INTENTION TO ADOPT SOLAR ENERGY TECHNOLOGY BY TOWNSHIP SMALL, MEDIUM, AND MICRO ENTERPRISES (SMMES) IN SOUTH AFRICA

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DECLARATION

I, Sakhile Ngcongwane, declare that this research report 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 Management in Energy Leadership at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Signature:

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On the …………………………….. day of ………………………… 20…..

ABSTRACT

The South African township small, medium, and micro enterprises (SMMEs) are facing a significant challenge in achieving their net zero ambitions due to a prolonged and worsening electricity supply shortfall. This crisis has raised concerns about the adequacy of electricity access and alternative energy provision for township enterprises. A study was conducted to examine the intention to adopt solar energy technology by SMMEs, identifying the determinants of acceptance, evaluating their perceptions of RE electricity's potential, and proposing a model for solar energy technology acceptance. The study used an extended Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) to conduct a quantitative research design, with an online cross-sectional survey conducted across 72 township SMMEs in South Africa. The results of the study indicated that perceived ease of use, perceived usefulness, and perceived behavioural control were key factors influencing the intention to adopt solar energy technology among township SMMEs. Although a connection between trust in stakeholders and adoption intention was demonstrated, it was nonetheless found to have an insignificant direct impact. The study provides insights into the methodological challenges associated with quantitative exploration of technology adoption and, particularly, where they relate to measurement aspects. By investigating the intention to adopt solar energy technology, the study reaffirms the relevance and importance of technology adoption theories for illuminating relationships that identify the impact of technological innovations on society. Insights regarding the motivational and contextual factors that foster the uptake of solar energy technology by SMMEs can prove invaluable to policymakers and practitioners in the design of programmes to ensure a just energy transition.

KEYWORDS:

Energy, SMME, Solar Energy Technology, Technology Adoption, Township Economy

DEDICATION

This research is dedicated to my parents, Dikeledi Magdeline and Fana Lucas Ngcongwane; my siblings, Kuntha Khanyisile Ndimande and Mbalenhle Ngcongwane; my aunt; Puleng Adelaide Mokatsane, and my extended family and relatives – past, present, and future – of Ngcongwane, Mokatsane, Pooe, Mathebula, and Kasonga.

Ngcongwane, Ndimande Nkwankwa, "isambane esagubha umgodi sangawulala", Mvila, Maqeda, Mvundlela, Ndlovu, Mkhatshwana, "ayisitheli esithela ngendodakazi", nina bakwa Masombuka, nina bakwa Mabaso "Ngcongwane"

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ANC	African National Congress
AVE	Average Variance Extracted
DBSA	Development Bank of South Africa
DFFE	Department of forestry, fisheries and the environment
DME	Department of Minerals and Energy
DOE	Department of Energy
DOI	Innovation Diffusion Theory
EWSETA	Energy and Water Sector Education Training Authority
FAE	Formal Advanced Economy
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HTMT	Heterotriat-Monotrait Ratio of Correlations
ICTs	Information and Communication Technologies
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRP	Integrated Resource Plan
MIS	Modernising Informal Sector
NBI	National Business Initiative
NDC	Nationally Determined Contributions
NFI	Normed Fit Index
POPIA	Protection of Personal Information Act
RDP	Reconstruction and Development Programme

REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
RETs	Renewable Energy Technologies
SANEDI	South African National Energy Development Institute
SE	Standardized Errors
SEDA	Small Enterprise Development Agency
SEFA	Small Enterprise Finance Agency
SEM	Structural Equation Modelling
SETA	Sustainable Energy Technology Acceptance
SETA	Sustainable Energy Technology Acceptance
SMMEs	Small, Medium and Micro Enterprises
SRMR	Standardized Root Mean Square Residual
SSEG	Small-scale Embedded Generation
TAM	Technology Acceptance Model
TEA	Township Enterprise Alliance
TIS	Traditional Informal Sector
TPB	Theory of Planned Behaviour
UNFCCC	United Nations Framework Convention on Climate Change
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

1 INTRODUCTION

1.1 Context of the study

The impacts of anthropogenic greenhouse gas (GHG) emissions have been clearly and unequivocally linked to increased global temperatures, known as climate change (Wright, 2019). Among the predominant GHG is carbon dioxide (CO_2) and, as such, efforts to limit CO_2 emissions are central to reaching the global target of maintaining the global temperature at 1.5 ^{o}C (degrees Celsius) below preindustrial temperatures, first stipulated in the United Nations Framework Convention on Climate Change (UNFCCC) Cancun Agreement adopted at the sixteenth Conference of the People (COP16) in 2010 (IPCC, 2018). Subsequently, in 2015, the landmark Paris Agreement was adopted at the COP21 climate conference. The first of its kind, the Paris Agreement is a universal and legally binding global agreement that addresses climate change, where member states are party to commitments to reducing GHG emissions as a mitigation strategy against rising global temperatures. While all sectors of industry and society are pursuant to these mentioned commitments, the electricity sector is identified as among the more significant emitters – alongside heating and transport –and thus a focus area for emissions reduction (Wright, 2019). To this end, advanced economies have witnessed accelerated annual investment in renewable energy technologies in the last decade (International Energy Agency, 2022). These climate mitigation and adaptation efforts for the electricity sector are neatly aligned with the UN SDGs 13 and 7 – climate action and affordable and clean energy.

South Africa is a signatory to the Paris Agreement, and its role is defined in Nationally Determined Contributions (NDCs). In 2016, the Department of Forestry, Fisheries and the Environment (DFFE) set emissions reduction targets at 398 MtCO_2-eq and 614 MtCO_2-eq for 2025 and 2030 respectively, however in 2021 the targets were revised to range between 398 MtCO_2-eq and 510 MtCO_2-eq by 2025, and between 350 MtCO_2-eq and 420 MtCO_2-eq in 2030 (Presidential Climate Commission, 2021). Under pressure to respond to global climate change concerns – being among the top ten carbon emitting countries globally

(Lawrence, 2020) – coupled with a historic reliance on coal-based electricity, efforts to decarbonise South Africa's electricity supply sector have come quite a considerable way since the promulgation of the Integrated Resource Plan (IRP) in 2010 by the Department of Energy (DoE, 2011). Following the release of the IRP, the world-renowned renewable energy auction scheme known as the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) was launched in 2011 and, in the process, garnered global interest, which enabled significant international investment and signalled the commitment of the national government to move away from carbon-intense energy resources. Through the REIPPPP, several renewable energy technologies are allocated a predetermined volume with a pre-set maximum price cap per technology (Wright et al., 2019). Between bid windows one (BW1) and bid window four (BW4), 92 utility-scale solar and wind projects were awarded under REIPPPP, attracting a total investment of USD 20bn for 6.4GW of electricity capacity (IPP Office, 2021), as seen in **Error! Reference source not found.**.

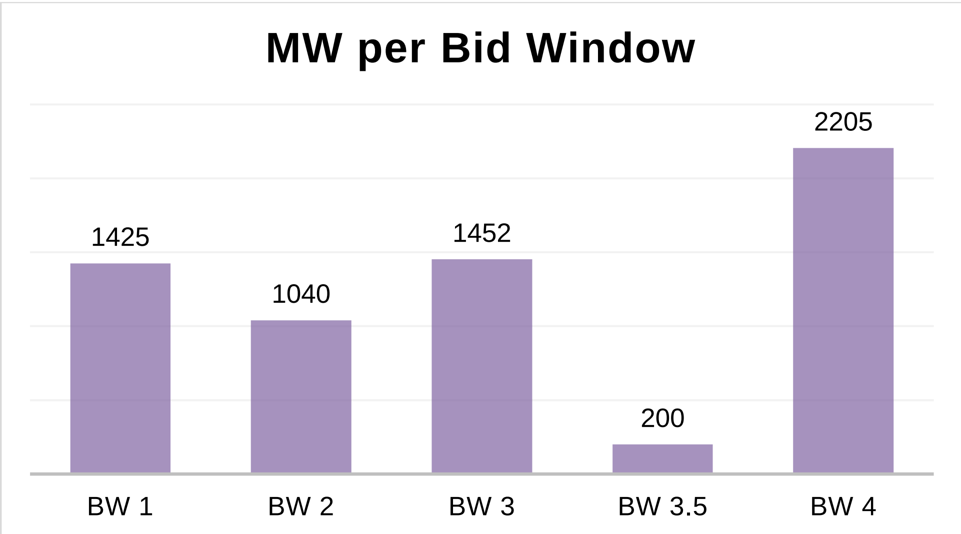

Figure 1: Megawatts procured per Bid Window
Source: IPP Office (2021)

Similarly, across all four bid windows of the REIPPPP, solar and wind emerge as the most bankable and cost-effective technologies (see **Error! Reference source not found.**), being procured at volumes of 2982 MW and 3357 MW, respectively.

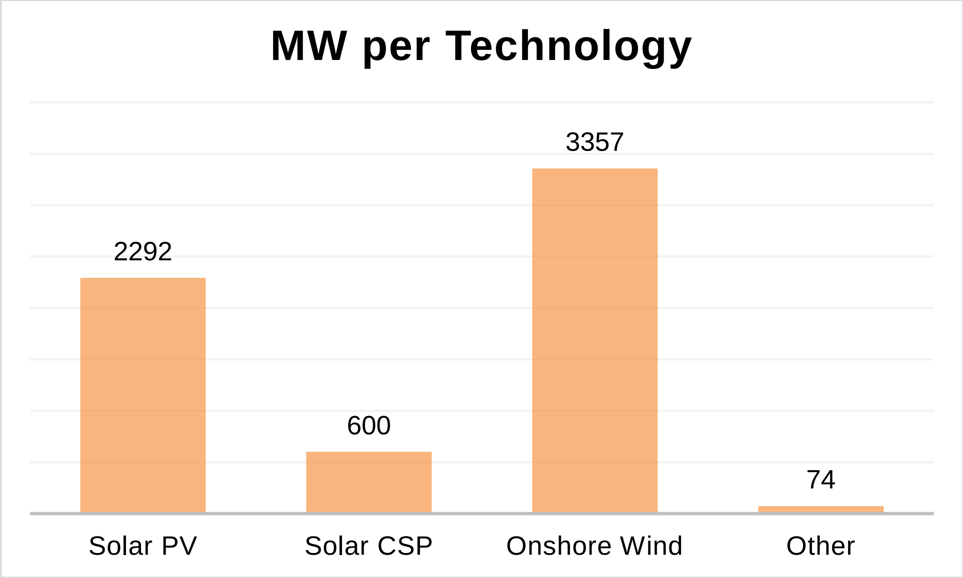

Figure 2: Megawatts procured per Technology

Source: IPP Office (2021)

This energy transition occurs against a worsening electricity supply shortfall at Eskom, the South African national electricity utility, precipitated by declining investment, an ageing coal-powered electricity generation fleet, and frequent unplanned operations and maintenance interruptions. Meanwhile, new thermal generation capacity, in the form of two 4.8GW coal-fired power station megaprojects, Kusile and Medupi, has been introduced to the grid with ongoing delays, at far higher costs than initially budgeted and with multiple technical failures (Bowman, 2020). Scheduled power outages, commonly known as "load-shedding", which debuted in 2008 as a mechanism to prevent energy system failure because demand tended to exceed supply, are now a permanent feature of Eskom's operations – appearing again in 2014, 2015, and since 2018. In 2021, Eskom imposed the most intensive load-shedding since 2008, with 1169 hours of outages recorded and 2521 GWh of energy shed, representing a 40% increase from 2020 (Omarjee, 2022). Furthermore, this persisting and worsening electricity supply shortfall is noted as having severely undermined South Africa's economic growth trajectory in the recent past by as much as 8 to 10%, which would have translated into an economy that is R360 billion to R450-billion larger, were Eskom not plagued by inefficiencies (Stofberg, 2021).

As a forerunner, solar energy technology has proven itself to be an essential driver of the energy system transition to low-carbon energy sources, being the least cost technology compared to new thermal and nuclear energy capacity and offering consumers much-appreciated respite from rising energy prices (Wright, 2019). These gains, together with its versatility of application, have enabled rapid uptake of solar energy technology across most sectors in supplementing unreliable grid electricity, achieving higher energy security, and realising cost savings over the long term (Field, 2021). One such sector of the economy that could benefit from the advantages of solar energy technology is the township economy, whose primary commercial actors are small, medium, and micro enterprises (SMMEs).

Moreover, within the context of a constrained centralised energy supply and the mandated moves to low-carbon energy resources, what are the enablers and barriers of solar energy technology adoption by township SMMEs? In addition, how do township SMME owners view distributed solar energy as an alternative to centralised supply? Against this background, this study sought to examine the determinants of renewable energy deployment through a literature review. Furthermore, it supports this with empirical data obtained from investigating the intention to adopt solar energy technology by South African township SMMEs.

1.2 Research problem

South Africa's commitment to achieving its Nationally Determined Contributions targets framed under the Paris Agreement is hamstrung by an ongoing reliance on coal-based electricity generation (Hagele, Iacobuţă, & Tops, 2022). This situation is exacerbated by a centralised electricity supply shortfall characterised by routine power outages, commonly referred to as load shedding, which threatens the nation's energy security (Lawrence, 2020).

As demonstrated by load-shedding, Eskom's constrained centralised electricity supply is linked to South Africa's low growth trajectory, costing the economy approximately R700 million per stage daily (Arnoldi, 2022). Solar energy technology is regarded as capable of alleviating a supply shortfall while also responding to the global shift to low-carbon energy sources (Qamar, Ahmad, Oryani, & Zhang, 2022).

Despite the adoption of renewable energy technologies being advocated by all sectors of the economy, not enough has been established about the attitudes and perceptions of South African township SMMEs about the uptake and utilisation of solar energy technology as supplementary or alternative to intermittent centralised electricity supply for their business operations.

As such, within the general problem of a carbon-intensive centralised electricity system experiencing a supply shortfall, the specific research problem investigated the adoption of solar energy technology by South African township SMMEs.

1.3 Research objectives

i. To identify the determinants of solar energy technology acceptance by South African township SMMEs.

ii. To evaluate township SMMEs' perceptions of the potential for RE electricity to remedy inadequate electricity access.

iii. To provide a framework for solar energy technology acceptance by township SMMEs.

1.4 Significance of the study

In much of the popular media and academic literature, there is widespread acknowledgement of the dire state of centralised electricity supply in South Africa and ample evidence of solar energy technology as a viable and affordable source of electricity (Adenle, 2020). However, the extent to which solar energy technology can be a reliable and credible alternative to centralised electricity supply for township SMMEs is only partially appreciated. Uncovering this knowledge – *intention to use solar energy technology adoption by township*

SMMEs – contributes to energy access and technology adoption literature by providing an academic perspective of challenges faced by small businesses within the supply-constrained urban and peri-urban areas in South Africa. Additionally, recommendations therein can be applied to the design of public policy aimed at improving solar energy utilisation. Ultimately, the uptake of solar technology by businesses in the SMME sector of South Africa can serve as a conduit to addressing unemployment and low economic growth brought about by the centralised electricity supply crisis (Adenle, 2020).

Establishing a link between the centralised electricity supply shortfall and the uptake of solar energy technology by township SMMEs illuminates vaguely understood issues surrounding the adequacy of access to electricity in townships, thereby contributing perspectives to the just energy transition debate that emerges from the township economy. Further justification for emphasizing the impact of the centralised electricity supply shortfall on township SMMEs is to draw attention to the sparseness of literature observing the unfolding clean energy transition as it occurs within South Africa's township economy and its disproportionate burden on township SMMEs. This report details an empirical study undertaken to analyse solar energy technology acceptance and adoption by township SMMEs using quantitative techniques.

1.5 Delimitations of the study

While the geographic locale of the study sought to cover the length and breadth of South Africa's townships, it was constrained by the extent of propagation of the online research instrument owing to the modalities used to disseminate it. The township economy has existed as the primary marketplace for the township SMMEs under investigation (Wiid & Cant, 2021b), wherein concepts and constructs were derived from adoption and diffusion theory to provide the theoretical basis of interpreting township SMME perceptions toward the uptake of solar energy technology. Both formal and informal enterprises with an existing grid connection were considered in this study.

1.6 Definition of terms

Township

Township refers to underdeveloped urban areas emerging out of racial segregation policies in the late 19th century and continued until the end of apartheid. In addition, townships include areas developed post-apartheid through the housing subsidy programme, known as the Reconstruction and Development Programme (RDP), typically situated at a distance from economic opportunities (Mahajan, 2014).

Township Economy

The township economy is circumscribed by the township, referring to any businesses and markets based in townships. A high rate of informality and microeconomic activities characterise enterprises within the township economy (Cant & Rabie, 2018).

SMMEs

In this study, SMMEs refer to enterprises with fewer than 50 paid employees and an annual turnover of less than 50 million South African Rand, irrespective of their registration under law or tax.

Technology Adoption

Technology adoption here is defined as the successful integration of new technology into the township enterprise from both a psychological and managerial perspective, thus encompassing individual and intermediate levels.

1.7 Assumptions

It was assumed that all enterprises identified in this research use electricity among their dominant sources of energy for productive and operational use. Furthermore, the siting of large-scale renewable energy plants in South Africa has occurred in areas far removed from townships. As such, this bias was assumed to be ongoing and to persist in future.

The most feasible and implementable renewable energy technology for township enterprises assumed by this research is solar energy technology, which enjoys the largest market share of embedded generation. It was also assumed that township SMMEs investigated in this research are founded, owned, and managed by current and former residents of township settlements.

1.8 Structure of the report

The chapters of this report are structured to fulfil the research objectives of the report and present data in the sequence it was obtained. Chapter 1 serves as an introduction to the study and outlines the research's problem, objectives, and significance. Chapter 2 comprises a literature review, evaluating the determinants of the adoption of renewable energy technologies, the perceptions of SMMEs regarding renewable energy, and providing insights about the township economy and its challenges. The third chapter establishes the research methodology applied to this research, and Chapter 4 presents a summary of the results of this study. Chapter 5 discusses the findings, and the sixth chapter concludes the study and offers implications and policy recommendations from insights gained about solar energy technology applications in the township economy. A reference list follows this last chapter, and appendices are found at the end of this research report. Figures and tables are numbered consecutively throughout the report.

2 LITERATURE REVIEW

2.1 Introduction

The case for the uptake of renewable energy technologies is established in the literature, which broadly advocates for increased diffusion and adoption by all sectors in transitioning toward lower carbon economies. This section of the study sought to review the extant literature on the determinants of renewable energy technology and evaluate small business owners' perceptions of renewable energy electricity utilisation. This chapter consists of five sections. A review of the literature on renewable energy technology adoption followed by an exploration of the perceptions and attitudes of SMMEs towards the adoption of renewable energy technology. The third section reviews South African township economy literature, while a conceptual framework – based on selected technology adoption and diffusion theories – describing the adoption of solar energy technology by township SMMEs is proposed in the fourth section. Concluding the chapter is a summary of the literature reviewed.

2.2 Determinants of Renewable Energy Technology Adoption

To capture the myriad factors that influence the adoption of renewable energy, this study borrowed from the comprehensive literature review on determinants of renewable energy deployment undertaken by Bourcet (2020). This was chosen as a framework for which determinants were investigated and distinguished because of its rigour and consolidated approach in the analysis and synthesis of extant literature. Before determining whether a particular factor positively or negatively influences the adoption of renewable energy technologies, its measurement is distinguished as contributing to either an absolute or a relative idea of renewable energy technology adoption. In this regard, the difference is reflected in the substitution potential of renewable energy technologies to replace fossil fuel sources and occupy an increasing share of the energy mix (Bourcet, 2020). This review considers both the absolute and relative growth of renewable energy technologies as determined by factors considered to be instrumental to their overall adoption and diffusion.

Literature on the determinants of renewable energy adoption has identified a multitude of mechanisms of interest to scholars, which necessitated only the selection of those factors that play an instrumental role in influencing adoption. Bourcet (2020) has distilled these various mechanisms and presented them in six main categories comprising economic, environmental, energy, regulatory, political, and demographic factors. These factors are considered in detail below.

2.2.1 Economic factors

2.2.1.1 Income

According to Bourcet (2020), the main economic variable – initially identified by Sadorsky (2009) – influencing the adoption of renewable energy is GDP. As an indicator of national income, a higher GDP is linked to higher energy demand and a resultant increase in RET deployment. Furthermore, large-scale adoption of renewable energy technologies (RETs) requires significant amounts of capital such that a higher GDP would enable affordability and increased mobilisation of RETs. The literature on determinants reveals an unexpected situation in this regard. For developing countries, GDP appears to positively influence RET adoption (Aguirre & Ibikunle, 2014; Pfeiffer & Mulder, 2013; Rafiq, Bloch, & Salim, 2014). However, in the developed economies of Europe, evidence of a negative effect of GDP on the adoption of RETs is found (Bourcet, 2020). This is attributed to the pace of energy demand in developed countries exceeding the capacity of RETs to adequately meet this sustained demand, which results in increased production from conventional energy sources. In a systematic review of studies investigating the impact of income on renewable energy deployment, (Dutta, Chand, & Huybers, 2022) found heterogeneity in income elasticity estimates across publications. Furthermore, they report that the mean income elasticity of developed economies is higher than the global average, thus supporting the notion that developed countries exhibit greater deployment of renewable energy to improve environmental quality.

2.2.1.2 Fossil Fuel Prices

The influence of energy prices on renewable energy deployment is another category of economic factors that are of interest in the literature on determinants. The effect of fossil fuel prices on RET adoption is expected to be positively correlated, where higher prices enable the substitution of traditional fossil fuels with renewable energy. On the contrary, scholars have found that fossil fuel prices have a negative effect on the adoption and deployment of RETs (Aguirre & Ibikunle, 2014; Bourcet, 2020; da Silva, Cerqueira, & Ogbe, 2018). According to da Silva et al. (2018), the reasons are two-fold: high-income countries absorb higher energy prices better than lower-income economies, thus raising the threshold of the impact of fossil fuel prices on RET adoption. Secondly, fossil fuel price increases in lower-income countries divert resources from investing in renewable energy infrastructure. Moreover, a study by Chang, Huang, and Lee (2009) finds that a positive effect of energy prices on the renewable energy supply exists only in countries that have undergone high economic growth in a previous period.

The negative of fossil fuel prices on RET adoption is further attributed to the type of fossil fuel, where coal and gas prices are found to be negatively associated with renewable energy deployment, while the oil price is found to boost RET adoption (Tee, Chin, & Abdul-Rahim, 2021).

2.2.1.3 Financial Sector Development

The level of financial sector development has been identified as a facilitator of RET adoption. The literature applies varying indicators to capture the maturity of local financial markets. For Brunnschweiler (2010), the development of the banking system is an enabler of RET adoption and deployment. However, this is found not to be the case in a study that investigates the diffusion of RET in developing countries (Pfeiffer & Mulder, 2013). Bourcet (2020) argues that these opposing findings are explained by the number of indicators measured in relation to the local financial sector, where observing fewer than two indicators results in no significant relationship with RET adoption. Where three or more indicators of financial sector development are measured, a positive association with RET deployment is observed. Recently, however, a study modelling the determinants of RE consumption across five of the most populous African states. (Akintande, Olubusoye, Adenikinju, & Olanrewaju, 2020) found the domestic credit provided by the local banking sector to be the only encouraging factor for South Africa.

2.2.2 Environmental factors

2.2.2.1 Carbon dioxide emissions

There has been considerable interest in exploring environmental determinants of RET adoption, with CO_2 emissions emerging as the widely used proxy – also introduced by Sadorsky (2009). A rise in CO_2 emissions is anticipated to facilitate the adoption of RETs such that low-carbon economic policy would compel households and businesses to consider and subsequently implement alternative energy sources. Surprisingly, empirical studies have concluded that CO_2 emissions negatively influence the adoption of RETs in emerging and developing economies (da Silva et al., 2018; Pfeiffer & Mulder, 2013). da Silva et al. (2018) suggest that environmental concerns such as CO_2 emissions represent a lesser priority for these countries, owing to the ratification of the Kyoto Protocol, which places socioeconomic development ahead of the impact of CO_2 emissions. Moreover, fossil fuel dependency is well entrenched and supported by established lobbying that effectively neutralises the effect of renewable energy policy and advocacy (Lucas, Francés, & González, 2016). Indeed, Bourcet (2020) confirms that overall, as evinced in a review of the literature, CO_2 emissions exert a negative effect on RET adoption.

Through a panel study, Hao and Shao (2021) confirm that countries with carbon-intensive economies exhibit low renewable energy deployment, once more linking this to the long-standing influence of the fossil fuel industry.

2.2.3 Regulatory factors

2.2.3.1 Public policies

The role of regulation is to stimulate markets by guiding participants to behave in an ethical manner while enabling the growth of the market and minimising failures. To account for the impact of regulatory factors that influence RET adoption, the literature investigated the role of energy and environmental policies that support the deployment of RETs. Particularly, public policy that is supportive of renewable energy positively influences the adoption of RETs as a share of the total energy supply (Bourcet, 2020). This illustrates the significance of the relative approach to measuring RET adoption by way of targets within the energy mix because it indicates the substitution capability of conventional energy sources with renewable energy sources. Liobikienė, Dagiliūtė, and Juknys (2021) noted that government aid in the form of subsidies enhances the usage intention of RETs.

In addition to national public policy, scholars have explored the effect of supranational policies such as the 1997 Kyoto Protocol – an international treaty aimed at combating climate change. Ratification of the Kyoto Protocol is assumed to signal a commitment by countries to limit global warming and promote the adoption of renewable energy (Brunnschweiler, 2010). Empirically, the influence of the Kyoto Protocol is positive for the adoption of RETs (Bourcet, 2020; Pfeiffer & Mulder, 2013).

2.2.4 Political factors

2.2.4.1 Political stability

As required for investment in all other assets, a country's political circumstances exist as either a catalyst or a deterrent for the adoption of RET. Stable democracies with a leftist orientation are found to have a positive association with the uptake of RETs (Nicolini & Tavoni, 2017; Pfeiffer & Mulder, 2013). This is consistent with the view (Brunnschweiler, 2010) that political stability, sound regulation, and secure property rights enable investment in RETs. Furthermore, the quality of governing institutions is expected to be positively related to the adoption of RETs (Wu & Broadstock, 2015). Overall, when these political variables are considered together, they positively influence RET adoption. In South Africa, the political economy surrounding electricity supply has seen the national utility refusing to undertake power purchase agreements with IPPs in REIPPPP, with the consequence of three suspensions of utility-scale renewable energy auctions (Baker & Phillips, 2019; Jain & Jain, 2017).

2.2.5 Energy factors

Several variables assessing the impact of energy-related factors have emerged in literature, with energy intensity, energy security, and fossil fuel production being the dominant among them.

2.2.5.1 Energy Intensity

The energy intensity of a country is expected to positively influence the growth of renewable energy, even as it would facilitate the growth in the use of conventional energy sources as well. When combining all forms of renewable energy, Bourcet (2020) estimated that increased energy consumption supported RET adoption. This is contradicted by findings by Pfeiffer and Mulder (2013) that a "robust negative relationship between growth in electricity consumption and the amount of NHRE (non-hydro renewable energy)" (p. 294), which they attribute to developing countries looking to fossil fuels to meet their projected energy demand. In support of Bourcet (2020), later research finds that energy intensity is an indicator of development (da Silva et al. (2018), with electricity consumption specifically linked to increased RET utilisation in the five most populous nations in Africa, which South Africa is among (Akintande et al., 2020). In a study exploring the effects of RET development on energy intensity, Yu, Liu, Hu, and Tian (2022) find that for every 10% rise in RE development, there is a 0.3% decrease in energy intensity; however, a threshold of 10.58 million MJ of RET consumption distinguishes low RE development states from high RE development states.

2.2.5.2 Energy Imports

As a proxy for energy security, energy imports are expected to inhibit RET adoption. This is confirmed by da Silva et al. (2018), noting that countries would sooner adopt conventional energy sources to resolve energy security concerns than RETs since the latter are still expensive. This persisting view about the high cost of RETs is another demonstration of the powerful lobbying capacity of the fossil fuels sector (Marques & Fuinhas, 2012).

2.2.5.3 Fossil Fuel Production

While it would be expected that fossil fuel production would negatively influence the uptake and deployment of RETs, the literature is split on its overall effect. Whereas local fossil fuel production in developing countries acts as a barrier to RET adoption (Pfeiffer & Mulder, 2013), it is suggested that the finiteness of fossil fuel resources and the rapid depletion thereof is likely to accelerate investments in RETs and uptake thereof (Romano & Scandurra, 2014).

When considering fossil fuel production for the use of electricity generation, Tee et al. (2021) noted a difference in the impact on RET deployment based on the type of fossil fuel – oil and coal production exhibit a negative relationship to renewable energy deployment. In contrast, natural gas production is seen to stimulate renewable energy.

2.3 Perceptions of SMMEs toward renewable energy technologies and their energy access

This section investigates SMME owners' perspectives toward implementing renewable energy technology for their businesses. The role of SMMEs in catalysing economic growth is well established in literature and practice, which is further emphasised by their central role in efforts aimed at attaining economic growth and sustainable development (Oguntona, Aigbavboa, Monnanyana, & Thwala, 2021). While the previous section explored the factors that influence the adoption of RETs, this section reviews the literature concerning the perceptions and attitudes of SMMEs specifically.

2.3.1 Awareness of renewable energy technologies

It appears that a lack of knowledge and awareness of the benefits and risks of renewable energy technology is the primary mediator of the decision by SMMEs to adopt RETs (Adepoju & Akinwale, 2019; Memka & Lekhanya, 2017; Rahbauer, Menapace, Menrad, & Decker, 2016; Rahbauer, Menapace, Menrad, & Lang, 2018; Segura, Ríos, Rivera, de la Rosa, & Zárate, 2016). These perspectives are shared by SMMEs in various geographic regions, with literature reaching consensus on the need for policymakers to communicate the importance of RETs to SMMEs in a coherent and consistent manner. In Germany, Rahbauer et al. (2016) found that SMMEs employ both economic and psychological resources, including environmental awareness and altruism, when considering the adoption of green electricity – defined as electricity generated from renewable energy sources. The case is similar for the rest of European SMMEs, for whom Segarra-Blasco and Jove-Llopis (2019) find that RET adoption is linked to public support and environmental awareness of the firms. This lack of awareness of the benefits and risks of RETs has been attributed to limited access to relevant information for SMMEs in Mexico (Segura et al., 2016). Adepoju and Akinwale (2019) corroborate this, noting that the leading driver of adopting RETs is knowledge and awareness of the technology by SMMEs in Lagos State, Nigeria. Generally, awareness of RETs is supported by concern about environmental problems (Liobikienė et al., 2021). Wall, Khalid, Urbański, and Kot (2021) support this, finding that awareness of climate change issues has a significant positive effect on the adoption of RETs.

2.3.2 Trust

Trust encapsulates the perceptions about the functioning of the system that facilitates the use of renewable energy technology. In this sense, the perceived reliability of the various stakeholders in the RET value chain influences the SMME's decision to invest. According to Rahbauer et al. (2018), trust that distribution systems will be continually available was demonstrated in SMMEs that adopted green electricity. This is consistent with perceptions of SMMEs in Lagos State, Nigeria, where trust in the stakeholders of RET was measured directly in a study by Adepoju and Akinwale (2019) and found to be influential to the willingness to adopt RETs. Furthermore, trust is also expressed as a positive attitude toward RETs and their environmental impact. The propensity to adopt green innovation practices, including renewable energy technology, is driven by the sustainability orientation of the SMME in relation to its assumed environmental responsibility (Aboelmaged & Hashem, 2019). Additionally, SMMEs with a positive attitude toward RETs, perceiving them as having cost savings potential, are more likely to adopt the technologies (Kortelainen, Ratinen, & Linnanen, 2012). In addition, Wall et al. (2021) found that trust is considered a catalyst of new technology adoption with the expectation of a beneficial exchange between adopters and the parties involved.

2.3.3 Cost of Adoption

The financial undertaking of adoption influences the perceptions that SMMEs have about RETs. Rahbauer et al. (2018) found that the perceived price of green electricity was the most decisive factor for adoption for German SMEs. Understandably, a higher price for electricity generated from renewable energy sources will be viewed unfavourably, thus lessening the likelihood of adoption. For many SMMEs, the adoption of RETs entails high switching costs from conventional sources, which can override altruistic and environmental awareness intentions, thus reducing their appeal (Segarra-Blasco & Jove-Llopis, 2019). In some instances, the perception of high investment costs is inflated when compared to the actual costs of an RET system, as found to be the case with Kenyan SMMEs (Bijvoet, 2018)

For SMMEs in Pakistan, the cost of adoption – encapsulated as the price of solar energy technology – is associated with a negative impact on the adoption and diffusion of RETs (Qamar et al., 2022).

2.3.4 Competing priorities

Finally, SMME attitudes towards RET adoption are further evaluated by deciding whether to implement RET solutions when made available. The literature indicates that organisational behaviours determine the likelihood of SMMEs eventually adopting RETs. Since the determinants and perceptions of RET adoption, respectively, represent a tension between structural and psychological factors, SMMEs face competing and often conflicting priorities with respect to investment decisions (Bijvoet, 2018). The interaction of adoption factors and their influence on one another, introduces complexity to the decision-making process of SMMEs, which is under-represented in existing literature (Rahbauer et al., 2016). According to Schroeder, Van de Ven, Scudder, and Polley (2000) cited in (Harkema, Leloux, Popescu, & van Santen, 2015), the rate of technology adoption relies on "strategy, structure, resources, and politics" which, for many SMMEs, is a privilege that they do not enjoy since they operate on short-term planning cycles that favour investment in production processes. Ofori, Aboagye, Afful-Dadzie, and Bokpin (2022) note that since SMEs are primarily focused on production and profitability, they seldom have the time and laxity to pay attention to their energy systems. Bijvoet (2018) echoes this sentiment, noting that Kenyan SMMEs prioritised investments in value-adding activities rather than cost-saving initiatives, where the latter includes investment in RETs. In contrast, microenterprises in Germany were found to be more likely to adopt green electricity compared to large SMEs, a situation attributed to their similarity to households whose decision-making processes are regarded as informal and have fewer actors involved (Rahbauer et al., 2018).

2.4 Township Economy and the Just Energy Transition

2.4.1 Townships

In South Africa, townships have their origins under the apartheid regime through the Group Areas Act of 1950, which introduced racial classification and enforced segregation of residential areas (Essex & de Groot, 2019). Established as an enclave of unskilled labour intended to supply urban economic centres and existing as areas of underdevelopment and informality. Townships are economically and politically significant in South Africa, and yet they continue to lurk on the margins, unable to attract formal private investment (Rakabe, 2017). The consequences of past neglect, overpopulation, poor investment and isolation from urban areas remain evident in townships, which are characterised by a lack of infrastructure and resources and high levels of unemployment (Bvuma & Marnewick, 2020). In addition, South African townships are geographically distant from urban economic centres and continue to serve as labour reservoirs (Tshuma, 2022).

2.4.2 Township Entrepreneurship and Economic Activities

Township economies emerging from the township setting differ from the broader mainstream economy (Wiid & Cant, 2021a). Borrowing from Ranis and Stewart (1999), the township economy is similarly conceptualised as an urban informal sector with a dichotomous structure comprising a traditional informal sector (TIS) and a modernising informal sector (MIS). The traditional informal sector is regarded as a stagnant economy associated with very low capitalisation, low labour productivity and low incomes, very small size (three or fewer workers), and static technology (Ranis & Stewart, 1999). In contrast, the modernising informal sector is capital-intensive, usually larger in size (as many as ten workers), more dynamic in technology, and often linked to the urban formal sector. The MIS often competes with the formal economy in lower-end consumer goods, while it is complementary to the formal economy through the production and trade of intermediate low-end capital goods (Ranis & Stewart, 1999).

In the South African context, Mahajan (2014) notes that the township economy dichotomy is spatial expressed with the TIS largely found in informal settlements and characterised by "low productivity, very low capital intensity, and unreliable or no electricity connection; lacks its own transport, relying on expensive private commercial transport facilities, has limited use of technology; lacks bank accounts and access to formal credit, offering only membership in informal savings clubs; largely comprises household-sector enterprises (with not more than one or two paid workers); has proprietors likely to have less than a high school education who, if given a choice, would pick stable salaried employment in the formal sector" (p.55). Unsurprisingly, the MIS is situated in larger urban townships "using moderate levels of technology (perhaps an Internet connection and e-mail use), own transport (but not for shipment of goods), reliable electricity connection, requires a proper business premise (either owned or rented) on land with a title deed, an owner or proprietor with at least a high school education, provides products and services that complement and do not compete with those of the formal advanced economy (FAE) (with the informing micro enterprises supplying intermediate goods and contract services to the FAE), has motivated owners and proprietors who would prefer running a business over salaried employment, access to informal and some formal credit, albeit at relatively high cost" (Mahajan, 2014), p.55).

(Battersby & Marshak, 2016), emphasising that township enterprises enable access to a growing segment of low-income consumers with a large collective spending power.

Officially, the plight of township enterprises is recognised and addressed through a range of supportive policies. For instance, in 2017, Preferential Procurement Regulations sought to enable competition and promote market access for township SMMEs through state procurement by setting a target of 30 % to be sourced from township enterprises (Tshuma, 2022).

Ultimately, the South African township economy comprises a diverse composition of multi-sectoral enterprises of varied sizes and productive capability, with owners of different backgrounds and aspirations (Rakabe, 2017).

2.4.3 Township Economy Sustainability

A growing interest in highlighting township entrepreneurs' opportunities and constraints is evident in the literature (Bvuma & Marnewick, 2020; Kubone, 2019; Udimal & Biyase, 2021; Wiid & Cant, 2021a). The challenges noted by township SMMEs emphasise a generalised lack, including a lack of access to resources, infrastructure, and skills, which constrain many of them from unlocking their full potential or generating wider economic benefits (Wiid & Cant, 2021a). As a sector, the township economy has been viewed as a vehicle to catalyse vast employment opportunities and have an instrumental role in uplifting communities (Bvuma & Marnewick, 2020). Furthermore, enabling the sustainability of township SMMEs is associated with the emergence of a vibrant and socially inclusive economy (LGSETA, 2020).

Although the literature reveals that SMMEs in South Africa may generally share common challenges, such as poor access to finance, they also have unique challenges that may be influenced by their environment and historical background (Bvuma & Marnewick, 2020). In recognition of the peculiar challenges confronting township SMMEs, the Gauteng provincial government embarked on a Township Economy Revitalisation Strategy in 2014, which sought to facilitate and enable a conducive environment within townships addressing seven strategic focus areas namely (Gauteng Provincial Government, 2013):

1. Ensuring an appropriate legal and regulatory framework
2. Promoting manufacturing and productive activities
3. Economic infrastructure support and clustered enterprise development
4. Promoting entrepreneurship development
5. Financing and investing in the township economy
6. Promoting access to markets
7. Promoting innovation and indigenous knowledge systems

Subsequently, in May 2022, the Gauteng Township Economic Development Act was passed into law with the aim of empowering townships to transition from their historical origins as labour dormitories and modern-day reserves of unemployment into active economic centres that can support inclusive self-employment creation (Tau, 2022).

2.4.4 Township Entrepreneurs and Technology Adoption

The uniqueness of township economic activities appears in technology adoption literature as well. Bvuma and Marnewick (2020) investigated township SMME adoption of information and communication technologies (ICTs), finding that Township SMMEs require unique interventions when encouraging them to fully adopt ICTs. Meanwhile, using the Energy-Economic Model (Samouilidis & Mitropoulos, 1982), it was found that the uptake of solar-powered LED lighting technology by small businesses in the Kraaifontein township of Cape would reduce energy poverty and help them realise increasing profitability as they were able to extend operating hours, modify their business processes, and decrease their energy costs (Maphosa, 2018).

Several studies of the adoption of solar and other renewable energy technologies by SMMEs in other developing countries with similar low-income conditions are found in the literature. For instance, in Senegal, using the Unified Theory of Acceptance and Use of Technology (UTAUT), Apfel and Herbes (2021) found that addressing the internal capabilities and external support for entrepreneurs is vital to the decision about the adoption of renewable energy technologies. In the Ghanaian capital city of Accra, Ahenkan, Alhassan, and Boon (2021) cite an inadequate institutional and policy framework as barriers to solar energy technology adoption and the growth of a solar energy market. Further afield, in Pakistan, perceived relative advantage, environmental motives, technical reliability and durability, enterprise size, factual attitude towards the environment, customer preference, and eco-labelling are noted as being encouraging of solar energy technology adoption, whereas perceived cost and energy intensity emerged as barriers to adoption of RET (Qamar et al., 2022).

2.4.5 Township Economy and the Energy Transition

The Energy Action Plan, proposed by South Africa's President Cyril Ramaphosa on July 25th, 2022, outlines a raft of policy and regulatory interventions to resolve the persisting and severe electricity supply shortfall and accelerate a wholesale transition to low-carbon energy sources. The impact of the supply shortfall cannot be overstated. Moreover, townships in major cities suffer considerable energy injustice, and most need energy security and availability (Todd & McCauley, 2021). For the township economy, the problem is crystallised by township SMMEs noting unreliable, inadequate and costly electricity as among the critical barriers to the future sustainability of their businesses (Wiid & Cant, 2021a). This is an argument echoed by Udimal and Biyase (2021), who found that the cost and supply of electricity pose a major impediment compared to other constraints (such as access to finance and other perceived constraints) for township SMMEs.

Indeed, small businesses are more vulnerable to power constraints than large ones (Aterido, Hallward-Driemeier, & Pagés, 2011). According to a Nedbank report, compiled in collaboration with the Township Entrepreneurs Alliance, which surveyed over 200 township SMMEs, almost two thirds (64%) of township enterprises are forced to halt operations, in their entirety, when load-shedding occurs which negatively impacts revenues, employee productivity, and oftentimes results in equipment damage due to unpredictable power supply (Nkonde, Vezi-Magigaba, & Ayandibu, 2023). Furthermore, (Wiid & Cant, 2021a) found that limited access to financing, adequate infrastructure, and training were the main constraints faced by township SMMEs in pursuit of economic growth, suggesting an asymmetry of access, in general, that weighs down on South Africa's township economy. This circumstance is exacerbated by declining investment in centralised electricity generation infrastructure and rising cost of supply. Thus, transitioning to low-carbon, cheaper energy sources such as solar energy technology is becoming urgent and unavoidable.

2.5 Theoretical and Conceptual Framework

Having reviewed the literature on the determinants of RET adoption as well as literature concerning the perceptions of SMME owners toward the utilisation of RETs in the previous two sections, this section endeavours to formulate a conceptual model for which the mechanism of adoption of solar energy technology by South African township SMMEs can be interpreted.

Renewable energy technologies have proven vital to sustainable economic development, ensuring the resilience of households and enterprises and maintaining the ecological integrity of the natural environment. As a means to achieve these objectives, scholars have sought to understand and present the adoption and diffusion of RETs by applying various theories of technology adoption (Alam et al., 2014; Elmustapha, Hoppe, & Bressers, 2018). Similarly, this study turned to the wider applied adoption and diffusion theories as the bedrock of the proposed conceptual model of the adoption of solar energy technology by township SMMEs.

While adoption and diffusion are often used interchangeably when referring to technology innovations, Sharma and Mishra (2014) urge for the distinction to be made apparent so that the subject of the study is clearly identified. In this instance, adoption refers to the use of a technology by individuals and organisations, whereas the diffusion of a technology refers to its proliferation in society (Rogers, 2010). Rather than seeking to explain the transmission of solar energy technology throughout society, this study examines the intention of its utilisation as an alternative or supplement to existing centralised electricity supply, thereby locating it firmly in adoption territory.

What follows is a review of the theories of adoption and diffusion considered in the formulation of the proposed conceptual model, which is then subsequently introduced.

2.5.1 Theories of Technology Adoption and Diffusion

2.5.1.1 Innovation Diffusion Theory (DOI)

As Rogers (2010), innovation diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system". Using five perceived attributes – namely relative advantage, compatibility, complexity, trialability, and observability – the spread of technological innovation throughout a social environment is measured. The diffusion of innovation theory emphasises the role of social influence in the adoption of technology and is applied to understand the rate of spread of innovations (Elmustapha et al., 2018; Sharma & Mishra, 2014). Rather than seeking to explain the diffusion of RETs in a social system of the township economy, the aim of this study is to provide perspective on the intention of small, micro, and medium enterprises to adopt RETs. Although perceived relative advantage is considered a determinant of technology adoption, which has been positively associated with the intention to adopt, (Alam et al., 2014) found it to be of low priority to consumers intention to adopt small-scale renewable energy.

2.5.1.2 Technology Acceptance Model (TAM)

A widely applied model to investigate technology adoption is the Technology Acceptance Model (van der Vleuten, Stam, & van der Plas) which is favoured for its parsimony in explaining the attitudes of users towards the adoption of a technology (Alam et al., 2014). TAM asserts that two attitudinal factors – perceived usefulness and perceived ease of use – predict behavioural intention to adopt. Perceived usefulness refers to "the degree to which a person believes that using a particular system would enhance his or her job performance" (Sharma & Mishra, 2014) which is considered a stronger predictor of intention to adopt than perceived ease of use, defined as "the degree to which a person believes that using a particular system would be free of effort" (Adepoju & Akinwale, 2019). For energy technologies, both usefulness and ease of use are found to be instrumental to both the intention to adopt and the adoption itself. Combining TAM with users' individual differences and their political orientation, Chen, Xu, and Arpan (2017) studied smart meter support and adoption in the US and found that usefulness is at once a strong predictor and mediator of intention to adopt. Meanwhile, ease of use is revealed to be significantly influential in the intention to adopt small-scale renewable energy in Malaysia (Alam et al., 2014).

2.5.1.3 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB) is based on an earlier model of acceptance known as the Theory of Reasoned Action, where acceptance is explained as the interaction of subjective norms and attitudes to determine behavioural intention to adopt (Sharma & Mishra, 2014). Subjective norm refers to perceived pressure to enact a behaviour, and attitude describes the degree to which engaging in behaviour is evaluated as either positive or negative (Haustein & Jensen, 2018). TPB extends this framework to include perceived behavioural control among the antecedents of behavioural intention, where perceived behavioural control refers to the perceived ability to perform a behaviour. TPB addresses the criticism that attitude is a relatively static construct and insufficient as a predictor of behaviour (Sharma & Mishra, 2014). The Theory of Planned Behaviour has been widely applied to evaluating technology adoption. For energy technologies, TPB has been extended and applied to investigate the adoption of battery-electric vehicles in Norway (Haustein & Jensen, 2018), small-scale renewable energy (Alam et al., 2014), and smart meters (Kranz & Picot, 2012).

2.5.1.4 Sustainable Energy Technology Acceptance (SETA)

Developed to conceptualise the acceptance of new energy technologies, the Sustainable Energy Technology Acceptance (SETA) framework is an extension of the Theory of Planned Behaviour, incorporating a wider range of psychological factors contributing to the attitude and behavioural intention of technology adoption. SETA is based on a review of various psychological theories underlying the acceptance of technological innovations (Huijts, Molin, & Steg, 2012). Among the theories comprising SETA include TPB, norm activation theory, hedonic motives, and perceived contextual factors of trust, fairness, knowledge, and experience. SETA captures the relationship between the factors in a framework illustrating their direct, indirect, and moderating effects on technology acceptance (Huijts et al., 2012). Moreover, scholars have applied and integrated SETA with other technology adoption models to investigate the acceptance of hydrogen fuel stations (Huijts, Molin, & van Wee, 2014), smart meters (Chen et al., 2017) and renewable energy (Kardooni, Yusoff, & Kari, 2016).

Of the evaluated models, this study combines TAM (Davis, 1989), TPB (Ajzen, 1991) and the SETA framework by Huijts et al. (2014) into an integrated framework describing the determinants of renewable energy technology by township entrepreneurs. These models are preferred because they seek to elucidate user attitude toward the technology (acceptability) and user intention to adopt it (acceptance) rather than the diffusion of the technology within society. The constructs of these models are deemed relevant to the elaboration of technology adoption and, through their integration, would enable the objective generalisation of the factors most influential to renewable energy uptake by township entrepreneurs.

Extensions of these models have been applied widely to explain the adoption of energy technologies, including residential renewable energy in Malaysia (Alam et al., 2014; Kardooni et al., 2016) and hydrogen fuel stations in the Netherlands (Huijts et al., 2014); and smart meter adoption in the US (Chen et al., 2017).

2.5.2 Conceptual Framework

While it would be ideal for Eskom's electricity generation fleet to supply all the consumers on its network consistently and reliably, and include a greater share of renewable energy sources to facilitate adequate access to modern, clean energy; the current reality is that the national utility suffers from a myriad of entrenched challenges that have resulted in a chronic supply shortfall that is manifested in routine and scheduled blackouts. Among the affected yet lesser investigated consumers are township SMMEs whose uptake and utilisation of solar energy technology could help alleviate the impact of a sustained centralised supply shortfall and, in addition, participate in the unfolding transition towards a low-carbon global economy (Qamar et al., 2022).

The literature review has revealed the various factors which are instrumental in facilitating and inhibiting the adoption of renewable energy technologies, together with an appraisal of the perceptions of small and medium business owners regarding the utilisation of RETs in their operations. Furthermore, the literature review has established the township economy and the prevailing infrastructure deficits confronting its commercial actors. This literature review suggests that intention to adopt a technological innovation is a good predictor of eventual adoption, which entails a complex interaction of behavioural, social, and economic factors. To this end, the identified determinants of the adoption of renewable energy technologies were found to include income/revenue, financial sector development, public policies, energy intensity, trust in the technology and its providers, awareness of renewable energy technologies, financial cost, and other competing business priorities.

To investigate the adoption of solar energy technology by township SMMEs, the literature review presented the theories of technology adoption and diffusion as the foundation for formulating a conceptual model that seeks to explain the mechanism of solar energy technology adoption in this research setting. The theories that were operationalised include the Theory of Planned Behaviour (Ajzen, 1991; Kim, Park, Kwon, Ohm, & Chang, 2014), the Technology Acceptance Model (Davis, 1989), and the Sustainable Energy Technology Acceptance Model (Huijts et al., 2012). In this instance, the intention to adopt solar technology by township SMMEs was the dependent variable, whereas the independent variables were drawn from the constructs of the technology adoption theories and incorporated psychological factors, including perceived costs, perceived ease of use, perceived usefulness, subjective norm, perceived behavioural control; as well as contextual factors – namely trust and policy incentives. A null hypothesis statement was formulated with each of these constructs, which was subsequently tested using an online survey as the preferred research instrument.

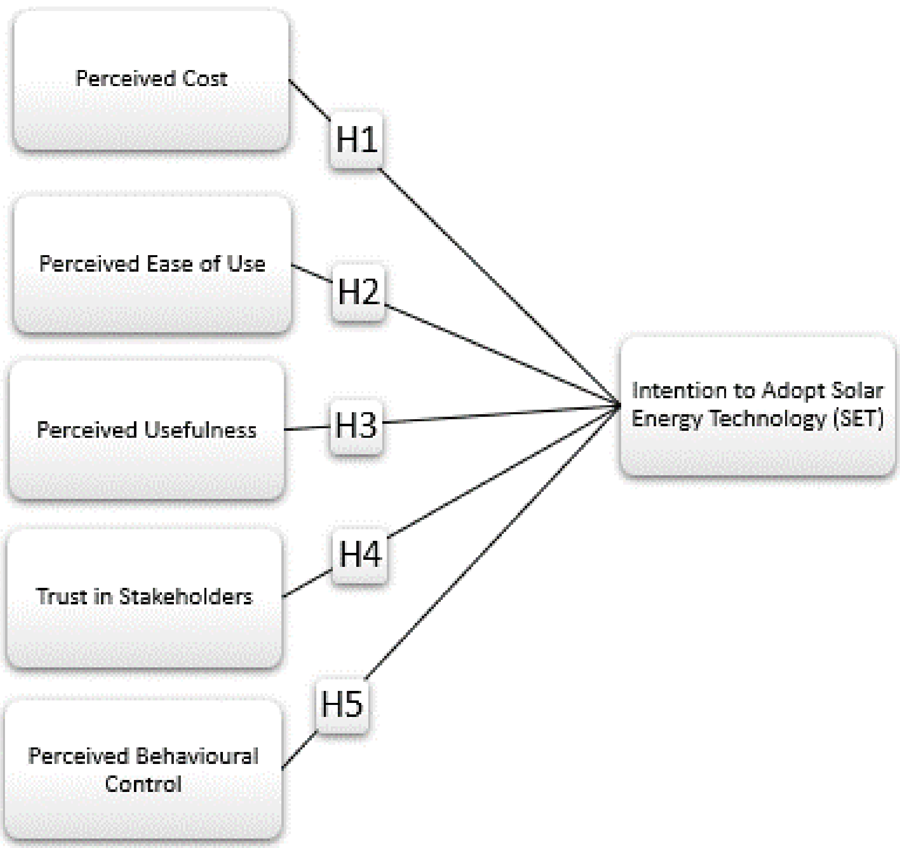

Figure 3: Conceptual framework for adoption intention of solar energy technology by township SMMEs

2.5.3 Hypotheses Development

2.5.3.1 Perceived cost

The costs associated with technology acceptance and use are crucial to the eventual adoption of technology. When costs are evaluated through the extension of technology adoption models, they consist of monetary and non-monetary aspects, including risks and benefits related to technology adoption (Huijts et al., 2012; Venkatesh, Thong, & Xu, 2012). Monetary costs refer to the cost of adoption and continued use of the technology, which is a predictor of technology acceptance and is found to have an inverse relationship with an intention to adopt new technology (Chen et al., 2017). Taken together, the evaluation of monetary and non-monetary costs of technology adoption are termed *perceived effects* by Huijts et al. (2012) in their SETA framework. Furthermore, previous studies on renewable energy technology adoption find the cost to be a significant determinant of adoption (Faiers & Neame, 2006; Kardooni et al., 2016; Qamar et al., 2022).

For these reasons, this study proposed the following hypothesis:
H1: Perceived cost influences intention to adopt solar energy technology.

2.5.3.2 Perceived ease of use

It is expected that consumers will consider the level of effort that accompanies the use of a new technology in their evaluation to adopt it. Perceived ease of use refers to the judgement of how easily understood, operated, and maintained a technological innovation is (Alam et al., 2014). Adepoju and Akinwale (2019) find that the willingness to adopt RETs is positively influenced by the extent to which the technology is considered simple to implement and enhance living standards. Furthermore, Alam et al. (2014) suggest that an effective quality control mechanism, together with an adequate understanding of the living standards of the target consumer, can ensure the ease of RET use. Verma, Bhattacharyya, and Kumar (2018) found that perceived ease of use is a significant predictor of attitude to perform a behaviour. Several studies (Bouaguel & Alsulimani, 2022; Fatoki, 2022; Qamar et al., 2022) note a significant positive relationship between perceived ease of use and intention to adopt renewable energy technology.

As such, this study proposed:
H2: Perceived ease of use influences intention to adopt solar energy technology.

2.5.3.3 Perceived usefulness

As a notable factor influencing technology adoption, perceived usefulness is relevant to this study as it relates to user perceptions of the impact of new technology on productive activities. Perceived usefulness is widely utilised in studies of technology acceptance within the organisational context and is found to be a significant predictor of attitude and intention to adopt (Chen et al., 2017; Fatoki, 2022; Kardooni et al., 2016; Sharma & Mishra, 2014). For this study, as borrowed from Chen et al. (2017), perceived usefulness refers to perceptions of

RET's role in energy management, realising cost savings, and providing reliable and timeous energy consumption information.

Based on the theories of technology acceptance and supporting empirical studies, this study hypothesised the following.
H3: Perceived usefulness influences intention to adopt solar energy technology.

2.5.3.4 Trust in stakeholders

Trust in the actors responsible for providing a technological innovation generally increases its adoption (Huijts et al., 2014). In addition, trust is instrumental to adoption because it influences the perceptions of risks and benefits as well as the effect consumers have towards the technology. The effect of trust on technology acceptance is pronounced in circumstances where a lack of knowledge about the technology exists (Poortinga, Spence, Whitmarsh, Capstick, & Pidgeon, 2011). In such instances, trust is found to be associated with adoption both as a direct (Huijts et al., 2014) and indirect (Chen et al., 2017) predictor.

Consequently, the following was hypothesised.
H4: Trust in stakeholders influences intention to adopt solar energy technology.

2.5.3.5 Perceived behaviour control

Perceived behavioural control describes a user's belief in their ability to execute a course of action based on how easy or difficult it is perceived to be (Ajzen, 1991). Less rigid than the perceived locus of control, perceived behavioural control is assumed to address the ability to perform behaviours in response to the influences of internal and external factors. Conceptualised as comprising of two dimensions – the level of control in executing the behaviour and the level of confidence in either performing or not performing – perceived behavioural control determines the ability to form the intent to adopt new technology (Alam et al., 2014). Adopting RETs by SMMEs entails calculating switching costs and evaluating several socioeconomic factors, which is facilitated by the consumer's perceived control over conducting such an exercise. The more control the consumer feels to consider RET adoption, the likelier they will formulate an intention to adopt (Alam et al., 2014).

In terms of this study, the following was hypothesised:
H5: Perceived behavioural control influences intention to adopt solar energy technology.

2.6 Conclusion of Literature Review

It is shown in the literature that the surest route to ensuring universal energy access entails widespread uptake of renewable energy, while the broader view of energy access points notes that productive uses of energy can unlock greater socioeconomic benefit from the provision of access to modern energy. It stands to reason, therefore, that factors determining the adoption of solar energy technology are critical considerations for scholars, practitioners, and policymakers alike.

The literature on the determinants of renewable energy adoption reveals that the facilitating and the inhibiting factors are categorised across technological, behavioural, economic, and political dimensions. It is both for policymakers and practitioners to recognise these determinants' role in implementing sustainable energy initiatives.

3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter addresses how this study was conducted to elucidate the stated research objectives based on a review of the literature outlined previously. In addition, the methodology used to carry out the study to completion is discussed. The two main objectives of this study were to identify the factors influencing the adoption of renewable energy technologies by small enterprises in South African townships and to ascertain the perceptions of enterprise owners toward these technologies. This chapter delves into the research approach and strategy, the study's intended participants, the measurement instrument, and the data collection and analysis methods utilised. Furthermore, the reliability and validity of the research are addressed, and so too are the relevant ethical issues explored.

3.2 Research approach

This study adopted a quantitative investigation approach to investigate the constructs of the objectives, which were informed by a review of the literature on the determinants of renewable energy adoption.

Quantitative research is selected based on its suitability to observe phenomena by way of testing hypotheses and theories to reach generalisations (Antwi & Hamza, 2015). From an epistemological standpoint, this study is underpinned by a positivist paradigm that seeks to objectively measure the phenomenon of solar energy technology uptake and utilisation by township SMMEs by testing hypotheses developed from technology adoption and diffusion theories. Using a survey, data were collected to obtain information that could be quantified and then subjected to statistical analysis to support or refute alternate hypotheses.

Moreover, quantitative research is characterised by the deductive approach, which assesses the causal relationships between variables using structured methodology – to ensure replication – well-operationalised constructs that can be measured quantitatively and rigorous statistical analysis techniques (Saunders, Lewis, & Thornhill, 2009). Adopting a quantitative research approach for this study was preferable to culminate in generalisations about the population from an appropriately selected and representative sample.

3.3 Population and sample

3.3.1 Population

Small, medium, and micro enterprises (SMMEs) entrepreneurs with businesses founded and operating in South African townships are the target population of this study. The respondents were selected from all provinces.

Table 1 below illustrates the first-quarter estimates of SMMEs in South Africa, which indicates that informal sector SMMEs account for close to 67% of this population in the third quarter of 2020.

Table 1: SMMEs by Sector 2020 Quarter 3

Type	Formal sector	Informal sector	Agriculture	Private households	Total	% Distribution
An employer	489 200	309 837	64 568	5 432	869 036	37.4%
Own account worker	177 911	1 242 978	24 648	10 630	1 456 167	62.6%
Total	**667 111**	**1 552 814**	**89 216**	**16 061**	**2 325 203**	**100.0%**
% Per sector	28.7%	66.8%	3.8%	0.7%	100%	

Republic of South Africa (2020) *Quarterly Labour Force Survey*

3.3.2 Sample and sampling method

The sample was derived from the population of township SMMEs sourced from, among others, public and private entities such as business associations and government agencies that focus on small, medium, and micro enterprises. These entities include the Township Enterprise Alliance (TEA), Small Enterprise Development Agency (SEDA), Small Enterprise Finance Agency (SEFA), and eKasiLabs (Innovation Hub).

The sampling approach for this study is known as convenience non-probability sampling. It was favoured due to its cost-effectiveness and the ease and convenience with which the data could be sourced from the respondents (Taherdoost, 2016a).

There are several approaches to sample size estimation for the structural equation modelling (SEM) technique suggested in the literature, including a handful of rules-of-thumb. Included among these is the general recommendation that the sample size for SEM should exceed 100 observations so as to limit problematic solutions and achieve an acceptable fit (Nasser & Wisenbaker, 2003). A more popular sample size determination for SEM is termed the" 10-times rule" (Hair, Ringle, & Sarstedt, 2011) which assumes that a credible sample size is one that is ten times the maximum number of model links directed at any latent variable in the entire model. Monte Carlo simulation techniques have also been used to determine the minimum sample size of SEM, which, while enabling researchers to evaluate the performance of estimators by creating controlled conditions, is computationally demanding and time-consuming (Kock & Hadaya, 2018).

For this study, the "minimum R-squared methods proposed by (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014) consider three elements for the estimation of sample size, namely:

1. Maximum number of arrows pointing to the latent variable in the model.
2. A significance level of 0.05.
3. Minimum R^2 in the model.

This approach to sample size estimation is preferred as an improvement upon the criticism of the popular "10-times rule", leading to inaccurate estimates (Kock & Hadaya, 2018) by considering an additional element of the model. Table 2 represents a condensed version of the "minimum R-squared method".

Table 2: Minimum R^2 sample size determination

Maximum number of arrows pointing at a construct	**Minimum R^2 in the model**			
	0.1	0.25	0.5	0.75
2	110	52	33	26
3	124	59	38	30

Maximum number of arrows pointing at a construct	Minimum R^2 in the model			
4	137	65	42	33
5	147	70	45	36
6	157	75	48	39
7	166	80	51	41
8	174	84	54	44
9	181	88	67	46
10	189	91	59	48

3.4 Research instrument

The questionnaire was designed and administered online using the Qualtrics platform, which enabled users to compile and disseminate surveys electronically. Apart from the demographic information, all other variables were measured using a 5-point Likert scale. The Likert scale is preferred because it enables quick data collection from many respondents and mimics physical measurement systems, such as the metric system, which runs from lower to higher amounts on a scale (Nemoto & Beglar, 2014). A major pitfall with the use of a 5-point Likert is found to be the existence of a neutral category that participants may gravitate toward in order to avoid using extreme options, known as central tendency bias, and which Nemoto and Beglar (2014) argue is unnecessary because the instrument ought to only include items that respondent can answer. For each of the items, respondents demonstrated their degree of agreement with the proffered statement by indicating numbers ranging from "1", representing "agree", to "5", representing "disagree".

The questionnaire comprised four main areas that coalesce to form valid psychometric measurements using categorical scales. The first section concerns the demographic information of the respondents. The questions capture the gender, age, and education level of the owners as well as specific enterprise information such as its size, age of operations, turnover, and the sector of the economy in which it participates. This set of questions aims to verify that income and firm size are independent variables that influence RET adoption by SMMEs (Rahbauer et al., 2018). In addition, education level is included since it is associated with a propensity to adopt new technologies (Pfeiffer & Mulder, 2013; Zeng, Tanveer, Fu, Gu, & Irfan, 2022).

The second section of the survey focused on technology adoption theories presented in the review of the literature. The questions, derived from the hypotheses, operationalise the constructs of the Technology Acceptance Model (Davis, 1989) – perceived ease of use and perceived usefulness – and those of Ajzen's Theory of Planned Behaviour (Ajzen, 1991), namely perceived behaviour control and subjective norm.

The fourth section of the investigation emphasised external variables' impact on the adoption of solar energy technology. Including these questions follows the modification and extension of the existing technology adoption theories, as Huijts et al. (2014) described in their Sustainable Energy Technology Acceptance framework, which observes perceived costs and trust as instrumental constructs in RET adoption.

Table 3: Theoretical constructs of the research instrument

Reference	Operationalised Construct
Rahbauer et al. (2016)	Income, Firm Size
Pfeiffer and Mulder (2013)	Educational attainment
Davis (1989)	Perceived ease of use, perceived usefulness
Ajzen (1991)	Perceived behaviour control, subjective norm
Huijts et al. (2012)	Perceived costs, trust

3.5 Data analysis and interpretation

The first phase of analysis detailed the demographic information of the sample data. Secondly, descriptive and inferential statistics were investigated using SmartPLS. Descriptive statistics refer to numerical procedures and graphical techniques that organise and describe the characteristics of a sample (Fisher & Marshall, 2009).

Partial Least Squares Structural Equation Modelling (PLS-SEM) is an analytical strategy widely adopted in social sciences and business research to measure causal relationships between observed and latent variables. The recognised advantage of the SEM statistical technique is its ability to perform complex, precise, and multidimensional analysis of empirical data while accounting for different aspects of examined reality and theoretical constructs (Tarka, 2018). PLS-SEM was advocated over other statistical techniques because it considers measurement errors, includes both measurement models and structural models for greater analytical rigour, is theory-based, and enables simultaneous testing of the hypothesised model with many mediators that exist in the entire variable system (Byrne, 2013).

3.6 Limitations of the study

In demonstrating scholarly commitment to improving the validity of the results, the limitations of the study are explored here. While the aim of the study was to investigate the factors influencing solar energy technology adoption by township enterprises across South Africa, efforts to gather data were localised in and around the townships in the Gauteng province.

The level of solar energy technology penetration in townships was also viewed as a limitation of this study. As most townships are located in peri-urban, low-income areas, they are likely not to be prioritised for extension of services by utilities due to the high costs of centralised electrical infrastructure, modest energy usage in these areas, and the prospect of low levels of revenue collection (Cantoni, Caprotti, & de Groot, 2022).

3.7 Validity and reliability

This quantitative study aimed to identify relevant cause-and-effect relationships to enable probabilistic predictions and generalisations (Taherdoost, 2016b). To achieve this, it is critical that the research instrument measures the constructs accurately and that the sample reflects the main characteristics of the population. This helped to ensure that the positivist inquiry of truth was fulfilled through verification and replication.

Validity refers to the alignment between the data collected and the actual area of investigation (Taherdoost, 2016b). For this study, validity was ensured by the constructs of the conceptual framework, which were derived from a review of the literature surrounding the research objectives; this is known as construct validity. Construct validity refers to the degree to which constructs have been translated into a functioning and operating reality (Taherdoost, 2016b). The developed hypotheses provide the basis for investigation and inform this study's research strategy. Furthermore, the identified variables were operationalised in the survey through the design of clear, comprehensible, and unambiguous questions. Principal component analysis was used to verify construct validity and determine which constructs are most suitable for continued analysis (Wee & Quazi, 2005).

Additionally, content validity was applied to this study's research instrument to assess that it adequately reflects the content universe to which it is generalised (Straub, Boudreau, & Gefen, 2004). For the survey, content validity entails refining it such that it contains only the necessary and essential items for each construct domain. Achieving content validity will be ensured through an expert judgement approach in the form of the research and ethics panel in the approval process of this research proposal.

Reliability is concerned with the repeatability of measurement and the consistency of results obtained thereof (Carmines & Zeller, 1979). As such, reliability mainly refers to the research instrument's stability, equivalence, and internal consistency (Souza, Alexandre, & Guirardello, 2017). Stability is an estimation of the consistency of results when the measurement is repeated after a reasonable interval, approximately 10 to 14 days. As this study was conducted over a predetermined duration with time constraints, a stability test-retest is not feasible.

The test for internal consistency to be employed in this study is the Cronbach Alpha coefficient because it is considered the most appropriate measure of reliability for Likert scales (Robinson, 2010). Internal consistency considers whether domains of a research instrument measure the same characteristic, which is referred to as the average correlation between items within the construct (Souza et al., 2017). Cronbach's alpha coefficient measures the covariance between items on a scale, thereby indicating consistency. A low covariance is indicative of a greater consistency among domains of the instrument. It is considered ideal when the Cronbach's alpha coefficient of a study is higher than 0.70; however, lower values near 0.60 are similarly deemed satisfactory (Souza et al., 2017).

The Cronbach's alpha values of this study's constructs were between 0.459 and 0.887. In the case of composite reliability, constructs achieved values from 0.773 and 0.929, which were above the threshold of 0.707. For Dijkstra–Henseler's ρ_{A}, values ranged between 0.514 and 0.929.

3.8 Ethical considerations

As previously stated, the main route to reaching township entrepreneurs as research participants was through the databases of organisations that, in some way, provide support and services tailored to this population. These organisations included business agencies, associations, and councils with a specific focus on the township entrepreneur ecosystem. This presented issues related to receiving permission to conduct research on these organisation's databases, known as physical access, and then subsequently issues related to accessing a representative sample of participants – cognitive access (Saunders et al., 2009).

Upon approval of the research proposal by Wits Business School and Wits University Ethics Committee, an ethics clearance certificate was obtained under protocol number WBS/EL2289107/841 (see Appendix C). Formal requests for access to databases for academic research purposes were issued to the identified organisations, indicating the objectives of the study, addressing confidentiality and consent, and demonstrating credibility to perform such research. Similarly, conditional on granting physical access, access to the relevant data from research participants was sought by formal request in the form of an invitation to participate in the study, including obtaining informed consent. While it was desirable that this process of negotiating access and consent could have been sequential, it inevitably took on an iterative nature, entailing repetition and informal mechanisms to gain access and reinforce consent at different levels and with different stakeholders.

This study was guided by the overarching ethical principle of ensuring no harm to the research participants or the researcher during the research process. Furthermore, the participants were informed of their right to withdraw participation at any point during the survey process. The participants were also assured of the confidentiality and anonymity of their responses.

In line with requirements of the Protection of Personal Information Act (POPIA), the specific consent that was sought stipulated that data collection and processing was for research purposes aligned solely to this study and that no further processing would occur without consent being requested prior to any additional processing. Moreover, care and diligence were taken to maintain the confidentiality of participants' personal data by ensuring its processing and storage occur in a manner that guarantees anonymity and privacy by using data aggregation methods.

3.9 Conclusion of Research Methodology

This chapter has outlined how the constructs, which derived from the various hypotheses, were developed during the literature review and operationalised for the purposes of conducting academic research. Guided by a positivist paradigm, the study was quantitative in nature with the aim of establishing causal relationships between variables and deducing generalisations about the adoption characteristics of township SMMEs concerning renewable energy technologies. To this end, an empirical survey was the preferred research strategy to enable the achievement of the desired sample size for the study to be valid. As a quantitative study, the need for statistical analysis is emphasised using both descriptive and inferential techniques. Lastly, the validity and reliability of the research instrument were addressed, and so too was the importance of research ethics, all of which were critical components of the research effort.

4 PRESENTATION OF RESULTS

4.1 Introduction

The fourth chapter presents an analysis of the data collected from the online survey, designed and distributed using the Qualtrics survey platform, targeting owner-managers of township-based SMMEs. This exercise demonstrates the nature of relationships between the adoption factors for the sampled township SMMEs. Tables and charts are provided to summarise and aid in the comparison of results.

The first section presents the respondents' demographic information, detailing key sample characteristics. The second section elaborates on the results of evaluating the reflective measurement model. An analysis of the internal consistency and reliability of the model is presented, and convergent validity and discriminant validity are addressed, together with an explanation of the modifications made to the hypothetical model.

This chapter's third section presents the results of evaluating the structural model. An assessment of each hypothesis and the overall model fit is presented based on a hypothesis acceptance at a 5% significance level.

4.2 Sample demographics

As mentioned above, the data were collected from owner-managers of township SMMEs in South Africa through convenience probability sampling. While it was anticipated that most of the sample responses would be derived from the membership databases of the *Township Enterprise Alliance* (TEA), *Small Enterprise Development Agency* (SEDA), *Small Enterprise Finance Agency* (SEFA), and *eKasiLabs* (Innovation Hub), as mentioned in Chapter 3, this route yielded very little success in accessing the target population. One of the agencies cited a COVID-19-related moratorium on research activities of their membership, and another suggested the questionnaire raised legal concerns. Despite these obstacles, the questionnaire was shared on social media platforms such as WhatsApp, Twitter, and Facebook. A total of 170 online survey responses were received, of which 72 were adequate for further analysis, which equated to a 42% response rate. Based on the minimum R2 method for sample size estimation chosen for this study (Hair et al., 2014), an assumed significance level of 0.5, having a maximum of 5 arrows pointing to a construct and the model's R2 value of 0.495, shows that at the nearest intersection of these parameters, the minimum sample size is 45 (see **Error! Reference source not found.**). Thus, 72 respondents were considered a sufficient sample for PLS-SEM modelling. Table 4 reports the demographic characteristics of the respondents.

Table 4: Respondent demographic characteristics

Characteristic	Groupings	Respondents	Share
Gender			
	Male	52	*72%*
	Female	20	*28%*
Age			
	18 – 35	30	*42%*
	36 – 50	32	*44%*
	51 – 65	9	*13%*
	Older than 65	1	*1%*
Education			
	No school	1	*1%*
	Primary school	1	*1%*
	High school	23	*32%*
	University / College	47	*65%*
Years of Operation			
	Less than three years	18	*25%*
	Between 3 and 10 years	40	*56%*
	Ten years or more	14	*19%*
Number of Employees			
	Fewer than five people	47	*65%*
	Between 5 and 20 people	19	*26%*
	Between 20 and 50 people	3	*4%*
	Between 100 and 200 people	3	*4%*

Characteristic	Groupings	Respondents	Share
Annual Turnover			
	Less than R2 million	60	*83%*
	Between R2 million and R5 million	6	*8%*
	Between R5 million and R25 million	4	*6%*
	Between R25 million and R150 million	2	*3%*
Formal Registration			
	No	7	*10%*
	Yes	65	*90%*

From the demographic characteristics, respondent township SMMES can generally be described as majority male-owned (71%), who are aged between 36 and 50 years (48%), with a tertiary level of education (64%). The businesses are typically formally registered (88%); have been in existence for more than three years but less than ten (57%); employ fewer than five people (67%); and report an annual turnover of two million South African Rands or less (86%).

4.3 Measurement model evaluation

4.3.1 Overall model fit

It is recommended that an overall fit of the model is assessed at the beginning of an evaluation of the reflective measurement model when performing PLS path modelling (Benitez, Henseler, Castillo, & Schuberth, 2020). The saturated model's overall model fit assesses the measurement model's validity, where it can unearth potential model misfits, which might be attributed to the misspecification of the model constructs. The results of the model's overall fit are presented in **Error! Reference source not found.** using Goodness-of-fit indices. For PLS-SEM, a threshold value of 0.08 or less of the standardised root mean square residual (SRMR) indicates an acceptable measure of fit. Furthermore, a normed fit index (NFI) exceeding 0.95 is considered to represent a good fit.

Table 5: Goodness-of-fit indices

	SRMR	Chi-square	NFI
Hypothetical model	0.122	447.267	0.524
Modified model	0.091	190.652	0.684

In the first instance, the hypothetical model indices demonstrated an unfavourable model fit (SRMR = 0.122; NFI = 0.524). This model was modified to a more favourable fit, improving its validity and reliability. However, the indices only approximated the overall goodness of fit, as shown by an improved SRMR of 0.091 and an NFI of 0.684.

The discussion of results in the following chapter explains the model modifications' implications. The remainder of this chapter evaluates aspects of the modified model.

4.4 Reliability

Reliability is the degree to which there is consistency among items measuring the same construct and whether the measurement is free from random error (Benitez et al., 2020). For PLS-SEM, the reliability of the model constructs is evaluated at the level of construct scores and at the level of the items that make up the construct (Benitez et al., 2020).

In the case of the latter, factor loading estimates were used to assess indicator reliability. Loadings higher than 0.707 are recommended, which indicates that the latent variable explains more than 50% of the variance in a single item. For constructs scores, composite reliability is the measure most often applied and, similarly, it is preferable to have composite reliability values greater than 0.707 however, not exceeding 0.95 as this indicates redundant items that reduce construct validity (Diamantopoulos, Sarstedt, Fuchs, Wilczynski, & Kaiser, 2012). As mentioned in the previous chapter, Cronbach's alpha is another measure of internal consistency which most describes how closely related the items of a construct are to one another as a group. In contrast, in terms of internal consistency, composite reliability is considered a liberal measure, while Cronbach's alpha is conservative. As such, Dijkstra–Henseler's ρ_A is proposed as an alternative measure of construct reliability, which lies between the two prior measures and more exactly approximates construct reliability.

Error! Reference source not found. presents the factor loadings of all the indicators that met the reliability acceptance criteria. Items with loading values less than the recommended value of 0.5 were removed from the model.

Cronbach's alpha, Dijkstra–Henseler's ρ_A and composite reliability values are also reported in **Error! Reference source not found.**. The Cronbach's alpha values range from 0.459 to 0.887. The constructs of Perceived Behavioural Control (Cronbach's alpha = 0.459), adapted from Ajzen (1991), and Trust (Cronbach's alpha = 0.497), adapted from Huijts et al. (2012), both recorded Cronbach's alpha values below the recommended threshold of 0.70. For composite reliability, all constructs are above the threshold of 0.707, ranging between 0.773 and 0.929. In terms of Dijkstra–Henseler's $\rho_{A,}$ values were from 0.514 to 0.929.

Table 6: Internal reliability's consistency evaluation

Construct	Items	Factor Loading	Cronbach's alpha	Dijkstra–Henseler's ρ_A	Composite Reliability
Intention to adopt	ITA1	0.898	0.819	0.825	0.892
	ITA2	0.861			
	ITA4	0.811			
Perceived behavioural control	PBC1	0.703	0.459	0.514	0.779
	PBC2	0.888			
Perceived ease of use	PEU1	0.836	0.887	0.928	0.929
	PEU2	0.931			
	PEU3	0.937			
Perceived usefulness	PU1	0.737	0.851	0.860	0.894
	PU2	0.872			
	PU3	0.792			
	PU4	0.750			
	PU5	0.803			
Trust in stakeholders	TRU1	0.945	0.497	0.751	0.773
	TRU3	0.622			

4.5 Validity

Next, the two measures of construct validity were evaluated in sequence. Convergent validity refers to the degree to which indicators of a latent variable measure the same construct (Benitez et al., 2020). The metric used to assess convergent validity is average variance extracted (AVE), which describes the indicator's variance explained by the latent variable. It is recommended that an AVE greater than 0.50 provides evidence of convergent validity, and thus, more than 50% of the variance of the indicators is explained by the construct (Sarstedt, Hair, Ringle, Thiele, & Gudergan, 2016). The AVE values range from 0.640 to 0.814, suggesting sufficient convergent validity.

Discriminant validity evaluates the extent to which a latent construct is distinct from other latent constructs in the model (Sarstedt, Ringle, Smith, Reams, & Hair Jr, 2014). The first approach for assessing discriminant validity entails the Fornell-Larcker criterion wherein the item loadings ought to be higher on their own constructs and that the square root of the AVE of each construct should be greater than its shared variance with other constructs (Hair, Sarstedt, Matthews, & Ringle, 2016). **Error! Reference source not found.** shows that the comparison between the AVE and the reflective correlation for each latent variable meets the Fornell-Larcker criterion.

Table 7: Discriminant validity: Average variance extracted (AVE) and Fornell-Larcker criterion

	Average variance extracted (AVE)	1	2	3	4	5
1. Intention to adopt	0.735	*0.857*				
2. Perceived behavioural control	0.642	0.492	*0.801*			
3. Perceived ease of use	0.814	0.536	0.228	*0.902*		
4. Perceived usefulness	0.628	0.614	0.45	0.42	*0.792*	
5. Trust in stakeholders	0.640	0.34	0.211	0.34	0.564	*0.800*

Table 8: Discriminant validity: Hetertrait-monotrait ratio of correlations

	1	2	3	4	5
1. Intention to adopt					
2. Perceived behavioural control	0.764				
3. Perceived ease of use	0.617	0.332			
4. Perceived usefulness	0.715	0.713	0.475		
5. Trust in stakeholders	0.463	0.406	0.444	0.825	

Additionally, discriminant validity was reinforced through the heterotriat-monotrait ratio of correlations (HTMT), which is defined as the mean value of the item correlations across constructs relative to the geometric mean of the average correlations for items measuring the same construct. HTMT values higher than 0.85 are indicative of a discriminant validity problem (Hair, Risher, Sarstedt, & Ringle, 2019). **Error! Reference source not found.** HTMT ratio of correlation values, and none exceed the 0.85 threshold.

The final part of the discriminant validity assessment considers the item cross-loadings to evaluate how well the items load on their construct compared to other constructs. In instances where the difference between an item's loading and its cross-loading is less than 0.10, it is recommended that such an item be removed from the model. Cross loadings are presented in **Error! Reference source not found.**.

Table 9: Cross loadings

		1	2	3	4	5
1. Intention to adopt	ITA1	**0.898**	0.470	0.472	0.566	0.258
	ITA2	**0.861**	0.321	0.519	0.372	0.132
	ITA4	**0.811**	0.455	0.394	0.614	0.461
2. Perceived behavioural control	PBC1	0.301	**0.703**	0.113	0.287	0.072
	PBC2	0.466	**0.888**	0.233	0.419	0.238
3. Perceived ease of use	PEU1	0.359	0.156	**0.836**	0.310	0.209
	PEU2	0.493	0.238	**0.931**	0.394	0.304
	PEU3	0.563	0.212	**0.937**	0.415	0.378
4. Perceived usefulness	PU1	0.503	0.283	0.441	**0.737**	0.319
	PU2	0.569	0.381	0.334	**0.872**	0.547
	PU3	0.488	0.288	0.284	**0.792**	0.417

		1	2	3	4	5
	PU4	0.408	0.449	0.333	**0.750**	0.459
	PU5	0.436	0.405	0.263	**0.803**	0.492
5. Trust in stakeholders	TRU1	0.349	0.182	0.348	0.540	**0.945**
	TRU3	0.146	0.174	0.148	0.334	**0.622**

4.6 Structural model evaluation

Following measurement model evaluation, hypothesis testing was performed to obtain path coefficients measuring the significance of relationships between the latent and endogenous variables. The path coefficients are standardised regression coefficients that describe the change in the dependent construct in terms of standard deviations (Benitez et al., 2020). A bootstrapping procedure of 5,000 subsamples was performed on the model to test for significance. Specifically, a one-tailed percentile bootstrap confidence interval with a 5% significance level yielded the results presented in **Error! Reference source not found.**.

Table 10: Structural model evaluation

	B	SE	T	Decision	f^2	VIF	R^2
PBC → ITA	0.252*	0.107	2.359	Supported	0.105	1.262	0.495
PEU → ITA	0.331*	0.133	2.490	Supported	0.185	1.241	
PU → ITA	0.385*	0.132	2.918	Supported	0.166	1.879	
TRU → ITA	-0.043	0.116	0.369	Not Supported	0.003	1.501	

PBC perceived behavioural control; *PEU* perceived ease of use; *PU* perceived usefulness; *TRU* trust in stakeholders; *ITA* intention to adopt

* $p < 0.05$

4.6.1 Results pertaining to Hypothesis 1

Hypothesis one (H1) postulated that the perceived cost of solar energy technology negatively influenced the intention to adopt solar energy technology exhibited by township SMMEs. Based on the very low factors loadings achieved and failure to register measurement validity and reliability, this construct was removed from the model. As such, it was not included in the results of the structural model assessment and due to its omission, evidence of its impact was not measured.

4.6.2 Results pertaining to Hypothesis 2

For the second hypothesis (H2), perceived ease of use was posited to positively influence adoption intention. The results indicated a positive and statistically significant impact of perceived ease of use on intention to adopt *($B = 0.331$; $t = 2.490$; $p < 0.05$)*. With this result, the null hypothesis is rejected, and H2 is supported.

4.6.3 Results pertaining to Hypothesis 3

The third hypothesis (H3) posited that perceived usefulness positively influences the intention to adopt by township SMMEs. A positive and significant impact of perceived usefulness on adoption intention is observed in the results *($B = 0.385$; $t = 2.918$; $p < 0.05$)*, thus supporting H3.

4.6.4 Results pertaining to Hypothesis 4

Hypothesis four (H4) postulated that perceived behavioural control influences the intention to adopt solar energy technology. The results exhibit a significant and positive effect of perceived behavioural control *($B = 0.252$; $t =2.359$; $p < 0.05$)*. As such, the fourth hypothesis is supported.

4.6.5 Results pertaining to Hypothesis 5

The fifth hypothesis (H5) suggested that trust in stakeholders influences adoption intention. Trust in stakeholders was found to have a negative but insignificant effect *(B = -0.043; t = 0.369; p = 0.356),* and hence the null hypothesis could not be rejected.

4.7 Multicollinearity

Multicollinearity evaluation regards the extent to which the correlation of the constructs affects the standardised errors (SE) of the weight estimates. Variance inflation factor (VIF) is the metric used to investigate multicollinearity, and it is suggested that VIF values higher than five indicate problematic multicollinearity (Hair et al., 2011). The resulting VIF values of the structural model range from 1.241 to 1.879.

4.8 Effect size

As a measure of the magnitude of effect size, f^2 values elucidate the effect of the relationships between constructs that are independent of sample size (Benitez et al., 2020). The f^2 values are ranked as weak, medium, and large in the ranges of 0.020 to 0.150, 0.150 to 0.350, and greater than 0.350, respectively (Cohen, 2013). The results in **Error! Reference source not found.** show that the constructs of trust in stakeholder ($f^2 = 0.003$) and perceived behavioural control ($f^2 = 0.105$) have weak magnitudes of effect, while those of perceived ease of use ($f^2 = 0.185$) and perceived usefulness ($f^2 = 0.166$) display medium effect.

4.9 R^2 assessment

R^2 is a measure of the explanatory power of the model, accounting for the variance in the endogenous variable (Shmueli & Koppius, 2011). R^2 values range from 0 to 1, where larger values correspond to greater explanatory power. The magnitude of the R^2 depends on the context under which phenomena are investigated. R2 values of 0.75, 0.50 and 0.25 are considered substantial, moderate and weak, respectively (Hair et al., 2019). For this study, an R^2 of 0.495 was observed, indicating a moderate explanatory power of the model.

4.10 Conclusion of Results

This chapter sought to present a detailed report on the results of this study. It provided an elaboration of the sample demographics, a methodical evaluation of the reflective measurement model, and concluded with the results of hypothesis testing of the structural model.

From the perspective of the measurement model, the overall model fit together with aspects of construct reliability and validity indicate concerns about model specification and content validity in the lead-up to data collection.

Regarding the structural aspects of the model, there was no evidence found in support of or in dispute of perceived cost (H1) on intention to adopt solar energy technology by township SMMEs, which is contrary to prior research. Perceived cost has been found to positively and significantly affect adoption intention (Alam et al., 2014).

Evidence was found of the significant positive effects of perceived ease of use (H2) and perceived usefulness (H3) on the dependent construct, which supports the findings of the technology acceptance model.

There was also supportive evidence of the influence of perceived behavioural control (H4) on intention to adopt, in alignment with the theory of planned behaviour.

No evidence in support of the influence of trust in stakeholders (H5) on intention to adopt was found in the results.

Additionally, multicollinearity problems were not detected; only weak to medium effects of the latent constructs on the endogenous variable were observed.

5 DISCUSSION OF THE RESULTS

5.1 Introduction

Following the presentation of results in the previous chapter, the aim of Chapter Five (5) is to provide an elaboration of the results. The results are discussed to compare the study's findings with extant literature that was formerly explored and presented as the theoretical foundation of this study.

Firstly, the sample demographics are discussed, followed by a discussion about the findings related to each of the evaluated hypotheses. Then, the aspects of the reflective measurement model are elaborated, and a summary of the discussion concludes the chapter.

5.2 Demographic profile of respondents

5.2.1 Gender

The survey respondents were predominantly male (72%), a gender bias which is noted by Udimal and Biyase (2021) when evaluating constraints in the South African township economy. This aligns with estimates that around a quarter of small formal business owners were women (Makgetla, Moshikaro, & Levenson, 2023).

5.2.2 Age

Over 80% of the surveyed respondents were younger than 50 (see **Error! Reference source not found.**), with the majority of owner-managers falling between the ages of 36 and 50 (44%). This augers well with the findings that the median age of business owners is 45 for formally registered businesses and 41 for informal businesses (Makgetla et al., 2023).

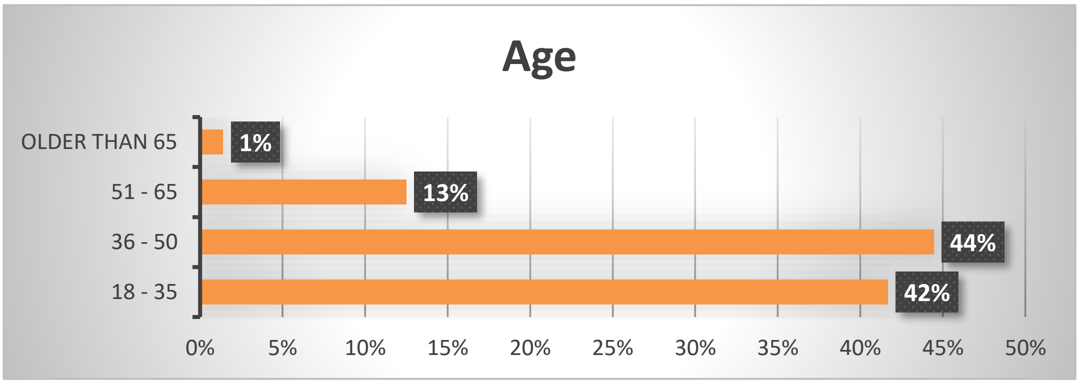

Figure 5: Age of survey respondents

5.2.3 Education

Error! Reference source not found. shows that the majority of township SMME owner-managers that participated in the study reported to hold some form of tertiary education qualification (65%). Those who possess high school educational attainment round out most of the remaining respondents of the survey at 32%. This is contrary to the education grouping of SMME owners reported by the Small Enterprise Development Agency in the first quarter of 2021 (SEDA, 2021), which put owners with tertiary education at 23% and those with high school education at 63%. They also note a higher yearly decline experienced by owners with high school education (21%) compared to owners with tertiary education (0.6%) (SEDA, 2021).

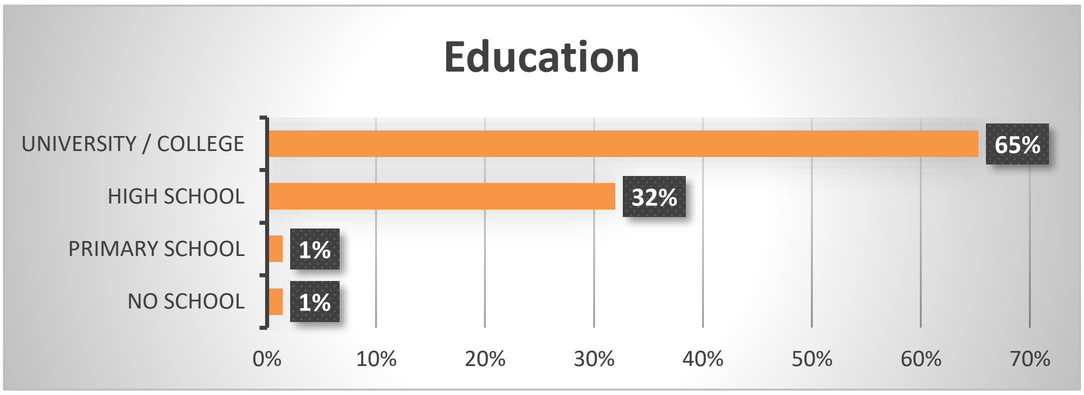

Figure 6: Educational attainment of township SMME owner-managers

5.2.4 Age of SMMEs

Most of the township enterprises surveyed reported being in operation for between three (3) and ten years (56%), followed by those younger than three years (25%) and only 19% of surveyed enterprises having been in operation for ten or more years (see **Error! Reference source not found.**). In its first quarterly report of 2021, SEDA found that the majority of SMMEs were also aged between 3 and 10 years (SEDA, 2021).

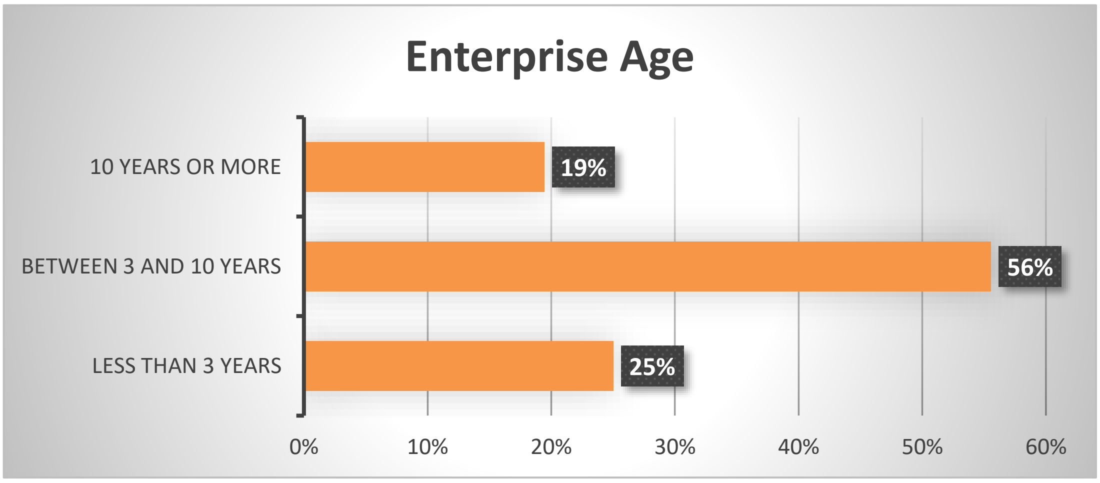

Figure 7: Enterprise age of township SMMEs

5.2.5 Number of employees

Since 65% of the surveyed township enterprises employed fewer than five people, they would be classified as micro-enterprises according to the National Small Business Act (Republic of South Africa, 1996) - but solely based on employee count. Just over a quarter (26%) of the SMMEs reported a staff complement of between five (5) and 20 people, making them very small enterprises. **Error! Reference source not found.** shows that the remaining 8% of respondents are split equally between being classified as small enterprises (between 20 and 50 employees) and medium enterprises (between 100 and 200 employees).

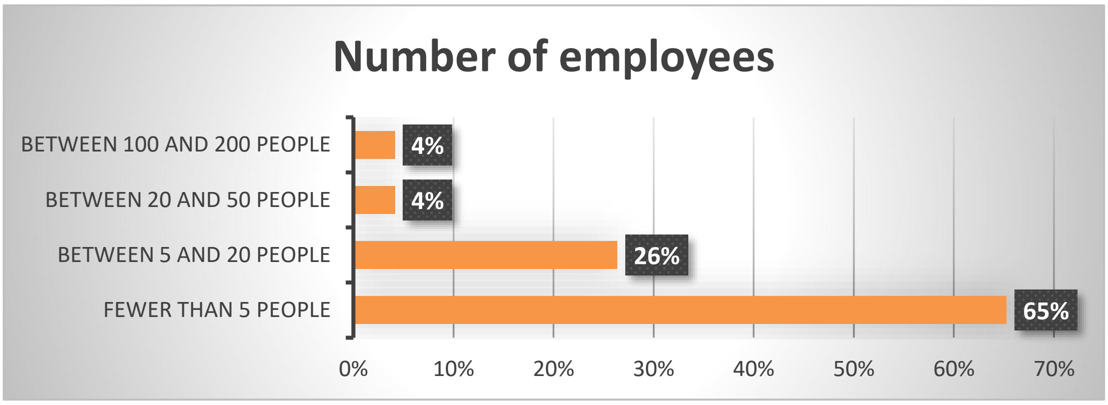

Figure 8: People under employment of township SMMEs

5.2.6 Annual Turnover

As seen in **Error! Reference source not found.**, an overwhelming of surveyed township SMMEs have an annual turnover of less than two million rand (83%). Although the National Small Business Act (Republic of South Africa, 1996) provides for differing turnover thresholds across sectors and firm size, a level of two million rand would classify them as including micro, very small, and small enterprises. However, according to the Small Enterprise Development Agency (SEDA, 2021), the Department of Trade and Industry determined two million rands annual turnover as the cut-off point for very small enterprises.

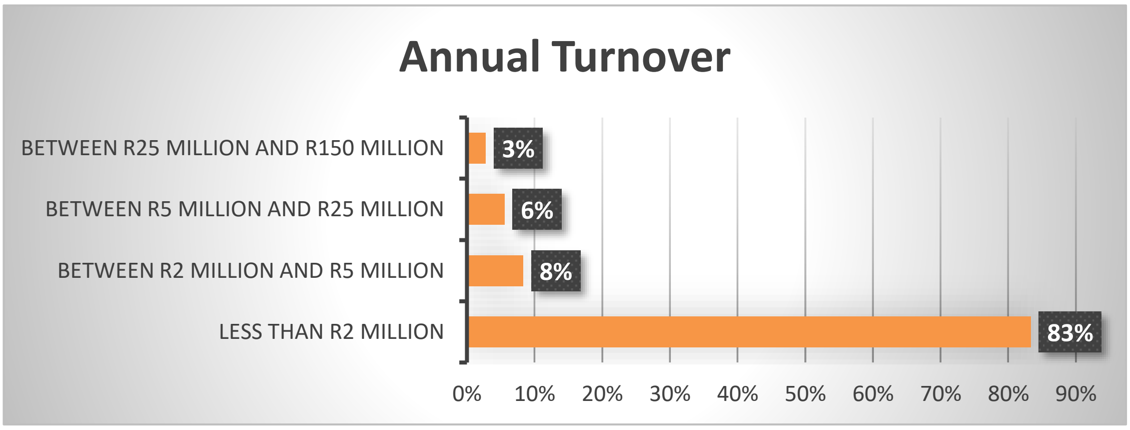

Figure 9: Turnover of township SMMEs

5.2.7 Formal registration

Capturing the status of formal registration of township enterprises was considered worthwhile and relevant to this study because of the pervasive informality of trade and commerce observed in the township economy, as discussed in the literature review chapter.

Once more, an overwhelming majority of the surveyed township enterprises reported being formally registered (90%), which sits in stark contrast to findings of Stats SA, as cited by the Small Enterprise Development Agency's quarterly reports, placing informal sector SMMEs in the majority (67%) in the first quarter of 2021 (SEDA, 2021). This is further corroborated by (Makgetla et al., 2023) who found that informal businesses far outnumbered formal in the last quarter of 2022, reaching 1,75 million compared to 710,000 formal businesses.

5.3 Discussion pertaining to Hypothesis 1 – Perceived cost

It was anticipated, in line with comparable studies, that perceived cost exert would significantly influence the adoption of solar energy technologies. Contrarily, this hypothesis could not be sufficiently tested, so evidence to support or reject its effect was not obtained. This absence of findings relating to the direct effect of perceived cost on intention to adopt is inconsistent with empirical literature identifying perceived cost as a direct negative determinant of intention to adopt solar energy technologies (Kim et al., 2014). However, it also supports the argument that perceived cost influences adoption intention indirectly through perceived usefulness and perceived ease of use (Kardooni et al., 2016).

Extensive literature has measured the direct effects of perceived cost on the intention to adopt renewable energy technology, most finding that a positive relationship exists where perceived cost has a statistically significant and positive effect on the intention to adopt (Alam et al., 2014).

Considering the adverse outcome regarding H1, the potential measurement elements that might have contributed are addressed below.

5.4 Discussion pertaining to reflective measurement model assessment

The study attempted to establish reliability and validity within the context of an emerging economy; however, the obtained results draw attention to the operationalised constructs. Concerns regarding potential measurement errors emerge with the lack of evidence supporting the constructs that were significant in other research contexts. These measurement errors are considered since the study made use of a single cross-sectional survey administered electronically within a constrained timeframe, which made the study vulnerable to the effect of *common method variance* and *acquiescence response bias.*

Common method variance exists when the estimated relationship between constructs is inflated and, consequently, a higher systematic covariation between the scale items is produced (Rodríguez-Ardura & Meseguer-Artola, 2020). The correlation matrix analysis in the previous chapter served as a technique to detect potential common method variance, which is indicated by correlation coefficients that are greater than 0.70 (Hair et al., 2011). The absence of coefficients greater than 0.70 in the matrix reduces the possibility of a high relationship among the items/constructs.

Interestingly, there are a plethora of potential sources of common method variance, including, among others, scale item complexity and ambiguity, respondent's ability to respond to scale items, respondent's tendency to agree with item statements, and the positioning of scale items such that respondents infer causal relationship among the constructs (Rodríguez-Ardura & Meseguer-Artola, 2020). Moreover, it is suspected that a combination of the sources of common method variance impacted the outcomes of perceived cost measures and stakeholder trust.

Common method bias literature provides ways to remedy the likelihood of common method variance in survey questionnaires. Those relevant to this study are identified as changing the order of questions to limit the respondent's desire to offer consistent responses (Podsakoff & Organ, 1986), using varying types of scale response options (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003); pretesting the questionnaire to improve and refine the wording of the items (Krosnick, 1999).

5.5 Discussion pertaining to Hypothesis 2 – Perceived ease of use

Perceived ease of use is a commonly modelled construct in technology adoption studies because it has proven to be a reliable predictor of intention to adopt as well as of attitudes towards various technologies (Bouaguel & Alsulimani, 2022; Bvuma & Marnewick, 2020; Qamar et al., 2022). In the context of this study, it can be regarded as the relatively hassle-free operation and maintenance of a small-scale solar energy system. H2 postulated that perceived ease of use influenced the intention to adopt solar energy technologies by township SMMEs and, in accordance with previous literature, evidence was found that perceived does indeed have a positive and significant effect on adoption intention *($B = 0.331$; $t = 2.490$; $p < 0.05$)*.

The effect exerted by perceived ease of use on technology adoption is demonstrated both directly and indirectly. In the former instance, perceived ease of use was found to be a driver of the adoption of solar energy technology by SMMEs in Pakistan (Qamar et al., 2022) owing to the technology's modularity and diverse applications, which enable accessibility. Similarly, Alam et al. (2014) reported a strong influence of perceived ease of use on renewable energy usage intention by Malaysia's public. In another Malaysian study, perceived ease of use was positively related to attitudes towards renewable technology, which, in turn, is a predictor of adoption and diffusion (Kardooni et al., 2016).

5.6 Discussion pertaining to Hypothesis 3 – Perceived usefulness

For the third hypothesis, claiming that perceived usefulness positively influences the adoption of solar energy technologies, evidence supported this hypothesis.

As demonstrated by previous studies conducted on the adoption intention of renewable energy technologies, perceived usefulness is shown to be a statistically significant predictor of intention to adopt solar energy technologies by township SMMEs *($B = 0.385$; $t = 2.918$; $p < 0.05$)*. Described as the user's belief that the technology can lead to an improvement in performance, it is regarded by some scholars as the most significant element that explains why users adopt technologies (Liang & Yeh, 2009).

Similarly to perceived ease of use, perceived usefulness has a direct influence on the intention to adopt technology and mediating influence through attitude (Kardooni et al., 2016).

A meta-study that analysed influential factors of technology adoption of various technologies across varying geographical regions found perceived usefulness to be an effective driver of behavioural intention to adopt technology. Hence, the TAM framework has endured in literature (Billanes & Enevoldsen, 2021).

5.7 Discussion pertaining to Hypothesis 4 – Perceived behavioural control

Conceptualised from the Theory of Planned Behaviour (TPB) by Ajzen (1991), perceived behavioural control refers to the ease or difficulty of undertaking a behaviour. In this study, H4 posited that perceived behavioural control positively influences intention to adopt solar energy technology, which was subsequently confirmed as having a statistically significant, positive impact on township SMMEs' willingness to adopt solar energy technology *($B = 0.252$; $t =2.359$; $p < 0.05$)*.

This result was anticipated since previous studies have reported a positive relationship between perceived behavioural control and technology acceptance (Alam et al., 2014; Huijts et al., 2014). Furthermore, Alam et al. (2014) suggest that the effect of perceived behavioural control on technology adoption indicates the instrumental role of non-motivational factors in users' intention to adopt small-scale renewable energy.

5.8 Discussion pertaining to Hypothesis 4 – Trust in stakeholders

Several studies have investigated the relationship between users' trust and their intention to adopt new technologies, including solar energy technology (Chen et al., 2017; Kim et al., 2014). In line with empirical literature, trust in stakeholders within the solar energy technology value chain was hypothesised to significantly affect the adoption intention of township SMMEs. However, there was no supporting evidence obtained from the analysis. While this finding runs contrary to most technology adoption literature, it also amplifies the argument that trust exerts its effect on the intention to adopt by mediating attitude, positively affecting the intention to use in South Korea (Kim et al., 2014). Similarly, Chen et al. (2017) found that trust in utilities has significantly mediated the adoption of smart meters through both perceived and perceived usefulness.

In a study that investigated factors influencing consumer's adoption of renewable energy in Thailand, Wall et al. (2021) found trust to have a positive but non-significant relationship with adoption intention.

It is worth noting that trust represents a cognitive state generated by the social atmosphere within the prevailing society whose public would respond to solar energy technology adoption from the social mood (Kim et al., 2014). From within the South African context of a deepening energy shortfall, it may be that trust in the relevant stakeholders has all but evaporated for township entrepreneurs.

5.9 Conclusion of Discussion

Chapter five (5) sought to systematically elaborate on this study's findings. The discussions covered sample characteristics, hypothesis testing, as well as measurement issues. Furthermore, similarities and peculiarities with extant technology adoption literature were brought into focus.

In summary, hypothesis testing revealed no evidence in support of hypothesis one (H1) relating to the influence of perceived cost on township SMMEs' intention to adopt solar energy technology. For hypothesis two (H2), a positive and significant relationship exists between perceived ease of use and adoption intention. Similarly, testing of perceived usefulness (H3) and perceived behavioural control (H4) found that both are important predictors of intention to adopt for township SMMEs. Contrary to expectation and extant literature, the hypothesised influence of trust in stakeholders (H5) on adoption intention was found not to be significant.

Finally, the chapter reviewed the measurement elements of the model and elaborated on potential measurement errors that were encountered during this study.

6 CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

This final chapter will provide an overview of all the insights gleaned from the preceding chapters. This section begins with a presentation of how the findings of this study respond to the research questions. From the findings, discuss practical implications and then translate recommendations for future research.

6.2 Conclusions regarding research objective 1 – Identifying the determinants of solar energy technology acceptance by township SMMEs

The motives of this study were condensed into three research objectives, which would be synthesised quantitatively to contribute to the just transition debate and enrich the literature on renewable energy adoption intention.

Against the prevalence of a deepening electricity supply shortfall, the urgent need to raise the energy availability factor of Eskom's predominantly coal-fuelled power generation fleet while attempting to pursue a just energy transition toward a low carbon economy, the proliferation of embedded generation is widespread as exhibited by households and enterprises resorting to self-generation to mitigate the dire impacts of routine power cuts.

A review of determinants literature focusing on the adoption and diffusion of renewable energy centres, mainly macro-scale indicators, including economic, environmental, regulatory, political, and institutional factors.

However, at the level of independent actors, efforts to explain this phenomenon rely on empirical evaluation that is operationalised through theories and models of technology adoption and behavioural intention.

6.3 Conclusions regarding research objective 2 – Evaluating township SMMEs' perception of the potential of renewable energy electricity to remedy inadequate electricity access

As discussed, this study found supporting evidence of a positive relationship between the constructs of the technology acceptance model, namely perceived ease of use *($B = 0.331; t = 2.490; p < 0.05$)* and perceived usefulness *($B = 0.385; t = 2.918; p < 0.05$)*, and solar energy technology adoption intention among township enterprises. Together, they obtained the highest path coefficients *($PEU \rightarrow ITA\ 0.331^*; PU \rightarrow ITA\ \ 0.385^*$),* which makes them the strongest predictors of intention to adopt, thereby further indicating the applicability of the technology acceptance model in the literature.

Furthermore, perceived behavioural control was found to be the third most influential predictor of adoption intention *($B = 0.252; t =2.359; p < 0.05$)*. As a construct of the theory of planned behaviour (Ajzen, 1991), perceived behavioural control – acting in concert with the technology acceptance model – is instrumental in the social acceptance of new technologies.

For the non-behavioural constructs – perceived cost and trust in stakeholders *($B = -0.043; t = 0.369; p = 0.356$)* – no evidence was found to support their influence on township enterprises' adoption intention. As discussed, these findings are contrary to those in the literature. On the one hand, the perceived cost of deploying renewable energy is found to have a moderate effect on intention (Alam et al., 2014), while on the other hand, Kardooni et al. (2016) found it to have an indirect effect on intention, mediated by TAM.

Although trust in stakeholders was found not to have a significant influence, it was negatively associated with the intention to adopt.

6.4 Conclusions regarding research objective 3 – Provide a framework for solar energy technology acceptance by township SMMEs

Overall fit indices show that the proposed model only approximated a good model fit, which raised concern about the measurement aspects applied in this investigation of solar energy technology adoption. The study's hypothesised model integrated the theories of technology adoption, which subsequently served to highlight the nuances in this research context, yielding results that contradict established literature. Even then, the modified model achieved an explanatory power of 49.5%, largely attributing the intention to adopt behavioural constructs rather than contextual factors. Common method variance and acquiescence response bias were the measurement errors detected and found to be responsible for the substantive modifications made to achieve a statistically representative model and for the instances where the evidence showed that the null hypothesis could not be rejected.

Regarding the final saturated model, it is noted that it corroborated several findings of energy technology adoption and diffusion models in developing countries. The model of relationships that emerged from this empirical study provides supporting findings of an integrated model approach to investigating renewable energy technology adoption. This illustrates a veritable contribution to technology adoption literature by offering peculiar insights about the quantitative analysis of technology adoption and the inherent challenges thereof, as attributed to the mentioned measurement errors. Furthermore, the study has succeeded in establishing the significance of factors that influence the intention to adopt solar energy technology in an urban low-income context.

Based on this study's evidence, a framework (**Error! Reference source not found.**) for solar energy technology adoption in South African townships can be inferred. This framework relies significantly on improving their perceptions regarding alternatives to centralised electricity supply. Furthermore, hypothesised constructs that would benefit from the inclusion of perceived benefits and perceived risk, together with perceived cost, are found to include an intention to accept a particular energy technology (Huijts et al., 2012). Additionally, efforts to promote solar energy technology acceptance ought to improve the credibility of all the stakeholders involved in deployment and implementation. This is premised on the results showing a positive, albeit not statistically significant, influence of trust in stakeholders on the intention to adopt the study's participants.

Contextually, the availability of incentives and financing mechanisms have been seen to be conducive to promoting the uptake of solar energy technology among SMMEs in developing and developed countries (Ajah, 2023), as such promotional campaigns that emphasise the existence of policy incentives, such as the Section 12B tax allowance, and innovative financing tailored to supporting township entrepreneurs is proposed.

Lastly, another route to influencing township entrepreneurs' intention to adopt concerns their skills, knowledge, and experience in renewable energy technologies (Naicker & Thopil, 2019). Therefore, educational and capacity-building programmes that equip consumers and installers with the skills and knowledge related to deploying solar energy technology for their operations are advised.

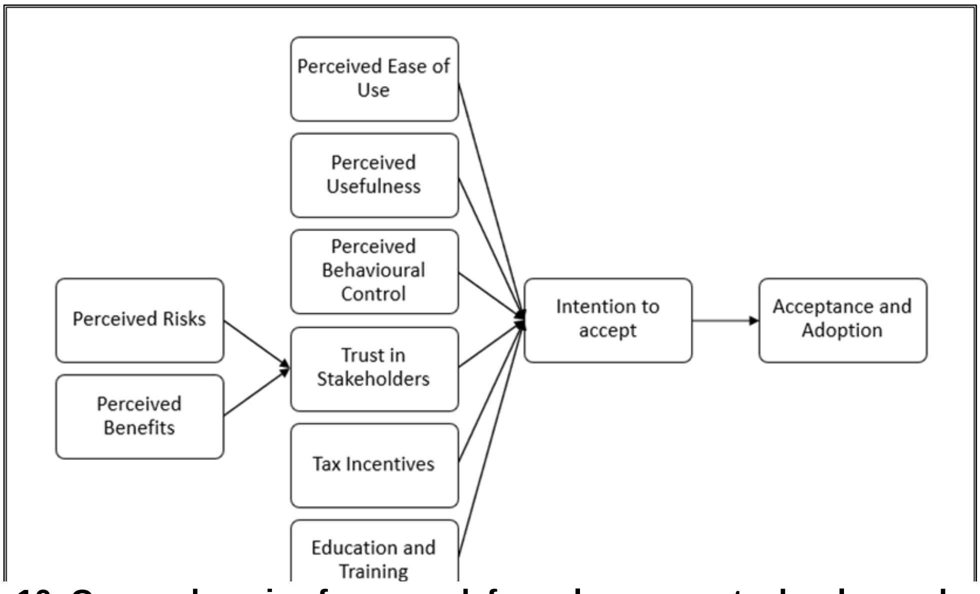

Figure 10: Comprehensive framework for solar energy technology adoption by township SMMEs

6.5 Policy Implications and Recommendations

6.5.1 Policy Implications

This study elucidated the challenges and opportunities associated with modern energy access and transition in low-income and informal economies. From an academic perspective, this study could enrich scholars' understanding of energy technology adoption during transition periods underscored by centralised energy supply shortfall.

Since less than half of the variance in the target population's solar energy technology adoption intention was demonstrated by the study, this provides an opportunity for investigation of the unexplained variation, thus encouraging efforts into refining measurement approaches and integrating other technology adoption constructs.

At a policy level, the prevailing energy crisis that has taken hold of South Africa's electricity supply industry may be fertile ground for institutional reform that enables increased decentralisation of renewable energy generation (Lawrence, 2020). To this end, incentives that promote public solar technology adoption, such as the Section 12B incentive of the Income Tax Act (Republic of South Africa, 1962), are a welcomed signal from the government; however, more needs to be considered to reduce the trust deficit between the public and the state.

6.5.2 Recommendations

The technology acceptance model and the theory of planned behaviour have been empirically found to be instrumental in the adoption and diffusion of technologies within firms. These theories describe how motivational and non-motivational factors influence owner-managers adoption intentions. As such, they occupy a central role in technology adoption literature.

- It is recommended that energy practitioners, both in industry and academia, collaborate on initiatives that can further the acceptance and eventual adoption of solar energy technologies in marginal communities that have historically been overlooked. This study has demonstrated that established theory is applicable to these populations, thereby necessitating an opportunity for further interrogation.

- Township enterprises ought to thoroughly appraise the option of investing in solar energy technology and investigate ways in which renewable energy can support their energy independence and improve their energy security.
- Agencies such as SEDA and SEFA could partner with energy sector-specific advocacy institutions such as EWSETA, SANEDI and NBI to establish forums and platforms that provide township enterprises with access to appropriate information, access to market opportunities, and access to capacity-building mechanisms that relate to solar energy technology applications.
- Banks and funding institutions could provide greater opportunities for township enterprises to access credit that enables the affordable purchase of solar systems. In addition, these institutions could include township enterprises as potential beneficiaries of innovative and sustainable finance designed to increase the uptake of renewable energy.
- Finally, it is recommended that large businesses encourage and enable township enterprises to register on their vendor databases so that they may transmit sustainability consciousness through mandates and commitments to green their supply chains.

6.6 Suggestions for further research

While the canon of technology adoption research is well established, the suggestions for further research arise out of the challenges encountered during the research process performed in this study.

From a measurement perspective, an instrument that measures attitudes and behavioural intentions towards solar energy technology that better avoids common method variance and acquiescent response set bias could be developed. Furthermore, the findings of this study may be limited in generalisability because of the size and composition of the sample from which the results were obtained. Although the townships across South Africa share common characteristics, there is likely to be heterogeneity in attitudes and behavioural intentions regarding renewable energy technologies, including solar energy technology, among SMME owner-managers. Therefore, future studies would benefit from examining a large, more diverse, and representative sample of township enterprises including those without a grid connection.

This study favoured parsimony in selecting the relationships between variables, and a simple and concise research model was employed. As such, it is possible that this study excluded notable relationships and other variables that significantly influence the intention to adopt; thus, future studies could consider other potential relationships and variables.

In attempting to resolve some of the challenges encountered in this study, the proposed model and findings provide a basis for improved investigation and exploration of adoption intentions and user perceptions of solar energy technology in similar emerging market nations.

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APPENDIX A – SURVEY QUESTIONNAIRE COVER LETTER

A questionnaire on the adoption of solar energy technology by township SMMEs in South Africa.

Good day

My name is Sakhile Ngcongwane, and I am a postgraduate student at the Wits Business School.

As a member of ______ and a township entrepreneur, you are invited to take an online survey that investigates factors that influence township entrepreneurs' decision to adopt renewable energy technology for the purpose of generating electricity for their business operations.

This survey forms part of my research project titled *Intention to Adopt Solar Energy Technology by Township Small, Medium, And Micro Enterprises (SMMEs) In South Africa,* which is supervised by Dr. Fanny Saruchera and required for the completion of my postgraduate studies.

The survey makes use of the Google Forms platform and consists of 36 questions, to which you are expected to provide the most appropriate answer from a choice of responses. It should not take longer than 15 minutes to complete this survey.

The survey can be accessed below.

There is no financial cost to taking this survey, and responses will be treated with the utmost confidentiality. The results of the survey will be presented in an aggregated form, which will ensure participants remain anonymous. Should participants wish to receive a summary of the report, kindly indicate so, and a copy will be provided once it is ready. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), Contact number (0)11 717 1408, email hrecnon-medical@wits.ac.za
You are welcome to reach out to me for further information.

Kind Regards,
Sakhile Ngcongwane.

APPENDIX B – SURVEY QUESTIONNAIRE

SECTION 1: DEMOGRAPHIC PROFILE

1. Gender

Male	
Female	

2. Age

18 – 35	
36 – 50	
51 – 65	
Older than 65	

3. What is your highest level of completed education?

No schooling	
Primary school	
High school matriculation	
University or College	
Post- Graduate Degree(s)	

4. Which township is the business situated?

5. How long has the business been operating?

Less than three years	
Between 3 and 10 years	
Ten years or more	

6. How many people does the business employ (including the owner)?

Less than 5	
Between 5 and 10	
More than 10	

7. What is the annual turnover of the business?

Less than R150 000	
Between R150 000 and R1 000 000	
Between R1 000 001 and R5 000 000	
Between R5 000 001 and R10 000 000	

8. Is the business formally registered?

Yes	
No	

SECTION 2: INTENTION TO ADOPT RET

Scale: strongly disagree – strongly agree

12. I intend to use renewable energy technology as often as necessary in my business.

13. I intend to continue using renewable energy in the future.

14. Assuming I have access to renewable energy technology, I intend to use it in my business operations.

15. I find the quality of electricity from renewable energy technology is not as good as ordinary Eskom/municipal electricity.

16. I will strongly recommend that other businesses use renewable energy technology

SECTION 3: OPINION ON RET ACCEPTANCE

Perceived Usefulness

Scale: strongly disagree – strongly agree

17. Renewable energy technology improves the quality of my business operations

18. Renewable energy technology makes it easier to protect the environment

19. Continuous use of renewable energy technology enables the business to reduce electricity costs.

20. Renewable energy technologies enable the business to protect the health of society.

21. Using renewable energy technology improves the effectiveness of using energy for business operations.

Perceived Ease of Use

Scale: strongly disagree – strongly agree

22. Learning to operate renewable energy is easy for me.

23. I find it easy to make renewable energy technology do what I want it to do.

24. I find renewable energy technology flexible to interact with.

25. I find renewable energy technology easy to use.

Perceived Behavioural Control

Scale: strongly disagree – strongly agree

26. I would use renewable energy even if it is slightly more expensive

27. I would use renewable energy even if another person advises me to use traditional energy

28. I would be able to make a difference by using renewable energy

29. Using renewable energy technology in the business is entirely within my control

Cost

Scale: strongly disagree – strongly agree

30. I find renewable energy technology to be more expensive.

31. I find the purchase of renewable energy technology to be a good investment for the future sustainability of my business.

32. I find that renewable energy technology products are more expensive compared with other energy products.

33. I think that renewable energy technology products should be at a lower price to encourage their purchase.

Trust

Scale: strongly disagree – strongly agree

34. I trust the companies providing renewable energy technologies to businesses and households

35. I trust the government has made it easy for businesses to use renewable energy technologies

36. I trust all the stakeholders involved in the supply of renewable energy technologies to care about the consumers

APPENDIX C – ETHICS CLEARANCE CERTIFICATE

Please refer to attached pdf document titled *Ethics clearance - Sakhile Ngcongwane*

APPENDIX D – PROOF-READING CERTIFICATE

Please refer to attached pdf document titled *RAIS Certificate*