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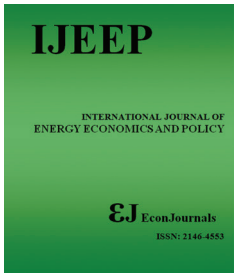

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Determinants of Intention to Purchase Photovoltaic Panel System: An Integration of Technology Acceptance Model and Theory of Planned Behaviour

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ABSTRACT

The emission of carbon dioxide and other greenhouse gases through electricity consumption by individuals and firms is one the significant drivers of climate change. Renewable energy can help to minimise the ecological footprint associated with the production and consumption of fossil fuels. Drawing on the Technology Acceptance model (TAM) and an extended Theory of Planned Behaviour (TPB), the study examined the determinants of intention to purchase rooftop photovoltaic (PV) panel system in residences in South Africa. The quantitative research design was adopted for the study and the cross-sectional survey method was used for data collection. The hypotheses of the study were tested using the Partial Least Square Structural Equation modelling. The results of the empirical study indicated that environmental concern, green perceived usefulness, perceive ease of use are associated with attitude and intention to purchase rooftop PV panel system. In addition, attitude, perceived behavioural control and awareness are positively related to intention to purchase rooftop PV panel system. Theoretically, the study confirms the applicability of an integrated model that consists of the TAM and TPB in explaining the intention to install rooftop PV panel system. Recommendations to improve the adoption of rooftop PV panel system in residences are suggested.

Keywords: Rooftop photovoltaic panel system, Purchase, Technology acceptance model, Theory of planned behaviour, South Africa
JEL Classifications: M10, M11

1. INTRODUCTION

Energy is a major part of modern society and has played a significant role in social-economic development. However, the dependence on fossil-fuel energy sources and anthropogenic emissions of greenhouse gases have negatively impacted the environment (Yazdanpanah, et al. 2015; Wall et al., 2021; Ashinze et al. 2021). Coal accounts for approximately 75% of primary energy supply and over 90% of electricity generation in South Africa and the country is ranked amongst the top 15 largest carbon dioxide emitters in the world. (Statista, 2021). In addition, the increasing demand for electricity has started to overwhelm the current generating capacity in South Africa. The conventional electricity generating plants are largely responsible for the high greenhouse gas emissions recorded in the country (Akinbami et al. 2021). The negative effects of the production and consumption of fossil fuel for energy generation in South Africa and the need to diversify energy sources to meet growing demand has led to interests in renewable energy (Ndlovu and Inglesi-Lotz, 2019; National Treasury, 2021).

Renewable energy (often referred to as clean energy) can be defined as energy flows that are continuously replenished by natural processes. This differentiates it from fossil and oil that consists of finite energy stocks (Hersh, 2006; Owusu et al. 2016). The sources of renewable energy include hydropower, geothermal,

solar, wind and marine energies (Panwar et al. 2011; Maradin, 2021). Renewable energy is the solution to the carbon emissions and ecological footprint associated with the production and consumption of fossil fuels (Xue et al. 2021). This has stimulated the growth of renewable energy worldwide. The share of renewable energy in the global electricity generation increased from 27% in 2019 to 29% in 2020. Renewable electricity generation is expected to expand by more than 8% in 2021 to reach 8 300 TWh (International Energy Agency, 2021). South Africa has set a target of 17800MW of renewable energy to be achieved by 2030 as the country transits to a low carbon economy (Department of Mineral Resources and Energy, 2021).

Solar energy is one of the fastest growing sources of renewable energy (International Energy Agency, 2022). Solar energy is derived from the photoms released by the sun and converted into electricity through photovoltaic (PV) cells. Solar panels are used to concentrate the solar radiation into energy to generate electricity (Solar Energy Industries Association, 2021). In recent years, solar technology has become relatively inexpensive and rooftop PV have started to be widely accepted by the population (Wall et al. 2021; Schulte et al. 2021). Rooftop PV systems unlike ground-mounted PV system power stations, does not require large amounts of land and are particularly convenient to use at home or work in rural or urban areas. Therefore, many countries are promoting the use of rooftop PV as a source of renewable energy (Sun et al. 2020). Although the use of renewable energy sources has started to grow, their consumption faces several challenges. First, the continued use of fossil fuels especially in many developing countries has limited the shift towards renewable energies. In addition, many developing countries despite having sizeable natural resources have not been able to transit to renewable energy because of the lack of necessary innovative technologies and infrastructure (Seetharaman et al. 2019; Wall et al. 2021). South Africa has an abundant supply of natural resources such as sun and wind and is a prime candidate for increased use of renewable energy. However, electricity generated from coal dominates despite the growth in the solar PV installed capacity (Department of Energy, 2019; Mordor Intelligence, 2021).

The successful transition from one energy source to another depends on the contribution of all stakeholders involved in the process. The acceptance of end users (the consumer) is very important to the growth of renewable energy sources. The decarbonisation of the residential sector is dependent on individual decision makers especially home owners (Shakeel and Rahman 2018; Schulte et al. 2021). Solar PV technology is viewed with concern in many parts of the world because of its costs, usefulness, efficiency and effectiveness (Mulaudzi et al. 2021). The adoption of renewable energy including the use of solar technology has stimulated empirical research with different theoretical models as the foundation. Wang et al. (2020) used the Norm Activation model to investigate the factors influencing the adoption intention of biogas technology by adoption by households in Pakistan. Aggarwal et al. (2019) adopted the Unified theory of acceptance and use of technology to explore the factors driving consumer purchase intention of roof top solar panels in India. This study intends to use an integrated model that includes the technology acceptance model (TAM) and the extended Theory of Planned Behaviour (TPB) to understand the intention to install roof top solar technology in residences in South Africa. This is because the use of technology is influenced by multidimensional factors and an integrated model allows the researcher to explore the effect of many constructs. The TAM is built on the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), TAM depicts attitudinal explanations on the intention to use a specific technology or service (Davis, 1989), However, TAM has been criticised by researchers for not fully depicting sufficient factors that are fundamental to potential users acceptance of a technology. Therefore, it is necessary to integrate TAM with other technological models (Alam et al. 2018). The TPB by Ajzen, 1991) is also based on the TRA. The TPB includes three components of behavioural Intention. These are attitude, subjective norms, and perceived behavioural Control. Thus, the aim of the study is to examine the determinants of intention to adopt rooftop solar panels (PV technology) by the owners of residences in South Africa using the TAM and TPB. Diaz et al. (2020) point out that the TPB can be enriched and broadened with the addition of new constructs or altering the pattern of the TPB variables. The inclusion of new constructs is expected to improve the predictive power of the TPB. A meta-analysis of research that used the TPB in the context pro-environmental behaviour indicated that 72% of studies analysed used behaviour the extended version of the TPB. This study uses awareness of Solar PV technology to extend the TPB.

The study will have theoretical, empirical and policy significance. Theoretically the study will test the applicability of an integrated model (TAM and extended TPB) in explaining the intention to adopt rooftop PV technology in South Africa. Empirically, the study will contribute to the literature on the factors that affect the adoption of renewable energy sources in the context of households in a developing country where research has been relatively sparse. The majority of studies done on renewable energy sources have been done in developed countries with different social, cultural, economic, legal and political contexts. This limits the generalisation of findings to developing countries (Alam et al. 2018; Cheam et al. 2021). In addition, South Africa has participated in many global climate summits including COP26. Renewable energy is needed for countries to reach net zero (International Energy Agency, 2021). Understanding the determinants of intention to purchase rooftop photovoltaic (PV) panel system in residences will help South Africa to reduce its dependence on coal and curb its high-carbon emissions.

2. LITERATURE REVIEW

2.1. Renewable Energy

Renewable energy can be described as energy from sources that are naturally replenishing but flow-limited. Renewable energy sources replenish themselves naturally without being depleted in the earth. Renewable energy resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time (United States Energy Information Administration, 2021). Renewable energy sources have the potential to provide energy with zero or almost zero emissions of both air pollutants and greenhouse gases (Panwar et al. 2011). The major types of renewable energy sources are biomass, hydropower, geothermal,

wind and Solar (Owusu et al. 2016). This study focuses on solar energy. Breeze (2019) points out that solar power converts sunlight into electricity. This can be done in two ways. (1) Concentrated Solar Power. This happens when sunlight is focused on an area that contains water, which is converted into steam that is used to generate power, as in a thermal power plant. (2 PV cells: light is converted into electricity using PV. Solar cells produce DC power, which fluctuates according to the intensity of irradiated light. The most commonly used solar technology at home is the solar PVs for electricity which can be a ground-mounted PV system or rooftop PV system. Compared with ground-mounted PV system that requires large amounts of land, a rooftop PV systems reduces land costs and are particularly convenient for households (Sun et al. 2018).

2.2. TAM

The TAM (Davis, 1989) is the most widely applied model to predict users' acceptance and usage of technology. TAM uses two technology acceptance measures (perceived ease of use, and perceived usefulness) with many of TRA's measures. Behavioural intention is influenced by attitude while actual system use is where people really use the technology. Attitude is influenced by perceived ease of use (PEOU) and perceived usefulness (PU). PEOU is described as the degree to which an individual believes that using a system would be free of from effort while PU describes the degree that an individual is of the opinion that a particular system will enhance their job performance (Davis, 1989). The model also incorporates external variables as significant determinants of attitude (Davis, 1989; Davis et al., 1992).

2.3. TPB

The TPB is an extension of the TRA (Ajzen and Fishbein 1980; Ajzen, 1991) The TRA argues that intention is the basis for actual behaviour. Intention depends on two factors namely attitude and subjective norms (Ajzen and Fishbein 1980). According to the TPB, intention also determines individual performance of a specific behaviour. The TPB is made up of three independent constructs namely attitude, subjective norms and perceived behavioural control (Ajzen, 1991). Attitude towards a behaviour is the extent to which an individual positively or negatively evaluates a behaviour. Subjective norms describe the possibility that an important person that is valued by an individual, will approve or disapprove a behaviour. Perceived behavioural control describes the perceived difficulty or ease of an individual in performance of a behaviour (Ajzen, 1991).

2.4. Hypotheses

2.4.1. Environmental concern

Chen and Tung (2014) describe environmental concern as a general attitude toward environmental protection and one of the factors that can affect the ecologically friendly behaviour of individuals. Environmental concern behaviour has been linked to green purchase behaviour and purchase of electric vehicles (Lin and Syrgabayeva, 2016; Mishra and Malhotra, 2019). The findings of empirical studies on environmental concern and attitude and intention to use renewable energy sources are inconclusive. Sun et al. (2018) investigate the effect of environmental concern on the purchase of rooftop PV installation by consumers in Taiwan. The results indicate a positive but insignificant relationship between environmental concern and attitude toward rooftop PV installation. Krishnaswamy et al. (2017) in a study on the reasons for the low purchase of PV panel system among Malaysian landed property owners find a negative relationship between environmental concern and intention. Shakeel and Rahman (2018) also find that environmental concern does not positively influence consumers' intention to use renewable energy technologies. Lin and Syrgabayeva (2016) examine the effect of environmental concern on the intention to pay more for renewable energy in Kazakhstan. The findings indicate that find that consumers' environmental concern has a positive effect attitude towards renewable energy. Palm and Tengvard (2011) in a study that investigated the motives for household adoption of small-scale production of electricity in Sweden find that environmental concern is one of the important factors and consumers that are concerned about the environment will participate in energy conservation behaviour. Wall et al. (2021) find that environmental concern positively affects the adoption of renewable energy by consumers in Thailand. Cheam et al. (2021) find that environmentalism has a significant impact on the intention to adopt solar PV in Malaysia. Environmental concern can also affect the PEOU of a technology. A high level of environmental concern will positively affect the willingness of an individual to learn to use a technology that can protect the environment. Wu et al. (2019) find that environmental concern is significantly related to PEOU of autonomous electric vehicles in China. Green perceived usefulness is a construct that was developed from perceived usefulness and describes as the extent to which a user believes that using a new product can improve their environmental performance (Chen and Lu 2016). Wu et al. (2019) find that environmental concern is significantly positively related to green perceived usefulness of autonomous electric vehicles. It is hypothesised that:

- Environmental concern is significantly positively related to (H1) attitude (H2) PEOU (H3) green perceived usefulness and (H4) intention to purchase rooftop PV panel system.

2.4.2. Attitude and intention

An individual's positive attitude towards a behaviour can influence the intention to perform the behaviour (Ajzen, 1991). The findings of empirical studies on the relationship between attitude and intention to purchase renewable energy sources are inconclusive. Masrahi et al. (2021) in a study on the factors influencing consumer behavioural intentions to use renewable energy in the United States residential sector find that the relationship between attitude and intention is not statistically significant. Gamel et al. (2022) find that attitude towards green investments does not influence an individual's intention to invest in wind energy in Germany. The results of the study by Yee et al. (2022) indicate that attitude towards renewable energy investments has a positive influence on renewable energy investment intention in Malaysia. Claudy et al. (2013) find a significant positive relationship between attitude and intention to use renewable energy. Sun et al. (2018) find that the intention to install rooftop PV installation is positively influenced by the attitude towards rooftop PV installation. The results of the study by Masukujjaman et al. (2021) show that attitude has a significant positive relationship with purchase intention of

renewable energy technology by households in Bangladesh. The higher the attitude towards adopting rooftop PV technology, the higher the likelihood that consumers will form an intention to use rooftop PV technology. It is hypothesised that:

- H5: Attitude towards adopting rooftop PV technology is positively related to intention to purchase rooftop PV panel system.

2.4.3. Subjective norms and intention

Yazdanpanah et al. (2015) find that the path from subjective norms to intention to use renewable energy sources indicate an insignificant relationship. These findings are consistent with the results of Masukujjaman et al. (2021) that social influences do not affect the intention to use renewable energy sources in Bangladesh. Another stream of research finds a positive relationship between subjective norms and intention to use renewable energy sources. Masrahi et al. (2021) find that the effect of subjective norms on consumer behavioural intentions to use renewable energy is significant Krishnaswamy, et al. (2017) find that social influence is significantly positively related to customer intention to purchase PV panel system. These findings are consistent with the results of Ashinze et al. (2021) that subjective norms are positively related to intention to use renewable energy. It is hypothesised that:

- H6. Subjective norms are positively related to intention to purchase rooftop PV panel system.

2.4.4. Perceived behavioural control and intention

If an individual believes he/she has the requisite expertise, skills, and resources to use renewable energy sources, he/she prefer to buy renewable energy sources and vice versa (Masukujjaman et al., 2021). The findings of the studies by Yazdanpanah et al. (2015), Shakeel and Rahman (2018), Masrahi et al. (2021) and Masukujjaman et al. (2021) find that perceived behavioural control significantly affects the willingness to use renewable energy sources. To use a renewable energy source, an individual must have access to the resources required for purchase and the skill to use it (Korcaj et al. 2015). It is hypothesised that:

- H7. Perceived behavioural control is positively related to intention to purchase rooftop PV panel system.

2.4.5. PEOU, green perceived usefulness, attitude and intention

Chen and Lu (2016) remark that in the context of the use of technology that protects the environment, perceived usefulness can be termed green perceived usefulness. Chen and Lu (2016) find that green perceived usefulness is positively associated with the intention to use YouBike. In addition, PEOU described as the degree to which users believe that using rooftop solar technology is free of effort and easy to use can also affect intention. Masukujjaman et al. (2021) find that the relationship between perceived usefulness and intention to purchase renewable energy technology is significant. However, the effect of PEOU is insignificant. In addition, both PEOU and PU positively impact on attitude towards renewable energy sources. Yang et al. (2021) find that both perceived usefulness and PEOU are positively related to attitude towards renewable energy. In addition, there is a significant positive relationship between PEOU and PU of renewable energy. Chen and Lu (2016) find that PEOU is positively associated with the intention to use YouBike. Wu et al. (2019) find that both green perceived usefulness and PEOU of use positively affect the intention to purchase autonomous electric vehicles in China. In addition, according to TAM, PEOU is supposed to influence perceived usefulness. Masukujjaman et al. (2021) find that PEOU positively affects perceived usefulness in the context of renewable energy sources. Wu et al. (2019) find that green perceived usefulness is positively related to PEOU in the context of the purchase of autonomous electric vehicles. It is hypothesised that:

- H8: Green perceived usefulness is positively related to attitude towards rooftop PV panel system
- H9: PEOU is positively related to attitude towards rooftop PV panel system
- H10: Green perceived usefulness is positively related to intention to purchase rooftop PV panel system
- H11: PEOU is positively related to intention to purchase rooftop PV panel system
- H12: PEOU is positively related to green perceived usefulness of rooftop PV panel system.

2.4.6. Awareness and intention

Alam et al. (2014) and Wall et al. (2021) describe awareness as the level of knowledge about the effectiveness, benefits and drawbacks of renewable energy technologies by consumers. Wall et al. (2021) find a significant positive relationship between awareness and intention to use renewable energy in Thailand. The findings of the study by Alam et al. (2014) indicate that a high level of awareness positively affects the intention of residents to use renewable energy for household purposes. These findings are consistent with the results of Ashinze et al. (2021) that a high level of awareness increases the intention of consumers to use renewable energy technologies. Consumers that are aware of renewable energy technologies are likely to have the intention to adopt them. It is hypothesised that:

- H13: Awareness is is positively related to intention to purchase rooftop PV panel system.

Figure 1 depicts the conceptual model of the study.

3. RESEARCH METHODOLOGY

The study adopted the quantitative research approach and a causal research design. The cross-sectional survey method was used to collect data from the respondents. Data was collected through the self-administered questionnaire method. The survey was conducted in Polokwane and Mokopane in the Limpopo Province of South Africa. The owners of houses that do not currently have solar technology are the participants in the survey. The convenience and snowball sampling methods were used to identify the survey participants. Data collection took place between March and September 2021 and two research assistants helped with data collection. The owners of the houses were contacted through personal meetings to explain the purpose of the research and seek the permission to participate in the survey. The emails and telephone numbers of the owners were obtained. Each participant was given 2 weeks to complete the questionnaire. If the questionnaire is completed, it is then collected. The participants were reminded every 2 weeks through phone calls or email

messages to complete the questionnaire. This process was repeated for 8 weeks. If the questionnaire is not completed after 8 weeks, it is considered as non-response. Before actual data collection, a pilot study was done with thirty owners. The participants in the pilot study did not participate in the actual survey. The results of the pilot study led to minor adjustments to the questionnaire. In addition, the questionnaire was examined by two experts in the area of sustainability and their comments were incorporated in developing the final questionnaire. The questionnaire had two versions English and Sepedi (a local language widely spoken in the study areas). The Partial Least Square Structural Equation Modelling (PLS SEM) using the Smart software was used for data analysis. The question items were developed from previous studies and depicted in Appendix 1. All the items to measure the constructs of the study were anchored on the five-point Likert scale ranging from "1 strongly disagree to 5 strongly agree." The Cronbach's alpha was used as a measure of reliability. The participants in the survey were assured of anonymity and confidentiality. Appendix one depicts the measures of the constructs of the study.

4. RESULTS

4.1. Response Rate and Biographical Detail

One thousand questionnaires were distributed and four hundred two questionnaires were returned and found usable. In determining the appropriate sample size, the study utilised the 10 times rule which assumes that when PLS SEM is used, the the sample size should be >10 times the maximum number of inner or outer model links that point to a given latent variable in a model (Hair et al. 2011). The biographical details of the respondents are: gender: 211 females and 191 males. Age: 21–30 (0) 31–40 years 155 respondents, 41–50 years, 172 respondents, 51–60 years 61 respondents. Educational qualifications: 170 with Matric qualification and 232 with post matric qualification).

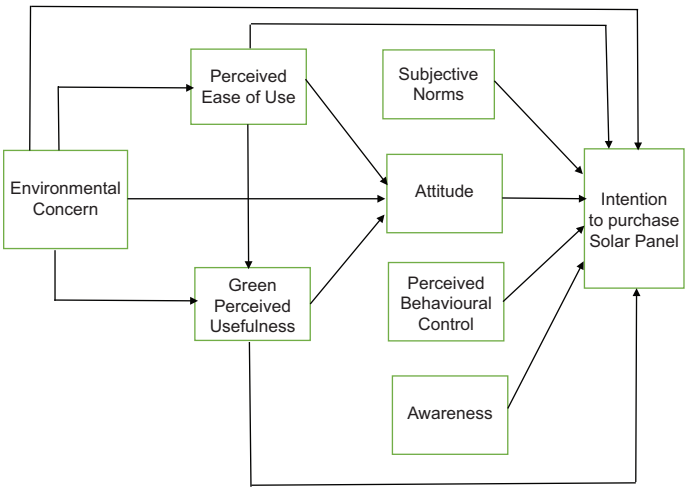
4.2. PLS SEM

Hair et al. (2019) remark that the PLS SEM consists of two sub- models. The measurement model which depicts the relationships between the observed data and the latent variables. Second, the structural model which shows the relationship between the latent variables.

4.2.1. The measurement model

The evaluation of the measurement model should include the factor loadings (>0.708), Average variance explained (>0.500), Cronbach's alpha (>0.700) and composite reliability. Table 1 shows that all these requirements are met and convergent validity is established. To assess discriminant validity, the study used the Fornell-Larcker criterion and the heterotrait–monotrait ratio (HTMT). Table 2 depicts the results of the the Fornell-Larcker criterion. The square root of the AVE should be higher than the correlations among the latent variables (Hair et al. 2019). In addition, all the values of the HTMT ratio were below the conservative threshold of 0.850. These two tests confirm an adequate discriminant validity of all latent variables.

Figure 1: Conceptual model



4.2.2. Structural model

Hair et al. (2019) point out that the assessment of the structural model should include the analysis of the common method bias, the $R^{2,}$ the Q^2 and the evaluation of the path coefficients. The variance inflation factor that helps to identify the existence of CMB should be equal or lower than 3.3. The model (R^2) explained 68.6% of the variance of intentionR^2 values are weak at 0.25, moderate at 0.50 and substantial at 0.75 (Kock 2015). In addition, the values of the GOF range from 0 to 1 with 0.10, small, 0.25 medium and 0.36 large. The GOF obtained by the study is 0.336472. A Q^2 >0.5 is considered a predictive model. The Q^2 obtained in the study is 0.411. The effect size (f^2) shows the effect of one construct on another construct and values are 0.02 (small), 0.15 (medium) and 0.35 (large). The effect sizes obtained in the study range from 0.262 to 0.293. The standardised root mean square residual (SRMR) was used to measure the model fit. SRMR has values from 0 to 1. The SRMR obtained in the study is 0.02.

Table 3 depicts the results of the structural model. The results show significant positive relationships between environmental concern and attitude, green perceived usefulness and intention. Hypotheses one, three and four are accepted. The results indicate significant positive relationship between attitude and perceived behavioural control and awareness and intention Hypotheses five, seven and thirteen are accepted. The results show significant positive relationships between green perceived usefulness and PEOU and attitude and intention. Hypotheses eight, nine, ten and eleven are accepted. Finally, the results show a significant positive relationship between PEOU and green perceived usefulness. Hypothesis twelve is accepted.

5. DISCUSSION

The study examined the determinants of intention to adopt rooftop PV technology in South Africa using the integrated TAM and TPB. The findings indicated a significant positive relationship between environmental concern and attitude, green perceived usefulness and intention. The findings are consistent with the results of similar empirical studies. Lin and Syrgabayeva (2016) find that consumers' concerns regarding renewable energy have

Table 1: Measurement model

Construct	Measurement items	Loading	Cronbach's alpha	Composite reliability	AVE
Attitude (ATT) (Mean 4.62 Standard deviation 0.99)	ATT1	0.892	0.808	0.891	0.732
	ATT2	0.864			
	ATT3	0.808			
Subjective norms (SN) Mean 1.90 Standard deviation (1.03)	SN 1	0.7.26	0.752	0.778	0.550
	SN2	0.749			
	SN3	0.728			
Perceived behavioural control (PBC) (Mean 3.75, standard deviation 1.01)	PBC1	0.827	0.782	0.833	0.625
	PBC2	0.801			
	PBC3	0.742			
Environmental Concern (EC) (Mean 3.92 Standard deviation 1.04)	EC1	0.804	0.818	0.904	0.576
	EC2	0.763			
	EC3	0.818			
	EC4	0.782			
	EC5	0.746			
	EC6	0.735			
	EC7	0.726			
Green perceived usefulness (GPU) Mean 3.85 Standard deviation 1.02	GPU1	0.744	0.736	0.804	0.577
	GPU2	0.738			
	GPU3	0.797			
Perceived ease of use (PEU) Mean 3.98 standard deviation 1.01)	PUE1	0.842	0.800	0.836	0.630
	PUE2	0.805			
	PUU3	0.731			
Awareness AWA Mean 4.15, standard deviation 1.05)	AWA1	0.806	0.804	0.820	0.603
	AWA2	0.782			
	AWA3	0.739			
Intention (INT Mean 4.02, standard deviation 1.01)	INT1	0.822	0.774	0.850	0.654
	INT2	0.796			
	INT3	0.808			

Table 2: Discriminant validity

CON	EC	GPU	PEOU	ATT	SN	PBC	AWA	INT
EC	0.759							
GPU	0.622	0.760						
PEOU	0.536	0.482	0.794					
ATT	0.417	0.362	0.615	0.856				
SN	0.502	0.447	0.521	0.398	0.742			
PBC	0.407	0.402	0.626	0.449	0.503	0.791		
AWA	0.614	0.493	0.666	0.612	0.531	0.584	0.777	
INT	0.566	0.493	0.431	0.563	0.608	0.594	0.601	0.809

Table 3: Path coefficient and T-statistics

Hypothesised path	Path coefficient	T-statistics	Decision
H1 EC→ATT	0.301	3.308**	Supported
H2 EC→PEOU	0.051	0.093	Rejected
H3 EC-GPU	0.282	5.088*	Supported
H4 EC- INT	0.163	3.006*	Supported
H5 ATT-INT	0.306	5.008*	Supported
H6 SN→INT	0.082	1.001	Rejected
H7 PBC→INT	0.227	4.608**	Supported
H8 GPU→ATT	0.261	4.931*	Supported
H9 PEOU-ATT	0.198	3.528**	Supported
H10 PGU-INT	0.330	6.179*	Supported
H11 PEOU-INT	0.204	3.147**	Supported
H12 PEOU-GPU	0.194	3.691**	Supported
H13 AWA-INT	0.209	4.363*	Supported

*P<0.01; **<0.05

a positive effect on their attitude. Palm and Tengvard (2011) find that environmental concern is one of the motives for household adoption of small-scale production of electricity. Wall et al. (2021) find that environmental concern positively affects consumer adoption of renewable energy in Thailand. Cheam et al. (2021) find that environmentalism has a significant impact on the intention to adopt solar PV in Malaysia. Environmental concern can also affect the PEOU of a technology. A high level of environmental concern will positively affect the willingness of an individual to learn to use a technology that can protect the environment. Wu et al. (2019) find that environmental concern is significantly related to PEOU of autonomous electric vehicles. Wu et al. (2019) find that environmental concern is significantly positively related to green perceived usefulness of autonomous electric vehicles. The results indicate significant positive relationships between attitude, perceived behavioural control and awareness and intention. The higher the consumer attitude towards adopting rooftop PV technology, the higher the likelihood that the consumer will form an intention to adopt use rooftop PV technology. To use a renewable energy source, an individual must have access to the resources required for the purchase and the skill to use it (Korcaj

et al. 2015). Sun et al. (2018) find that the intention for rooftop PV installation is positively influenced by the attitude towards rooftop PV installation. Masukujjaman et al. (2021) find that attitude has a significant positive relationship with intention to purchase intention by households in Bangladesh. Yazdanpanah et al. (2015), Shakeel and Rahman (2018), Masrahi et al. (2021) and Masukujjaman et al. (2021) find that perceived behavioural control is a significant factor influencing the willingness to use renewable energy sources. The findings of this study are consistent with the results of Alam et al. (2014), Wall et al. (2021) and Ashinze et al. (2021) that awareness of solar panel technology positively impacts on the intention to install solar panel at home.

The results show significant positive relationships between green perceived usefulness and PEOU and attitude and intention. Finally, the results show a significant positive relationship between PEOU and green perceived usefulness. Masukujjaman et al. (2021) find that the relationship between perceived usefulness and intention to purchase renewable energy technology is significant. Yang et al. (2021) find that both perceived usefulness and PEOU are positively related to attitude towards renewable energy Chen and Lu (2016) find that PEOU is positively associated with the intention to use YouBike. Wu et al. (2019) find that both green perceived usefulness and PEOU positively affect the intention to purchase autonomous electric vehicles in China. Masukujjaman et al. (2021) find that PEOU positively affects perceived usefulness in the context of renewable energy sources. Wu et al. (2019) find that green perceived usefulness is positively related to PEOU in the context of the purchase of autonomous electric vehicles.

6. CONCLUSION

The study examined the determinants of intention to adopt rooftop PV technology (solar panels) in South Africa. Theoretically, the study integrated the TAM and an extended TPB to obtain a multidimensional understanding of the factors that can affect the intention to use solar technology at home. Empirically, the findings can assist researchers in understanding the factors that can affect the purchase of solar panels especially from a developing country perspective where research has been relatively limited. The findings indicate that environmental concern, green perceived usefulness and PEOU positively affect attitude towards solar panel technology. Therefore, it is important to improve the attitude of people towards solar technology. This can be done through an increase in the level of awareness about the positive effects of renewable energy by government, non-governmental organisations, firms that produce solar panels and the media. Firms that produce and install solar panels should be involved in aggressive marketing campaigns to create awareness of the product. Commercial banks can finance the installation of solar panels as part home loans. Government financial incentives should be extended to households to purchase solar panels.

7. LIMITATIONS OF THE STUDY

First data was collected from respondents in only two towns in South Africa and this may limit the generalisability of the results. The use of cross sectional survey limits cause and effect relationship. The study focused on intention to use solar panels. Other studies can investigate the determinants of actual use of solar panels. In addition, other studies can examine the moderating effects of demographic factors (age, income, level of education and gender) in the relationship between the TAM and TPB and intention to purchase solar panels. A longitudinal study that includes mediating variables will help researchers to improve cause and effect and understand intervening variables.

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APPENDIX

Appendix 1: Questionnaire

Construct	Questions	Source
Attitude	For me using a rooftop photovoltaic (solar panels) at home is beneficial For me using a rooftop photovoltaic (solar panels) at home is valuable For me using a rooftop photovoltaic (solar panels) at home is good	Ajzen (1991) Yazdanpanah et al. (2015), Sun et al. (2020)
Subjective norms	Most people who are important to me think that I should use a rooftop photovoltaic (solar panels) at home Most people who are important to me think that using a rooftop photovoltaic (solar panels) at home is desirable People in my life, whose opinions I value, would approve if I use a a rooftop photovoltaic (solar panels) at home	Ajzen (1991), Yazdanpanah et al. (2015)
Perceived behavioural control	It is mostly up to me whether or not to use a rooftop photovoltaic (solar panels) at home For me using a rooftop photovoltaic (solar panels) at home is easy If I wanted to, I could easily use a rooftop photovoltaic (solar panels) at home	Ajzen (1991), Yazdanpanah et al. (2015)
Environmental concern	I am extremely worried about the state of the world's environment and what it means for the future Mankind is severely abusing the environment When mankind interferes with nature, it often produces disastrous consequences The balance of nature is delicate and easily upset Human must live in harmony with nature in order to survive I think that environmental problems are important I think that we should care about environmental problems	Chen and Tung (2014), Yadav and Pathak (2015) Sun et al. (2020)
Green perceived usefulness	I believe that the use of a rooftop photovoltaic (solar panels) can reduce pollution caused by fossil energy I believe that the use of a rooftop photovoltaic (solar panels) will reduce global warming I believe that the use of a rooftop photovoltaic (solar panels) will improve environmental quality	Davis 1989; Chen, 2016; Wu, 2019
Perceived ease of use	I think it would be easy to use a rooftop photovoltaic (solar panels) I think it I would easily understand how to use a rooftop photovoltaic (solar panels) It would be easy for me to become skilful in the use of a rooftop photovoltaic (solar panels)	
Awareness	I am aware of a rooftop photovoltaic (solar panels) I can easily recognise a rooftop photovoltaic (solar panels) I am aware of the use of a rooftop photovoltaic (solar panels) systems	Alam et al. (2014)
Intention	I intend to install a rooftop photovoltaic (solar panels) at home I plan to install a rooftop photovoltaic (solar panels) at home I am willing to install a rooftop photovoltaic (solar panels) at home	Sun et al. (2020)