Factors influencing the adoption of solar PV technology by South African householders

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DECLARATION

I, Lucky Zondi, declare that this research article is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Lucky Zondi

Signed at Centurion

On the 21st day of June 2023

DEDICATION

This research is dedicated to my family, and in particular my wife, whose support for me to pursue my dreams has been phenomenal, and to everyone that inspired and supported me from the very beginning. To my research supervisor, for giving me the best of your time to accomplish this task.

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- The participants who answered the research questionnaire diligently and honestly to provide information that was needed for this research,
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ABSTRACT

South Africa is endowed with one of the best solar resources in the world. Yet South African households are experiencing load shedding or rolling blackouts due to poor performance of coal-fired power stations that are operated by the national power utility, Eskom. One of the options to reduce the impact of load shedding for households is to generate and supply their own electricity from rooftop solar photovoltaic (PV) systems. This study was aimed at developing an understanding of motivational and control factors that influence decision-making in the adoption of rooftop solar PV technology by South African households. The framework of the Theory of Planned Behaviour (TPB) was applied to investigate the extent to which attitude, perceived social pressure and subjective knowledge influence the intention of households to purchase and install rooftop solar PV systems. This study expands the body of knowledge that can inform marketing activities and government policymaking aimed at improving the uptake of rooftop solar PV systems in South Africa. The study targeted a population of post-graduate students through an online survey that yielded 239 respondents. The data and results were analysed using the structural equation modelling (SEM). The results of this study established that South African households had a positive attitude towards rooftop solar PV technology. But the attitude had an inconclusive association with the intention to purchase a rooftop solar PV system. Both the perceived social pressure and subjective knowledge had a positive association with the intention of households to purchase a rooftop solar PV system. It was recommended that marketers should disseminate relevant information to communities, and policymakers should develop policies and incentives that support the adoption of solar PV technology in South Africa. Future research was recommended to examine the household attitude construct in a larger sample, including other factors that may affect the household intention to purchase rooftop solar PV system.

Keywords: Theory of Planned Behaviour, solar photovoltaic, attitude, perceived social pressure, subjective knowledge, behavioural intention

1. INTRODUCTION

South African consumers are facing a crisis of electricity blackouts that negatively impact the operations of businesses and households (Nkosi & Dikgang, 2018). The shortage of electricity generation capacity is compounded by the poor performance of Eskom's existing coal-fired power stations, which ultimately has a negative impact to the South African economy (Kock & Govender, 2021).

Consumers have an option of reducing the impact of blackouts through supplying their own electricity from technologies such as rooftop solar electric or photovoltaic (PV) systems. The increase of installed rooftop solar PV capacity in South Africa can contribute towards attainment of sustainable development goals, promote sustainable ecosystems and help to combat climate change among other benefits (Schwerhoff & Sy, 2017).

Despite the enormous solar energy resource in South Africa, decreasing prices of solar PV technology, and rising electricity cost, the installed solar PV capacity in South Africa remains less than the rest of the world (Senatla, Bansal, Naidoo, Chiloane, & Mudau, 2020). By 2018, the installed solar PV capacity in South Africa was 1.5 GW for utility scale power generation and 0.3 GW at distribution level, compared to 509 GW of installed solar PV globally which was expected to reach 1600 GW by 2023 (Senatla, Bansal, Naidoo, Chiloane, & Mudau, 2020). By 2019, the South African solar PV industry was growing and ranked ninth in the world, and it had an installed capacity of 2.5 GW (Akinbami, Oke, & Bodunrin, 2021). Marketers and policymakers need to understand the influences of householder's behavioural intention to adopt solar PV technology to inform their messaging and policies (Mkhize, 2021).

Previous studies have been completed to understand the influences of households in adoption of rooftop solar PV technology. It has been found that the influences of adopting solar PV technology include individual household attitudes and social concerns, while subjective or perceived knowledge could have an influence on the household's behavioural intention to adopt solar PV technology (Abreu, Wingartz, & Hardy, 2019; Mkhize, 2021; Zulu, Chabala, & Zulu, 2021).

Prior research has also found that early adopters of solar PV technology showed an interest in the technical details of solar PV technology, including numerical information and environmental values (Gręboszk-Krawczyk, Zakrzewska-Bielawska, Glinka, & Glińska-Neweś, 2021; Schelly, 2014).

Studies from Sub-Saharan African countries by Ugulu (2019) in Nigeria, Kwame et al. (2021) in Ghana, Mkhize (2021) in South Africa, and Zulu (2021) in Zambia, highlighted that rising electricity costs and unreliable grid electricity supply encourage households to adopt solar PV technology. However, there was no universal conclusion on the ranking of motivating factors for households to invest in solar PV technology. Markus and Kitayama (2021) highlighted that the country's or community's cultural attributes may affect social norms in each country or community (Markus & Kitayama, 1991).

This research was intended to address the highlighted knowledge gaps by examining the attitude, subjective norms and subjective or perceived knowledge and their relationship with behavioural intention of South African households to invest in rooftop solar PV technology. The study was intended to expand the body of knowledge which could inform messaging for marketers and policymakers in South Africa.

This study was divided into six sections. The first section examines prior research on influences of household behaviour in the adoption of solar PV technology, which leads to the establishment of the problem statement, research questions, and assumptions made in this study. Literature review follows in the second section on electricity supply, rooftop solar PV, sustainable development, theories and models of consumer behavior, and leading to the adoption of the Theory of Planned Behaviour (TPB) as the theoretical framework that underpins this study.

The second section includes the analysis of the research problem, research knowledge gap analysis, and the discussion of research propositions or hypotheses. The third section discusses the research design, sampling framework, data collection methods and analysis, and ethics considerations.

The fourth section presents the statistical analysis results and the outputs from the structural equation model (SEM) that was analysed on the IBM's SPSS AMOS software version 28, including the assessment of the hypotheses through path coefficients analysis. The fifth section provides the discussion of the results, and the sixth and last section presents conclusions and the recommendations by the researcher.

1.1. Prior Research

Ugulu (2019) studied barriers and incentives for Nigerian households to adopt solar PV technology instead of utilising the unreliable national electricity grid (Ugulu, 2019). Findings showed that barriers for adoption of solar PV in Nigeria were led by high investment costs, followed by installer dishonesty, and lack of government incentives (Ugulu, 2019). While the barriers to adoption of solar PV were found to be socio-cultural, technical and economic, the motivating factors were found to be socio-economic and environmental (Ugulu, 2019). The unreliable grid electricity supply was found to be the biggest motivating factor, followed by energy cost savings for households, and lastly, technical competence and knowledge of solar PV technology (Ugulu, 2019).

Ugulu's (2019) findings were different to what Grebosz-Krawczyk et al. (2021) found in Poland, where environmental values were the most important motivating factor. Grebosz-Krawczyk et al. (2021) studied consumer's attitudes and behaviours, and tested consumers' consumption values including "*functional, social, emotional, conditional, epistemic, and environmental values*" (Grębosz-Krawczyk et al., 2021, p. 1). Grebosz-Krawczyk et al. (2021) found that functional and environmental values were the most important factors for Polish consumers towards adopting solar PV technology, indicating high environmental awareness among Polish consumers (Grębosz-Krawczyk et al., 2021). It was found that Polish consumers base their decisions on functional and pro-environmental concerns (Grębosz-Krawczyk et al., 2021).

Schelly (2014) studied the human decision-making process and factors that motivated early adopters of solar electric technology in the United States of

America (US). The findings pointed out that environmental benefit factors were not sufficient to motivate households in the US to adopt solar PV technology, and economic value or payback time was not a motivating factor either. Social networks and communities of information were important, where homeowners inspired each other to adopt solar PV technology (Schelly, 2014). Another motivating factor that emerged during Schelly's (2014) study was the awareness of early adopters about technical details of solar PV technology, and other numerical information such as meter readings and their energy bills (Schelly, 2014).

Kesari, Atulkar, and Pandey (2021) conducted a study on environmental factors and their influence on consumer behaviour in India. Findings showed that the awareness of environmental problems caused by fossil fuels played an insignificant role in the adoption of solar PV technology in India (Kesari, Atulkar, & Pandey, 2021). However, five other factors of social influence, environmental attitude, environmental knowledge, environmental responsibility, and government incentives, were significant motivating factors (Kesari et al., 2021).

Therefore, the findings by Kesari et al. (2021) agreed with other international findings on the influence of social networks and environmental values as found by Schelly (2014) and Grebosz-Krawczyk et al. (2021). However, the study by Kesari et al. (2021) was limited to environmental concerns and did not consider economic value to households as a motivating factor (Kesari et al., 2021).

Mkhize (2021) studied the intention of households in Gauteng province of South Africa to adopt microgeneration technologies such as solar PV on the basis of the theory of planned behaviour (Mkhize, 2021). Mkhize (2021) highlighted that more households in South Africa were encouraged to adopt microgeneration technologies because of electricity price increases and inconsistent electricity supply (Mkhize, 2021).

Contrary to Schelly (2014) and Ugulu (2019), Mkhize (2021) found that the perceived knowledge of microgeneration technologies had an insignificant influence on the adoption by households (Mkhize, 2021). Households were found

to be guided more by reference groups or close friends, and environmental concerns, when deciding to adopt microgeneration technologies (Mkhize, 2021).

Prior research showed that factors that motivated households to adopt solar PV may differ from one country or region to another. However, common factors could be found such as households receiving guidance from social networks, technical competence, and environmental considerations by households. The relative importance of technical competence or knowledge as an emerging factor could vary from one country to another. The next section introduces the problem statement for this study.

1.2. Problem Statement

The marketing of solar PV technology in South Africa, and policymaking on renewable energy and small-scale power generation can rely on understanding of the household behavioural intention to adopt solar PV technology (Mkhize, 2021).

There was no universal conclusion about the influences of consumer behaviour in the adoption of solar PV technology by households between different countries in a continent, and between different regions or states (Gręboszc-Krawczyk et al., 2021; Kesari et al., 2021; Mkhize, 2021; Schelly, 2014; Ugulu, 2019). South African households are heavily reliant on grid electricity, and their welfare is expected to be negatively affected into the foreseeable future due to power blackouts or load shedding (Nkosi & Dikgang, 2018).

Prior research in South Africa found that there was no significantly positive relationship between householders' subjective knowledge and intention to adopt solar PV (Mkhize, 2021). However, it was pointed out that findings could be different between studies because of the multidimensional nature of the knowledge construct (Ahmad & Nordin, 2014, as cited by Mkhize, 2021).

Another study could examine if perceived or subjective knowledge has a significant impact on household's consumer behavioural intention to adopt rooftop solar PV technology in South Africa (Mkhize, 2021). Previous research

showed that household demographics, as well as property ownership could impact the household's behavioural intention (Mkhize, 2021; Ugulu, 2019).

It was found that if households believed that solar PV technology will save the environment, and if they have technical knowledge, they are likely to have a positive attitude towards solar PV technology (Mkhize, 2021; Ugulu, 2019). Given the context of a looming climate change crisis, load shedding, electricity price increase, and South African government's commitments to reduce greenhouse gas or carbon emissions, the attitude of households towards solar PV could be impacted in South Africa.

Individual households in South Africa are expected to make their own investment decisions on rooftop solar PV technology. These individual household investment decisions would result in an aggregated rooftop solar PV capacity for South Africa (Senatla et al., 2020). The growth of the installed rooftop solar PV capacity in South Africa will provide energy security for households and contribute towards the reduction of carbon emissions (Akinbami, Oke, & Bodunrin, 2021)

The extent to which consumer attitudes, subjective knowledge and other social factors influence the intention to invest in solar PV technology will inform solar PV industry stakeholders such as policy makers, technology providers, marketers, entrepreneurs, and financial institutions, about the consumer decision-making process.

Even though South Africa has one of the best solar radiations in the world, the installed solar PV capacity in South Africa remains less than the rest of the world (Senatla et al., 2020). The study was undertaken within the context of the socio-economic conditions and electricity supply realities in South Africa. This study did not attempt to evaluate solar PV performance, or cost-benefit analysis between rooftop solar PV and grid electricity, nor does it discount other potential factors of influence such as household income and government incentives.

1.3. Research Questions

Given the background context given in section 1.2, the unreliable grid electricity, the looming climate change crisis, environmental imperatives, decreasing prices of solar PV technology in South Africa, and the installed solar PV capacity in South Africa which is less than the rest of the world, this study was driven towards answering the following research questions:

Question 1: What is the attitude of South African households towards rooftop solar PV technology?

Question 2: To what extent does the South African households' attitude influence the behavioural intention to adopt solar PV technology?

Question 3: To what extent does the social pressure influence the South African households' behavioural intention to adopt solar PV technology?

Question 4: To what extent does the South African households' technical competence and financial knowledge influence their behavioural intention to adopt solar PV technology?

1.4. Assumptions

The following assumptions have been made and applied to this research:

- A household was considered as a consumer unit.
- Rooftop solar PV installations considered for this study would be grid-tied to supply electricity to urban households for their own use.

  A grid-tied solar PV installation means that the solar PV system is connected to the utility's electricity grid through an inverter, and the households can draw power from the electricity grid when solar power is unavailable or at night. However, a bidirectional power flow was not considered for this study. Bidirectional power flow would mean that the household's solar PV system can also feed power to the utility's electricity

grid, with bidirectional metering installed to determine net energy usage or export.

An alternative to the grid-tied solar PV system would be an off-grid solar PV system. An off-grid solar PV system would be a stand-alone PV system that is not connected to the utility's electricity grid. A battery bank, or even a generator, is typically used as a backup to supply energy when solar power is unavailable.

A hybrid solar PV system would combine a grid-tied system with the battery storage system.

- The installation of rooftop solar PV technology on commercial and industrial facilities was not part of this study.
- The study did not assess the solar PV system performance, cost and affordability or economic justification against any other alternative technology.

2. LITERATURE REVIEW

Literature review was conducted on human behavior theories and models in accordance with the research objectives of this study. The word "*consumer*" was used interchangeably with "*household*", where a consumer is defined as "*an individual who purchases, has the capacity to purchase, goods and services offered for sale by marketing institutions in order to satisfy personal or household needs, wants, or desires*" (Walters, 1974, p. 4).

Human behaviour theories and models were reviewed, and the proposed theoretical framework that underpins this study are introduced in this section. The research problem analysis and research gap analysis are discussed, leading to the formation of research propositions or hypotheses for this study. Lastly, the conceptual framework for this study is introduced.

2.1. Electricity Supply in South Africa

South Africa's state-owned power utility, Eskom, supplies approximately 90% of electricity consumed in South Africa, and nearly 85% or 44,013 Megawatts (MW) of Eskom's installed generation capacity of 51,867 MW comes from fifteen coal-fired base-load power stations (Eskom, 2021). The consumers of electricity in South Africa, including businesses and households, were facing rotational blackouts or load shedding since 2007, primarily due to the failure of government to invest in new generation capacity (Nkosi & Dikgang, 2018).

There were 17.2 million households in South Africa by 2017, and those that were connected to the national electricity grid increased from 76% in 2002 to 85% by 2019 (StatsSA, 2019). The average electricity price (in nominal terms) had increased by 333% between 2007 and 2018, and it was expected to reach an increase of 490% between 2007 and 2021, making grid electricity less affordable for some South African households (Wright & Calitz, 2019).

Rooftop solar PV technology can provide electricity consumers with the ability to supply their own electricity from a renewable energy source, and in some cases reduce the energy cost in the long term (Wright & Calitz, 2019). The next section discusses load shedding and energy security in South Africa.

2.2. Load Shedding

South Africa started to experience severe power cuts or load shedding in 2007/2008. Eskom's reserve margin had decreased from 25% in 2001 to between 8% and 10% by 2007 (Nkosi & Govender, 2022). The reserve margin indicates the difference between Eskom's available generation capacity and demand.

A total of 2.8 million households were connected to the electricity grid between 1994 and 1999, as part of an electrification programme following the dawn of democracy in South Africa (Nowakowska & Tubis, 2015). By 1998, Eskom's generation capacity model showed that the forecast demand would not be met by existing plant in ten years' time without new generation capacity. However, no new generation capacity was added to the electricity grid between 1998 and 2007/2008 (Nowakowska & Tubis, 2015).

Eskom improved coal stockpiles at power stations and added new generation capacity in Medupi and Kusile power stations (Nkosi & Govender, 2022). But by 2019, the electricity grid in South Africa remained constrained due to poor performance of the coal-fired power stations and the declining Energy Availability Factor (EAF) (Nkosi & Govender, 2022). The EAF measures availability across the fleet of Eskom generators.

Eskom's 2019 system adequacy outlook indicated that the system would be adequate for an EAF of 72% (Nkosi & Govender, 2022). However, Eskom experienced a drastic decline in EAF since 2019. At one power station, Camden, the EAF declined from 78% in 2017 to 42% by 2020 (Kock & Govender, 2021).

Load shedding has persisted because Eskom's power stations require ever increasing maintenance, most have reached their mid-life, and some maintenance had been deferred due to shortage of capacity (Nkosi & Govender, 2022). Eskom communicated that load shedding is the last resort to protect the power grid and to prevent a total grid collapse (Eskom, 2021).

2.3. Solar PV Technology and Sustainable Development

Rising fossil fuel prices and decreasing prices of solar PV technology are driving its increasing deployment as an alternative to grid electricity (Ebhota & Tabakov, 2021). The solar PV systems for households are usually rooftop mounted. The grid-tied systems generally consist of "*solar PV panel arrays, a solar inverter, electrical panel, array mounting racks, cabling, meters, combiner box, surge protection, disconnects, grounding equipment and other electrical accessories*" (Ebhota & Tabakov, 2021, para. 3)

Solar PV technology, as a renewable energy source, supports the attainment of Sustainable Development Goals (SDGs) as adopted by the United Nations in 2015 (Schwerhoff & Sy, 2017). Goal number seven aims to ensure access to "*affordable, reliable, sustainable and modern energy for all*" (United Nations, 2015, as cited by Schwerhoff & Sy, 2017, p. 3).

Renewable energy supports the attainment of other SDGs, namely; ending poverty, ending hunger, promoting well-being, ensuring inclusive education, gender equality, as well as achieving inclusive and sustainable economic growth (Ebhota & Tabakov, 2021; Schwerhoff & Sy, 2017).

South Africa's average solar radiation is one of the best in the world, ranging between 4.5 kilo-watt hours (kWh) and 7kWh per square meter, and solar PV's installed capacity in South Africa is projected to grow to 50GW by 2050 (Mulaudzi, Muchie, & Makhado, 2012).

Even with the enormous solar energy resource in South Africa, and decreasing prices of solar PV technology, increasing cost of electricity, and the crisis of Eskom's load shedding, the installed capacity of solar PV in South Africa remains less than the installed solar PV capacity in the rest of the world.

By 2018, the installed solar PV capacity in South Africa was 1.5 GW for utility scale power generation, and 0.3 GW at distribution level, compared to 509 GW of installed solar PV globally, which was expected to reach 1600 GW by 2023 (Senatla, Bansal, Naidoo, Chiloane, & Mudau, 2020). By 2019, the South African solar PV industry was growing and ranked ninth in the world, with an installed capacity of 2.5 GW (Akinbami, Oke, & Bodunrin, 2021).

2.4. Consumer Behaviour

According to Walters (1974), consumer behaviour is defined as "*the process whereby individuals decide whether, what, when, where, how, and from whom to purchase goods and services*" (Walters, 1974, p. 7). Lin, Wang and Hwang (2010) defined consumer behaviour as "*the activity that is acted under a specific scenario or situation for a specific purpose*" (Lin, Wang, & Hwang, 2010, p. 3240).

Parengkuan (2017) defined consumer behaviour as a step in a process, and this step includes factors that influence decisions to purchase a product and how it is used (Parengkuan, 2017). The behavioural intention, on the other hand, was defined by Lin, Wang and Hwang (2010) as "*possible action adopted by an individual to a specific objective*" (Lin et al., 2010, p. 3240). The actual consumer behaviour or action is influenced by controls, chances, and resources, that a consumer may have for that specific behaviour (Lin et al., 2010).

2.5. Human Behaviour Theories

The above-mentioned definitions of consumer behaviour show that the purchase of a product is a process, and that steps in this process can be influenced by factors that depend on the individual consumer's psyche, circumstances, and intentions.

2.5.1. The Theory of Reasoned Action

The Theory of Reasoned Action (TRA) is a predictive model that investigates the human behavior from "*principles of compatibility and behavioral intention*" (Mishra, Akman, & Mishra, 2014, p. 30). The TRA is an influential theory in consumer behavior, and it states that the consumer's attitude comes from beliefs held by the consumer about the expected outcomes of their behavior (Kostadinova, 2016).

According to Fishbein and Ajzen (1975) and Ajzen and Fishbein (1980), the consumers attitude, and perception about what those close to him or her think about the behaviour, have a significant impact on the intention to perform an action or behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). **Figure 1** illustrates the TRA.

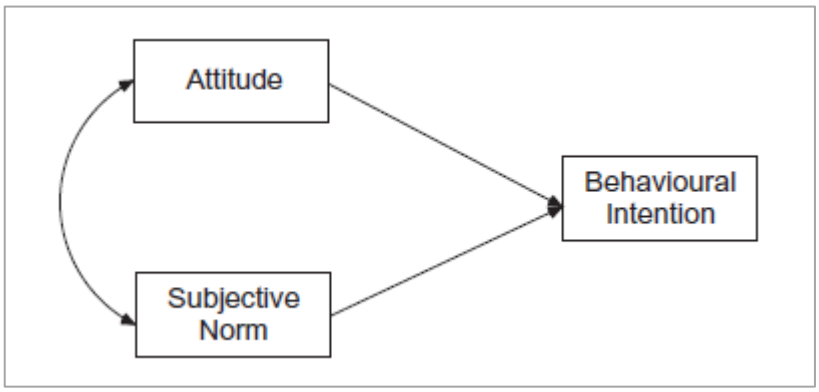


Figure 1: The Theory of Reasoned Action (Teo & Van Schaik, 2012)

According to Teo and Schaik (2012), the TRA has been used as a model for investigating consumer behavior in information technology, and it assumes that consumer's behaviors can be predicted from their intentions (Teo & Van Schaik, 2012). The TRA has limitations for behaviors that are not entirely in the consumer's control such as adoption of technology (Teo & Van Schaik, 2012).

2.5.2. The Theory of Planned Behaviour

Ajzen (1988) extended the TRA into the Theory of Planned Behavior (TPB) by adding the perceived behavioural control, which is about the consumer's belief about the ease or difficulty of performing the action or behaviour. The TPB is one of the most used models for pro-environmental consumer behavior (Kostadinova, 2016). Therefore, the TPB incpoporates the consumer attitude, the subjective influencies and controls that a consumer may or may not have (Lin et al., 2010). Therefore the TPB has three core components or constructs; the consumer's attitude towards the behaviour in question, subjective norm, and behavioural control (Teo & Van Schaik, 2012).

The TPB, as shown in **Figure 3**, has been been applied in situations where consumers have perceived ease or difficulty to perform the behavior, and found to be useful in predicting the adoption of technology (Teo & Van Schaik, 2012). The premise for the difference between TRA and TPB is that in the TPB the consumer's actions are dependent on the strength of belief in his or her ability to perform the action (Kostadinova, 2016).

2.5.3. The Technology Acceptance Model

The Technology Acceptance Model (TAM) has been applied in informaton technology, and the main components of the model are the attitude towards the technology and perceived usefulness which impacts the consumer's behavioral intention (Lin et al., 2010). The TAM was developed by Davis (1989) and, similar to the TPB, links consumer beliefs to behavioural intention and actual behaviour. The ease of use is expected to play a significant role in the adoption of innovations (Davis, 1989). The TAM highlights the consumer's independence in determining the ease of use and usefulness of technology, which will influence the resultant behaviour (Lin et al., 2010). The TAM is illustrated in **Figure 2**.

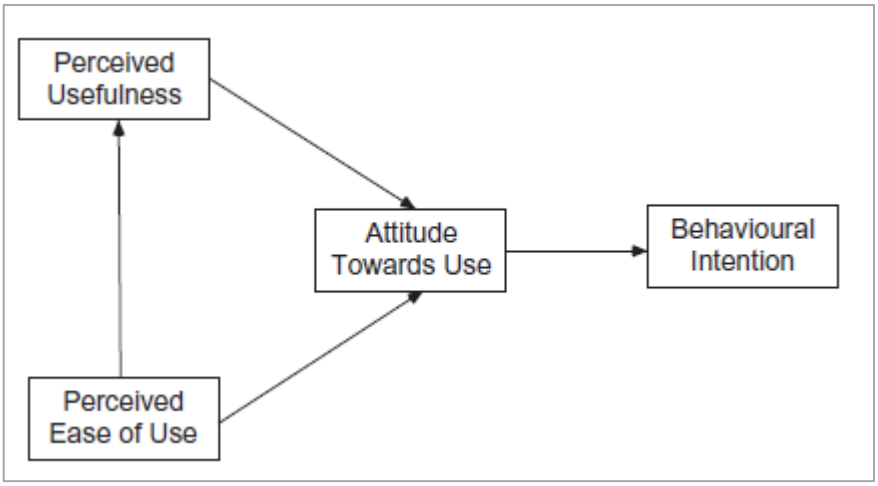


Figure 2: The Technology Acceptance Model (Teo & Van Schaik, 2012)

Unlike the TPB, the TAM does not feature the societal pressure to the consumer that comes from information communities or close friends and relatives. According to Davies (1989), the preceived usefulness is defined as "*the degree to which a person believes that using a technology would enhance his or her job performance*" (Davis, 1989, p. 320). The perceived ease of use is defined as "*the degree to which a person believes that using a particular system would be free of effort*" (Davis, 1989, p. 320). The TAM has been found to be a model for application in educational contexts (Teo & Van Schaik, 2012).

Teo and Schaik (2012) proposed an integrated model because the three above-mentioned models (TRA, TPB and TAM) were complimentary in that constructs such as consumer attitude is found in all three models. It was proposed that further studies should focus on factors beyond those prescribed by the TRA, TPB and the TAM (Teo & Van Schaik, 2012).

2.5.4. The Ecological Value Theory

The Ecological Value Theory by Schwartz (1977) predicted that sustainable or pro-environmental consumer behavior was a function of moral and pro-social values of consumers. It differentiated between individuals who are oriented towards their own self-interest and those who are externally focused or pro-social in orientation (Schwartz, 1977). The pro-environmental consumer behavior is covered by subjective norm construct of the TPB.

This research used the TPB as its theoretical framework because the TPB addressed the limitations of the TRA and, in contrast to TAM, the TPB considered the perceived personal inadequacies or self-efficacy which could be a key factor for adoption of rooftop solar PV technology in South Africa. The next section provides a detailed literature review of the constructs of TPB as the theoretical framework that underpins this study.

2.6. Constructs of the Theory of Planned Behaviour

Arjen (1991) described the Theory of Planned Behaviour (TPB) as attitudes towards the behaviour, subjective norms, and perceived behavioural controls that can predict the intention to perform the actual behaviour (Ajzen, 1991). **Figure 3** illustrates the TPB.

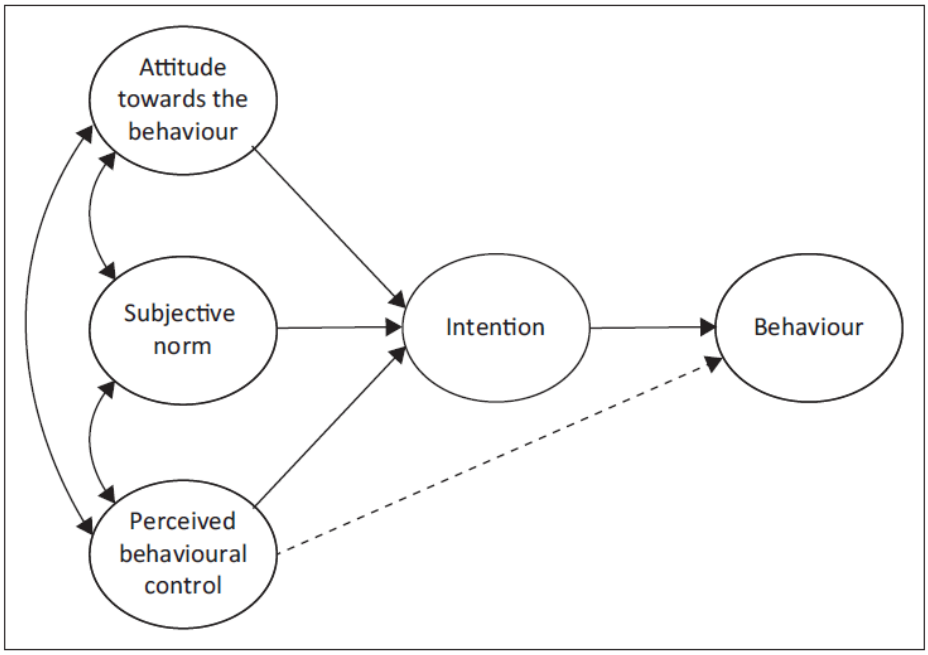


Figure 3: The Theory of Planned Behaviour (Ajzen, 1991)

The TPB's central factor is the individual's intention to perform a certain behaviour, and intentions capture the motivational factors that drive the willingness of the individual to perform the behaviour (Ajzen, 1991). TPB is an extension of the Theory of Reasoned Action and has three core components, namely, *attitude*, *subjective norm*, and *perceived behavioural control* (Ajzen, 1991).

2.6.1. Attitude

According to Ajzen (1991), "*Attitude towards the behaviour refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question*" (Ajzen, 1991, p. 188). It is understood that a consumer goes through various steps and processes when deciding to buy a certain product (Ajzen, Haugtvedt, Herr, & Cardes, 2008). The TRA says that a person's behaviour can be predicted from that person's attitude towards the act (Foxall & Yani-de-Soriano, 2005). The TPB by Ajzen (1991) further states that; "*Attitude towards the behaviour refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question*" (Ajzen, 1991, p. 188).

In choosing products, consumers look for product attributes that best satisfy their needs, and some of the dimensions of product attributes that are considered by consumers are value and cost (Manaktola & Jauhari, 2007). However, while investigating consumer's behaviour towards green practices, Manaktola and Jauhari (2007) found that the consumer's positive attitude does not guarantee willingness to pay (Manaktola & Jauhari, 2007). The household's attitude will capture the household's evaluation of the consequences of adopting solar PV technology (Foxall & Yani-de-Soriano, 2005).

Consumers link their behaviour to specific outcomes, and positive attitudes are developed from the belief that desirable outcomes will be achieved, and the opposite is true for undesirable outcomes (Ajzen, 2015). If the household's attitude for adoption of solar PV technology is positive, there is a high likelihood that they will adopt it (Mkhize, 2021).

Literature review showed that households can be influenced by attitude towards solar PV. This agreed with Ajzen (2015) that a positive relationship exists between attitude and behaviour. However, Ajzen (2015) cautions that attitude alone is not enough, because the TPB goes beyond attitude, but it also considers social norms and behavioral control (Ajzen, 2015).

2.6.2. Subjective Norms

"*Subjective norm refers to the perceived social pressure to perform or not to perform the behaviour*" (Ajzen, 1991, p. 188). Subjective norm is a belief by an individual that their behaviour will be approved by a section of society and therefore has an impact on the individual's behavioural intention (Mkhize, 2021).

Subjective norm describes the household action because of society's pressure, in a manner that a household is more likely to adopt solar PV technology if those that are close to the household adopt solar PV (Mkhize, 2021). In a study on early adoption of solar PV in the US, Schelly (2014) also found that consumers make technology adoption decisions within a social context (Schelly, 2014). Ajzen (1991) described subjective norm as *"the perceived social pressure to perform or not to perform the behaviour*" (Ajzen, 1991, p. 188).

Subjective norm is the behaviour that aligns with the majority and it has been found to be effective in pro-environment campaigns (Taufique & Vaithianathan, 2018). However, Markus and Kitayama suggest that the influence of society on individual behaviour can be culture-specific in a manner that "*construals of the self, of others, and of the relationship between the self and others may be even more powerful than previously suggested and that their influence is clearly reflected in differences among cultures*" (Markus & Kitayama, 1991, p. 225).

The study by Mkhize (2021) found support in the relationship between household subjective norms and adoption of microgeneration technologies including solar PV technology (Mkhize, 2021). It has been found that the relationship and interactions between affinity for technology and environmental motivations can be a factor in consumer behaviour (Wittenberg, Blöbaum, & Matthies, 2018). Taufique and Vaithianathan (2018) found that a positive attitude towards the environment had a positive influence on the ecologically conscious consumer behaviour (Taufique & Vaithianathan, 2018).

Literature review showed that social pressure plays a role in influencing consumer behaviour. However, other factors such as cultural details, affinity to technology and attitude are determinants of consumer intent and behaviour.

Therefore, TPB allowed this study to consider all these factors and their influence on household behavioural intention.

The perceived behavioural control is another TPB factor that may influence behavioural intention, and it is examined in the next section.

2.6.3. Perceived Behavioural Control

According to Ajzen (1991), the perceived behavioural control refers to "*the perceived ease or difficulty of performing the behaviour and it is assumed to reflect past experience as well as anticipated impediments and obstacles*" (Ajzen, 1991, p. 188). Ajzen (2002) split the perceived behavioural control construct into two components; controllability and perceived self-efficacy (Ajzen, 2002). Perceived self-efficacy is about "*people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives*" (Bandura, 1977, p. 257). Self-efficacy is based on the belief a consumer has that they can execute the behaviour to attain desired results (Ajzen, 2002).

Ajzen (2002) found that lack of knowledge could be one of the factors that determine the perceived presence or lack of control towards the behaviour (Ajzen, 2002).Therefore, the control belief's strength can be impacted by the consumer's skills and knowledge.

The consumer's knowledge is important in marketing and could be a motivating factor for the household to adopt solar PV technology (Flynn & Goldsmith, 1999; Schelly, 2014; Ugulu, 2019). Mkhize (2021) stated that;

> "*Subjective knowledge deals with the confidence that individuals have in the knowledge that they have attained about a certain subject – in this case, knowledge related to microgeneration technologies. Subjective knowledge is also about the belief that an individual has in his or her knowledge*" (Mkhize, 2021, p. 4).

While objective knowledge is the actual and measurable consumer's knowledge, subjective or perceived knowledge refers to what the consumer thinks he or she knows (Flynn & Goldsmith, 1999). It has been found that the consumer's knowledge is important for predicting consumer behaviour, and subjective knowledge is a relatively stronger motivation (Selnes & Gronhaug, 1986, as cited by Flynn & Goldsmith, 1999).

Mkhize (2021) pointed out that subjective knowledge refered to the confidence of the individual about knowledge they have attained about a subject, and studies use self-reporting to measure subjective knowldedge (Mkhize, 2021). Schelly (2014) found that early adopters of solar PV technology were interested not only in technical details of solar PV technology, but also in the numerical information such as tariffs, meter readings and energy bills (Schelly, 2014). The household's subjective knowledge could include an understanding the household's financial wellbeing (Lind et al., 2020).

Ahmad (2014) found that subjective knowledge could have a multidimensional construct (Ahmad & Nordin, 2014). Palm and Eriksson (2018) pointed out that the process of adopting solar PV technology is complex, and that householders were likely to adopt the technology without all the information about the technology (Palm & Eriksson, 2018). Householders tend to trust information from independent sources when they are purchasing white goods, but this is diffrerent to behavior when they decide to adopt solar PV technology (Palm & Eriksson, 2018).

Literature review showed that household's subjective knowledge can influence household behavioural intention in the adoption of solar PV technology. However, it has been found that subjective knowledge can be multidimensional and can include dimensions such as vocabulary and numerical dimensions (Ahmad & Nordin, 2014; Lind et al., 2020; Schelly, 2014). Literature review showed that it is possible for households to adopt solar PV technology without all the information about the technology.

2.7. Research Problem Analysis

The objective of this research was to evaluate factors that influence South African householders in the adoption of solar PV technology. The factors that influence behavioural intention to adopt solar PV technology were to be underpinned by the constructs of the Theory of Planned Behaviour (TPB).

Previous studies have shown that current country-specific circumstances, such environmental awareness, property ownership, culture, social networks, subjective knowledge, reliability of electricity supply, and trajectory of energy costs may impact the motivation and attitude of households to adopt solar PV technology.

Therefore, motivations that affect the household's behavioural intention are neither universal nor static. A household could develop a positive or negative behavioural intention towards adopting solar PV technology by reacting to pressure exerted by social networks or react to their own subjective knowledge about the potential impact of adopting solar PV technology.

This study recognised that the process of adopting solar PV technology is complex, and households may not have all the knowledge by the time of deciding to invest in solar PV technology. A previous study showed that households do not depend on outside information when deciding to invest in solar PV technology (Palm & Eriksson, 2018).

Subjective knowledge is not limited to scientific knowledge, but it may include dimensions such as vocabulary and numerical information. Therefore, the relationship between consumer knowledge and behavioural intention must be understood. This study will evaluate the influence of consumer's subjective knowledge on consumer's behavioural intention to adopt solar PV technology.

Findings from this study will expand the body of knowledge on the applicability of the TPB for studying the influences of household behaviour that should be considered by marketers and policy makers regarding the adoption of rooftop solar PV technology in South Africa.

2.8. Research Knowledge Gap Analysis

Studies that are underpinned by the TPB have been conducted in high-, middle- and low-income countries on influences of household intention to adopt solar PV, and several studies have been completed in Sub-Saharan Africa (Kwame et al., 2021; Mkhize, 2021; Zulu et al., 2021).

Mkhize (2021) studied factors influencing the adoption of microgeneration technologies by households in South Africa using the theory of planned behaviour on a sample size of 260 participants. Support was found for positive relationship between household's attitude and behavioural intention, as well as between the household's subjective norms and behavioural intention.

However, no support was found between the household's subjective knowledge and behavioural intention (Mkhize, 2021). Mkhize (2021) pointed out that subjective knowledge is multidimensional. The consumer knowledge that was studied could have been insufficient to understand the relationship between subjective knowledge and behavioural intention (Mkhize, 2021).

The conclusion was that another study could come to a different conclusion by considering other dimensions of subjective knowledge (Mkhize, 2021). Mkhize (2021) further recommended that future studies should consider whether respondents own or rent their homes, and whether the household is a stand-alone house or a flat (Mkhize, 2021).

Zulu, Chabala and Zulu (2021) studied the factors that influence Zambian households in the adoption of solar energy solutions through the TPB. The study found that attitude had a significant influence on household's behavioral intention to adopt solar energy solutions, and subjective norms, trust, and benefits also had a positive influence on household behavioral intension (Zulu et al., 2021).

Zulu et al. (2021) highlighted that the limitation of the study was that data were collected from an affluent section of the population using an online data collection instrument, and results were therefore not representative of the underprivileged Zambian population (Zulu et al., 2021).

Kwame et al. (2021) studied the social construct on the adoption of green energy in Ghana through the theory of planned behavior (Kwame et al., 2021). The study found that consumer attitudes on solar energy were influenced by environmental beliefs, and consumer knowledge was the most influential factor in the decision-making process that leads to adoption of green energy (Kwame et al., 2021).

Kwame et al (2021) pointed out that the study had shortcomings of the sample size (N = 372) and that the TPB has other variables that were not considered by the study (Kwame et al., 2021). The study also did not consider influences such as "*societal expectations, materialism, perhaps social interaction, or even political expectations*" (Kwame et al., 2021, p. 181).

2.9. Research Propositions

Literature review and analysis of the research problem led to the formulation of the following propositions or hypotheses:

a. **H1**: South African households have a positive attitude towards rooftop solar PV technology.
b. **H2**: Household attitude has a positive influence on behavioural intention of the household to adopt rooftop solar PV technology.
c. **H3**: Perceived social pressure has a positive influence on behavioural intention of households to adopt rooftop solar PV technology.
d. **H4**: Subjective knowledge has a positive influence on behavioural intention of households to adopt rooftop solar PV technology.

2.10. The Conceptual Framework

The conceptual framework for this research was based on the TPB and consisted of three core components or constructs (*household attitude*, *perceived social pressure* and *subjective knowledge)* as determinants of the behavioral intention to adopt solar PV technology, as shown in **Figure 4**.

The strenght of the perceived control belief was represented by subjective knowledge of the householders. Subjective knowledge was not limited to technical understanding of solar PV technology, but it included the financial dimentions of investing in rooftop solar PV technology.

Therefore, the conceptual framework for this research provided basis for prediction of behavioural intention from attitude, perceived social pressure, and subjective knowledge of householders.

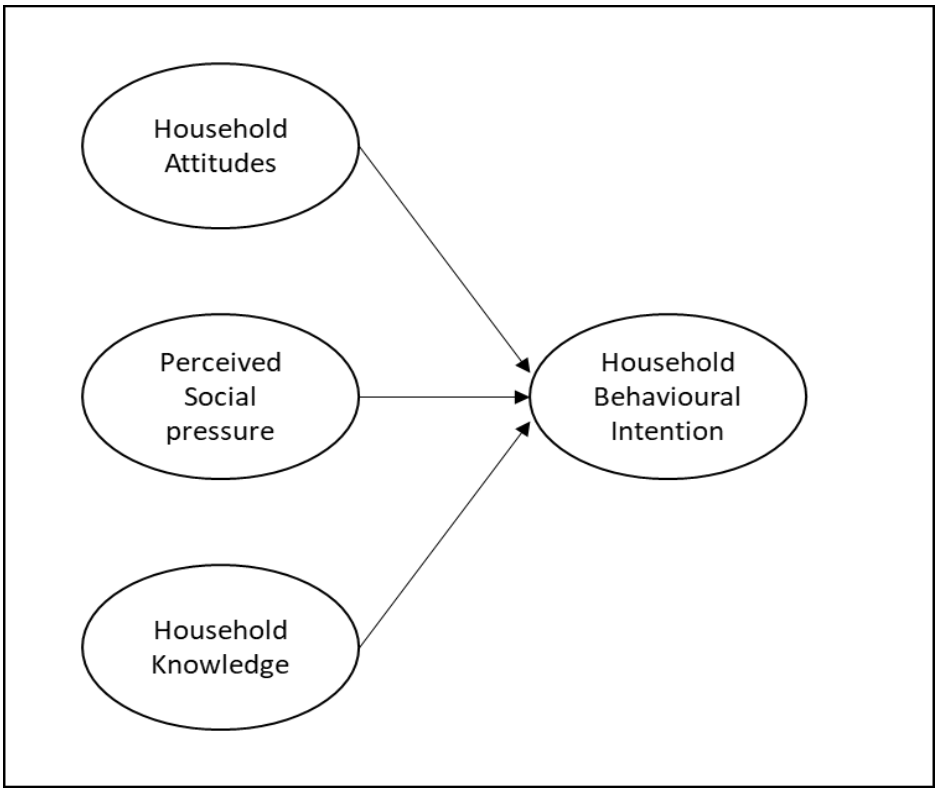


Figure 4: The proposed conceptual framework

In summary, the hypotheses for this research supported a positive relationship between household attitude, perceived social pressure, and household subjective knowledge. The TPB was chosen as the theoretical framework for this research because it provides the basis to study the influence of the three constructs on the household's behavioural intention to adopt rooftop solar PV technology.

The proposed conceptual framework was underpinned by the TPB. The next section provides details of research design, data collection and analysis procedures.

3. RESEARCH DESIGN AND DATA COLLECTION

This section describes the research design and data collection method that was implemented, target population, sampling framework, survey instrument design, review of collected data, the determination of a usable sample, and the reliability and validity of the measurement scales. The design of the data collection instrument consisted of sections that covered the demographic characteristics of the target population, and four TPB constructs as shown in **Appendix 1**.

3.1. Survey Method and Procedures

This research was a cross-sectional quantitative research because it focused on a snapshot of factors that influenced a household's behavioural intention to adopt solar PV at a particular time (Saunders, Lewis, & Thornhill, 2009). A quantitative study relies on data to explain a relationship between a handful of measurable variables (Mertler, 2021). The data collection instrument for this research was a self-administered online survey that was developed on the Qualtrics® XM platform.

A quantitative research follows a statistical approach for the analysis and interpretation of data, which introduces objectivity to the process (Mertler, 2021). Therefore, the quantitative research approach was justified for this study because data were collected directly from participants that were responsible for investment decisions of households.

3.1.1. Sampling Framework

A simple random sampling method was used to target the community of post-graduate students from the University of the Witwatersrand. Random sampling allows for selection of participants without bias, and can be said to be representative of the population for large samples of "*more than a few hundred cases*" (Saunders et al., 2009, p. 226).

The sampling framework targeted adult individuals were responsible for technology investment decisions of the household. Permission was obtained from the University of the Witwatersrand to distribute the online survey link to post-graduate students.

The sample size guidance of between 15 and 25 observations per studied measurement item was used to calculate the required sample size for this research (Hair et al., 1998, as cited by Mkhize, 2021). Siddiqui (2013) recommended at least 15 observations for each measurement item for Structural Equation Modelling (SEM) technique, with at least 100 cases, and 200 as the preferred sample size (Siddiqui, 2013). This research had four constructs with five measurement items each. Therefore, the desired sample size was 15 multiplied by 20, equalling 300 participants.

3.1.2. Key Variables and the Survey Instrument

A five-point Likert scale was adopted for the self-administered questionnaire for independent variables of household attitude (*ATT*), perceived social pressure (*SP*) and household knowledge (*HK*), and one dependent variable of behavioural intention (*BI*).

The scales that were previously used by Park and Ohm (2014), Zulu et al. (2021), Abreu, Wingartz and Hardy (2019) and Korcaj, Liridon and Spada (2015) were found to be appropriate for this study. It was preferred to adopt existing scales that have been measured in previous studies and adapt them for the South African context. The reliability and validity of the adopted scales had been checked in previous studies and were expected to meet the reliability and validity criteria.

It was important for the collected data to yield the same findings when analysed on other occasions and answering the same research questions, by showing reliability and internal validity (Saunders et al., 2009). Results from this research should be able to be generalised to a bigger population, indicating external validity (Saunders et al., 2009). The design of the measurement items for the four constructs is shown in **Table 1**.

Measurement items for the scales
Household Attitude 1. *Use of solar PV is extremely good for my household (ATT1)* 2. *Installing solar PV is extremely wise for us (ATT2)* 3. *I strongly support the use of solar PV by South African households (ATT3)* 4. *For me, purchasing solar PV for my home would be valuable (ATT4)* 5. *If I purchase solar PV, it will increase my energy self-sufficiency (ATT5)*
Perceived Social Pressure 1. *Solar PV may lead to new and better ways to clean up the environment (SP1)* 2. *Solar PV may help South Africa develop increased industrial competitive advantage (SP2)* 3. *Solar PV may lead to new and better ways to treat social problems (SP3)* 4. *My neighbours would approve if I purchased solar PV (SP4)* 5. *What my family thinks I should do matters to me (SP5)*
Household Knowledge 1. *A solar PV system is a secure financial investment (HK1)* 2. *A solar PV system can produce the amount of electricity I need (HK2)* 3. *A solar PV system is profitable (HK3)* 4. *The initial cost of a solar PV system will be recovered (HK4)* 5. *A solar PV system gives me more control over my electricity supply (HK5)*
Behavioural Intention 1. *I expect to purchase solar PV for my home in the next few years (BI1)* 2. *I plan to use less grid electricity in my home in preference for solar PV (BI2)* 3. *I plan to use solar PV technology in the near future (BI3)* 4. *If I could, I would prefer to use solar PV (BI4)* 5. *I predict our society will use solar PV in the near future (BI5)*

Table 1: Measurement items from the scales (extracted from Appendix 1)

3.1.3. The Population

This study was quantitative survey-based research that applied deductive reasoning to reach conclusions. The target population was the University of the

Witwatersrand's post-graduate students who contributed to their household's investment decisions.

The final self-administered online survey questionnaire based on Qualtrics XM platform was circulated by e-mail during December 2022 to 16 165 post-graduate students from all faculties and academic programmes. The survey link was embedded in the body of the email. Participation on the survey was voluntary.

The survey link was also shared via WhatsApp social media groups for additional access to the survey. The distribution of the survey link via WhatsApp social media was done to reach out to those students who do not regularly check their emails.

3.1.4. Data Errors and Usable Sample

The survey yielded a total of 239 participants who completed the questionnaire on the Qualtrics XM platform. The survey data were exported from Qualtrics XM and saved as a Microsoft® (MS) Excel file. The MS Excel file of the initial data was imported into IBM SPSS Statistics for further analysis. The *Missing Value Analysis* was conducted on the initial data using IBM® SPSS Statistics software.

The data were screened on SPSS for errors and missing values, as shown in **Appendix 3**. No data entry errors were found. However, there were participants who had missing values ranging from 12% and up to 27% of each variable. Survey participants that had excessive missing data, such as those that stopped to complete the survey at less than halfway, were excluded from the final cleaned data set. Participants who did not answer any question related to a construct, were also excluded from the final cleaned data set.

A total of 61 (25.5%) participants were removed from the final data set due to the significant number of missing values, leaving 178 usable surveys. The missing values in the final data set were not computed or replaced. The participants were requested to only complete the year in which they were born instead of age to minimise data-entry errors. The participants' ages were computed in MS Excel by subtracting the year in which participants were born from the year 2022.

3.2. Reliability and Validity of the Measurement Instrument

The reliability of the measurement items in a scale reveals the degree in which the items of the instrument indicate the same construct and can deliver consistent results (Cooper & Schindler, 2008). Cronbach's Alpha was used to assess the internal consistency of each of the multi-item scale in the four constructs of this study, as shown in **Table 2**. A Cronbach's Alpha value of 0.65 was regarded as the threshold level for reliability of the measurement instrument.

3.2.1. Reliability of the Measurement Scales

The Cronbach's Alpha based on standardised items for the *Attitude* scale was 0.956, which was good and higher than the threshold of 0.65, and it was achieved with 5.6% of items excluded. The Cronbach's Alpha did not improve with the removal of any of the five items in the scale. The correlation between measurement items was good, with the minimum of 0.759. This meant the measurement items for the scale fitted well together. Therefore, a new aggregated variable (*Household Attitude*) was created from the five items of the Attitude scale.

The Cronbach's Alpha based on standardised items for *Perceived Social Pressure* scale was 0.792 which was acceptable and above the threshold of 0.65, and it was achieved with 6.7% of items excluded. There was marginal improvement to 0.810 if item 5 was removed. But it was decided to keep item 5 due to the very small magnitude of improvement that would be achieved by removing it. There was weak correlation between item SP5 and items SP1, SP2 and SP3, and a moderate correlation between item SP5 and SP4. Therefore, a new aggregated variable (*Perceived Social Pressure)* was created from the five items of the scale.

The Cronbach's Alpha based on standardised items for the *Knowledge* scale was 0.871 which was good, and it was achieved with 4.6% of measurement items excluded. There was a good correlation between items with the minimum correlation of 4.99 between items HK2 and HK3. There was no improvement in Cronbach's Alpha if any of the measurement items was removed. Therefore, a

new aggregated variable (*Household Knowledge*) was created from the five items of the scale.

The Cronbach's Alpha based on standardised items for the *Behavioural Intention* scale was 0.891 which was good and achieved with 3.4% of items excluded. There was a slight improvement to 0.928 if item BI5 was removed. It was decided to keep the item due to the marginal improvement. The inter-item correlation ranged from moderate at 0.461 between BI1 and BI5, to strong at 0.851 between BI2 and BI3. Therefore, a new aggregated variable was created from the five items of the *Behavioural Intention* scale.

Constructs	Mean	Std. Dev	Cronbach's Alpha	Cronbach's Alpha based on standardised items	No. of valid items	% Items excluded
Attitude						
ATT1	4.27	1.097	0.959	**0.959**	168	5.6%
ATT2	4.33	1.087				
ATT3	4.51	1.015				
ATT4	4.36	1.091				
ATT5	4.43	1.036				
Perceived Social Pressure						
SP1	4.35	0.933	0.783	**0.792**	166	6.7%
SP2	4.16	0.991				
SP3	3.96	1.097				
SP4						
SP5	4.05	1.105				
	3.90	1.199				
Knowledge						
HK1	3.99	1.088	0.870	**0.871**	170	4.5%
HK2	3.84	1.188				

Constructs	Mean	Std. Dev	Cronbach's Alpha	Cronbach's Alpha based on standardised items	No. of valid items	% Items excluded
HK3	3.48	1.168				
HK4	3.52	1.217				
HK5	4.29	1.017				
Behavioural Intention						
BI1	4.13	1.165	0.894	**0.891**	172	3.4%
BI2	4.22	1.132				
BI3	4.28	1.110				
BI4	4.44	0.956				
BI5	4.16	0.964				

Table 2: Scale reliability statistics

Notes: ATT = *Household Attitude*, SP = *Household Perceived Social Pressure*, HK = *Household Subjective Knowledge*, BI = *Household Behavioural Intention*

The four new variables were computed as follows:

a. *Household_Attitude*: The mean of the five attitude items on the scale.
b. *Perceived_Social_Pressure*: The mean of the five perceived social pressure items on the scale.
c. *Household_Knowledge*: The mean of the five household knowledge items on the scale.
d. *Behavioural_Intention*: The mean of the five household behavioural intention items on the scale.

3.2.2. Validity of the Constructs

The validity of the constructs was tested by using the Pearson bivariate correlation matrix from IBM SPSS Statistics version 28. The desired outcome was for independent variables of *Attitude*, *Perceived social pressure* and *Subjective knowledge* not to be significantly correlated. A linear relationship between the variables would indicate *multicollinearity*. Multicollinearity can cause the regression coefficients to be unstable by increasing their variance (Shrestha, 2020).

Correlations

		Household_Attitude	Perceived_Social_Pressure	Household_Knowledge	Behavioural_Intention
Household_Attitude	Pearson Correlation	1	.613**	.532**	.523**
	Sig. (2-tailed)		<,001	<,001	<,001
	N	178	178	178	178
Perceived_Social_Pressure	Pearson Correlation	.613**	1	.540**	.596**
	Sig. (2-tailed)	<,001		<,001	<,001
	N	178	178	178	178
Household_Knowledge	Pearson Correlation	.532**	.540**	1	.644**
	Sig. (2-tailed)	<,001	<,001		<,001
	N	178	178	178	178
Behavioural_Intention	Pearson Correlation	.523**	.596**	.644**	1
	Sig. (2-tailed)	<,001	<,001	<,001	
	N	178	178	178	178

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

Table 3: Scale validity statistics

The results of the Pearson bivariate analysis were as shown in **Table 3**. The Pearson Correlations matrix indicated that there was no strong correlation or relationship between independent variables because there was no correlation value near or above 0.9. The highest Pearson bivariate correlation value was found between household attitude and perceived social pressure at 0.613.

3.3. Research Ethics

Consent was requested from all participants at the beginning of the survey questionnaire, and there was no association between the researcher and the participants. Only adult participants of between the ages of 18 and 65 years were targeted by this study.

No children, under-age or vulnerable groups were targeted or included in the study. Participation was on an anonymous and confidential basis, and there was no exposure, potential risk, or harm to participants. The Ethics Clearance Certificate for this research is shown in **Appendix 2** with protocol number *WBS/BA2499821/556*.

4. RESULTS PRESENTATION AND INTERPRETATION

This section presents results from the statistical analysis of the data. It reports on the demographic statistics of the participants, linear regression, output from the analysis of the SEM model, and outcomes from the use of path coefficients for assessment of research hypotheses.

4.1. Final Survey Data

The online survey yielded 239 responses, but 178 responses were usable from the final data set. The statistical analysis of the final data set (N = 178) was performed on IBM® SPSS Statistics version 28, and on IBM® SPSS AMOS (Analysis of Moment Structures) version 28 software for SEM model.

4.1.1. Socio-Demographic Statistics of the Sample

There was marginally higher participation from female students (50.6%) than male students (49.4%) in the survey, as shown in **Figure 5** and **Table 4**. There were more female students (56.43%) registered at the university than male students, and postgraduate students made up 39.4% of the entire headcount of 42 175 students at the University of the Witwatersrand in 2022 (Wits, 2022).

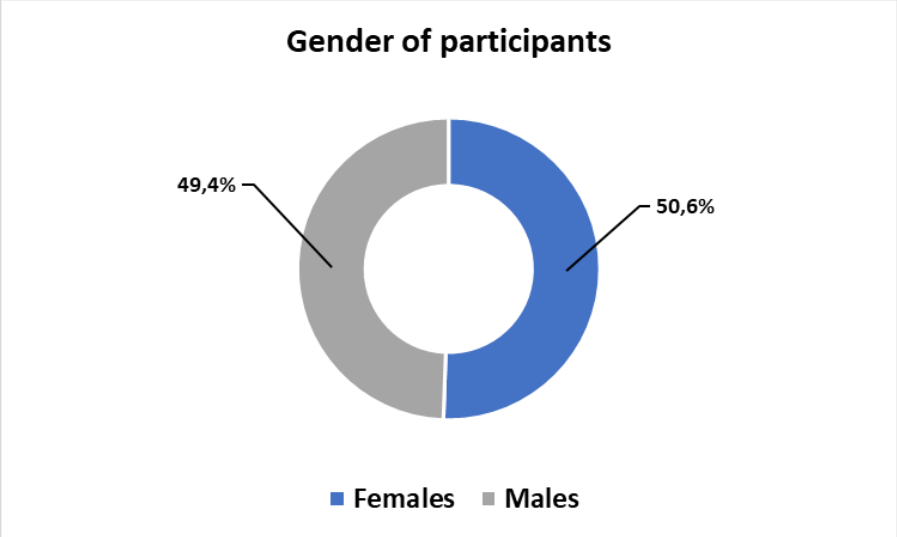


Figure 5: Gender distribution of participants (N = 178)

The mean age (± standard deviation) of participants was 37 (± 8) years, which was not unexpected because the survey targeted postgraduate students. The mean spending on electricity (± standard deviation) by participants was R2 632 (± R2 752) per month, as shown in **Figure 8**.

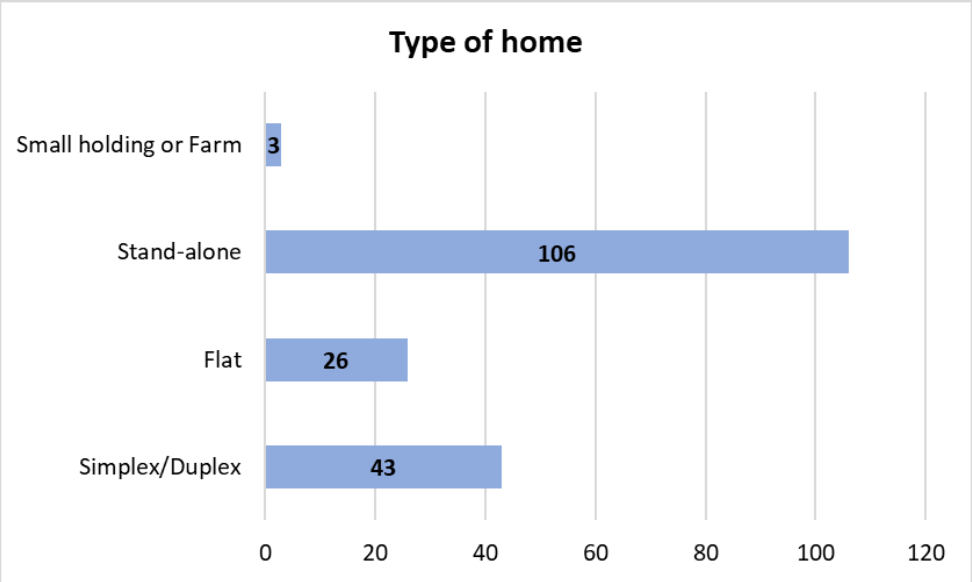


Figure 6: Type of homes of participants (N = 178)

Most participants (59.6%) were living in stand-alone homes, and 80.3% of participants were living in owned homes as compared to 17.4% who lived in rented homes, as shown in **Figure 7**.

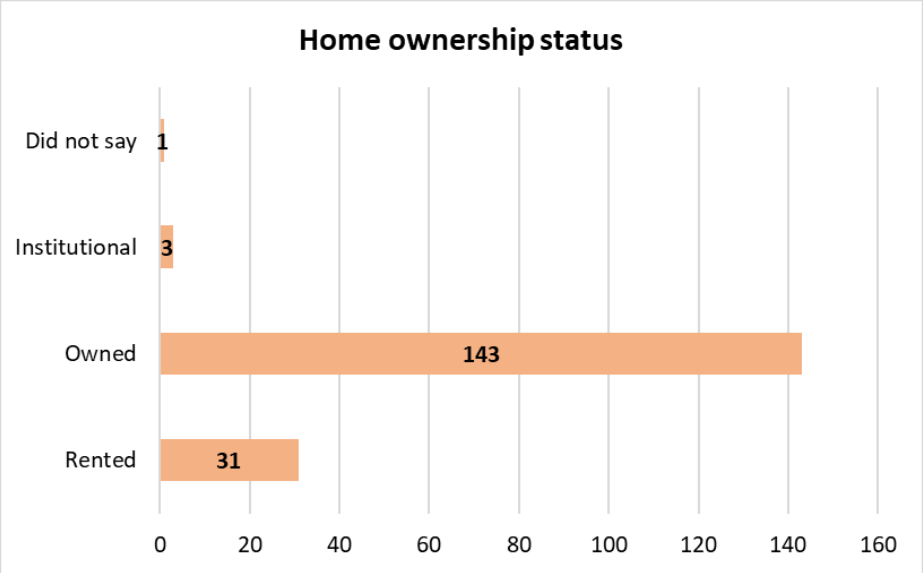


Figure 7: Home ownership status of participants (N = 178)

The maximum expenditure on electricity that was recorded was R17 135 per month from an institutional home, while the minimum was zero. The zero expenditure on electricity could indicate that the participants were using other alternative forms of energy in their homes, or they were not directly responsible for the electricity expense. The data show that household expenditure on electricity could vary depending on the status of home ownership and gender, as shown in **Figure 8** and **Table 4**.

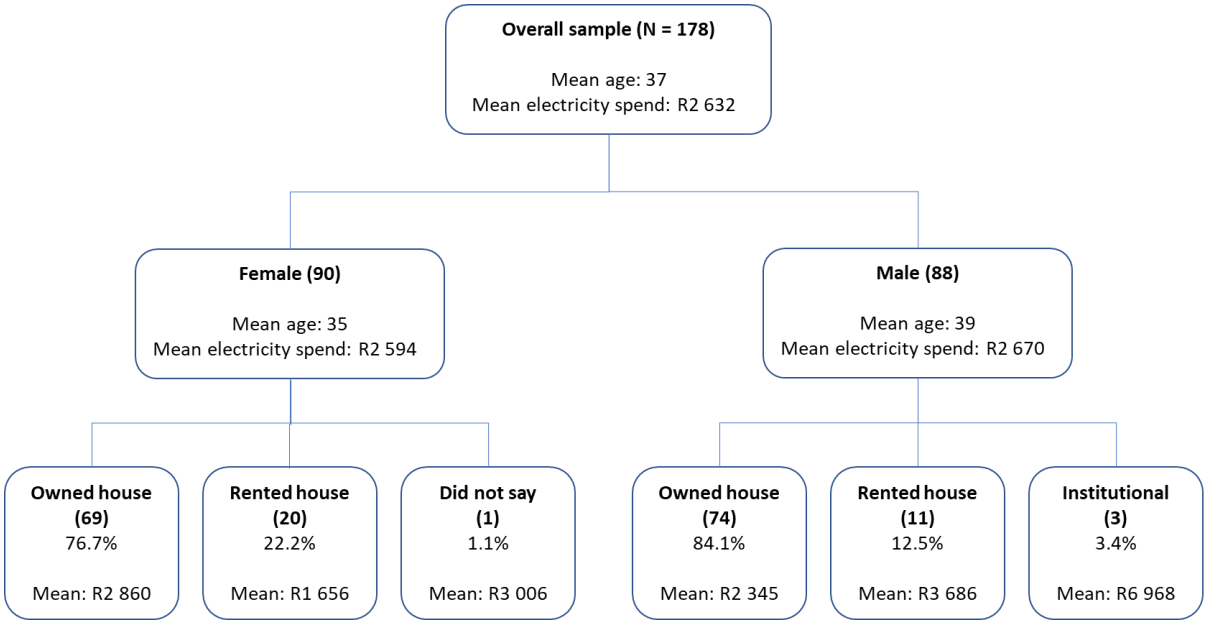


Figure 8: Socio-demographic statistics

	Frequency (N)	Minimum	Maximum	Mean	Std. Dev.
Age (Years)					
Female	90	21	58	35	8
Male	88	20	55	39	8
Total	178	20	58	37	8
Electricity Spend					
Female	90	0	12 472	2 594	2 245
Male	88	122	17 135	2 670	2 670
Total	178	0	17 135	2 632	2 752

Table 4: Socio-demographic information of participants by gender

Most participants (61.3%) were living in homes that were either stand-alone or small holding/farms, in comparison with 38.7% who lived in flats and simplexes/duplexes which could have had more restrictions on rooftop space for solar PV technology.

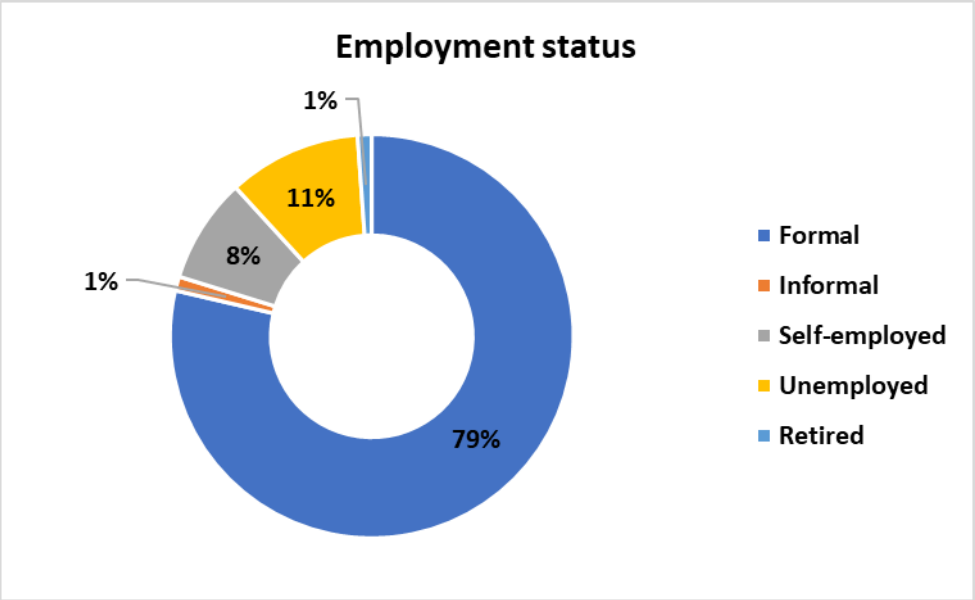


Figure 9: Employment status of participants

A total of 157 participants (87.2%) were employed (formal, informal, or self-employed). This was a larger percentage of employed group compared to official statistics of unemployment rate in South Africa that was reported at 32.9% as of November 2022 (StatsSA, 2022).

The full socio-demographic statistics for the sample are provided in **Table 5**.

	Frequency (N)	Percent (%)
Gender		
Female	90	50.6%
Male	88	49.4%
Prefer not to say	0	0

	Frequency (N)	Percent (%)
Total	178	100%
Level of Education		
High school or prior	1	0.6%
College	1	0.6%
Diploma	5	2.8%
Bachelor's degree	32	18%
Honours	74	41.6%
Master’s degree	58	32.6%
Doctoral degree	6	3.4%
Other	1	0.6%
Total	178	100%
Type of House		
Simplex/duplex	43	24.2%
Flat	26	14.6%
Stand-alone house	106	59.6%
Small-holding or farm	3	1.7%
Total	178	100%
Home Status		
Rented	31	17.4%
Owned	143	80.3%
Institutional	3	1.7%
Did not say	1	0.6%
Total	178	100%
Employment Status		
Formal	140	78.7%
Informal	2	1.1%
Self-employed	15	8.4%
Unemployed	19	10.7%
Retired	2	1.1%
Total	178	100%

Table 5: Demographic statistics of the sample

4.2. Linear Regression Analysis

The linear regression analysis of the model consisting of three independent variables (*Attitude*, *Perceived Social Pressure* and *Knowledge*) and one dependent variable (*Behavioural Intention*) was undertaken on IBM SPSS Statistics. The results for the descriptive statistics of the composite scales are shown in **Figure 10**.

The statistic of the mean score for household attitude was 4.3583 (± 1.00085), with the standard error at 7.59%. The value of the mean for household Attitude was between 4.1978 (± 0.81027) and 4.4903 (± 1.18223) at 95% confidence interval.

Descriptive Statistics

			Bootstrap[a]			
					95% Confidence Interval	
		Statistic	Bias	Std. Error	Lower	Upper
Household_Attitude	N	178	0	0	178	178
	Minimum	1.00				
	Maximum	5.00				
	Mean	4.3583	-.0026	.0759	4.1978	4.4903
	Std. Deviation	1.00085	-.00440	.09446	.81027	1.18223
Perceived_Social_Pressure	N	178	0	0	178	178
	Minimum	1.00				
	Maximum	5.00				
	Mean	4.0956	.0002	.0590	3.9801	4.2105
	Std. Deviation	.77189	-.00333	.06544	.64627	.89993
Household_Knowledge	N	178	0	0	178	178
	Minimum	1.00				
	Maximum	5.00				
	Mean	3.8301	.0010	.0687	3.6880	3.9643
	Std. Deviation	.91131	-.00194	.05568	.80126	1.01481
Behavioural_Intention	N	178	0	0	178	178
	Minimum	1.00				
	Maximum	5.00				
	Mean	4.2567	.0022	.0677	4.1236	4.3933
	Std. Deviation	.88551	-.00647	.07005	.74189	1.01602
Valid N (listwise)	N	178	0	0	178	178

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 10: Descriptive statistics

		Gender		Employment_Status				
		Female	Male	Formal	Informal	Retired	Self-employed	Unemployed
Household_Attitude	Mean	4.35	4.37	4.34	4.40	5.00	4.73	4.13
	Standard Deviation	.98	1.03	1.00	.57	.00	.43	1.34
	Maximum	5.00	5.00	5.00	4.80	5.00	5.00	5.00
	Minimum	1.00	1.00	1.00	4.00	5.00	3.80	1.00
Perceived_Social_Pressure	Mean	4.14	4.05	4.11	3.90	4.40	4.02	4.03
	Standard Deviation	.75	.80	.74	.42	.28	.86	.98
	Maximum	5.00	5.00	5.00	4.20	4.60	5.00	5.00
	Minimum	1.00	1.00	1.00	3.60	4.20	2.20	2.00
Household_Knowledge	Mean	3.89	3.77	3.82	2.70	4.20	3.76	4.01
	Standard Deviation	.82	1.00	.90	.42	.57	1.02	.93
	Maximum	5.00	5.00	5.00	3.00	4.60	5.00	5.00
	Minimum	1.60	1.00	1.00	2.40	3.80	1.60	1.80
Behavioural_Intention	Mean	4.19	4.33	4.24	4.00	4.40	4.29	4.35
	Standard Deviation	.90	.87	.91	1.41	.85	.87	.78
	Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	Minimum	1.20	1.00	1.00	3.00	3.80	2.20	2.40

Figure 11: Descriptives by gender and employment status

There was a marginal difference in the mean score for attitude, perceived social pressure, knowledge, and intention between male and female participants, as shown in **Figure 11**. However, the retired and self-employed participants had the largest and second largest mean score for attitude to adopt solar PV, respectively.

The retired participants consistently had the largest mean score for all four constructs in the study. The formally employed participants had the fourth largest mean score of 4.24 (± 0.87) for the intention to adopt solar PV, the lowest being the informally employed at 4.00 (± 1.41).

The informally employed participants had the lowest mean score for subjective knowledge at 2.70 (± 0.42) followed by self-employed and formally employed participants at 3.82 (± 0.90) and 3.76 (± 1.02).

The formally employed participants consistently scored lower on the study constructs than the retired or self-employed participants. The mean scores for intention, perceived social pressure, and knowledge for the unemployed participants were second only to those of retired participants.

		Type_of_house				Home_status			
		Flat	Simplex/duplex	Small-holding or farm	Stand-alone house		Institutional	Owned	Rented
Household_Attitude	Mean	4.15	4.40	4.73	4.38	5.00	3.73	4.41	4.15
	Standard Deviation	1.08	.81	.46	1.06	.	1.51	.95	1.17
	Maximum	5.00	5.00	5.00	5.00	5.00	4.80	5.00	5.00
	Minimum	1.20	1.40	4.20	1.00	5.00	2.00	1.00	1.00
Perceived_Social_Pressure	Mean	4.02	4.07	4.40	4.12	4.00	3.27	4.15	3.91
	Standard Deviation	.60	.77	.20	.82	.	.58	.73	.93
	Maximum	5.00	5.00	4.60	5.00	4.00	3.60	5.00	5.00
	Minimum	2.60	2.00	4.20	1.00	4.00	2.60	1.00	1.00
Household_Knowledge	Mean	3.72	3.89	4.47	3.82	3.60	4.00	3.92	3.40
	Standard Deviation	.72	.93	.23	.95	.	.35	.87	1.04
	Maximum	5.00	5.00	4.60	5.00	3.60	4.40	5.00	5.00
	Minimum	1.00	1.60	4.20	1.00	3.60	3.80	1.40	1.00
Behavioural_Intention	Mean	4.02	4.24	4.73	4.31	3.60	4.27	4.37	3.77
	Standard Deviation	.97	.82	.46	.89	.	.46	.81	1.08
	Maximum	5.00	5.00	5.00	5.00	3.60	4.80	5.00	5.00
	Minimum	1.60	2.20	4.20	1.00	3.60	4.00	1.20	1.00

Figure 12: Descriptives by home type and ownership status

Participants that lived in small-holdings or farms, and in stand-alone or simplexes, as well as those in owned homes consistently scored higher in the attitude, perceived social pressure and intention to purchase a solar PV system, as shown in **Figure 12**. There was marginal difference between those participants who lived in simplexes/duplexes and those who lived in stand-alone homes.

The participants that lived in rented homes had the second lowest mean score of 3.77 (± 1.08) for intention to purchase a solar PV system. Participants that had the lowest score of 3.6 (± 0) did not state the status of their home.

The participants that lived in flats consistently had the lowest mean scores for attitude, perceived social pressure, knowledge, and intention to purchase a solar PV system. This was expected due to restrictions or unavailability of space for rooftop solar PV in flats.

Participants that lived in owned homes consistently had the largest mean score for all constructs. Mkhize (2021) suggested that home ownership could be a factor in the attitude and intention to adopt a microgeneration technology (Mkhize, 2021).

The ANOVA *F-statistic*'s output (overall model fit) was assessed for significance, as shown in **Figure 13**. The F-statistic was 60.258, and the model was statistically significant ($p < 0.001$). This meant that at least one of the independent variables in the model was predicting the dependent variable (*Behavioural Intention*).

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70.721	3	23.574	60.258	<,001[b]
	Residual	68.071	174	.391		
	Total	138.792	177			

a. Dependent Variable: Behavioural_Intention

b. Predictors: (Constant), Household_Knowledge, Household_Attitude, Perceived_Social_Pressure

Figure 13: Analysis of variance

The R Square from the Model Summary output was 0.510 and dropped-off slightly to an Adjusted R Square of 0.501 as shown in **Figure 14**. The R Square of 0.501 meant that the combined variability of the independent variables explained 50.1% of the dependent variable. The Durbin-Watson value of 2.033 meant that there was no autocorrelation on the model.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.714[a]	.510	.501	.62547	2.033

a. Predictors: (Constant), Household_Knowledge, Household_Attitude, Perceived_Social_Pressure

b. Dependent Variable: Behavioural_Intention

Figure 14: Model summary

Figure 15 (histogram) and **Figure 16** show that the model had a normal distribution.

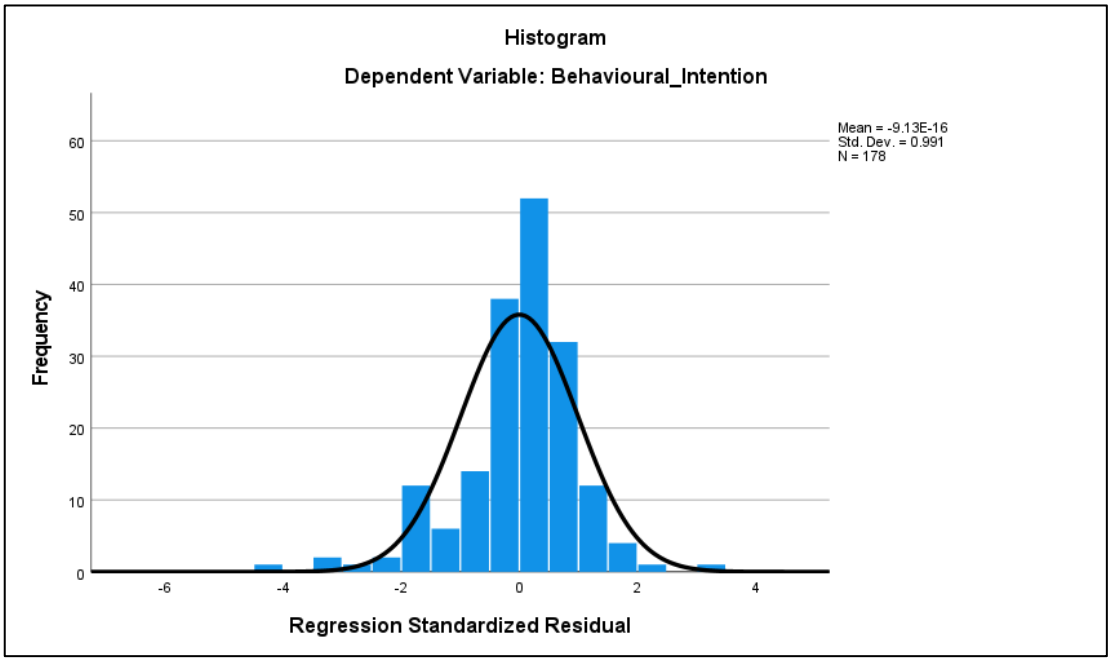


Figure 15: Normal distribution chart

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.6973	5.1107	4.2567	.63210	178
Residual	-2.51841	1.88382	.00000	.62015	178
Std. Predicted Value	-4.049	1.351	.000	1.000	178
Std. Residual	-4.026	3.012	.000	.991	178

a. Dependent Variable: Behavioural_Intention

Figure 16: Residual statistics from linear regression

The next section presents the structural equation modelling and path analysis results. A structural equation model was developed on AMOS software and its outputs were used to assess the research questions and the hypotheses of this study.

4.3. Structural Equation Modelling

Structural equation modelling (SEM) was chosen as the preferred method of analysing data to establish relationships between the independent variables and the depend variable. The SEM technique was preferred because it is able to analyse multiple causal relationships or dependencies such as those found in the conceptual framework of this research, in a single analysis (Hox & Bechger, 1998). Therefore, SEM can test interrelated dependencies or relationships between multiple observed variables simultaneously (Ullman, 2006).

SEM allows the examination of the relationship between variables free from the error because the error is “estimated and removed” (Ullman, 2006, p. 38). The SEM diagram allows the researcher to hypothesize relations among the variables (Ullman, 2006).

The structure of the SEM model that was developed for this study is shown in **Figure 17**, including the error element. The testing of the hypotheses used the *standardised coefficients* generated from the AMOS model outputs.

The SEM model included the three observed variables, linkage between predicting constructs and the outcome construct (Behavioural Intention), as well covariance linkages between the predicting constructs. The independent constructs (ATT, SP and HK) represented the endogenous variables, and the dependent variable (BI) represented the exogenous variable. The “e” block on the structural model indicated the error variable.

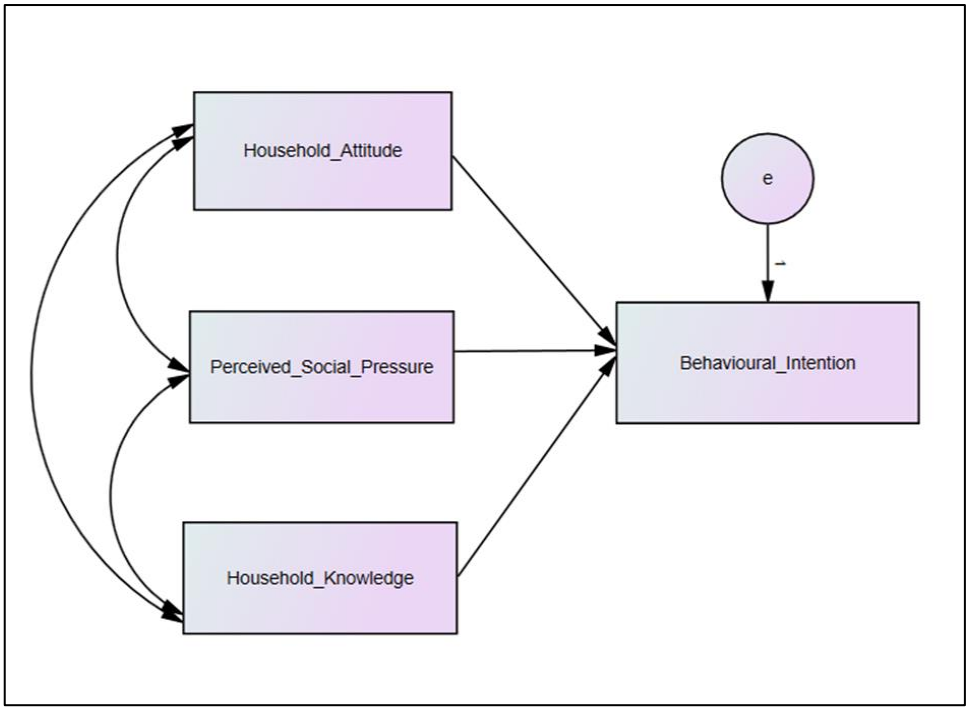


Figure 17: The structural model that was developed for analysis

4.3.1. Model Fit

The structural equation model for this study was a *Just-Identified Model*, because the degrees of freedom and chi-square were equal to zero (*df* = 0), as shown in **Table 6**. Just-identified models are those that fit the model data perfectly and cannot be meaningfully assessed for model fitness (Ramamoorthy, Flood, Slattery, & Sardessai, 2005).

Model Fit Index	Acceptable Threshold	Default Structural Model
Chi-Square Value (CMIN)	> 0.05	0
Degrees of freedom (df)	< 3	0
Goodness of Fit Index (GFI)	> 0.95	1
Comparative Fit Index (CFI)	> 0.900	1
Root Mean Square Error of Approximation (RMSEA)	< 0.08	0.515

Model Fit Index	Acceptable Threshold	Default Structural Model
Standardized Root Mean Square Residual (SRMR)	< 0.08	0

Table 6: SEM fit indices

The default model for this study had no other parameters to estimate because each parameter had a solution. In just-identified models, there is a path from each variable to another variable (Elsayed & Aneis, 2021). **Table 6** shows the structural model fit indices in comparison with recommended thresholds (Byrne, 2006; Hu & Bentler, 1999). The assessment of normality results for the AMOS model are shown in **Appendix 4**.

4.3.2. SEM Analysis Results

Independent variable	Dependent variable	Weight (or Coefficient)	p-value	Comment
Household Attitude (ATT)	Behavioural Intention	0.116	0.098	Non-significant (p > 0.05)
Perceived Social Pressure (SP)	Behavioural Intention	0.296	< 0.001	Significant
Household Knowledge	Behavioural Intention	0.423	< 0.001	Significant

Table 7: Standardised coefficients and statistical significance

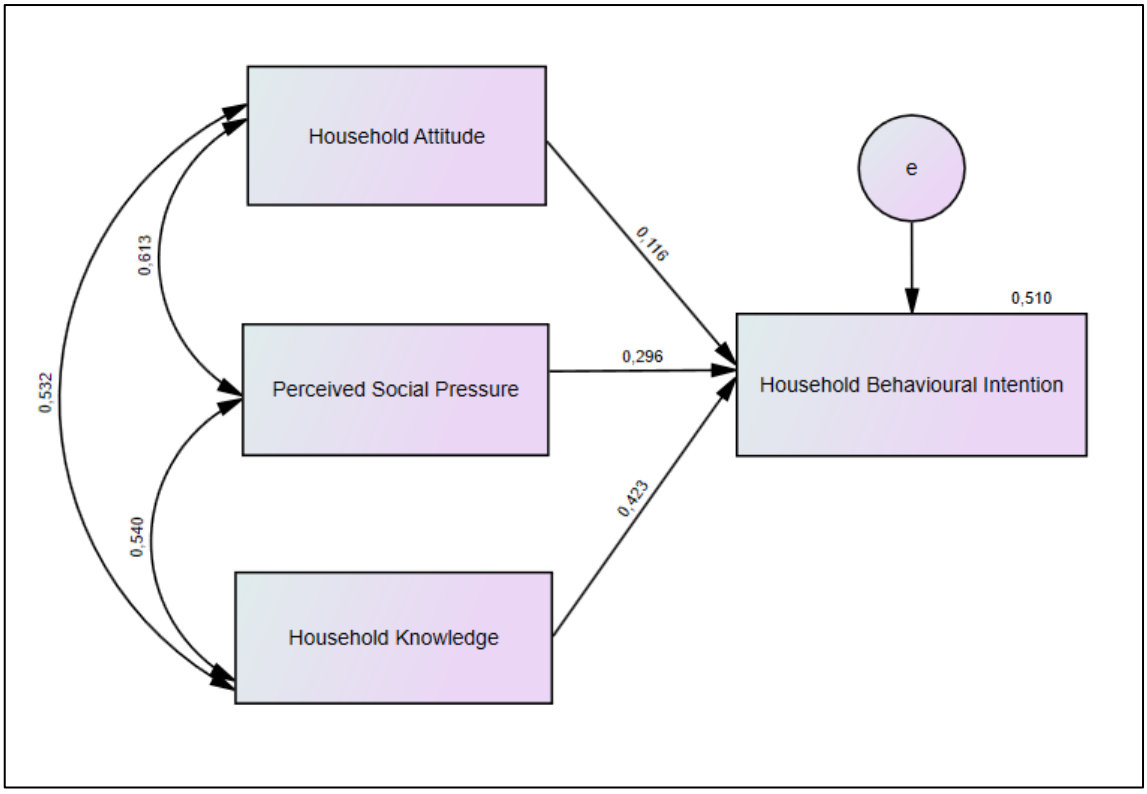
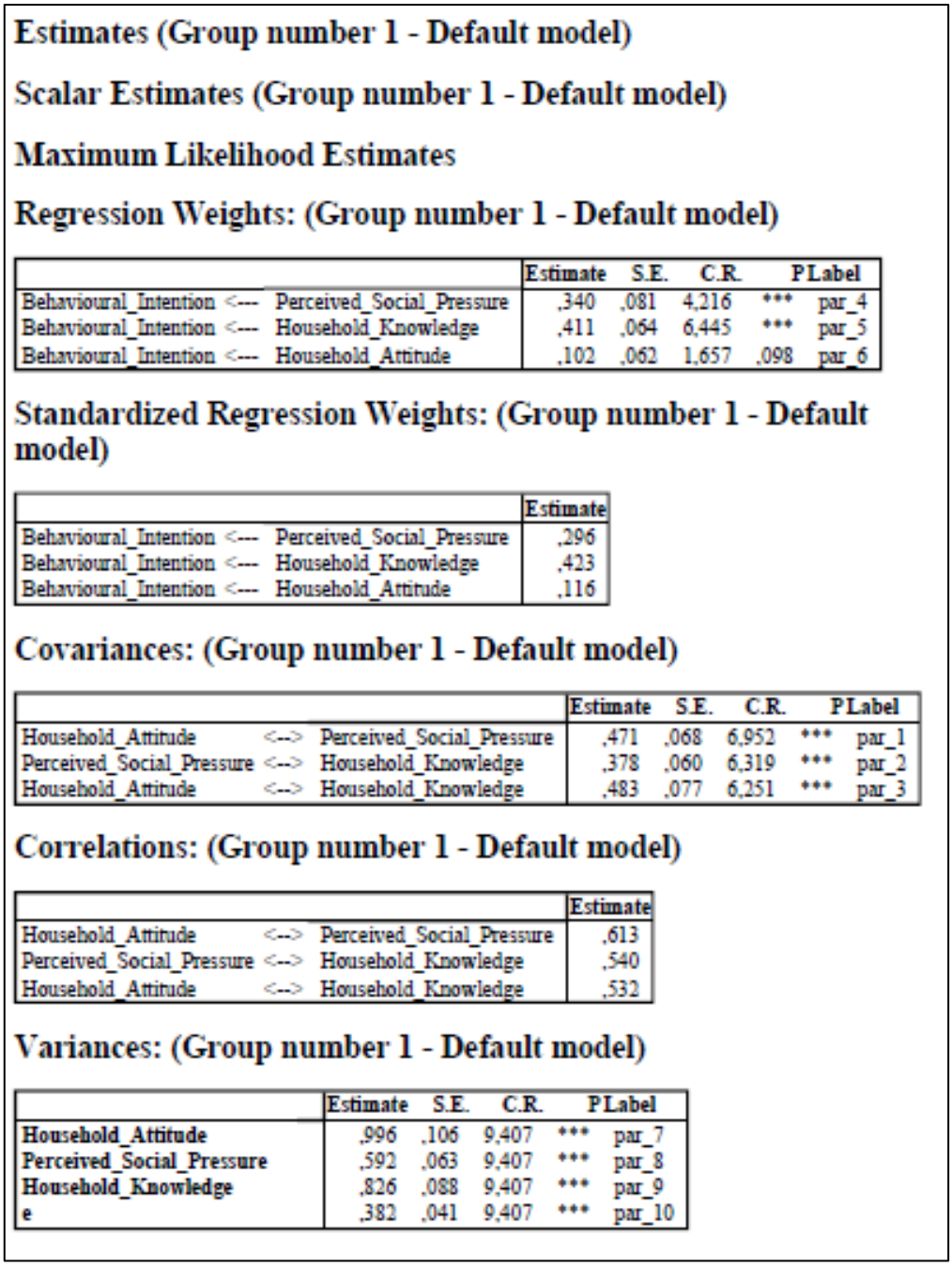


Figure 18: The SEM model path coefficients (n = 178)

The SEM model output showing standardised coefficients and their statistical significance is shown in **Figure 18** and **Table 8**. The standardised coefficients were used to compare the strengths of relationships between independent variables and the dependent variable. The full estimates output from the structural model in AMOS is shown in **Figure 19**.

Other associations		Weight (or Coefficient)	P-value	Evaluation comments
ATT	SP	0.613	< 0.001	Supported
SP	HK	0.540	< 0.001	Supported
ATT	HK	0.532	< 0.001	Supported

Table 8: Other correlations from SEM output



Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.		PLabel
Behavioural_Intention	<---	Perceived_Social_Pressure	,340	,081	4,216	***	par_4
Behavioural_Intention	<---	Household_Knowledge	,411	,064	6,445	***	par_5
Behavioural_Intention	<---	Household_Attitude	,102	,062	1,657	,098	par_6

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Behavioural_Intention	<---	Perceived_Social_Pressure	,296
Behavioural_Intention	<---	Household_Knowledge	,423
Behavioural_Intention	<---	Household_Attitude	,116

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.		PLabel
Household_Attitude	<-->	Perceived_Social_Pressure	,471	,068	6,952	***	par_1
Perceived_Social_Pressure	<-->	Household_Knowledge	,378	,060	6,319	***	par_2
Household_Attitude	<-->	Household_Knowledge	,483	,077	6,251	***	par_3

Correlations: (Group number 1 - Default model)

			Estimate
Household_Attitude	<-->	Perceived_Social_Pressure	,613
Perceived_Social_Pressure	<-->	Household_Knowledge	,540
Household_Attitude	<-->	Household_Knowledge	,532

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.		PLabel
Household_Attitude	,996	,106	9,407	***	par_7
Perceived_Social_Pressure	,592	,063	9,407	***	par_8
Household_Knowledge	,826	,088	9,407	***	par_9
e	,382	,041	9,407	***	par_10

Figure 19: Estimates output from the AMOS model

The value of standardised R Square for multiple correlations was 0.510. This meant that the combined variability of the independent constructs (or predictors) could explain 51% of the dependent construct (or outcome). The standardised coefficients for independent variables are provided in **Table 7**.

4.4. Hypothesis Evaluation

The hypotheses that were proposed in section 2 were tested by examining the statistical values of independent variables from descriptive statistics and the path coefficients from the SEM model analysis.

4.4.1. Hypothesis 1: Household Attitude

Research question: What is the attitude of South African households towards the rooftop solar PV technology?

Hypothesis 1: South African households have a positive attitude towards rooftop solar PV technology.

Research proposition		Mean	Std. Dev.	Std. Error	95% confidence interval		Comment
Hypothesis 1	ATT is positive	4.3583	1.00085	0.0759	4.1978	4.4903	Supported

Table 9: Hypothesis 1 evaluation

Hypothesis 1 was supported by the mean of household attitude at 4.3583 and the 95% confidence interval of mean between 4.1978 and 4.49043, as shown in **Table 9**. This means that households had a positive attitude towards the rooftop solar PV technology.

It was expected that South African households would have a positive attitude towards rooftop solar PV technology due to electricity price increases and increasing frequency of load shedding.

4.4.2. Hypothesis 2: Household Attitude and Behavioural Intention

Research question: To what extent does the South African households' attitude influence the behavioural intention to adopt rooftop solar PV technology?

Hypothesis 2: Household attitude has a positive influence on behavioural intention of the household to adopt solar PV technology.

Research proposition			Weight (or Coefficient)	p-value	Evaluation comment
Hypothesis 2	ATT	BI	0.116	0.098	Non-significant not supported

Table 10: Hypothesis 2 evaluation

The relationship between household attitude and household behavioural intention to adopt rooftop solar PV technology was positive but statistically not significant. Household attitude had a positive standard coefficient of 0.116 ($p > 0.05$), as shown in **Table 10**.

4.4.3. Hypothesis 3: Perceived Social Pressure and Behavioural Intention

Research question: To what extent does the social pressure influence the South African households' behavioural intention to adopt rooftop solar PV technology?

Hypothesis 3: Perceived social pressure has a positive influence on behavioural intention of households to adopt rooftop solar PV technology.

Research propositions			Weight (or Coefficient)	p-value	Evaluation comment
Hypothesis 3	SP	BI	0.296	< 0.001	Supported

Table 11: Hypothesis 3 evaluation

Hypothesis 3 was supported by a positive standard coefficient of 0.296 ($p< 0.001$) which was statistically significant as shown in **Table 11**. This meant that the perceived social pressure had a moderately positive relationship with household behavioural intention to adopt rooftop solar PV technology.

4.4.4. Hypothesis 4: Subjective Knowledge and Behavioural Intention

Research question: To what extent does the South African households' technical competence and financial knowledge influence their behavioural intention to adopt rooftop solar PV technology?

Hypothesis 4: Subjective knowledge has a positive influence on behavioural intention of households to adopt rooftop solar PV technology.

Research propositions			Weight (or Coefficient)	p-value	Evaluation comments
Hypothesis 4	HK	BI	0.423	< 0.001	Supported

Table 12: Hypothesis 4 evaluation

Hypothesis 4 was supported by a positive standard coefficient of 0.423 ($p < 0.001$) which was statistically significant as shown in **Table 12**. This meant that household subjective knowledge had the strongest relationship with the household's behavioural intention to adopt the rooftop solar PV technology.

4.5. Summary

This chapter presented the statistical analysis and SEM model results and interpretation thereof. It was found that slightly more females participated in this study than males, which was consistent with the population of registered students at the University of the Witwatersrand. The average age of participants was 37 years, and majority of participants (59.6%) lived in stand-alone homes. The vast majority (80.3%) of participants were living in owned homes and most (88.2%) were employed. The mean value of electricity expenditure per household was R2 632 (±R2 752) per month.

The results of descriptive statistics showed that attitude had the mean score of 4.3583 (± 1.00085) which was considered as high. Linear regression was

undertaken, and the model was found to be statistically significant with the ANOVA F-statistic of 60.258 ($p < 0.001$) and R Square of 0.501. This meant that at least one independent variable predicted the dependent variable. The model had no autocorrelation and had a normal distribution, as explained in section 4.

Results showed that participants who lived in owned homes and in smallholdings, stand alone or simplexes, had a higher mean score for attitude and intention to purchase a solar PV system. Participants that were formally and informally employed had a lower mean score for subjective knowledge about solar PV, and they had a lower mean score for attitude compared to retired and self-employed participants.

The resultant SEM model was a *just-identified model*. The standardised coefficients were used to assess research hypotheses. Hypotheses 1, 3, and 4 were supported by the outcome of SEM model analysis. Hypothesis 2 was positive but statistically non-significant, or inconclusive. It was established that households had a positive attitude towards solar PV technology. But attitude had the weakest (and non-significant) relationship with the intention to adopt solar PV. Perceived social pressure had a moderate relationship, and household knowledge had the strongest influence on behavioural intention to purchase a solar PV system.

5. DISCUSSION

5.1. Descriptive Statistics and Relevant Theory

This study sought to establish the extent to which household attitude, perceived social pressure, and subjective knowledge were associated with the behavioural intention to adopt rooftop solar PV technology. Central to the Theory of Planned Behaviour (TPB) is the intention of an individual to perform an action. And intention captures the motivational factors that drive the will of an individual to act (Ajzen, 1991).

The core components of the TPB were the survey participants' attitude towards purchasing a rooftop solar PV system, the perceived social pressure to act as the subjective norm, as well as subjective knowledge as the perceived control belief.

The results showed that the attitude construct had the largest mean of the three TPB constructs at 4.3583 (± 1.00085) as shown in **Figure 10**. If participants believed that solar PV could solve their problem of load shedding and increasing electricity costs, household attitude would be high in accordance with literature review (Park & Ohm, 2014).

There was a marginal difference between male and female mean scores for attitude, with a mean score of 4.35 (± 0.98) for females and 4.37 (± 1.03) for males, as shown in **Figure 11**. Home ownership was a key factor because those who lived in owned homes consistently had higher mean scores for all constructs, except for subjective knowledge where they were only second to those living in institutional homes.

The interesting result was that participants that were formally, informally, or self-employed had a much lower mean score for subjective knowledge and intention to purchase solar PV, than retired and unemployed participants. It raises the question as to why the employed participants lagged in acquiring information and intention to invest in solar PV?

It was unexpected that employed participants had acquired the least knowledge about solar PV, and that they had the lowest intention to purchase a solar PV system for their homes. The employed population could represent a significant market for rooftop solar PV in South Africa. The uptake of solar PV in South Africa could remain less than the rest of the world if this situation is not changed.

Marketing activities and government policies needs to bring the employed population to the forefront of solar PV technology for South Africa to increase the pace of adoption of solar PV. Government needs to consider how South Africans can be incentivised to adopt solar PV technology.

5.2. SEM Model Path Coefficients and Findings

The SEM model was developed for this study to establish the relationship between variables confirm the covariances between all independent variables. The final SEM model final estimates are shown in **Figure 18**. The standard path coefficients showed that all three constructs of the TPB for this study had positive relationship with the intention of participants to invest in a solar PV system.

The following sub-sections provide the discussion of findings through the lens of the Theory of Planned Behaviour.

5.2.1. Household Attitude and Behavioural Intention

The SEM model output showed that attitude had a weak positive association (0.116) with behavioural intention, but it was statistically non-significant ($p > 0.05$) as shown in **Figure 18**. This means that it was inconclusive whether attitude had a relationship with intention to purchase a solar PV system or not. The p-value was 0.098, so it could not be confirmed if attitude was associated with intention to invest in solar PV.

There was a possibility that a bigger sample size could result in statistically significant relationship between attitude and intention, because the ideal sample size for SEM model was between 200 and 400 (Siddiqui, 2013).

It was possible that another factor influenced the attitude construct in decision-making to invest in solar PV. Previous studies identified that public attitude towards a technology can be altered by other variables such as perceived *social trust*, perceived *cost*, perceived *risk*, *knowledge* and perceived *benefits* (Park & Ohm, 2014; Zulu et al., 2021).

These additional variables (*trust*, *risk*, *benefit*, and *cost*) and their role on the relationship between attitude and behavioural intention were not part of this study. This omission may have impacted the attitude construct and its association with the intention to invest in sola PV. Another factors that may be related to attitude is government incentives and it was not assessed by this study.

The SEM model outputs include correlation coefficients between all the observed independent variables. The correlation coefficients between attitude, perceived social pressure and household knowledge were all statistically significant ($p<0.001$) as shown in **Table 8**. This was an interesting finding because positive correlations between all the constructs was consistent with Ajzen's (1991) Theory of Planned Behaviour.

The correlation between attitude and perceived social pressure had a value of 0.613, and 0.540 between perceived social pressure and subjective knowledge of 0.540, as well as 0.532 between attitude and subjective knowledge, as shown in **Figure 18**. The moderate positive correlations between the TPB constructs indicated that there was an association between the variables, but it did not necessarily confirm causation.

The lack of support for the relationship between attitude and behavioural intention to adopt solar PV technology was contrary to findings from previous studies by Mkhize (2021) in South Africa, Kwame et al. (2021) in Ghana, and by Zulu et al. (2021) in Zambia, who found a positive association between attitude and willingness to pay for solar PV.

Foxall and Yani-de-Soriano (2005) questioned the consistency of associating attitude to intention and suggested that there may be other situational influences on attitude formation that consider the consumer's emotions, and it varies across cultural settings (Foxall & Yani-de-Soriano, 2005). This may explain why two studies within the same region or different counties within the African continent could result in different findings.

Palm and Eriksson (2018) pointed out that information may be as key as attitude in influencing the consumer behaviour (Palm & Eriksson, 2018). The Theory of Planned Behavior states that attitude emanates from belief about the outcome of behaviour (Ajzen, 1991).

5.2.2. Perceived Social Pressure and Behavioural Intention

The perceived social pressure had a positive relationship (0.296) with the intention to invest in a solar PV system, and the association was statistically significant ($p < 0.001$) as shown in **Figure 18**. The survey targeted participants who did not previously own a solar PV system. The results indicated that participants cared about what society thinks about the environment and solar PV as the technology solution. This was consistent with the previous studies that were completed in Sub-Saharan Africa.

This result meant that householders cared about what those closest to them think about their decisions and actions. This finding was consistent with findings by Mkhize (2021) in South Africa, Schelly (2014) in the United States, and Zulu et al. (2021) in Zambia, in that subjective norms had a strong relationship with behavioural intention.

The mean score for perceived social pressure was highest for participants who lived in owned homes, and in stand-alone or small-holding and farms. The mean score was lowest for those living in flats and rented homes.

Social influence and environmental concerns influence the intention to adopt environmentally friendly technologies (Kesari et al., 2021). Therefore, it is important for policymakers and marketers in South Africa to formulate messaging around the benefits to communities of transitioning from fossil fuel-based energy sources to clean energy technologies.

Wittenberg et al. (2018) found that social influence grew more as adoption of solar PV technology progressed in society (Wittenberg et al., 2018). This means that more households may adopt solar PV technology as the electricity supply situation worsens in South Africa, which will influence other households to follow.

5.2.3. Subjective Knowledge and Behavioural Intention

Subjective knowledge had a positive and the strongest relationship (0.423) with the intention to purchase a solar PV system, which was statistically significant ($p<0.001$). This indicated that survey participants had acquired significant technical and financial information about solar PV technology which served as control belief strength for them.

This result agreed with Ugulu's (2019) finding that lack of knowledge and awareness was the barrier for adoption of solar PV technology in urban Nigeria (Ugulu, 2019). It also agreed with findings by Kwame et al. (2021) in Ghana where knowledge had a positive relationship with willingness to pay for solar energy (Kwame et al., 2021).

However, literature review revealed that consumers gather information about white products they are interested in, but they were likely to adopt technology without all the information about that technology (Palm & Eriksson, 2018).

Subjective knowledge of the survey participants demonstrated a moderate positive correlation with both attitude (0.532) and perceived social pressure (0.540). The subjective knowledge construct also had the smallest mean of 3.8301 (± 0.91131) among the three constructs, but subjective knowledge had the strongest relationship with behavioural intention to purchase a solar PV system.

Consumers do not need to acquire expert knowledge about solar PV technology before deciding to purchase it. The findings suggest that households need to understand high level technical and financial information about solar PV technology to influence the household's purchasing decision.

Marketing strategies need to focus on disseminating information to communities to collectively improve the knowledge of society about solar PV technology. Flynn and Goldsmith (1999) pointed out that subjective knowledge may have a bigger role to play in purchasing decisions (Flynn & Goldsmith, 1999).

Mkhize (2021) had found no relationship between subjective knowledge and behavioural intention in South Africa, but it was highlighted that knowledge was a multidimensional construct (Mkhize, 2021). Ahmad and Nordin (2014) confirmed the multidimension nature of the subjective construct and its strong association with influencing the pro-environmental behavior (Ahmad & Nordin, 2014).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions on Major Findings

Finding on Research Question 1: What is the attitude of South African households towards rooftop solar PV technology?

The results of this study confirmed that South African households had a positive attitude towards solar PV technology. The attitude was stronger from homes that were owned by participants in small-holdings or farms, stand-alone and simplexes/duplexes, as compared to homes that were flats, institutional or rented. The employment status of the homeowner had an impact on the attitude because unemployed participants had the lowest attitude towards solar PV.

This research established that participants that were formally or informally employed had a lower attitude, and they were less knowledgeable about solar PV than those who were retired or self-employed. It was concerning that there was a possible lack of information for the employed population. The retired and unemployed participants seemed to be able to gather more information about solar PV.

Finding on Research Question 2: To what extent does the South African households' attitude influence the behavioural intention to adopt solar PV technology?

This study confirmed a positive association between the household attitude and behavioural intention to purchase a solar PV system. But this relationship was weak and statistically non-significant ($p > 0.05$). This result was therefore inconclusive. The result did not support past findings on the application of the Theory of Planned Behaviour in Sub-Saharan Africa.

No information was shared with participants about the cost of a typical solar PV system during this study. Therefore, the results suggest that either the sample size for this study was inadequate, or other factors such as perceived risk,

perceived cost of solar PV, perceived benefit or perceived social trust could have affected the relationship between attitude and intention to invest in solar PV.

There was a moderate and positive correlation between perceived social pressure and the attitude, and between the subjective knowledge and attitude. These associations supported the Theory of Planned Behaviour from previous studies.

Finding on Research Question 3: To what extent does the social pressure influence the South African households' behavioural intention to adopt solar PV technology?

This study confirmed that the perceived social pressure was positively associated with the intention of households to purchase solar PV. The relationship was statistically significant, and it supported past findings on the application of the Theory of Planned Behavior.

The relationship between the perceived social pressure and intention to purchase a solar PV system was weak, but it indicated that householders rely on the extent to which those important to them think when deciding to purchase solar PV. These normative beliefs support Ajzen's (1991) Theory of Planned Behavior.

Finding on Research Question 4: To what extent does the South African households' technical competence and financial knowledge influence their behavioural intention to adopt solar PV technology?

Subjective knowledge had the strongest relationship with the intention to purchase solar PV, which supported the Theory of Planned Behaviour. The relationship was statistically significant, and this was an important indicator for willingness to purchase solar PV. The surprising finding was that employed participants (formally, informally, and self-employed) had the lowest mean scores compared to the retired and unemployed participants.

This research found that technical and financial information about solar PV might not be reaching the employed participants. This suggests that interventions are required from technology providers, marketers, and government policymakers to improve access to information for employed homeowners.

6.2. Recommendations

This research suggested that technology providers and marketers should design messaging and disseminate relevant information that empowers South African communities to understand the technical and financial aspects of investing in solar PV systems.

The dissemination of information should target communities rather than individuals due to the association between perceived social pressure and behavioural intention. Government should investigate incentives that will encourage households to adopt solar PV.

The findings showed that stand-alone and owned homes (including small-holdings and simplexes/duplexes) had the largest attitude towards solar PV. These consumers could be a growth segment for solar PV in South Africa. Therefore, it is recommended that the proposed messaging and design of solar PV product offerings should provide attractive options for homeowners in stand-alone households.

6.3. Implications to Practice

This study suggested that the strength of the individual's perceived control belief has the biggest influence on the decision to invest in solar PV. This represented TPB's perceived behavioural control as a key factor that affects the intent to purchase solar PV.

Subjective knowledge gave homeowners belief that they were in control of the outcomes, and they developed belief that the consequences of investing in solar PV were good for them.

Households with knowledge about solar PV were most likely to invest if solar PV technology. It also meant that attitude alone was not sufficient, but it was an important factor to influence households, and it was positively correlated with perceived social pressure and subjective knowledge.

6.4. Implications to Academics

This research supported the application of the Theory of Planned Behaviour (TPB) framework to study factors influencing the adoption of solar PV by South African households. Despite the shortcomings of the sample size, the TPB framework was effective in predicting the intention of households to adopt solar PV technology.

One construct, attitude, failed to contribute to the TPB framework. But this case presents an opportunity for further examination of the attitude construct, including other factors that may affect its relationship with behavioural intention.

The path analysis showed that structural equation modelling (SEM) can be applied to the TPB constructs to predict the observed dependent variable from observed independent variables.

6.5. Implications to Policymakers

This research suggests that policymakers need to understand factors that influence investment in rooftop solar PV technology. Government policy framework that regulates solar PV needs to be aligned with the South African cultural context and influences of the consumer decision-making process.

Government incentives are needed to encourage homeowners, especially the employed population in South Africa, to purchase solar PV systems and improve the uptake of solar PV through social networks.

6.6. Limitations of the Research

The major limitation for this study was the inadequate sample size. The preferred sample size for structural equation modelling (SEM) was between 200 and 400 participants (Siddiqui, 2013).

It was also possible that there was a sample bias for this research, because 138 (77.5%) of participants had completed a postgraduate degree and 157 (87.2%) were in some form of employment (formal, informal, or self-employed). The Department of Higher Education and Training found that only 5.9% of the South African population between the ages of 25 and 64 years had attained a degree as the highest level of achievement in education (DHET, 2022). Therefore, the participants on this study may not be representative of the population of South Africa.

Literature review also showed that there could be other factors that may influence the attitude and intention to adopt solar PV technology, such as cost, risk, benefits, trust, and government incentives. These variables were not included in this research and could be added in future research.

6.7. Recommendations for Future Research

This examination of the factors influencing the adoption of solar PV by South African households can be repeated using a bigger sample size as recommended for the SEM model analysis. The findings could verify if the non-significance of the attitude constructs was due to the inadequate sample size or other factors.

There is a need to examine the effects of other factors, such as perceived risk, perceived cost, perceived benefits, and perceived social trust, on the TPB's constructs and their impact to the intention to purchase a solar PV system.

Additional research can be done to examine the impact of government incentives such as tax rebates and grants or subsidies on the affordability and intention to invest in rooftop solar PV technology.

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Appendix 1 - Survey Questionnaire

Factors Influencing the Adoption of Solar PV Technology by South African Householders

Start of Block: CONSENT FORM

Consent **INFORMED CONSENT FOR THE APPLIED RESEARCH PROJECT**

STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY

I have read the informed consent document and understand each part of the document, and I freely and voluntarily choose to participate in this study.

- ○ Yes I Consent (1)
- ○ No I do not Consent (2)

End of Block: CONSENT FORM

Start of Block: Demographic characteristics

*

Age 1. What year were you born in (yyyy)?

_____

Gender 2. What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to answer (3)

Education 3. What level of education have you completed?

- ○ High school or prior (1)
- ○ College (2)
- ○ Diploma (3)
- ○ Bachelor's degree (4)
- ○ Honours (5)
- ○ Master's degree (6)
- ○ Doctoral degree (7)
- ○ Other (8)

Type of house 4. What type of house is your home?

- ○ Simplex/duplex (1)
- ○ Flat (2)
- ○ Stand-alone house (3)
- ○ Small-holding or farm (4)

Home status 5. What is the status of your home?

- ○ Rented (1)
- ○ Owned (2)
- ○ Institutional (3)

Expenditure 6. What is the approximate average expenditure on electricity for your home per month in Rands?

	0 4000 8000 12000 16000 20000
Electricity cost per month in Rands ()	

Employment 7. What is you employment status?

- ○ Formal (1)
- ○ Informal (2)
- ○ Self-employed (3)
- ○ Unemployed (4)
- ○ Retired (5)

End of Block: Demographic characteristics

Start of Block: Household attitude

ATT Please indicate the extent to which you agree or disagree with each of the statements below.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Use of solar PV is extremely good for my household (1)	○	○	○	○	○
Installing solar PV is extremely wise for us (2)	○	○	○	○	○
I strongly support the use of solar PV by South African households (3)	○	○	○	○	○
For me, purchasing solar PV for my home would be valuable (4)	○	○	○	○	○
If I purchase solar PV, it will increase my energy self-sufficiency (5)	○	○	○	○	○

End of Block: Household attitude

Start of Block: Perceived social pressure

SP Please indicate the extent to which you agree or disagree with each of the statements below.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Solar PV may lead to new and better ways to clean up the environment (1)	○	○	○	○	○
Solar PV may help South Africa develop increased industrial competitive advantage (2)	○	○	○	○	○
Solar PV may lead to new and better ways to treat social problems (3)	○	○	○	○	○
My neighbours would approve if I purchased solar PV (4)	○	○	○	○	○
What my family thinks I should do matters to me (5)	○	○	○	○	○

End of Block: Perceived social pressure

Start of Block: Household knowledge

HK Please indicate the extent to which you agree or disagree with each of the statements below.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
A solar PV system is a secure financial investment (1)	○	○	○	○	○
A solar PV system can produce the amount of electricity I need (2)	○	○	○	○	○
A solar PV system is profitable (3)	○	○	○	○	○
The initial cost of a solar PV system will be recovered (4)	○	○	○	○	○
A solar PV system gives me more control over my electricity supply (5)	○	○	○	○	○

End of Block: Household knowledge

Start of Block: Behavioural intention

BI Please indicate the extent to which you agree or disagree with each of the statements below.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I expect to purchase solar PV for my home in the next few years (1)	○	○	○	○	○
I plan to use less grid electricity in my home in preference for solar PV (2)	○	○	○	○	○
I plan to use solar PV technology in the near future (3)	○	○	○	○	○
If I could, I would prefer to use solar PV (4)	○	○	○	○	○
I predict our society will use solar PV in the near future (5)	○	○	○	○	○

End of Block: Behavioural intention

Appendix 2 – Ethics Clearance Certificate

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/BA2499821/556
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	Factors influencing the adoption of solar PV technology by South African householders
Investigator / Researcher	Mr Lucky Zondi
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed anonymity and confidentiality.
Issue Date of Certificate	2022-09-01
Expiry date	Date of submission of the project / research report
Chairperson	Prof Anthony Stacey ☎ +27 11 717 3587 +27 82 880 4531 anthony.stacey@wits.ac.za

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Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

17 SEPTEMBER 2022
Date:

Appendix 3 - Missing Variable Analysis for the Initial Data Set

Univariate Statistics

	N	Mean	Std. Deviation	Missing Count	Missing Percent	No. of Extremes[a] Low	No. of Extremes[a] High
Respondent	239	120.00	69.138	0	.0	0	0
DateofBirth	175	1985.43	8.534	64	26.8	1	0
ElectricityExpenditure_Rands	210	2671.83	2906.120	29	12.1	0	14
ATT_1	197	4.17	1.191	42	17.6	21	0
ATT_2	193	4.25	1.190	46	19.2	21	0
ATT_3	196	4.40	1.148	43	18.0	18	0
ATT_4	196	4.33	1.135	43	18.0	20	0
ATT_5	196	4.41	1.075	43	18.0	15	0
SP_1	173	4.35	.931	66	27.6	10	0
SP_2	181	4.17	.986	58	24.3	12	0
SP_3	180	3.97	1.083	59	24.7	0	0
SP_4	180	4.04	1.100	59	24.7	0	0
SP_5	179	3.92	1.185	60	25.1	0	0
HK_1	176	3.99	1.088	63	26.4	0	0
HK_2	184	3.86	1.177	55	23.0	0	0
HK_3	185	3.50	1.166	54	22.6	12	0
HK_4	185	3.56	1.206	54	22.6	0	0
HK_5	185	4.29	1.001	54	22.6	16	0
BI_1	178	4.15	1.152	61	25.5	19	0
BI_2	183	4.22	1.132	56	23.4	20	0
BI_3	183	4.28	1.103	56	23.4	16	0
BI_4	185	4.44	.966	54	22.6	11	0
BI_5	185	4.17	.963	54	22.6	12	0
Gender	239			0	.0		
Education	239			0	.0		
Typeofhouse	239			0	.0		
Homestatus	239			0	.0		
Employment	239			0	.0		

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

Appendix 4 – Assessment of Normality from the AMOS Model

Assessment of normality (Group number 1)

Variable	min	max	skew	c.r.	kurtosis	c.r.
Household_Knowledge	1,000	5,000	-,963	-5,244	,670	1,825
Perceived_Social_Pressure	1,000	5,000	-1,402	-7,637	2,772	7,549
Household_Attitude	1,000	5,000	-2,120	-11,545	4,017	10,939
Behavioural_Intention	1,000	5,000	-1,515	-8,252	2,077	5,655
Multivariate					24,919	23,993