intention in their research. Additionally, Reyes et al. (2021) noted that while perceived usefulness played a role in adopting e-learning platforms, factors like internet connectivity and digital literacy were more significant. Smith and Brown (2018) also argued that in some contexts, particularly in developing regions, perceived usefulness is overshadowed by trust and risk perception. These contrasting findings suggest that the influence of perceived usefulness may vary depending on contextual and moderating factors. Based on these insights, it is hypothesized that:

H3. Perceived Usefulness significantly influences Attitude

Attitudes are often formed by experience or upbringing. They have a strong effect on behavior and affect how people act in different situations. Attitudes are permanent, but they can also change (Cherry, 2022). Attitude is how consumers feel about a certain behavior, whether they like it or don't like it. Attitude is a key factor in shaping human behavior, from the choices people make about how to live their lives to the daily health behaviors they engage in. Studies show that green buying habits and government programs have a big impact on how people feel about solar products (Kumar et al., 2022). Also, a customer's attitude has a big and positive effect on whether they plan to buy solar PV technology (Ali et al., 2020). Also, Cousse (2021) says that the size of the installation affects how people feel about solar energy and that large installations make people feel stronger emotions, which affects how people feel. Attitude has a big effect on whether or not someone plans to buy (Rahmiati and Yuannita, 2019). Hence, it is hypothesized that:

H4. Attitude significantly influences the Intention to Use

Intention to use is a measure of whether or not a person has planned to do or not do a certain behavior in the future to use the technology (Ahmed et al., 2020). A previous study showed that there is a strong link between subjective norms and intention to use a solar PV system (Schulte, 2022). Mularczyk et al. (2022) say that people's intentions are mostly affected by how they feel about PV technology and, to a lesser extent, by how the media presents this technology. According to another study (Irfan et al., 2021), the level of acceptance for actions like installation goes down when prices go up, and market uncertainty of the firm's business is a major driver for adoption in the short, medium, and long term (Prause, 2019). The goal of technology is affected by how people feel and what they think is normal (Hesselink and Chappin, 2019). Also, the intention to buy has a positive effect on actual buying behavior, while subjective norms have a negative effect (Testa et al., 2019). Hence, it is hypothesized that:

H5. Intention to Use significantly influences Actual Usage

Monetary promotions like price discounts are commonly used to influence consumer behavior (Sinha & Verma, 2020). Studies such as Ray and Bala (2019) and Buyukdag et al. (2020) found that discounts lower financial barriers and encourage purchases. Ahmad et al. (2020) showed that reduced upfront costs motivate consumers to adopt solar PV systems. However, some researchers argue that discounts have a limited influence on solar adoption. Santos and Tan (2021) found that in the Philippines, price discounts attract initial interest but do not significantly impact consumers already planning to adopt solar. These consumers are more influenced by long-term benefits like energy savings, environmental impact, and

government incentives. Setyawati (2020) emphasized that discounts fail to address ongoing affordability or concerns about maintaining solar systems. In rural areas, Perez and Navarro (2023) noted that reliability and practicality matter more than temporary price cuts. Similarly, Reyes and Dela Cruz (2023) found that consumers already intent on adopting solar are less swayed by discounts compared to those without prior plans.

Globally, studies show similar patterns. Kim et al. (2021) reported that discounts have less impact on environmentally motivated consumers, who prioritize long-term savings and sustainability. Moser et al. (2022) noted that pro-environmental attitudes and financial readiness reduce the need for discounts. Rogers and Chang (2023) added that while promotions raise awareness, they are insufficient to drive the adoption of high-cost technologies like solar PV systems, as trust in technology and broader economic factors play a bigger role.

H6. Price discount moderates the significant and positive relationship between Intention to Use and Actual Usage.

The reputation of a company reflects how the public perceives its operations, including its products, services, and treatment of employees (Indeed, 2021). A strong corporate reputation offers numerous benefits, such as higher revenue, enhanced public trust, and increased customer loyalty (Energage, 2021). This concept is particularly relevant in the renewable energy industry, where the use of ground-mounted and rooftop solar photovoltaic (PV) systems is recognized as an effective method to reduce reliance on fossil fuels (Qiu et al., 2019). In this context, corporate reputation plays a crucial role in shaping consumer choices. Budiono et al. (2020) suggest that a company's reputation and origin are important considerations for technological purchases. Ali (2019) highlights that brand awareness strongly influences repurchase behavior, although Ansari et al. (2019) report that its effect on purchase decisions is moderately significant. Previous research has consistently indicated that a company's reputation directly impacts customer purchase intentions. Studies examining solar PV adoption demonstrate how a company's reputation influences the translation of consumer intentions into actual behavior. Zhang et al. (2021) argue that a solid reputation enhances customer trust, increasing the likelihood of choosing a particular solar PV provider. Likewise, Liu et al. (2022) point out that perceived reliability, along with a strong reputation, plays a significant role in homeowners' decisions to adopt solar PV systems. However, Hsu et al. (2020) highlight the moderating influence of external factors, such as government incentives and financial policies, which can diminish the role of corporate reputation and create a more intricate decision-making process.

Local research further illustrates the importance of corporate reputation. In the Philippines, Dela Cruz et al. (2018) found that companies with a positive reputation are more likely to gain consumer trust, especially in the renewable energy sector. Alipio (2020) notes that Filipino consumers value reliability and customer service over cost when choosing solar PV providers. Contrarily, Reyes and Santos (2021) observe that even well-regarded companies face challenges stemming from regulatory uncertainty, which can delay customer decisions. Bautista et al. (2019) highlight that while reputation matters, the availability of affordable financing often plays a more decisive role in solar PV adoption.

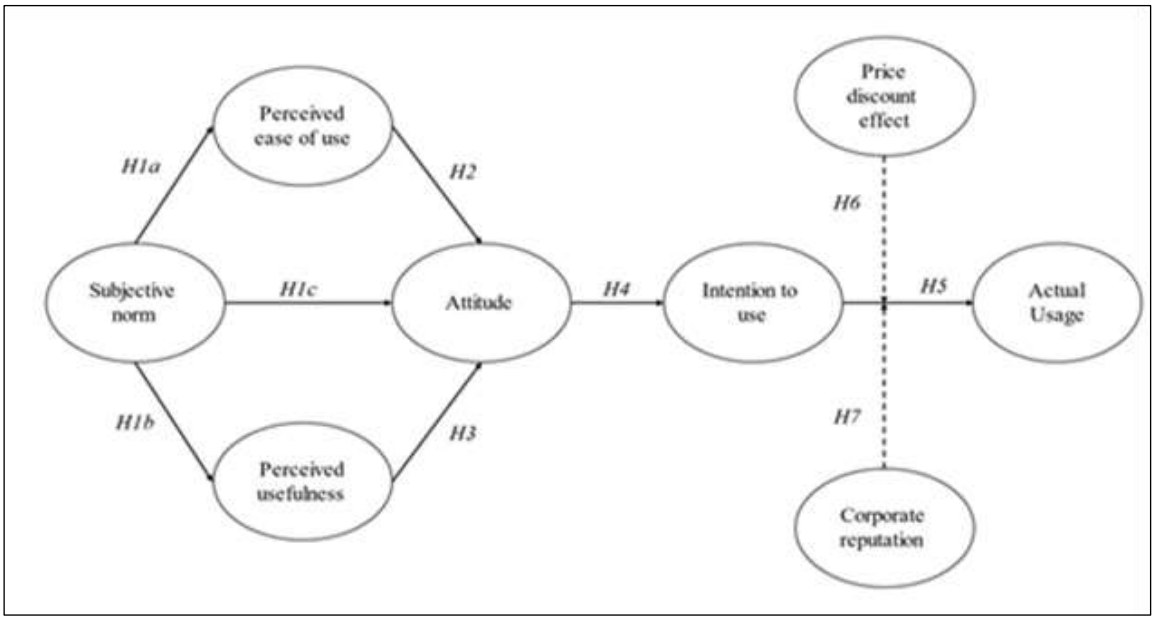
Contradicting views emerge in international literature. For instance, Grubb and Newbery (2018) assert that policy stability and subsidies are more influential than reputation in promoting renewable energy adoption. Bhattacharya and Sen (2003) argue that reputation contributes to trust only when companies also deliver tangible benefits, emphasizing the need for functional alignment. Verhoef et al. (2010) contend that corporate reputation must be bolstered by consistent customer engagement to remain

effective. Furthermore, Wang et al. (2022) argue that in areas with limited public awareness of solar PV technology, corporate reputation has minimal impact, underscoring the need for educational initiatives to inform potential adopters.

In summary, corporate reputation significantly influences the relationship between consumer intentions and the actual adoption of solar PV systems. However, its effectiveness depends on various factors, including financial incentives, regulatory conditions, and consumer awareness. These findings emphasize the complex interplay between reputation and other determinants in shaping consumer behavior in the renewable energy market. Hence:

H7. Corporate reputation moderates the significant and positive relationship between Intention to Use and Actual Usage

Figure 1. Research Framework



RESEARCH METHODOLOGY

The purpose of this study was to determine the level of acceptance of installed solar PV systems among selected business owners and decision-makers in the commercial and industrial sectors. The research examined the process these business owners went through before adopting the technology. The study focused on constructs such as subjective norms, perceived ease of use, perceived usefulness, attitude, intention to use, and actual usage. Predictive causal research was used to achieve the objectives of the study. Predictive causal research was used to make predictions about future outcomes that could be applied for selection, monitoring, or screening (Hamaker et al., 2020). These models included thousands of predictor variables and demonstrated high levels of accuracy (Ma and Tourani, 2020). A predictive causal model connected controllable independent factors to measurable dependent variables, predicting the dependent variables' values based on those of the independent variables. Prediction models have existed for many years and include tools widely used by experts, academics, decision-makers, and the general public (Collins and Moons, 2019). The goal of these models was to predict dependent variables using observed independent variables (Allison, 2014).

|The researcher used Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the data.

PLS-SEM was an effective tool for studying complex relationships and making predictions in business. It was particularly useful for small sample sizes or non-normal data (Hair et al., 2019). Unlike other methods, PLS-SEM emphasized prediction, making it well-suited for exploring new ideas and theories (Sarstedt et al., 2021).

Population, Sample Size and Sampling Technique

A total of 119 respondents participated, all of whom were owners or key decision-makers of commercial and industrial businesses in Luzon with grid-tiled rooftop solar PV systems. They held positions such as CEOs, COOs, General Managers, Directors, or Department Heads and were responsible for managing solar projects in their organizations. The businesses operated in industries such as manufacturing, agribusiness, cold storage, education, and warehousing.

To ensure only qualified participants were included, the survey had three screening questions: whether the company had an installed solar PV system, whether the respondent was an owner or decision-maker for the project and the industry of the company. Only those who met all criteria and had facilities in Luzon were selected for the study.

A purposive sampling method was used to select respondents. This method ensures that only individuals with the right knowledge and involvement in their companies' solar projects are included, which strengthens the quality of the research (Etikan, Musa, & Alkassim, 2016).

To decide how many participants were needed, the researcher used a special calculation called a priori power analysis with the G*Power software. This analysis helps find the right sample size by considering factors like effect size, significance level, and the likelihood of reliable results (Faul, Erdfelder, Buchner, & Lang, 2009). GPower is widely recognized for its reliability. Studies like those by Andrade (2020) and Faul et al. (2007) highlight its use in ensuring accurate sample sizes. Kline (2018) and Reichenheim and Silva (2018) also confirm its usefulness for reliable statistical analysis. These references show that GPower is trusted across different fields for research that requires clear and reliable sample size estimates. The analysis confirmed that 119 respondents were enough to ensure reliable and valid findings for this study

Description of Respondents

The study surveyed 119 key decision-makers or owners from selected commercial and industrial businesses in Luzon with installed rooftop solar PV systems. These included CEOs, COOs, GMs, VPs, department heads and managers. Most were aged 36–55 (53%), male (71%), and college graduates (61%). About 21% were company owners, while 79% were non-owners managing solar projects. Data was gathered through online surveys, and Google Maps was used to verify solar installations. Respondents came from industries like manufacturing, agribusiness, cold storage, education, and warehousing. The study followed ethical guidelines, with voluntary participation and full privacy protection.

Research Instrument

An online survey questionnaire, designed for participants to self-administer, was created using Google Forms as the research tool for this study. The survey questionnaire was divided into the following sections: Part 1 contains the respondents' demographic profile and company information. The demographic profile includes details such as age, gender, level of education, and occupation. The company profile captures information on estimated monthly energy bills, operating hours, and the type of industry. Part 2 consists of questions aimed at evaluating the respondents' level of agreement regarding the installation and usage

of solar PV systems. These questions were based on constructs used in the study: subjective norms included three (3) items adapted from Alam et al., 2021; perceived ease of use included three (3) items adapted from Alam et al., 2021; perceived usefulness included three (3) items adapted from Boon-itt, 2019; attitude included three (3) items adapted from Alam et al., 2021; intention to use included three (3) items adapted from Alam et al., 2021; and actual usage included three (3) items adapted from Irfan et al., 2021. A Likert scale was used to measure all constructs, with 5 indicating strong agreement and 1 indicating strong disagreement.

Statistical Treatment of Data

In this study, the collected data were coded, added up, and put into tables to make them easier to present and understand the results. Partial least squares-structural equation modeling (PLS-SEM) was used by the researcher. PLS-SEM, or partial least squares structural equation modeling, is a popular way to estimate path models with latent variables and how they are related (Sarstedt et al., 2021). One common goal of PLS-SEM analyses is to find key success factors and sources of competitive advantage for important target constructs like customer satisfaction, customer loyalty, behavioral intentions, and user behavior. PLS-SEM is a way to look at data that considers more than one factor. It combines regression and linear analysis. It is used a lot in business, management, and accounting, as well as in the social sciences, economics, finance, environmental sciences, medicine and health professions, and other fields where unobservable or latent variables need to be dealt with (Martinez et al., 2022).

Moderation analysis was used to look at how the reputation of the company and the price discount affect both the plan to use and the actual use. A moderator analysis is used to find out if the relationship between two variables depends on the value of a third variable, or if it is "moderated by" that value (Laerd, 2022). This relationship is usually between: (a) a continuous dependent variable and a continuous independent variable, which is changed by a dichotomous moderator variable; (b) a continuous dependent variable and a continuous independent variable, which is changed by a polytomous moderator variable; or (c) a continuous dependent variable and a continuous independent variable, which is changed by a continuous moderator variable. This guide focuses on (a), which is the relationship between a continuous dependent variable and a continuous independent variable that is changed by a dichotomous moderator variable.

RESULTS AND DISCUSSION

This portion presents the analyzed data gathered from the respondents' questionnaires and presented the key findings using Partial Least Squares – Structural Equation Modeling (PLS-SEM). This statistical technique was particularly effective at handling complex models with multiple variables and relationships (Hair et al., 2019). PLS-SEM was implemented in two main phases: the first phase involved assessing the measurement model, which evaluated the reliability and validity of the constructs and their indicators. The second phase focused on evaluating the structural model, which examined the relationships between the constructs and tested the research hypotheses (Lacap, 2019; Lacap, 2020; Lacap & Sicat, 2022). This approach enabled a comprehensive analysis of both the measurement properties and the structural relationships within the model.

Assessment of Measurement Model

The assessment of the measurement model involves gauging the reliability and validity of the latent constructs. For latent constructs, reliability is measured using Cronbach's alpha (CA) composite reliability

(CR). Moreover, validity is gauged by performing convergent and discriminant validity tests.

In measuring the reliability of the latent constructs, the values of CA and CR must be at least 0.70 (Kock, 2014). Based on the results in Table 1 – subjective norm (CA = 0.923; CR = 0.951), perceived ease of use (CA = 0.964; CR = 0.977), attitude (CA = 0.849; CR = 0.909), intention to use (CA = 0.913; CR = 0.945), actual usage (CA = 0.729; CR = 0.847), price discount effect (CA = 0.913; CR = 0.936), corporate reputation (CA = 0.919; CR = 0.940), and perceived usefulness (CA = 0.972; CR = 0.982) passed the reliability requirements.

In terms of convergent validity, latent constructs must have average variance extracted (AVE) and factor loadings equal to or higher than 0.50. Furthermore, each factor loading must have a p-value equal to or lower than 0.05 to be significant (Kock & Lynn, 2012; Kock, 2014). Based on the results in Table 1 - subjective norm (AVE = 0.867), perceived ease of use (AVE = 0.933), attitude (AVE = 0.769), intention to use (AVE = 0.852), actual usage (AVE = 0.649), price discount effect (AVE = 0.744), corporate reputation (AVE = 0.761), and perceived usefulness (AVE = 0.947) passed the convergent validity requirements.

Table 1. Convergent Validity and Reliability Measures

Latent construct	Item	Indicator loading	Average Variance Extracted	Cronbach's Alpha	Composite reliability
Subjective norm			0.867	0.923	0.951
	SN1	0.934			
	SN2	0.943			
	SN3	0.919			
Perceived ease of use			0.933	0.964	0.977
	PE1	0.959			
	PE2	0.973			
	PE3	0.955			
Attitude			0.769	0.849	0.909
	AT1	0.923			
	AT2	0.871			
	AT3	0.930			
Intention to use			0.852	0.913	0.945
	IU1	0.933			
	IU2	0.937			
	IU3	0.874			
Actual usage			0.649	0.729	0.847
	AU1	0.815			
	AU2	0.866			
	AU3	0.890			
Price discount effect			0.744	0.913	0.936

	PD1	0.758			
	PD2	0.891			
	PD3	0.878			
	PD4	0.868			
	PD5	0.916			
Corporate reputation			0.761	0.919	0.940
	CR1	0.939			
	CR2	0.871			
	CR3	0.917			
	CR4	0.708			
	CR5	0.935			
Perceived usefulness			0.947	0.972	0.982
	PU1	0.964			
	PU2	0.982			
	PU3	0.969			

All item loadings are significant ($p < 0.001$). AVE-average variance extracted;CA-Cronbach's alpha; CA-composite reliability

The discriminant validity of the latent constructs was assessed using the heterotrait-monotrait ratio of correlations (HTMT). According to Gold et al. (2001), an HTMT ratio threshold of 0.90 is necessary to confirm that discriminant validity is achieved within the model. More recent research supports this criterion, emphasizing its importance in validating the uniqueness of constructs (Henseler et al., 2015; Voorhees et al., 2016). As indicated in Table 2, all latent constructs in this study exhibited HTMT ratios below the 0.90 threshold, thereby confirming the presence of discriminant validity.

Table 2. Discriminant Validity Using HTMT Ratios

	SN	PE	AT	IU	AU	PD	CR	PU
SN								
PE	0.729							
AT	0.706	0.828						
IU	0.624	0.448	0.487					
AU	0.795	0.645	0.606	0.830				
PD	0.633	0.526	0.432	0.766	0.731			
CR	0.609	0.607	0.548	0.699	0.721	0.583		
PU	0.724	0.712	0.729	0.556	0.755	0.518	0.661	

SN-subjective norm; PE-perceived ease of use; AT-attitude; IU-intention to use: AU- actual usage; PD-price discount effect; CR-corporate reputation; PU-perceived usefulness.

Structural Model Evaluation

The evaluation of the structural model involves analyzing key statistical parameters, including path coefficients, p-values, standard errors, and effect sizes. Path coefficients show the strength and direction of relationships between variables, while p-values indicate their statistical significance. Standard errors

measure the accuracy of these estimates, and effect sizes reveal the magnitude of these relationships (Lacap & Sicat, 2022; Hair et al., 2019; Henseler, Ringle, & Sarstedt, 2015).

Figure 2. The Study's Structural Model Assessment

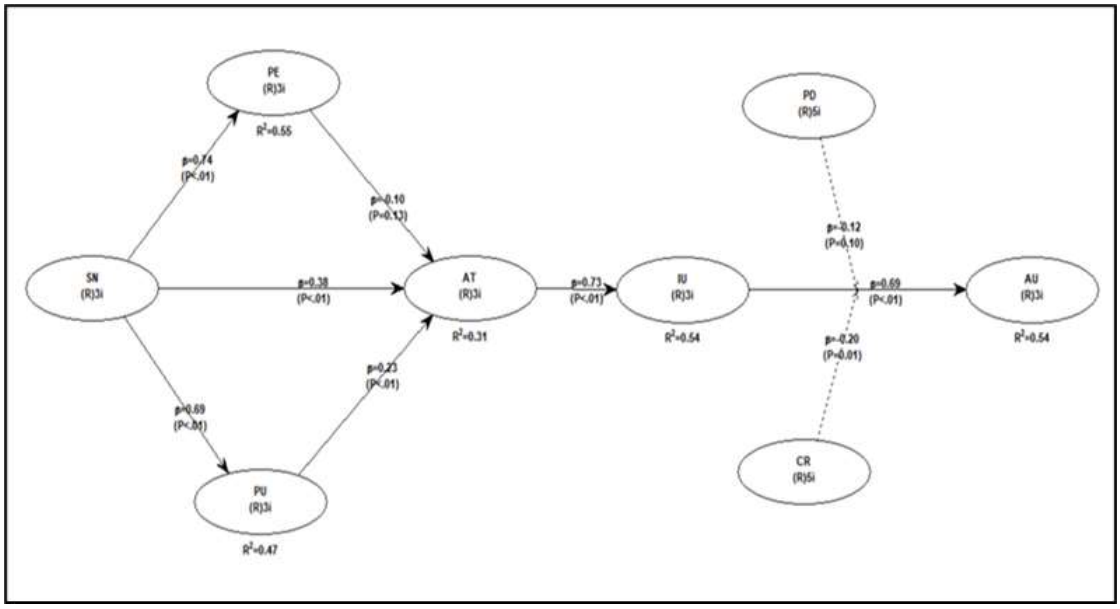


Table 3. Direct and Moderating Effects

Hypothesis	β	p	SE	f^2	Decision
Direct effects					
H1a. SN → PE	0.739	<0.001	0.076	0.546	Supported
H1b. SN → PU	0.687	<0.001	0.077	0.472	Supported
H1c. SN → AT	0.381	<0.001	0.083	0.235	Supported
H2. PE → AT	-0.103	0.127	0.089	0.060	Unsupported
H3. PU → AT	0.226	0.005	0.087	0.134	Supported
H4. AT → IU	0.735	<0.001	0.076	0.540	Supported
H5. IU → AU	0.691	<0.001	0.077	0.443	Supported
Moderating effects					
H6. PD * IU → AU	-0.116	0.098	0.089	0.043	Unsupported
H7. CR * IU → AU	-0.202	0.011	0.087	0.054	Supported

Effect sizes evaluation (Cohen, 1988): 0.02 – small; 0.15 – medium; 0.35 – large. β-path coefficient; p-p-value; SE-standard error; f2-effect size. SN-subjective norm; PE-perceived ease of use; AT-attitude; IU-intention to use: AU-actual usage; PD-price discount effect; CR-corporate reputation; PU-perceived usefulness.

Subjective Norms on Perceived Ease of Use, Perceived Usefulness and Attitude

Subjective norms have a clear and positive effect on the perceived ease of using solar technology. Usman et al. (2020) found that these norms significantly influenced perceived ease of use, especially when adopting new technologies like solar systems. La Morte (2019) emphasized that individuals' comfort with using new technology is shaped by the opinions of people around them. This aligns with the findings of Songkram et al. (2023), who showed that peer opinions improved individuals' confidence in using solar energy. Similarly, Kurniawati et al. (2020) confirmed that social pressure from peers or colleagues

increased users' comfort with adopting new systems. These studies consistently support the idea that subjective norms play a key role in shaping perceptions of ease of use.

Likewise, subjective norms have been shown to positively influence perceived usefulness. Wolske et al. (2020) demonstrated that peer influence affected energy behaviors and shaped how useful people believed solar technologies to be. Bekti et al. (2022) reported that strong social support increased the perceived value of rooftop solar systems. These results are consistent with the findings of Gbongli et al. (2019), Min et al. (2019), and Theo and Huang (2019), who all found that subjective norms significantly influenced perceived usefulness in various technological contexts. These studies suggest that social acceptance enhances the perceived benefits of solar technology.

Finally, subjective norms have also been found to affect attitudes toward adopting solar energy systems. Social pressure—whether from peers, stakeholders, or regulatory bodies—has influenced how individuals and organizations form their attitudes toward renewable energy. Sangroya and Nayak (2021) found that household adoption of rooftop solar panels was driven by social support. Similarly, Shahbaz et al. (2022) revealed that stakeholder expectations influenced corporate leaders' decisions to invest in solar energy. These findings highlight that subjective norms not only shape attitudes but also promote positive perceptions and support for solar energy adoption.

Perceived Ease of Use and Perceived Usefulness on Attitude

Research shows that perceived ease of use has a weaker influence on attitudes toward adopting solar energy compared to other factors. While Bandara et al. (2020), Masukujjaman et al. (2021), and Zadeh (2022) acknowledged that user-friendly systems may foster positive perceptions, many studies suggest that ease of use is often secondary. Kumar et al. (2021) found that businesses prioritize financial incentives over usability, and Zhang and Liu (2022) noted that consumers focus more on environmental and practical benefits.

In rural areas, ease of use appears even less significant. Corpuz (2023) emphasized cultural acceptance and renewable energy awareness as key, while Lantin and Cruz (2023) highlighted the greater influence of maintenance and technical support availability. Globally, Santos and De Guzman (2022) pointed to affordability and government support as primary drivers in the Philippines. Similarly, Min et al. (2019) and Venkatesh et al. (2003) stressed the stronger role of social influence. Rogers (2003) also argued that perceived benefits and compatibility outweigh usability. Supporting this, Nguyen et al. (2024) and Gbongli et al. (2019) concluded that cost, reliability, and availability more strongly shape attitudes than ease of use.

In contrast, perceived usefulness consistently influences adoption attitudes. Defined by Islami et al. (2021) as the belief that technology enhances performance, usefulness has been widely supported. Saravanos et al. (2022) and Hsu et al. (2021) found that recognizing solar energy's economic and environmental benefits improves adoption likelihood. Kim et al. (2022) and Johnson et al. (2023) echoed this, showing that perceived advantages drive business and consumer interest. This aligns with the Technology Acceptance Model (Gbongli et al., 2019; Min et al., 2019). While Rahmiati and Yuannita (2019) observed an exception, the broader consensus confirms that usefulness has a stronger and more consistent impact on attitudes than ease of use.

Overall, while ease of use may aid adoption, its role is often limited. Perceived usefulness through tangible benefits like cost savings and improved performance remains the dominant factor shaping positive attitudes toward solar energy.

Attitude on Intention To Use

Attitude has a significant and positive impact on the intention to use technology, shaped by personal experiences and upbringing (Cherry, 2022). For solar photovoltaic (PV) systems, a positive attitude increases the likelihood of adoption. Studies by Singh and Kumar (2022) show that favorable feelings about renewable energy led to higher adoption rates, emphasizing the importance of perceived control. Zhang and Li (2021) found that attitudes favoring sustainability and cost-effectiveness strongly predict solar PV adoption in industries, while Johnson and Thompson (2020) highlighted that positive attitudes toward energy efficiency and long-term savings boost adoption. These findings align with the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM), which state that attitudes, perceived usefulness, and ease of use are crucial for technology adoption (Ali et al., 2020; Cousse, 2021). Additionally, Kumar et al. (2022) noted that green buying habits and government programs influence consumer attitudes toward solar products, and Cousse (2021) observed that larger solar installations can enhance emotional responses and attitudes. Overall, this highlights that attitudes significantly shape the intention to use solar technology, affecting both purchase plans and consumer engagement (Rahmiati and Yuannita, 2019).

Intention To Use on Actual Usage

Intention to use has been shown to significantly and positively influence actual usage. Intention to use, which reflects an individual's plan to engage with a technology in the future (Ahmed et al., 2020), is a strong predictor of whether or not they will adopt it. Research consistently supports the idea that a strong intention to use solar photovoltaic (PV) systems translates into actual implementation. For instance, studies by Jain and Bansal (2022), Kumar and Sharma (2021), and White and Singh (2020) demonstrate that when individuals or organizations have a strong intention to adopt solar PV, they are more likely to follow through, driven by perceived benefits and incentives. This is consistent with earlier findings that subjective norms and personal attitudes toward PV technology play a significant role in shaping intention (Schulte, 2022; Mularczyk et al., 2022). However, the relationship between intention and actual usage is not always straightforward. Barriers such as rising costs and market uncertainty can disrupt this link. For example, Irfan et al. (2021) observed that higher prices and market uncertainties negatively affect acceptance of installation actions, while Prause (2019) highlighted that these factors impact adoption in both the short and long term. Additionally, Testa et al. (2019) found that while intention positively influences buying behavior, subjective norms can sometimes have a negative effect. This nuanced understanding suggests that although intention is a significant driver of actual usage, external factors like financial constraints and market conditions can complicate the direct link between intention and actual adoption (Lee and Kim, 2023; Zhang and Chen, 2021).

Moderating Effects of Price Discounts and Corporate Reputation

Simple moderation analysis was conducted to assess the moderating effects of price discounts and corporate reputation. Results showed that price discounts did not significantly moderate the link between intention to use (IU) and actual usage (AU), while corporate reputation did, though with a small negative effect. This indicates that corporate reputation, despite being a moderator, weakens the IU–AU relationship. Hence, H6 is not supported, while H7 is.

Price discounts, while often used to lower upfront costs, have limited influence on translating intention into actual adoption. Ahmad et al. (2020) and Sinha and Verma (2020) noted that discounts can stimulate

short-term interest but rarely lead to sustained adoption. Santos and Tan (2021) observed that in the Philippines; discounts mainly attract those already inclined toward solar PV systems. Moser et al. (2022) and Kim et al. (2021) added that consumers driven by environmental or long-term savings often overlook temporary financial incentives.

Research also suggests that discounts alone are insufficient to close the gap between intention and usage. Raghubir et al. (2004) and Monroe (2003) warned that deep discounts may raise quality concerns. Setyawati (2020) emphasized that while upfront costs are reduced, ongoing concerns like maintenance remain unaddressed. Perez and Navarro (2023), and Reyes and Dela Cruz (2023), found that consumers, especially in rural areas, prioritize reliability and support over price reductions.

More broadly, long-term benefits tend to outweigh the impact of price discounts. Rogers and Chang (2023) reported that energy savings, sustainability, and trust in technology are stronger adoption drivers. Moser et al. (2022) also noted that pro-environmental consumers focus on independence and environmental gains rather than short-term savings.

In contrast, corporate reputation strengthens the IU–AU link by enhancing trust and perceived reliability. Zhang et al. (2021) and Liu et al. (2022) found that consumers are more likely to act on their intentions when the provider has a strong reputation. In the Philippine context, Dela Cruz et al. (2018) and Alipio (2020) observed that consumers often prioritize reliability and service over price.

Reputation reduces perceived risk in high-cost technologies. Budiono et al. (2020) and Ali (2019) highlighted the role of brand origin and awareness in building trust. Penaloza et al. (2022) stressed that reputation addresses concerns about product durability and service quality, essential for solar PV adoption.

External factors can shape the impact of reputation. Hsu et al. (2020) cited the importance of regulatory support, while Bautista et al. (2019) noted that financing access may outweigh reputation. Bhattacharya and Sen (2003) and Verhoef et al. (2010) argued that ongoing customer engagement is necessary to maintain a reputation's influence.

However, reputation alone may not be sufficient. Wang et al. (2022) found that in areas with low awareness, its impact is limited unless paired with education. Reyes and Santos (2021) and Grubb and Newbery (2018) emphasized the need for stable policies and subsidies to support reputation's role in adoption.

Overall, while price discounts have minimal effect on actual usage, corporate reputation meaningfully shapes consumer trust and can influence the successful adoption of solar PV systems.

CONCLUSIONS

Practical Implications

From a practical perspective, the study offers valuable guidance for solar energy providers, policymakers, and leaders of commercial and industrial businesses aiming to promote wider adoption of solar PV systems. Strategies should focus on leveraging social proof through peer testimonials, community engagement, and referral programs to influence attitudes and intentions positively. Financial support mechanisms, such as tax incentives, installment plans, and leasing options, can help lower entry barriers, especially for small and medium-sized enterprises as well as larger commercial and industrial users. Companies should prioritize transparent communication, excellent customer service, and reliable system performance to strengthen their reputation and convert intention into actual use. Governments can support these efforts by simplifying permit processes through centralized platforms and encouraging solar use through clear policies and education campaigns. Together, these actions can create a more enabling

environment where the benefits of solar energy are well understood, trusted, and more easily accessible to businesses across different regions.

Theoretical Implications

The findings of this study reinforce and extend the application of the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) in understanding how commercial and industrial businesses adopt solar photovoltaic (PV) systems. The research highlights the strong influence of subjective norms on perceptions of ease of use, usefulness, and attitude, underscoring the value of social and peer influence in decision-making. The study also reveals that perceived usefulness is a more consistent driver of positive attitudes and intentions compared to perceived ease of use, suggesting that real-world benefits carry more weight than simplicity of use in the business context. Additionally, the role of company reputation in strengthening the link between intention and actual usage emphasizes the importance of trust and credibility in technology adoption. The minimal impact of price discounts suggests that internal motivators and perceived long-term value are more decisive. These results suggest that TPB and TAM may be enhanced by integrating factors such as brand trust, market context, and implementation challenges, particularly in emerging economies.

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