# POLICY ENABLERS AND PERCEIVED IMPEDIMENTS OF ROOFTOP SOLAR PHOTOVOLTAIC PROJECTS IN GAUTENG, SOUTH AFRICA


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## ABSTRACT

The issue of climate change has necessitated that many countries shift to greener and more sustainable energy sources. South Africa's plans to encourage the generation of power from solar energy is a positive move in decarbonising the country's economy. The National Integrated Resource Plan (IRP) intends to, among others, contribute to this shift and transition in power generation technologies. Despite being one of the two provinces in South Africa with the highest solar PV potential that may aid the penetration of rooftop solar PV (RSPV), the Gauteng province's roll-out of such projects is perceived to be slower than anticipated. This research sought to study the perceived impediments that are hindering the growth of RSPV in the Gauteng province, reveal their impact in this sector, and explore the enablers for the diffusion of RSPV evolution. The Diffusion of Innovation theory forms the foundation for this study.

The research investigated perceived policy impediments and enablers and suggested some policy measures to address these cross-cutting issues and contribute to the academic body of knowledge. The research approach was quantitative, and descriptive in nature, and information was obtained using a questionnaire that was administered via Survey Monkey. Data was gathered by integrating perspectives from key rooftop solar industry experts from energy service companies and regulatory sector officials. The study administered questions to participants in key energy leadership positions in the rooftop solar industry in the Gauteng province to understand perceived barriers and policy enablers. This research paper may assist academics, energy practitioners, and regulators in focusing their future efforts on the adoption of rooftop solar technologies in the Gauteng province. Furthermore, it may help in developing a framework for policies and strategies to increase the uptake of rooftop solar in South Africa.

## KEYWORDS

Impediments; Enablers; Rooftop Solar; PV Uptake; Diffusion; Policy; Gauteng Province

## DECLARATION

I, Pride Takudzwa Munemo, declare that this research report is my 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**: Pride Takudzwa Munemo **Signature**:

**Signed at**: Bromhof

**On the** 26th **day of** September **20**24

## DEDICATION

This research is dedicated to my late mum and dad.

*Ndinokurangarirai amai na baba vangu. Zororai murugare.*

## ACKNOWLEDGEMENTS

I would like to thank the MMEL department at the Wits Business School for their support in compiling this proposal. I hope that the work presented in this paper will contribute positively to the department and its body of knowledge. I would also like to thank my supervisor, Professor Lwazi Ngubevana, for your guidance and academic support; your thorough assessment of my work assisted in producing this proposal.

To my fiancé, Rumbie, and my daughter Kayla, I thank you for your continued love and support. Thank you for understanding that Taku is studying and giving him space; your love and support are amazing.

God Bless you.

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## LIST OF ACRONYMS

$CO_2$ – Carbon dioxide

CPI – Consumer Price Index

CSP – Concentrated Solar Power

DME – Department of Energy

DMRE – The Department of Minerals Resources and Energy

DoE – The Department of Energy

EAF – Energy Availability Factor

FiT – Feed-in tariff

IRP – Integrated Resource Plan

kWh - Kilowatt-hour

MW – Megawatt

NDP – National Development Plan

NERSA – National Energy Regulator of South Africa

PV – Photovoltaic

RSPV – Rooftop Solar Photovoltaic

SAPVIA - The South African Photovoltaic Industry Association

SSEG – Small Scale Embedded Generators

# CHAPTER 1: BACKGROUND OF THE STUDY

This chapter highlights the purpose, context, and objectives of the research study and highlights the significance and delimitations of this research paper.

## 1.1 Purpose of study

The research aimed to identify and analyse the impact of perceived policy impediments and, additionally, explore the enablers for the uptake of the rooftop solar revolution in the Gauteng Province in South Africa. It is posited that these policy challenges may be affecting the rate of rooftop solar photovoltaic (RSPV) project uptake. Provinces and Cities, which largely include developed urban and emerging cities and small settlements, are increasingly becoming the focal point for the deployment of solar photovoltaic ("PV") technology (IEA, 2020).

Research on the implementation of solar PV emerged in the 1980s, and the world has seen rapid growth in this sector in the last decade (Amankwah-Amoah & Sarpong, 2016; IEA, 2020). Past studies on the rapid developmental trends have cast more light on the growth of this technology in terms of application types such as rooftop, ground-mounted utility, building integrated, and floating PV systems (Mah et al., 2018). Such trends and findings are proof that there is also demand for solar or renewable energy in general.

To improve the diffusion of renewable energy technologies, it has been argued that firstly, there must be a better understanding of the barriers that are inhibiting adoption (Faiers, Cook, & Neame, 2007; Faiers & Neame, 2006; Juszczyk, Juszczyk, Juszczyk, & Takala, 2022). High capital outlay, lack of incentives, and legal and regulatory constraints that are often cited as the primary impediments to renewable energy adoption (Cooke, Cripps, Irwin, & Kolokotroni, 2007; Oryani, Koo, Rezania, & Shafiee, 2021; Zhang, Shen, & Chan, 2012) Furthermore, another stream of literature on solar PV suggests multi-dimensional factors that affect the deployment of technology includes technical, economic, social, and policy factors (Mah et al., 2018; Musango, Amigun, & Brent, 2011; Winkler, 2005).

One theoretical approach to understanding how change may be achieved is Rogers' (1995) innovation diffusion theory (IDT). The theory identifies three pillars of innovation diffusion through the characteristics. Rogers (1995) indicates that adopters are influenced by many factors, which are categorized into technological, organizational and environmental factors. He argues that certain characteristics of the innovation itself may facilitate its adoption (Rogers, 2004). The theorist indicates that other factors influence the acceptance of technology, such as its promotion by influential role models, the degree of complexity of the change, compatibility with existing values and needs, and the ability to test and modify the new procedure before adopting a technology.

According to Painuly (2001), the diffusion and adoption of solar PV technology require an effective institutional support system to be in place and must be all-inclusive. As institutions and technology co-evolve and adjust to each other with time, the initial stages of technologies are marked with uncertainties that may hinder potential growth (Bianco, Cascetta, & Nardini, 2021). This study intends to identify any perceived policy impediments and enabling factors, with the view of investigating their impact on the deployment rate of rooftop solar PV projects in Gauteng, South Africa.

The South African energy sector is experiencing an increasing interest in rooftop PV installations regardless of the absence of sector-specific policies and standards for the promotion of this subsector (Greencape, 2021). The generated electricity from a rooftop installation can be used to supplement electrical requirements for a facility or can be directed back into the grid in certain instances where permitted. However, a NERSA-approved tariff has to be agreed upon (SAPVIA, 2021).

The findings of this research can aid academics, energy practitioners, and regulators in directing their future endeavours toward the widespread adoption of rooftop solar technologies in the Gauteng province. Furthermore, the study will provide a basis for developing a framework for policies and strategies to increase the uptake of rooftop solar in South Africa. The recommendations and proposed policy strategies may assist energy industry actors in creating an enabling environment that will increase the diffusion of RSPV in the Gauteng province.

## 1.2 Context of study

This research is motivated by the need to identify potential policy barriers that may impede the uptake of solar PV energy for residential, commercial, and industrial rooftop applications. It is also aimed at improving stakeholders' influence on rooftop solar energy policy development and regulation in South Africa. Solar PV uptake is helping ease the burden on the South African utility power grid, which is currently constrained due to the high demand, limited generation capacity, and unplanned power cuts.

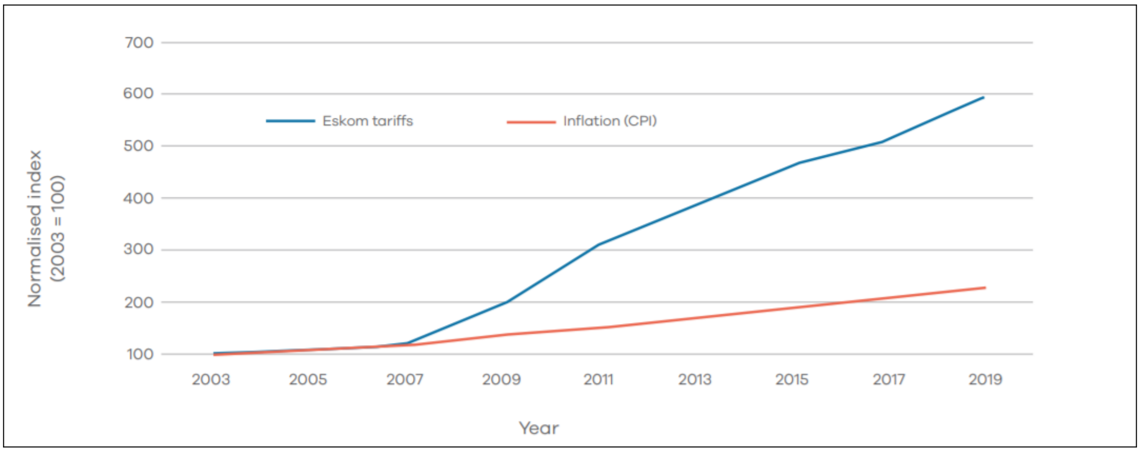
Solar power has experienced tremendous growth and has become the world’s fastest-growing renewable energy source (BRC, 2020). As per the solar power outlook report of South Africa, rapid solar installations across the world are due to energy policy support, a sharp decrease in solar technology costs, and the growing concerns about environmental impacts caused by fossil-based power generation.

The energy market in South Africa is dominated by coal-based energy electricity generation, constituting about 83% of the maximum power generating capacity mix in 2018 (DoE, 2019). The country’s Energy Whitepaper of December 1998 possessed a policy vision with a primary goal of enhancing access to cost-effective services. (DME, 1998). South Africa’s National Development Plan “NDP” envisages that at least 95% of the country’s population will have access to grid or off-grid electricity by 2030 (DoE, 2019; National Planning Commission, 2013).

The cost of solar photovoltaic electricity generation has reduced drastically since 2010, to nearly 7 cents per kWh in 2019 (Irena, 2020). Although residential and commercial (C&I) rooftop PV systems generally have higher generation costs than utility-scale projects, they have also experienced a steep decline over the last decade from an "LCOE" of USD0,455 per kWh to a range of between USD 0,062 per kWh to USD 0,064 per kWh in 2010 and 2019 respectively (Irena, 2019, 2020) This is emanating from a decrease in solar panel production costs from cradle to grave due to technological advancements, more efficient production methods and economies of scale.

The escalating electricity prices in South Africa over the past decade, coupled with heightened consumer awareness of Eskom power outages and the diminishing costs of solar technology, have collectively rendered solar rooftop generation more appealing to a majority of consumers. (Okharedia, 2019; Pandarum, Lekoloane, & Milazi, 2019). **Figure 1** shows the exponential rise in the average Eskom tariff and the rise in inflation since 1987 (Eskom, 2020; Greencape, 2021; Moolman, 2017).

**Figure 1: Average Eskom tariff versus inflation (CPI) until 2019**




Source: STATS SA (2020)

The earlier stated challenges have pushed consumers to pivot towards the use of standalone or embedded small-scale solar rooftop energy generation for self-consumption and potentially feeding back excess power to the utility grid.

Despite growth in solar PV usage worldwide and increasing electricity prices since 2011, the uptake of rooftop solar PV has been relatively slower than predicted. According to the latest Integrated Resources Plan "IRP," there will be restrictions to additional capacity to 1,000 MW per year for solar PV power and

1600 MW per year for wind power (DMRE, 2019). Hence, the motivation behind this study is to investigate whether the sluggish adoption could be attributed to barriers related to policies.

The announcement of the amended Schedule 2 of the Electricity Regulation Act by the South African President in June 2021 provided the needed boost in the small-scale embedded power industry by proposing a shift of the licensing exemption threshold from 1MW to 100MW for embedded power generators (NERSA, 2021). However, Nersa reiterated that generation facilities will still be required to apply to NERSA for registration to ensure that they meet all the requirements. The previous 1MW cap required that all projects above this capacity apply for a generating license with the regulator. To certain prospective investors, such regulations are perceived as obstacles to the utilization of renewable energy. It is part of the study's objectives to examine how such regulation encourages the use of solar PV energy.

Despite the above announcements, there are still structural issues that have previously been reported. Impediments have been extensively covered in the media, and previous studies have investigated the challenges associated with the deployment of renewable energy technologies in the country (Krupa & Burch, 2011; Naicker & Thopil, 2019). Geh, Emuze, and Das (2023) and Ntsoane (2017) indicate that there is not enough policy for rooftop solar PV in South Africa, and the main challenges include intra-sector competition. It is perceived that more policy attention and interpretation is on utility-scale solar projects, and rooftop solar project policy is relegated to a minority sector (SAPVIA, 2020b; WWF, 2017). SAPVIA (2020b) highlights the paucity of specific standards, rules, and policies for small-scale embedded generators (SSEG) that leave room for uncertainty in the sector. The association states that this is hindering the progression of the sector as many are skeptical about entering into an unclear regulatory environment and under transition.

Furthermore, the rapid change in technology and equipment price requires consistent policy improvements to keep up with the emerging global trends swiftly. Geh et al. (2023) and Ntsoane (2017) indicate that there is not enough policy for rooftop solar PV in South Africa, and the main challenges include intra-sector competition. It is perceived that more policy attention and interpretation is on utility-scale solar projects, and rooftop solar project policy is relegated to a minority sector (SAPVIA, 2020b; WWF, 2017). SAPVIA (2020b) highlights the paucity of specific standards, rules, and policies for small-scale embedded generators (SSEG) that leave room for uncertainty in the sector. The association states that this is hindering the progression of the sector as many are skeptical about entering into an unclear regulatory environment and under transition. Furthermore, the rapid change in technology and equipment price requires consistent policy improvements to keep up with the emerging global trends and swift development of solar PV (Irena, 2019).

### 1.3 Research Problem

Property owners and solar PV companies in the Gauteng province are increasingly installing solar PV panels and battery energy storage systems to counter the effect of increased load shedding and satisfy their interest in the clean and renewable energy source whilst taking advantage of the reduced technology costs to mitigate against the future rise in electricity prices (Greencape, 2021). The Gauteng province provides a set of unique conditions, such as favourable, high solar insolation, an unstable electricity supply, and escalating electricity prices, which have contributed to the increased uptake of solar PV technology in the province, with four out of nine municipalities in allowing small scale embedded generation (Pandarum et al., 2019; SALGA, 2020). Generally, it is perceived that the number of municipalities with SSEG tariff structures in place tends to be behind the ones allowing SSEG, partially due to the uncertainties relating to ambiguous and unclear NERSA application and approval processes, as well as internal municipal revenue concerns and billing system integration issues. **Table 1** below shows the statistics of SSEG installed capacity in the Gauteng region and other provinces (SALGA, 2020).

**Table 1: The estimated number of registered SSEG installed capacity in Gauteng**

| | Number of municipal electricity distributors in the Province | Number of municipalities allowing SSEG installations | Number of municipalities with official application processes | Number of municipalities with SSEG tariffs | Estimated capacity (MW) of registered SSEG systems |
|---|---|---|---|---|---|
| Eastern Cape | 22 | 6 | 6 | 2 | 10.7 |
| Free State | 17 | No data | No data | No data | 0.0 |
| Gauteng | 9 | 4 | 3 | 2 | 129 |
| Kwazulu-Natal | 25 | 3 | 2 | 1 | 35.5 |
| Limpopo | 16 | 6 | 5 | 1 | 3.7 |
| Mpumalanga | 14 | 4 | 4 | 3 | 17.0 |
| Northern Cape | 24 | 9 | 4 | 3 | 4.4 |
| North West | 13 | 2 | 2 | 0 | 17.6 |
| Western Cape | 25 | 22 | 18 | 19 | 64.3 |
| TOTAL | 165 | 56 | 44 | 31 | 282.1 |
| % Licensed | | 34% | 27% | 19% | |

Source: SALGA (2020)

Pegels (2010) highlighted several policy issues that were impeding the implementation of renewable energy projects, including solar PV at scale in South Africa, and a majority of the barriers are still being experienced in this sector. The author further highlighted several policy issues that were impeding the implementation of renewable energy projects, including solar PV at scale in South Africa, and a majority of the barriers are still being experienced in this sector (Moorthy, Patwa, & Gupta, 2019; Todd & McCauley, 2021). If policymakers intend to enable the widespread adoption of rooftop solar PV, they will need to address such barriers to support ESCOs in implementing the emerging technology. Concurrently, market participants must work with policymakers to develop enabling policies that allow progress in implementing these solar projects.

The DME (1998) Whitepaper on energy policy sets out a vision, policy principles, goals, and strategic objectives to promote the uptake of renewables, including solar PV technology. It further highlights a target to review the policies every five years to ascertain whether or not the set targets, objectives, and deliverables are being met. The DME (1998) Whitepaper on energy policy sets out a vision, policy principles, goals, and strategic objectives to promote the uptake of renewables, including solar PV technology. It further highlights a target to review the policies every five years to ascertain whether or not the set targets, objectives, and deliverables are being met (Pegels, 2010). Mendonça (2012) describes feed-in tariffs as the most common and effective policy instruments to support the adoption of renewable energy technologies, which were first applied in Germany and later spread across the world. The REFIT program was introduced in South Africa in 2009 to support the adoption of renewable energy technologies. However, there is a gap between renewable energy policy statements and the actual implementation nationwide, as seen in the application and interpretation of the concept by municipalities. Mendonça (2012) describes feed-in tariffs as the most common and effective policy instruments to support the adoption of renewable energy technologies, which were first applied in Germany and later spread across the world. The REFIT program was introduced in South Africa in 2009 to support the adoption of renewable energy technologies. However, there is a gap between renewable energy policy statements and the actual implementation nationwide, as seen in the application and interpretation of the concept by municipalities.

According to Khumalo, Fontana, and Dladla (2021), South Africa has inadequate government-led regulatory and tax incentive programs for renewable energy implementation, and the current regulation does not allow for effective rooftop solar excess energy to be sold back into the national power grid and reform to allow for this would stimulate and promote faster growth in the rooftop solar market. The development and implementation of reforms to this end would stimulate and enable faster growth of the rooftop solar market in

SA (DoE, 2019). There is a perceived lack of sufficient government-led programs and incentives that can help cultivate a wider growth of the renewables market (DoE, 2019). Currently, there are no tariff top-up arrangements in place, as successfully implemented in other African countries, such as Uganda's GET FiT program (Bhamidipati, Haselip, & Hansen, 2019).

Net Metering, where credits are issued for surplus electricity fed back into the grid, was successfully implemented in other African countries such as Ghana, and this represents an effective example of private investment in solar PV systems (Opoku, Obeng, Adjei, Davis, & Akuffo, 2020). Ndanga and Gorn (2012). Ndanga and Gorn (2012) highlight the lack of formal incentives for SSEGs, like net metering, as a major impediment in SA. The two authors further indicate that there are no formal and well-defined net metering policies in South Africa, where the municipality pays a homeowner to produce excess electricity for use somewhere else. In the Western Cape, some municipalities have already developed rules and tariffs for feeding into the grid when installing a PV system. However, most municipalities are perceived to be reluctant to implement similar rules in Gauteng and other provinces (SALGA, 2020).

The Ministry of Energy in 2021 announced that two projects, amounting to 225 MW in combined capacity, are hybrid solar photovoltaic (PV) and battery storage facilities, while the other two, with a total capacity of 203 MW, are hybrid solar PV wind, and battery storage plants. The remaining 197 MW project is a hybrid LNG and solar PV plant (African Energy, 2021). The government is trying to create an enabling environment for large, independent renewable energy power producers even though there the allocation process of these projects has been touted to be questionable by some members of the energy industry. However, very little, if not none, is being done to create an enabling environment for smaller renewable power companies such as rooftop solar PV providers.

Another point of interest is the Conduct rules as envisaged in Section 10 (2) (b) of the Sectional Title Schemes Management Act ("the Act") (Squier & Venter, 2019). "In terms of PMR 4 of the Prescribed Conduct Rules (which will apply unless the developer or body corporate has amended them to the contrary), a party to a scheme may not, without the written consent of the relevant trustees, erect anything on the structure forming part of the common property, which in doing so will cause damage to that common property" (Squier & Venter, 2019).

According to Creamer (2021), the easing of licensing requirements for additional embedded generation is expected to unlock up to 5 000MW of new capacity and assist in reducing the impact of load shedding. The license exemption cap was lifted to 100MW to create an enabling environment for energy service companies through increased capacity for embedded generation. However, the proposed amendments also fall short of what the energy industry is expecting, bringing along new issues. According to Creamer (2021), the easing of licensing requirements for additional embedded generation is expected to unlock up to 5 000MW of new capacity and assist in reducing the impact of load shedding. The license exemption cap was lifted to 100MW to create an enabling environment for energy service companies through increased capacity for embedded generation. However, the proposed amendments also fall short of what the energy industry is expecting, bringing along new issues (DMRE, 2021). The amendment largely presents several positive changes in the energy industry. However, on the other hand, it is said to have not provided comprehensive definitions, creating unnecessary ambiguity and raising more questions of clarity around self-generation, the application of wheeling and trading, as well as how including energy storage in generation projects will impact the requirements. It is also unclear whether the operator of an exempted generation facility would be required to obtain a trading license to sell electricity to an end-use customer (Engineering News, 2021; SAPVIA, 2021).

## 1.4 Research objectives

Guided by the research problem, the study broke down the primary research objective into sub-research objectives, which are interconnected to accomplish the overarching research goal collectively. The sub-research objectives are listed below:

i. To identify and quantify the extent of the effect of policy barriers impeding the uptake of RSPV through statistical analysis of survey data

ii. To assess and quantify the extent of the impact of policy enablers on the uptake of RSPV in South Africa

iii. To examine the perceived extent of the uptake of RSPV in Gauteng, South Africa

iv. To statistically analyze and evaluate solar policies and strategies to develop a data-driven framework of recommendations aimed at improving RSPV adoption

### 1.5 Research Questions

Based on the above research objectives, the following research questions were identified:

i. How can policy barriers affecting the uptake of RSPV be identified through statistical analysis of survey data?

ii. What is the extent of the impact of policy enablers on the uptake of RSPV in South Africa?

iii. To what extent is the uptake of RSPV in Gauteng province, South Africa

iv. How can solar policies and strategies be statistically analyzed and evaluated to develop a data-driven framework of recommendations for improving RSPV adoption?

## 1.6 Significance of study

Currently, there is a lack of available, affordable financial policy incentives for smaller solar rooftop projects, as they are not as attractive in terms of modern financing mechanisms (Greencape, 2021; SAPVIA, 2020a).(Greencape, 2021; SAPVIA, 2020a). Such smaller-sized inquiries normally have to wait until the energy service companies have multiple similarly sized clients and bundle them together to reach desired economies of scale. Distributed energy systems such as rooftop solar PV allow anyone to generate electricity. However, the integration and configuration of these systems to work with the existing electrical network is an engineering feat that requires critical attention. Equally, it is important to consider discussions around the changing relationship between the electricity service providers and the consumers and the implications this has for social equity. The current issues being experienced by Eskom in maintaining a stable electricity supply nationwide pose a further power supply risk to businesses and the industry at large. The aging power plants of the utility, approaching the end of their operational life, coupled with inadequate infrastructure maintenance, have resulted in persistent power interruptions, with the anticipation that this trend will further deteriorate in the upcoming years (Lawrence & Ballard, 2020). This study intends to investigate the impediments that exist in the implementation of rooftop solar projects in the Gauteng province. In addition to that, the study also seeks to reveal the policy enablers that are in place and their effectiveness.

On a micro-scale, the study will benefit energy service companies that are rolling out rooftop solar projects and policymakers in their process of creating a more enabling environment to unlock potential new capacities for rooftop solar. The study will also benefit roof-top solar companies in understanding impediments and policy enablers that are currently in place. On a macro scale, the research will assist in promoting solar energy, thereby reducing pressure on the already strained ESKOM electricity grid. The conceptual framework that will be developed will help energy regulatory bodies determine ways of integrating solar energy into existing electrical systems.

The study will contribute to the development of the academic body of knowledge. The academic theories employed in this research paper will assist future researchers in further developing the theories that improve the uptake of new and evolving energy technologies. Furthermore, the research will contribute to the development of RSPV policies and strategies to enhance the uptake of rooftop solar in South Africa.

### 1.7 Delimitations of the study

i. Although there are many solar rooftop projects in South Africa, the research will focus on energy experts who are currently involved in the rolling out of RSPV projects in the Gauteng Province due to the time constraints of conducting research across the whole country.
ii. Policy enablers that are put in place apply both to commercial and utility-scale projects, but for this research, policy enablers relating to residential, commercial, and industrial rooftop solar PV systems will be looked at.
iii. Although there may be other challenges, such as access to finance and technology advancement, the research will only focus on policy barriers.

### 1.8 Definition of terms

i. Feed-in tariffs – Feed-in tariffs refer to an electricity price paid to a renewable energy producer for every unit injected into the electricity grid (Couture, Cory, Kreycik, & Williams, 2010). This is defined as the most common and effective policy instrument to support the adoption of renewable energy technologies, which was first applied in Germany and later spread across the world (Mendonça, 2012).
ii. Solar PV - this is defined as solar photovoltaics derived from the process of converting light (photons) to electricity (voltage), which is called the photovoltaic effect

## 1.9 Assumptions

i. It is assumed that policy impediments will affect energy services companies rolling out rooftop solar PV in the same way.
ii. It is assumed that the policy enablers will have the same effect on all the energy service companies.

## 1.10 Research report structure

**Chapter 1: Orientation of the study**

This chapter introduces the research topic and a brief background about the rooftop PV industry. The chapter also highlights the research problem, delimitations of the study, assumptions, research questions, and research objectives of the study. Additionally, the study delved into the research questions, the significance of the research, and its limitations.

**Chapter 2: Literature Review**

This chapter encompasses a comprehensive examination of existing literature conducted by various researchers on both policy impediments and policy enablers within the solar PV industry. Additionally, it includes a concise exploration of the energy policy landscape in South Africa. Key definitions and contradictory arguments around energy transitions are also discussed. Hypotheses are also developed, which form the basis for the conceptual framework. Ultimately, the chapter concludes with the development of a conceptual framework.

**Chapter 3: Research Methodology**

This chapter delves into the chosen research methodology for the study. It encompasses the following key elements:

i. The research method employed for sample selection;

ii. The identification of the research population;

iii. The creation and application of the research instrument;

iv. The methods employed for data collection;

i. v. The assessment of reliability and validity of the collected data.

**Chapter 4: Presentation of results**

The objective of this chapter is to showcase the study's findings. Drawing from the detailed processes and procedures outlined in the methodology section, this chapter will systematically present the collected data, elucidate the findings, and elaborate on the conceptual framework, hypotheses, and analytical methods applied to the data.

**Chapter 5: Analysis of results**

The chapter aimed to analyse the results as presented in chapter four. As a quantitative study, the presentation will encompass descriptive statistics, confirmatory analysis, exploratory analysis, and outcomes from structural equation modelling.

**Chapter 6: Recommendation and Conclusion**

In the concluding chapter of the research, the study's findings are examined to draw insightful conclusions. These conclusions serve as a foundation for offering recommendations and suggesting potential areas for future studies, all informed by the study's discoveries and identified limitations.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This section focused on the presenting relevant body of literature in the research topic under investigation. The primary purpose of the study was to examine policy impediments and enablers within the solar PV industry. Throughout this review, key words were defined, major theories were investigated, and hypotheses were developed for the study.

## 2.2 Theoretical models

Several theoretical models can support the present understanding of the policy barriers and facilitators that impede the adoption of solar PV systems. This section of the chapter looked at some important theoretical models that could serve as the foundation for the study. These models were described as below.

### 2.2.1 Innovation Diffusion Theory (IDT)

Innovation Diffusion Theory was developed by Everett Rogers in 1962 and it explains how, why, and at what rate new ideas, technologies, or innovations spread through social systems. This theory identifies the process through which an innovation is communicated and adopted by individuals or groups over time. It is widely used in understanding the adoption of technologies, products, social movements, or behaviors.

**i. Key elements of innovation diffusion theory**

(Rogers, 2004) identified 5 elements of innovation diffusion theory and these included innovation, communication channel, time adopter and social systems.

An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. Innovations can include new technologies, processes, or practices(Sherry & Gibson, 2002).

Innovations spread through communication channels are how information about the innovation is passed between individuals or groups. This can happen through mass media, social networks, or interpersonal communication. (Rogers, 2004) argued that the innovation process takes time, and individuals or organizations adopt innovations at different rates. The innovation-decision process consists of five stages which are as follows;

- **Knowledge**: The individual first becomes aware of the innovation.
- **Persuasion**: The individual forms an attitude (positive or negative) toward the innovation.
- **Decision**: The individual decides whether to adopt or reject the innovation.
- **Implementation**: The individual puts the innovation into use.
- **Confirmation**: The individual seeks reinforcement of their decision, either continuing or discontinuing the use of the innovation.

The social system is the network of individuals, groups, or organizations that engage in communication and influence each other’s decision-making process. The structure of the social system (e.g., peer networks, authority figures) can significantly affect the spread of innovation. Individuals adopt innovations at different times and can be grouped into five adopter categories based on their willingness to accept new ideas. These groups are typically represented by a bell curve, with most people adopting innovations during the middle phases.

Rogers' Diffusion of Innovation Theory has undergone revisions and updates over the years, reflecting changing communication technologies and social dynamics. Criticisms of the theory have centred around its linearity, its focus on individual adopters rather than organizational or societal factors, and its limited applicability to certain cultural contexts.

Despite these critiques, Rogers' Diffusion of Innovation Theory remains a foundational and widely cited framework for understanding the spread of innovations. Its insights into the process of diffusion and the characteristics of adopters have informed numerous studies and practical applications, contributing to the successful adoption of innovations in various fields, including technology, healthcare, agriculture, and education.

The theory posits that three main factors influence the diffusion of an innovation:

i. Relative advantage: The perceived superiority of an innovation over the existing norm.
ii. Compatibility: The degree to which an innovation is consistent with existing values, norms, and practices.
iii. Complexity: The perceived difficulty of understanding and using an innovation.

Innovation diffusion theory is not recommended for a study of this nature, which is looking at the adoption of new technologies based on policy impediments/incentives.

### 2.2.2 The multilevel perspective (MLP)

The multilevel perspective (MLP) was developed by Frank Geels (2018) and Geels & Schot (2010) and is a widely used framework for understanding transitions in socio-technical systems which can include energy, transport, or water management. It emphasises that transitions unfold over time and involve interactions between multiple levels of a system which are briefly presented below.

**Landscape Level (Macro**): This is the broader social, cultural, political, and economic environment in which transitions occur. This includes factors like international politics, environmental pressures, and cultural norms that are often slow-changing but can have significant effects on lower levels.

**Regime Level (Meso):** The dominant set of practices, rules, and institutions that define the current system. This is the established status quo—technologies, policies, infrastructures, and user practices that reinforce stability in the system.

**Niche Level (Micro):** The space where radical innovations and experiments emerge. It includes new technologies, business models, and practices that deviate from the dominant regime. Niche innovations often require protection or support (e.g., funding or policy incentives) before they can challenge the regime.

Geels & Schot (2010) argued that change often starts in the niche, but external pressures from the landscape can create windows of opportunity for innovations to influence or transform the regime. Transitions are non-linear and typically involve a dynamic interplay between the niche, regime, and landscape.

The multilevel perspective framework was used to guide this study as it is a more widely used and accepted framework particularly for the energy industry. This framework also includes the way in which new innovations are contested by the regime. The Multilevel Perspective (MLP) framework is particularly useful in solar PV adoption projects because it provides a structured way to understand the complex, systemic nature of socio-technical transitions. Solar PV adoption involves technological, social, political, and economic shifts, and MLP helps to analyze how these factors interact across different levels.

## 2.3 RSPV implementation barriers

The diffusion and adoption of a newly developing technology, such as RSPV, necessitate the establishment of a robust and effective institutional support framework. The early stages of technology spread are characterized by uncertainty (Painuly, 2001), which must be addressed through appropriate interventions. In the past, restrictive factors such as perceived high capital costs on the adoption of solar technology have been well recognized in global literature (Zhang et al. 2012). As a result, favourable institutional and managerial support is required for the adoption of innovations (Rogers 1995).

Joubert, Hess, and Van Niekerk (2016) suggested that there are available concepts and literature on the legal and policy impediments to renewable and sustainable energy sources globally and from a South African context. The existing notions and literature on the legal and policy impediments to renewable and sustainable energy sources in South Africa also acknowledged this (Joubert et al., 2016; Murombo, 2016). However, there is a lack in the literature regarding the perception of policy impediments related to RSPV in the Gauteng province, which this study intends to fill.

Some of the key barriers to the implementation of solar technologies are briefly described below;

### i. High Initial Capital Costs

Bazilian and Pielke (2013) in their study on making energy access meaningful argued that solar energy projects, especially at large scales, require significant upfront investments world over. This is a similar case with the South African context as suggested by (DoE, 2019). The DoE (2019) report suggested that even though operational costs are low, the initial expense of purchasing and installing solar panels, inverters, and other infrastructure are still high in South Africa.

### ii. Grid and Infrastructure Challenges

Moksnes, Korkovelos, Mentis, and Howells (2017) expressed strongly that in many regions in Kenya, existing electricity grids are not designed to handle the integration of renewable energy sources, including solar. The intermittent nature of solar energy, along with the lack of sufficient storage solutions, limits its penetration into the energy grid in East and Southern Africa (Moksnes, et al 2017). This is one of the factors that is inhibiting the adoption of solar technologies.

### iii. Lack of Policy Support and Regulatory Barriers

Solar technology often requires supportive policy frameworks, such as subsidies, tax incentives, or favourable regulations, to make it cost-competitive with traditional energy sources. A lack of stable and clear policy incentives as is the case with most African countries hinders investments in this area (Couture, Cory, Kreycik, and Williams, 2010).

### iv. Social and Cultural Resistance

Sovacool and Drupady (2011) revealed in their findings on examining the small renewable Energy Power (SREP) program in Malaysia, that resistance from local communities, especially in cases where large solar farms required substantial land use, slowed or halted the implementation of solar technologies. Cultural preferences for traditional energy sources, or fear of new technology, was posing a lot of challenges in African countries as well due to fear of the unknown (Kim, Lee, and Lee, 2019).

### v. Technical and Human Capacity Limitations

Maleki, Rosen, and Pourfayaz (2017) claimed that there lack of technical expertise and capacity to install, operate, and maintain solar technologies is a significant barrier, especially in developing countries in Africa and Asia. They further suggested that the availability of skilled labour, training programs, and local industry expertise is often inadequate to support the growth of the solar sector.

### vi. Market Structure and Energy Pricing

Yergin (2011) in his study on The Quest: Energy, Security, and the Remaking of the Modern World, revealed that existing energy market structures often favour traditional utilities and fossil fuel industries in Africa. He suggested that regulatory frameworks in some regions lacked provisions for independent renewable energy producers, limiting opportunities for smaller-scale solar projects. However, this was contrary to the South African context where independent energy producers have the opportunity and are involved in the renewables (World Bank, 2018).

## 2.4 An Overview of the South Africa Energy Sector

Energy is the central component of development (World Bank, 2018). It is an important force that provides power to companies, manufacturing facilities, transport businesses, and service delivery in the country. Energy is the heart of the modernisation of livelihood, as it impacts everything that humans do and affects day-to-day life.

South Africa’s energy sector is at the nucleus of its social and economic development (DoE, 2019). The energy industry has a direct impact on the economy through the use of labour and capital in the energy production processes (Ndlovu & Inglesi-Lotz, 2020). The energy sector continues to support the economic growth, job creation, and the pursuit of a decarbonized environment (Ng, 2017). Furthermore, the energy sector in South Africa is dominated by a public utility company which offers affordable energy (Blimpo &

Cosgrove-Davies, 2019; Tyurina, Frumina, Demidova, Kairbekuly, & Kakaulina, 2023).

The Department of Energy is mandated to ensure the availability of sufficient energy resources and accessible energy services that are affordable, reliable, and sustainable, with minimal impact on the environment (DoE, 2019). South Africa’s National Development Plan (“NDP”) predicted that by 2030, the local energy sector will be a conducive environment that enhances socio-economic growth and development through sufficient investment in energy resources and infrastructure (National Planning Commission, 2013). The plan further envisaged that by the same year, the country will have a stable and sufficient electricity supply to ensure that there is no disruption to economic activities and welfare.

The utility grid and off-grid electricity are expected to be accessible to at least 95% of the country’s population by 2030 (National Planning Commission, 2013). IEA (2019) report reflects that South Africa set its targets and measures to decommission 35 GW of the 42 GW of coal power plants that are currently operational (IEA, 2019). This is a strong signal that shows that the country is moving towards renewables. South Africa's key indicators and policy initiatives up to the year 2040 are indicated in Table 2.

**Table 2: South Africa's key indicators and policy initiatives**

| | | | Stated Policies | | Africa Case | | CAAGR 2018 - 40 | |
|---|---|---|---|---|---|---|---|---|
| | **2000** | **2018** | **2030** | **2040** | **2030** | **2040** | **STEPS** | **AC** |
| GDP ($2018 billion, PPP) | 491 | 789 | 1 010 | 1 348 | 1 174 | 1 600 | 2.5% | 3.3% |
| Population (million) | 46 | 57 | 66 | 71 | 66 | 71 | 1.0% | 1.0% |
| With electricity access | 77% | 95% | 100% | 100% | 100% | 100% | 0.2% | 0.2% |
| With access to clean cooking | 56% | 87% | 90% | 93% | 100% | 100% | 0.3% | 0.7% |
| CO2 emissions (Mt $CO_2$) | 280 | 420 | 321 | 279 | 289 | 187 | -1.8% | -3.6.% |

Source: AFSIA (2021)

Currently, coal, a cheap and widely abundant resource, is the most dominant energy source in the South African energy sector. Coal is classified as one of the lowest-cost primary energy sources in the world. In addition to coal, which provided approximately 69% of the total primary energy supply in 2016, other local energy sources in South Africa included biomass, natural gas, hydro energy, nuclear power, solar PV and CSP, and wind energy (DoE, 2019).

At present, South Africa is highly dependent on coal to generate 92% of its electricity and to produce 20% (estimated) of its liquid fuels. Coal emerges as a cost-effective method for satisfying local primary energy requirements alongside oil and natural gas. Because of its abundance, coal presents itself as affordable, easy to handle, store, and utilize, and is also free from geopolitical tensions. These characteristics make it a popular primary resource (DoE, 2019). According to (IEA, 2019), coal was the dominant source of energy in South Africa, contributing 226,710 GWh of annual electricity. Eskom serves as the primary electricity provider in South Africa, supplying over 90% of the country's electricity and an additional 40% within the African continent (DPE, 2019).In 2017, Eskom announced that it would shut down five of its coal-fired power stations. Public discourse and concern about the transformation of the country's energy system have been ongoing for years. However, this announcement sparked panic and led to unavoidable socio-economic consequences (DoE, 2019). DoE (2018) reported that one-third of Eskom's power stations will soon be approaching the end of their life span. DoE (2018) reported that one-third of Eskom's power stations will soon be approaching the end of their life span. This is a strong motivation to move away from fossil fuel in South Africa. Figure 2 shows an overview of the age of Eskom's power stations; one-third (in blue) is approaching the end of life.

**Figure 2: Operation Life of Eskom Power Stations**

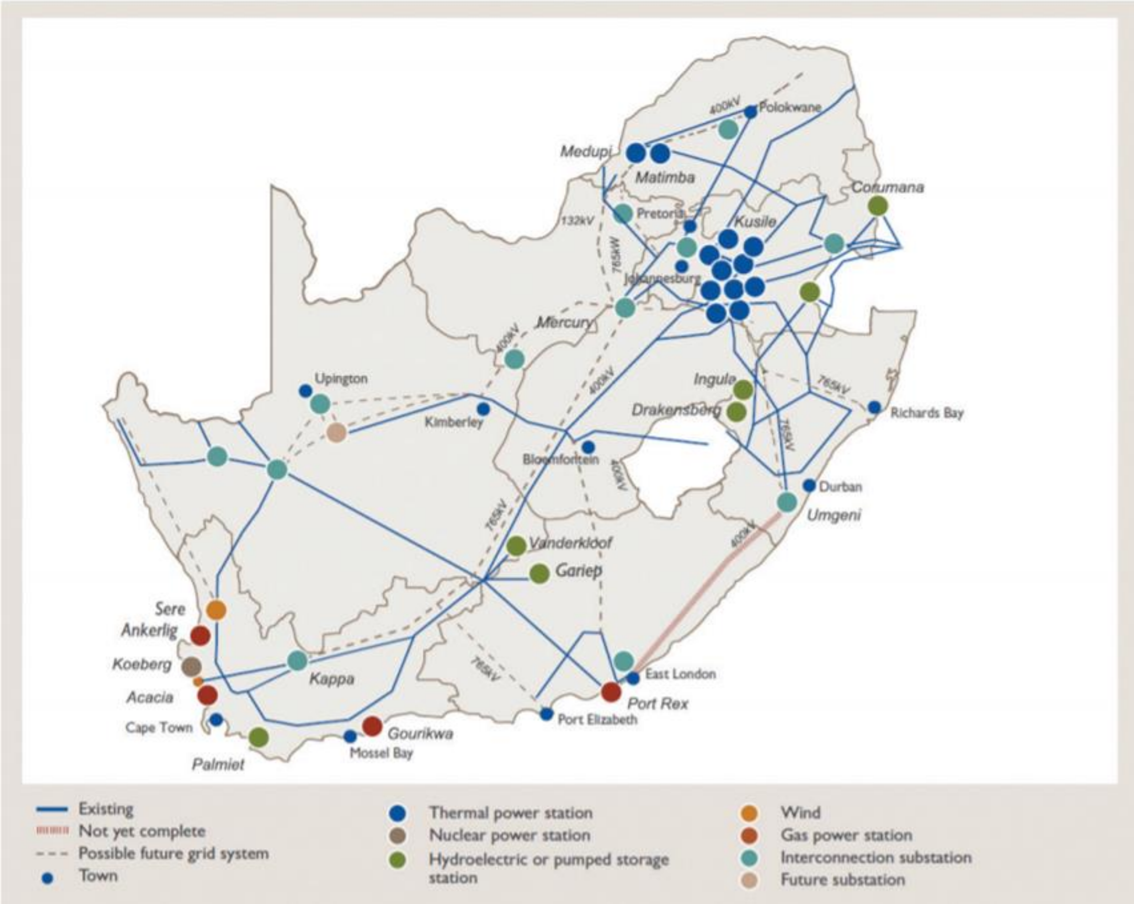

Source: Bloomberg (2020)

South Africa relies strongly on coal, but the country is putting significant efforts to diversify its energy mix. With most of its aging coal-fired fleet on the brink of decommissioning, new power plants will not be able to completely offset the deterioration of the existing fleet (IEA, 2019). The report further indicated that the country's leadership is concentrating on the diversity of the energy mix through the introduction of natural gas peaking plants and renewable energy, including CSP and solar PV. The country has an exceptional natural resources base for both CSP and solar PV development. Therefore, this research serves as a focal point for policymakers to identify the barriers and motivators of renewable energy adoption.

Furthermore, the IEA (2019), articulated that South Africa has various policy opportunities, such as diversifying its energy supply away from fossil-based energy sources, yielding many benefits, including reduced air pollution and the risks associated with it. However, The transition to a more decarbonized environment will necessitate the careful management and consideration of potential social setbacks and their associated implications. The reforming and restructuring of the power utility Eskom to a more reliable power system and fostering increased environmentally friendly industrialisation may help in the ambition to achieve a more diverse energy mix. Promoting efficient use of energy in the economy will assist in lowering the demand for both resources and energy, while the implementation of minimum energy performance standards for industrial and mining machinery and equipment would be a key gateway to unlock potential energy efficiency gains (Igogo, Awuah-Offei, Newman, Lowder, & Engel-Cox, 2021; Parker, 2016).

According to Eskom's integrated resource plan, SA's electricity supply mix comprises approximately 215 000GWh generated annually by Eskom power stations, with about 12000GWh provided by independent power producers and a further 8600GWh covered through imports from neighbouring countries. Eskom owns, operates, and maintains the country's electricity transmission network and shares the distribution network across the various licensed municipalities. Figure 3 shows the current structure of the country's electricity system, highlighting major locations of thermal power stations (Greenpeace, 2019). The creation of more adaptable and modular renewable energy capacities, especially near points of consumption, is expected to assist Eskom in minimizing transmission losses over extensive distances and significantly mitigating the risk of load shedding. (Greenpeace, 2019).

**Figure 3: Technical structure of the South African electricity system**




Source: Eskom IRP (2019)

## 2.5 The Evolution of Key Energy Policies and Legislation

The SA government has been committed to promoting renewable energy technologies after the apartheid era. Numerous policy documents have been published, including the DME (1998) Whitepaper on Energy Policy and the DMRE (2003) White Paper on Renewable Energy. The SA government has been committed to promoting renewable energy technologies since its 1996 constitution after the apartheid era. Numerous policy documents have been published, including the DME (1998) Whitepaper on Energy Policy and the DMRE (2003) White Paper on Renewable Energy. These policies were legislated to ensure there is energy security in the country.

### 2.5.1 The Petroleum Products Act, 1977

The major goal of the Petroleum Products Act 120 of 1977 was to provide measures that allowed the saving of petroleum products and control of price (Gazette, 1977). The act facilitated the issuance of licenses for individuals engaged in the manufacturing and sale of specific petroleum products. It aimed to promote a transformed South African petroleum and liquid fuels industry, allowing for the promulgation of regulations related to these licenses. (Fagbadebo, Makiva, & Ile, 2019).

### 2.5.2 The White Paper on Renewable Energy, 1998

The SA Energy Policy whitepaper was established in December 1998 to clarify administrative policy regarding energy supply and consumption for the next ten years (DME, 1998). The paper aimed to provide clarity and make amendments to all energy sectors, practically addressing them. This paper provided an outline of the SA energy sector, its contributions to the GDP, employment, and taxes.

The objectives of the White Paper were to:

- Increase access and affordable energy service delivery
- Improve energy governance
- Stimulation of the economy and development through job creation and skills development.
- Management and mitigation of energy-related environmental impacts
- Provision of a secure energy supply through diversification (DME, 1998).

### 2.5.3 National Energy Act, 2008

The National Energy Act, 34 of 2008, was enacted to ensure that varied energy supplies were available in South Africa in sufficient quantities and at reasonable prices. It also called for expanded use of renewable energy as an emergency energy source, the security of strategic energy sources and transporters, and enough investment in energy infrastructure.

### 2.5.4 Integrated Resource Plan (“IRP”) 2010-30

The IRP, along with the Section 34 ministerial determinations of the Electricity Regulation Act (Act No.4 of 2006), was developed to assist investors with investment planning for the SA energy sector and for use as a road map to address the growing electricity demand in the country (DMRE, 2019, 2021; DoE, 2006). To address shortcomings observed in the assumptions made in the 2010 SA integrated resource plan, the Department of Energy conducted a review and updated the plan, extending the review period up to 2050 (DMRE, 2019). When the 2010 IRP was promulgated, it was envisaged that revisions would be made every two years to account for new economic data, fluctuating technology costs, and the increasing demand for electricity in the country. However, the frequency of the updates has been slower than previously envisioned.

The IRP updates were mainly targeted to ensure a secure supply of electricity, optimise electricity costs, reduce emissions, and reduce water usage. In November 2018, an updated IRP was issued for public comment, giving approximately two months for interested parties and stakeholders to post written comments to the Department of Energy (DoE, 2018). After the consolidation of public contributions, the updated 2018 IRP was presented to the National Economic Development and Labour Council (Nedlac) (DoE, 2019). In October 2019, the eagerly awaited and long overdue 2019 IRP was gazetted by the Ministry (DMRE, 2019), updating the energy forecast for South Africa up to the year 2030. Table 3 demonstrates how the national integrated resource plan anticipated the evolution of the country’s energy mix, with solar PV targeted to have a total installed capacity of 5900 MW.

**Table 3: 2023 Draft IRP Update – Emerging Plan from Horizon One Analysis**

| | Coal | Gas - IPP Programme | Gas -Eskom | Dispatchable Capacity | Nuclear | Hydro | Pumped Storage | CSP | Solar PV | Wind | Hybrid - IPP Programme | Distributed Generation | BESS- IPP Programme | BESS -Eskom | Unused Energy (TWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current | 38 | 1005 | | - | 186 | 1600 | 2732 | 500 | 228 | 3443 | - | 5000 | - | 20 | |
| 2024 | 720 | | | | | | | 100 | | | 150 | 900 | | 199 | 13.06 |
| 2025 | 720 | 1220 | | | | | | | 211 | 644 | 476 | 900 | 513 | 141 | 7.63 |
| 2026 | | | | | | | | | | 140 | | 900 | | | 7.66 |
| 2027 | | 1000 | | | | | | | | 684 | | 900 | 200 615 | | 4.55 |
| 2028 | | 1000 | 3000 | | | | | | 500 | | | 900 | 615 | | 0.22 |
| 2029 | | | | | | | | | 500 | 1500 | | 900 | | | 0.25 |
| 2030 | | 1000 | | 1376 | | | | | 500 | 1500 | | 900 | | | 0.27 |
| Additional New Capacity (MW) | **1440** | **4220** | **3000** | | | | | **100** | **3615** | **4468** | **626** | **6300** | **3743** | **360** | |

| | |
|---|---|
| | Installed Capacity |
| | Capacity under construction |
| | Capacity procured |
| | New Capacity |
| | Distributed Generation Capacity for own use |
| | Unserved Energy is preferred as low as possible. |

Source: South Africa IRP (DoE, 2019)

## 2.6 The South Africa Solar Energy Sector

In the past decade, Eskom, the country's primary power utility, has experienced challenges in maintaining a stable and reliable electricity grid, resulting in the implementation of load shedding to keep up with the growing electricity demand (du Plooy, Brent & de Kock, 2017). The 2019 IRP appreciated the potential of renewable energy technologies, particularly solar PV, with an expected penetration of nearly 8.29GW by 2030 (DoE, 2019). Solar PV technology investments were forecasted to stagnate in 2019 and then increase by an average of 900 MW yearly between 2021 and 2023. Subsequently, the trend is anticipated to decline from 2024 to 2027, averaging 250 MW per year, and then rise to 1000 MW per year during the period from 2028 to 2030 (DoE, 2019). This underscored the necessity for an enabling policy environment to attain the established targets.

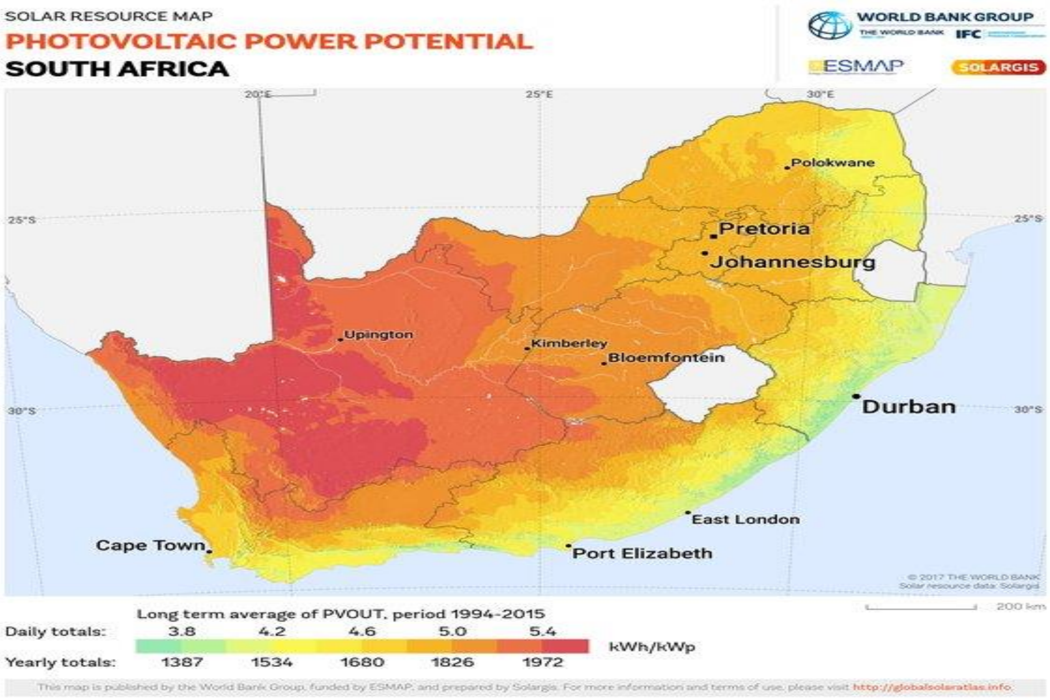
DPE (2019) reported that Eskom's fleet of power stations that broadly rely on fossil-based coal as a feedstock are averaging 37 years old and are currently operating at lower capacity levels. The capacity levels have dropped from 90% in 2005 to 70% in 2018. By early 2019, the capacity factor had dropped to below 60%, and the plants had become increasingly prone to frequent breakdowns. Simultaneously, the country was placed tenth on the list of countries with the highest carbon emissions per capita (DPE, 2019). In 2020 alone, unscheduled power cuts and load-shedding, as reported by STATS SA (2021), resulted in an estimated R75 billion GDP loss for the country and an additional 450,000 jobs. The rollout of renewable energy projects is expected to provide a faster alternative to the country's energy challenges. South Africa has vast solar and wind resources that can provide multiple times more than the country's anticipated 40 000MW of energy consumption requirements by 2025 (Sterl, 2021; Wu et al., 2017).

### 2.6.1 Rooftop Solar PV Implementation in South Africa

A high amount of solar irradiation hits South Africa throughout the year and receives rainfall that is about 50% of the global average (SAWS, 2020). A greater part of the country receives, on average, 8 to 10 sunshine hours daily, with the country receiving about 2,500 hours a year and approximately 4.5 to 6.6 kilowatt-hours per square meter of radiation level (Jain & Jain, 2017). Solar energy is considered the most plentiful energy resource. Solar energy is accessible globally and is targeted for both power and heating applications in the country (Jain & Jain, 2017).SA requires robust policies that are favourable for the implementation of rooftop solar PV projects.

The country uses data records from fifteen weather stations, thirteen of which are within the country’s borders. Solar energy resource maps are being developed to improve the quality of satellite-derived in the SADC region (Edwards et al., 2022; Jain & Jain, 2017). GIZ, a German non-governmental organization, is supporting this project**.** Figure 4  illustrates the global radiation potential for South Africa.

**Figure 4: Global  radiation map for South Africa**




Source: SolarGIS (2022)

Rooftop solar PV in South Africa is predominantly utilized in grid-tied and off-grid applications across residential, commercial, and industrial sectors, including remote off-grid solutions (DoE,2017). Photovoltaic systems are also employed as standalone energy sources in areas where the electricity grid is unavailable. Such solutions are considered capital-intensive compared to grid-integrated systems in South Africa. However, the cost of battery technology has reduced significantly in the last decade (Louie, 2018; Oyewo, Aghahosseini, Ram, Lohrmann, & Breyer, 2019).

### 2.6.2 Current Trends in Rooftop Solar PV in South Africa

Over the past two years, the uptake of solar technologies in South Africa has surged, particularly in the installation of rooftop solar photovoltaic (PV) systems. Rooftop solar capacity increased significantly, from 983 MW in March 2022 to 4.4 GW by June 2023—a growth of 349% (Kumba, AkpanTwite and Olanrewaju, 2023). This rapid adoption was driven by the country's ongoing energy crisis, frequent load shedding, and the unreliability of coal-based power generation, which still constitutes over 80% of the energy mix (Oryani, Koo, Rezania and Shafiee, 2021).

Despite this massive progress that has been made in the uptake of solar technologies in South Africa, challenges remain that hinder widespread adoption. The main challenges inhibiting uptake of solar technologies in South Africa include;

**Financial Constraints**: One of the largest obstacles to the uptake of solar technologies in South Africa is the high upfront cost of solar PV systems (Fontana, 2020). Although government initiatives such as a tax rebate introduced in 2023 offer some financial relief (up to 25% of the installation cost), the start-up costs are still prohibitively high for most households, particularly for low-income families. This is exacerbated by the high cost of financing, as many South Africans, especially those in lower-income brackets, are unable to access loans or credit (Fontana, 2020).

**Institutional and Technical Barriers**: Lengthy and complex approval processes for rooftop solar installations, as well as a lack of streamlined systems for connecting solar-generated power to the national grid, have hindered adoption. Efforts are being made to improve this, such as Cape Town's creation of an online portal to simplify and fast-track the authorization of solar systems (Kumba, et al, 2023).

**Inequality**: Solar power remains predominantly a solution for wealthier households due to the financial constraints faced by the majority of South Africans. With about 55% of the population living in low-income conditions, the unequal access to solar power risks exacerbating energy inequality in the country (Lawrence and Ballard, 2020). There is a growing concern that solar will only benefit those who are affluent.

These challenges suggest that while solar energy is growing in South Africa, much more needs to be done to make it accessible to all households and reduce the country's reliance on coal. Addressing the financial, personal, institutional, technical, and social barriers is crucial for increasing solar PV adoption in South Africa. With strategic government interventions and increased public awareness, the transition from coal-fired power to renewable energy can become a reality, contributing to a more sustainable and equitable energy future for all South Africans.

### 2.6.3 National Treasury support of solar technology uptake

The National Treasury of South Africa has played a pivotal role in stimulating the uptake of solar technologies primarily through financial incentives, tax reliefs, and policy frameworks. Some of initiatives that the National Treasury Annual Report (2022) described are briefly discussed below.

#### i. Section 12B of the Income Tax Act

This section provides for accelerated capital allowances for renewable energy investments, including solar photovoltaic (PV) systems. It allows businesses to deduct the cost of these systems over a short period, specifically 100% of the cost in the first year. This has encouraged businesses to adopt solar technologies by lowering the upfront financial burden.

### ii. Green Fund and Renewable Energy Initiatives

The National Treasury has supported the Green Fund, managed by the Development Bank of Southern Africa (DBSA, 2023). This fund provides financial support for green economy projects, including solar energy initiatives, particularly for municipalities and smaller enterprises.

Renewable Energy Independent Power Producer Procurement Programme (REIPPPP): Though driven by the Department of Energy, National Treasury plays a role in ensuring financial backing and the regulatory framework for this programme, which encourages private investment in solar power generation.

### iii. Solar Tax Rebates for Individuals (2023 Announcement)

As part of efforts to address the energy crisis and reduce reliance on the national grid, the National Treasury introduced a solar tax rebate for individuals in 2023. Households that invest in solar PV systems can claim a portion of their investment back as a tax rebate, which reduces the net cost of adopting solar technology for residential purposes.

### iv. Municipal Support and Incentives

National Treasury has also worked with municipalities to provide financial frameworks that allow for greater integration of solar technologies, especially at the local government level (CSIR, 2010). Municipalities have been encouraged to use solar energy to reduce electricity demand from Eskom, often supported by Treasury's Municipal Finance Management Act (MFMA).

## 2.7 Enabling policy factors for the implementation of renewable energy projects

The SA government has acknowledged the need for private capital to foster renewable energy projects and foresees the important role for foreign independent power producers (IPPs)  ((Nel, 2015). The government set up the implementation of the REIPPP program to leverage private capital and stimulate the country's renewable energy sector without utilising public funds. The pace of private investment in the renewable energy industry is growing, but the overall potential is still relatively lower than the industry demand (STATS SA, 2021).

According to the DME (1998), the government's energy policy outlined its major objectives in its white paper as follows:

1)To improve access to affordable energy

2) To develop energy governance.

3) To increase economic development.

4) To manage environmental impacts relating to energy generation and use) To improve security supply a diverse energy system.

Renewable energy has the potential to play a pivotal role in mitigating energy-related environmental impacts. It has the potential to address local environmental issues such as air and water pollution, amongst others. The SA Department of Environmental Affairs and Tourism, in 2009, published Sulphur oxide emissions standards, which formed part of an initiative to establish a national ambient air quality standard for the country (Gazette, 2009). Renewable energy can provide a massive boost to the reduction of local air pollution, with joint benefits being realised on climate change through decarbonization of the energy industry.

## 2.8 Policy impediments affecting rooftop solar PV implementation in South Africa

This section highlights the policy impediments that are affecting the implementation of rooftop solar PV projects in Gauteng Province. The government should continuously create an enabling environment by putting in place policies that help address the impediments being faced by energy service providers. While renewable capacity will undergo a major increase, there will still be restrictions on how many new renewable energy systems can be commissioned per year. This restricts the addition of new capacities to 1,000 MW per year for solar PV and 1 600 MW per year for wind energy (DMRE, 2019). This policy has a direct impact on the development of the rooftop solar PV sub-sector.

There are several policy impediments affecting rooftop solar PV implementation in South Africa. These are briefly discussed below.

### i. Unclear Regulatory Framework

Baker (2015) claimed that the process for obtaining necessary approvals and licenses to install rooftop solar PV systems in South Africa is often lengthy and complicated. He also argued that there is a lack of a streamlined regulatory framework that simplifies the approval process for both small-scale and large-scale rooftop solar installations.

There is uncertainty surrounding grid connection regulations for rooftop solar PV systems (Maleki, Rosen, and Pourfayaz (2017). They further disputed that municipalities have clear guidelines for how homeowners or businesses can connect their systems to the grid, leading to delays in project implementation.

### ii. Lack of Consistent Policy Support and Incentives

Unlike other countries that incentivize rooftop solar PV through feed-in tariffs (where users can sell excess electricity back to the grid at favorable rates), Pegels (2010) was of the view that South Africa lacks a unified national policy that mandates such programs across all municipalities. Furthermore, Pegels (2010) argued that there have been inconsistent financial incentives for homeowners and businesses to invest in solar PV systems, such as tax breaks or rebates. DMRE(2019) report suggested that the lack of long-term, stable subsidies reduces the financial attractiveness of rooftop solar.

### iii. Limited Access to Financing and Credit

Winkler (2017) submitted that for many residential and commercial property owners, the initial capital required to install rooftop solar PV systems is high. He further expressed that while financing options exist, access to affordable credit is often limited, particularly for lower-income households or small businesses. There is a lack of financial products specifically tailored for rooftop solar PV investment, such as green bonds or low-interest loans. The absence of innovative financing mechanisms prevents many consumers from adopting solar technology (DoE, 2019).

### iv. Technical and Capacity Limitations

Wright, Calitz and Bischof-Niemz, (2017) were of the view that there is a shortage of trained professionals capable of installing and maintaining rooftop solar PV systems in South Africa. They pointed out that this was limiting the scalability of the technology, especially in more rural or underdeveloped parts of the country. The lack of robust standards for solar PV system components and installations has led to concerns over the quality and safety of rooftop installations (Wright, et al,2017). They argued that this created hesitation among potential adopters who worry about system reliability and long-term performance.

## 2.9 A legal framework for small independent power producers

Eskom Report (2020) indicated that there was an immediate intervention in both supply and demand-side management (DSM) to mitigate the impact of load shedding and the extensive reliance on diesel-fired peaking plants.. At the time, the short-term deficit was in the region of 2 000 to 3 000 MW. Generally, A greenfield utility-scale project typically requires approximately three years from the initial phase to the generation of its first unit of electricity. A medium-term power purchase program (MTPPP) for rooftop energy producers, like the approach adopted in the 2010 IRP, must be considered (National Planning Commission, 2013).

The 2010 MTPPP power purchase program was based on existing facilities co-generation and small hydro facilities that generally run intermittently due to high operating costs and levelized cost of energy compared to the Eskom power. This calls for the encouragement and development of renewable-based power plants for on-site and off-site consumption, such as rooftop solar. By implementing policies and regulations, the industry's bureaucratic hurdles can be removed without compromising the security of the energy supply (DMRE, 2019).

With restrictions on the allocation of sites and building construction protocols, rooftop solar facilities may also face restrictions based on building heights, glint, glare, aesthetics, noise, or safety, predominantly in urban settlements (Apostol, Palmer, Pasqualetti, Smardon, & Sullivan, 2016). For example, wind turbines have been susceptible to specific environmental concerns relating to site allocation along with the parts of migratory birds and coastal regions.

Disruptive and emerging technologies such as solar power may be unfamiliar events to urban planning custodians, building inspectors, building councils, and regulators; therefore, they need to be slowly integrated into such habitats. In some instances, they may not have established procedures for dealing with siting and permits relating to such energy development, which is also a major challenge for adoption. Competition for land use with residential, commercial, and industrial expansion, as well as recreational and scenic interests, may also be barriers (Fredric Beck & Martinot, 2004; Fred Beck & Martinot, 2016).

### 2.9.1 Transmission access

Utilities are reluctant to allocate transmission access to renewable energy producers or may charge high wheeling charges when the framework exists for transmission access (Fredric Beck & Martinot, 2004). Access to transmission infrastructure is a necessity, particularly for renewable energy projects like rooftop solar PV systems that may be located far from centers with a higher populace and energy demand (Amir & Khan, 2022; Suberu, Mustafa, Bashir, Muhamad, & Mokhtar, 2013). The provision of transmission and distribution infrastructure access is also necessary for direct energy transactions between a renewable energy producer and its consumers. Blockages by transmission access policies, regulations, and rulings, and the right of access routes may hamper the potential for new transmission access to newly established renewable energy sites (Beck & Martinot, 2004).

### 2.9.2 Utility interconnection requirements and associated barriers

Individual residential, commercial, and industrial rooftop solar systems connected to the utility grid face tedious, inconsistent, or ambiguous small-scale embedded generator (SSEG) interconnection requirements, processes, and timelines (M. L. Davies, 2021; Morar, 2017). Lack of consistent connection requirements adds to transaction costs between rooftop generators and customers. One of the biggest legitimate concerns by power utilities is the safety and power-quality risks posed by non-utility energy generators. The utility have overly stringent interconnection requirements that surpass necessity and practicality. This is hindering small producers from entering the market. In the absence of enabling incentives, utilities need to set reasonable interconnection requirements whilst maintaining technical compliance (Greencape, 2021).

Additionally, the cost of hiring legal consultants and technical experts to interpret and ensure compliance with interconnection requirements is significant for emerging rooftop solar companies (Todd & McCauley, 2021). The provision of a policy and regulation that creates structured, consistent, and reasonable interconnection standards assists in reducing the interconnection hurdles and associated costs for rooftop solar companies and consumers (African Union, 2018; Greencape, 2021; Ntumba, 2022). There is a need for improved grid infrastructure integration and access as the increasing numbers in urban and rural communities and the previously disadvantaged come online (DoE, 2018).

### 2.9.3 Technical skills

There is a growing demand for skills required to implement renewable energy projects and the development of the industry (Fig, 2017). Moreover, leadership skills are required in key energy positions to ensure a strong bond between government institutions and the private sector. Hence, such expertise is not readily accessible in the existing labour pool, making the integration of renewable energy solutions a challenging task.

## 2.10 Hypothesis Development

### 2.10.1 Hypothesis 1: Policy Impediments

The policy impediments of RSPV adoption in Gauteng, South Africa, are a lack of sufficient policy enablers for small-scale embedded generators, restrictions on SSEG system points of connection, transmission access for feed-in of excess solar power, stringent and ambiguous utility interconnection requirements, and unavailability of SSEG registration structures in some municipal institutions. Based on the above arguments, the study proposed the following hypothesis:

H1: Policy impediments negatively influence the uptake of RSPV in Gauteng Province.

### 2.10.2 Hypothesis 2: Existing policy enablers

The South African government has enacted various policies to nurture and grow a conducive environment for rooftop solar projects to flourish. An essential element is the upfront identification of a clear policy objective. If the aim is to enhance the penetration of renewable-based electricity in a cost-effective manner, prioritizing budget constraints, the adoption of a fixed feed-in tariff could assist in cost minimization (Winkler, 2005).

By the year 2024, the 1 800 MW of nuclear power generation at the Koeberg power station is anticipated to reach the end of its operational life, with the possibility of extending the plant's life until 2044, pending regulatory approvals. (GBA, 2021). Considering the projected lower availability for Eskom coal plants, the 2019 IRP assumes that the plant life for Koeberg would be successfully extended as planned (DMRE, 2019). The assumed average energy availability (EAF) factor for Eskom's power plants was 86% in the IRP 2010 to 2030, whilst the actual EAF at the time was believed to be averaging 85%. Since then, it has been on a steady decline, hitting 71% in 2015-16 before recovering to 77% in the following financial year (DoE, 2019). However, in 2018, the EAF resumed the downtrend to as low as 70%, resulting in constrained capacity and load shedding beyond 2019.

Eskom's existing fossil-based fleet will remain dominant in SA's electricity market in terms of supply and capacity for several years to come (DMRE, 2019). However, the ongoing and prospective performance of its power plants is paramount for ensuring a stable energy supply and poses a significant challenge to the projected capacities outlined in the latest IRP. In 2018, Eskom submitted revised system availability projections per power station, encompassing two scenarios: (i) scenario one and (ii) scenario 2, projecting an average EAF of 80% and 75% by 2030, respectively (DMRE, 2019; DoE, 2018). In detail, the IRP sets out a breakdown of the proposed generation capacities until 2030. It specifies that, alongside all existing and planned capacities, the integrated resource plan will incorporate 9,6 GW of nuclear power, 6,3 GW of coal power plants, 17.8 GW of renewable energy, and 8.9 GW of other energy sources (DMRE, 2019).

The objective of the SA solar energy technology roadmap (SETRM) was to formulate a detailed guideline to promote a green industry through the local development of solar technology. This will lead to the creation of a capability base for manufacturing, employment, and develop the local industry. The roadmap anticipated that 40 GW of Solar PV can be developed by 2050 in the country (DoE, 2015).

Owing to an erratic electricity supply, the sharp increase of utility electricity, and areas isolated from the electricity grid, SA has seen tremendous growth in semi- to off-grid solar projects. Currently, there are 60,000 solar PV installations installed in residential, commercial, and industrial sectors. According to (SAPVIA, 2020b), the total rooftop solar capacity is approximately 300MW, and only 38MW has been officially registered with municipalities. Owing to an erratic electricity supply, the sharp increase of utility electricity, and areas isolated from the electricity grid, SA has seen tremendous growth in semi- to off-grid solar projects. Currently, there are 60,000 solar PV installations installed in residential, commercial, and industrial sectors. According to (SAPVIA, 2020b), the total rooftop solar capacity is approximately 300MW, and only 38MW has been officially registered with municipalities. (SAPVIA, 2020b).

For small-scale applications, electrification of remote rural and previously disadvantaged communities has not been left out. The South African government has been at the forefront of launching solar power initiatives, such as the Solar Home Systems (SHS) program. This program offers households fundamental solutions for lighting and all other appliances. The rollout started in 2001 and had reached 96,000 installed by 2015 (DoE, 2015).

The most effective policy enablers for rooftop PV implementation are the REIPPP launched in August 2011, the integrated resource plan (IRP), the solar home systems (SHS) program, and the solar energy technology roadmap (SETRM) (CSIR, 2010; DMRE, 2019; DoE, 2010). Therefore, the study proposed the following hypothesis:

H2: Policy enablers positively influence the uptake of RSPV in Gauteng Province.

## 2.11 Conceptual Framework

The conceptual framework, as depicted in Figure 5, delineates the interplay between impediments and policy enablers, elucidating their impact on the adoption of rooftop solar PV within the Gauteng province. Guided by the research objectives and formulated hypotheses, this framework serves as a roadmap for the study, outlining how research questions will be addressed. While recognizing the multifaceted linkages of rooftop solar PV across diverse sectors, Figure 5 specifically focuses on policy-related issues. It delves into the identification and evaluation of both real and perceived barriers to the adoption of rooftop solar PV. Moreover, it explores how the creation of an enabling environment can unleash the untapped potential of rooftop solar PV in the Gauteng province. This conceptual framework draws inspiration from various models found in pertinent literature, amalgamating insights from the works of Obeng and Evers (2009) as well as Walters, Kaminsky, and Huepe (2018). By integrating these models, the framework provides a comprehensive understanding of the complex dynamics surrounding rooftop solar PV, offering a basis for examining policy implications and fostering a conducive environment for its sustainable growth in Gauteng.

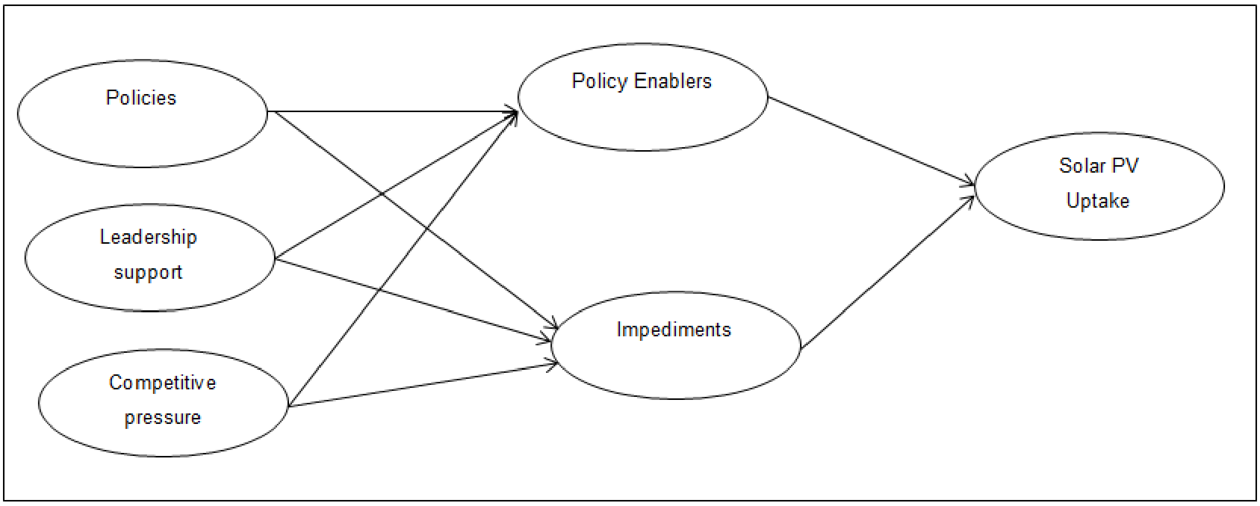



**Figure 5: Conceptual framework for the study**

## 2.12 Conclusions of Literature Review

The National Planning Commission (2013) estimated that by 2030, the country's energy sector will be geared up to promote socio-economic growth and development through the provision of sufficient energy infrastructure. The plan also establishes that by 2030, South Africa will possess a sufficient electricity supply to meet its energy demand requirements. Furthermore, it aimed to minimize disruptions to economic activities and welfare while ensuring electricity access for at least 95% of the population. The purpose of the SETRM was to formulate a detailed guideline to promote a green industry through the local development of solar technology (CSIR, 2010). The literature review has managed to ascertain the policy impediments and policy enablers for rooftop solar photovoltaics. Table 4 shows the research questions and the hypotheses of the study.

**Table 4: Consistency table: research questions and hypotheses**

| RQ # | State Research Question or Objective | Hyp # | Hypothesis |
|---|---|---|---|
| 1 | **What are the perceived policy impediments that may be inhibiting the uptake of RSPV in Gauteng, South Africa?** | 1 | The policy impediments that are inhibiting the uptake of rooftop solar PV in Gauteng Province are a lack of legal and policy framework for Small-scale embedded generators, restrictions on SSEG system points of connection, transmission access for feed-in of excess solar power, stringent and ambiguous utility interconnection requirements, and unavailability of SSEG registration structures in some municipal institutions. |
| 2 | **What policy enablers are currently in place for RSPV projects in Gauteng, South Africa?** | 2 | The policy enablers for rooftop PV implementation are the Renewable Energy Independent Power Production Programme (REIPP) launched in August 2011, the Solar Home Systems (SHS) Program, and the Solar Energy Technology Roadmap (SETRM). The newly gazetted Amended Schedule 2 of the Electricity Regulation Act 4 of 2006 for license exemption on up |

| RQ # | State Research Question or Objective | Hyp # | Hypothesis |
|---|---|---|---|
| | | | to 100MW of embedded electricity generation (DMRE, 2021) |
| 3 | **To determine to what extent these perceived impediments and policy enablers are affecting the uptake of RSPV.** | 3 | The perceived policy barriers are severely affecting the roll-out rate of RSPV projects. |
| 4 | **What is the impact of these impediments and policy enablers on the rollout of RSPV?** | 3.1 | A policy-enabling environment in the Gauteng province has a role to play in the uptake of RSPV in South Africa. |
| 5 | **Recommend strategies and policies that may improve the adoption of RSPV** | 5 | Policy Enablers have a significant influence on the uptake of rooftop solar PV projects in South Africa. |

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.0 Introduction

This chapter covers the research methodology, as applied in this study, including the important methodological components of the research approach, research design, population size, sampling strategy, research instrument, data collection, data analysis, and ethics.

## 3.1 Research approach

Leedy, Ormrod, and Johnson (2020) defined research methodology as "the general approach the researcher takes in carrying out the research project." Two major types of methodologies can be used during research, namely, quantitative and qualitative. Quantitative approach involves the collection and analysis of data, allowing information to be quantified and subjected to statistical analysis (Creswell, Plano Clark, Gutmann, and Hanson, 2003a). According to Creswell (2002), the quantitative research approach is a systematic investigation that focuses on quantifying variables, collecting numerical data, and using statistical methods to analyze and interpret the data. It is often used to test hypotheses, measure outcomes, and establish patterns or relationships between variables.

On the other hand, the qualitative research approach focuses on exploring and understanding complex human experiences, behaviors, emotions, and interactions. Unlike quantitative research, which deals with numerical data, qualitative research is concerned with words, observations, and interpretations to gain insights into people's thoughts, feelings, and motivations (Leedy and Ormrod, 2005). While the qualitative research approach offers rich, in-depth insights into human experiences and social phenomena, it is subjective, has limited generalizability, difficult to replicating the study under the same conditions is difficult, if not impossible. Analyzing qualitative data can be highly complex due to the volume and richness of the data collected.

This study used quantitative approach as it is objective, and is useful in testing the hypothesis of the study that were formulated in Chapter 1. Furthermore, the findings of the quantitative approach study are generalizable to a larger population and its results are generally more precise and accurate than qualitative methods.

## 3.2 Research Strategy

Several research strategies are used in a research study. There are case studies, survey, experiments, action research, and grounded theory. This study used a questionnaire survey research strategy to identify policy enablers and perceived impediments for rooftop solar photovoltaic projects in Gauteng, South Africa.

A survey was preferred as it is a widely used data collection method in research due to its efficiency, versatility, and ability to gather large amounts of data from many respondents. Questionnaire surveys are relatively inexpensive, especially when conducted online as in this case. They do not require much overhead compared to other methods like face-to-face interviews, where logistical costs (e.g., travel, equipment) are higher (Leedy & Ormrod, 2019).

Surveys are an efficient way to collect data from large numbers of respondents in a short amount of time. This is especially useful when the goal is to generalize findings to a broader population. Data collected through questionnaires, especially closed-ended questions (e.g., multiple-choice, Likert scales), are easy to quantify and analyze using statistical software. Since respondents complete the questionnaire independently, there is little to no researcher interference, reducing the likelihood of introducing researcher bias into the data collection process (Zikmund, Babin, Carr, & Griffen, 2003).

### 3.3 Population, sample size, and sampling method

(Wani, 2015) defines a “population as the universe, the totality of entities in which we have an interest, that is the collection of individuals, objects or events about which we want to make inferences”. However, before evaluating the population it is essential to define the unit of analysis of the study. In this case, the unit of analysis for the study was individuals who were selected from 20 companies that were rolling out solar PV projects in Gauteng Province. The total population was estimated at 1021.

Diamantopoulos, Schlegelmilch, Sinkovics, and Bohlen (2003) define a “sample as part of the larger population. The sample in this study was comprised of six participants from each company to make a sample size of one hundred and twenty (120) participants. The rationale behind gathering information from 120 participants was that this was more than 10% of the population as suggested by Leavy (2022). Therefore, this was deemed sufficient to represent and mimic the population of the study. The number of participants that were sampled is shown in Table 5.

**Table 5: Profile of respondents**

| Description of respondent type | Number to be sampled |
|---|---|
| Senior Business Managers | 35 |
| Senior Engineering Managers | 35 |
| Senior Project Managers | 35 |
| Regulatory and Municipal Officials | 15 |
| **Total number of respondents** | **120** |

Source: Author's Compilation (2024)

For this study, probability sampling method was used to select participants. It was used in this research study because it allows for more reliable, objective, and generalizable results. Furthermore, the probability sampling method was used as it helps to minimize selection bias and ensure that the sample is representative of the population.

Therefore, stratified random sampling was used in this study to select sample elements. Stratified sampling was used to ensure that each subgroup (stratum) of the population was represented in the final sample. This is necessary to improve the generalizability of the results because all important groups within the population were included.

## 3.4 The research instrument

Data collection utilized an online questionnaire administered through SurveyMonkey. This method was chosen due to its ease of administration, ability to ensure uniformity in responses, cost-effectiveness, and the convenience it offers respondents. Respondents had the flexibility to provide answers at their convenience and from any location with internet connectivity. The identified target participants received the questionnaire via SurveyMonkey. The responses gathered played a crucial role in addressing the research problem and testing the formulated hypotheses. A comprehensive introductory letter accompanied the questionnaire, explaining the study's purpose and requesting participants' contributions. Before proceeding with the responses, participants were allowed to agree to the terms outlined in the questionnaire. The questionnaire was meticulously structured to ensure consistency, allowing participants to respond to the same set of questions. This approach aimed to streamline the data collection process and facilitate a standardized analysis of responses.

### 3.4.1 Structure of the instrument

The survey questionnaire was split into 3 sections which included background information of participants, Policy enablers for PV solar projects, and Impediments on the roll-out of on rooftop solar PV projects.

Section A covered background information of participants which included functional department, position at work, experience in working with rooftop solar technologies, and size of the company in terms of number of people employed.

Section B covered policy enablers for PV solar projects and these enablers included relevant government policies and escalation of electricity prices in South Africa. The policy enablers were obtained from a literature study which was presented in Chapter 2. The perception of participants on the extent of the impact of policy enablers on the uptake of RSPV was based on a 5-point Lickert scale ranging from Very slightly, Slightly, Medium, High to Very High extent.

Section C covered impediments on the roll-out of rooftop solar PV projects and These impediments included high capital cost, competition for land use, blockages by transmission access, high wheeling charges for transmission access, lack of established procedures, limited rooftop solar PV policies and restrictions based upon building heights, noise pollution. The above-mentioned impediments were informed by literature that was presented in chapter 2 of the study and were chosen based of their complexity and contribution to slow down the pace of adoption of RSPV.

In particular, wheeling charges and competition for land were added as one of the barriers on the roll-out of rooftop solar PV. Wheeling is perceived to make the transportation of solar-generated electricity through the national or municipal grid expensive and complicated, reducing the financial attractiveness of solar projects and discouraging investment in decentralized solar energy. On the other hand, competition for land is perceived to increase project costs and complicate site selection, especially for large-scale solar farms that require significant space to operate efficiently. The perception of participants on the extent of the effect of policy barriers impeding the uptake of RSPV through statistical analysis of survey data was based on a 5-point Lickert scale ranging from Very slightly, Slightly, Medium, High to Very High extent.

### 3.5 Procedure for data collection

A survey questionnaire was used as a data-gathering instrument. The questionnaire was administered using Monkey Survey (an online platform). This was platform was chosen for its flexibility as well as that it provides descriptive statistics for responses in real-time. The link to Survey Monkey was shared with potential respondents using emails. Potential respondents were given 2 weeks to respond after which reminders were sent for feedback. The participants who were targeted in this study included subject matter experts, namely Project Managers, Engineering Managers, Business Managers, and Regulatory Officials.

#### 3.5.1 Data analysis and interpretation

Data was coded numerically in Excel before it was sent to SPSS version 26 for final analysis to answer the main questions of the study. Meanscore was used as a measure of central tendency in this study. On the other hand, standard deviation and coefficient of variation (CV) were used to measure the extent of the spread of the perceptions of participants from the mean value.

A multiple linear regression model was carried out to establish relationships between the identified variables of the study. Uptake of Solar PV was the dependent variable while policy enablers and impediments were the independent variables. The influence of policy enablers and impediments was measured using the F statistics or the p-value. For example, if the p-value of the Policy Enablers coefficient was less than 0.05 ($p < 0.05$). This could have meant that Policy Enablers have a positive and significant influence on the uptake of rooftop solar PV projects. The contra holds true too.

### 3.6 Limitations of the study

The study identified the following limitations:

- Time constraints – The time to conduct the research was limited as the researcher had a deadline for completion
- Lack of previous research on the topic under investigation
- Technological challenges – Some participants failed to access the questionnaire via Survey Monkey due to internet connectivity issues

### 3.7 Validity and reliability

Ensuring validity in a research study involves using methods and strategies that confirm the research findings are accurate, credible, and relevant to the research questions or hypotheses. Validity can be divided into different types, each addressing various aspects of research design and outcomes.

#### i. Internal Validity

Internal validity refers to the extent to which the research design and execution ensure that observed effects are truly due to the independent variable and not due to extraneous variables or confounders (Leedy and Ormrod, 2005). To ensure internal validity, participants were randomly assigned to different study groups to minimize biases.

#### ii. External Validity

External validity refers to the generalizability of the research findings to other settings, populations, or times(Leedy and Ormrod, 2005). To ensure external validity the sample of the study was constituted in a way that was representative of the the broader population to enhance generalisability. Furthermore, the sample was made up of participants from various demographics and backgrounds to increase the applicability of the results.

#### iii. Construct Validity

Construct validity refers to whether the study accurately measures the concept or theoretical framework it intends to measure. To ensure construct validity the researcher clearly defined all variables of the study and ensured that they reflect the constructs being studied. A standard questionnaire was used and was validated using a pilot study. This was done to guarantee that the instrument accurately measures what it was designed to measure.

#### iv. Content Validity

Content validity assesses whether the research instruments cover all relevant aspects of the concept being studied. To ensure content validity the researcher consulted subject matter experts to evaluate whether the research tools adequately covered the scope of the topic. The instrument was designed based on available and published literature.

### 3.8 Reliability

The reliability of the study's constructs was assessed using Cronbach's Alpha values. Hair Jr et al. (2021) suggested that Cronbach's Alpha values of at least 60% are satisfactory and show that an instrument is reliable and can give dependable results when used repeatedly. However, alpha values under 60%, are regarded as subpar and unsatisfactory.

Improving the reliability of a survey questionnaire ensures that the instrument consistently produces accurate and dependable results. To enhance the reliability of a survey questionnaire, the researcher ensured that each question was clear, specific, and easy to understand without ambiguity. A simple, direct language that was deemed appropriate for the target audience was used. The researcher kept the survey concise and focused on essential questions to avoid exhausting respondents. Long surveys can lead to respondent fatigue, causing random or inconsistent answers. Furthermore, a 5-point Likert scale was used to measure the perceptions of respondents. This scale helps with consistency in measurement, reducing variability due to subjective interpretation.

### 3.9 Ethical considerations

Several ethical issues were adhered to ensure the protection of participants' rights and well-being while maintaining the integrity of the research study.

Below are key ethical considerations and strategies that were employed to address them.

### i. Informed Consent

Participants were fully informed about the study's purpose, procedures, potential risks, benefits, and their rights before they agreed to take part. They were informed that taking part in the study was voluntary and they were free to withdraw at any time.

### ii. Confidentiality and Anonymity

The researcher made it a point that the participants' data was kept confidential and, where appropriate, anonymous, so that individual identities could not be traced back to specific responses or results. A coding systems was used to anonymise data and store personal information separately from the research data. Data was securely stored using password.

### iii. Avoiding Harm and Ensuring Participant Well-Being

The researcher ensured that participants were not subjected to harm, whether physical, emotional, or psychological. This included risks such as stress, embarrassment, or exposure to unsafe conditions.

### iv. Voluntary Participation and the Right to Withdraw

The researcher made certain that participants understood that their participation was entirely voluntary and that they could withdraw at any moment if they so desired. This was expressed clearly in the informed consent form and throughout the recruitment process.

### v. Data Integrity and Misconduct

The researcher was cognisant that it was his responsibility to ensure the accuracy and honesty of the data. He was aware that fabricating, falsifying, or selectively reporting results undermines the integrity of the research. Therefore, he followed all the ethical guidelines for data collection, storage, and analysis.

# CHAPTER 4: PRESENTATION OF RESULTS

## 4.1 Introduction

The literature review chapter presented barriers to RSPV implementation and key energy policies and legislation that influence RSPV implementation. Other pertinent aspects that have a bearing on RSPV implementation, such as the structure, operation, and expectations of the solar energy industry and enabling policy factors, were covered. Subsequently, the methodology chapter presented details on how the research will be conducted, the data collected, and the analysis procedures to answer the overall research objective.

i. To identify and quantify the extent of the effect of policy barriers impeding the uptake of RSPV through statistical analysis of survey data

ii. To assess and quantify the extent of the impact of policy enablers on the uptake of RSPV in South Africa.

iii. To examine the perceived extent of the uptake of RSPV in Gauteng, South Africa

iv. To statistically analyze and evaluate solar policies and strategies to develop a data-driven framework of recommendations aimed at improving RSPV adoption

This chapter presents the findings of the study. Specifically, the response rate, instrument reliability, respondent background information, preliminary analysis, assessment of respondent perceptions using descriptive statistics, and hypothesis validation were all addressed.

## 4.2 Response rate

Table 6 shows the study's response rate. It can be observed that a total of 120 questionnaires were distributed to Executive Management, Senior Management, General Management, and Advisors. A total of 80 questionnaires were completed and returned. Based on this information, it means that a response rate of 66.7% was achieved. This is a very good return rate, bearing in mind that a response rate for online surveys of at least 35% is acceptable in theory (Nazarian, 2013).

**Table 6: A response rate of the study**

| Position | No. Contacted | No. Participated | % Response |
|---|---|---|---|
| Executive Management | 35 | 26 | 74.3 |
| Snr Management | 55 | 18 | 51.4 |
| General Management | 50 | 30 | 75.0 |
| Advisor | 30 | 6 | 60.0 |
| **Total** | **120** | **80** | **66.7** |

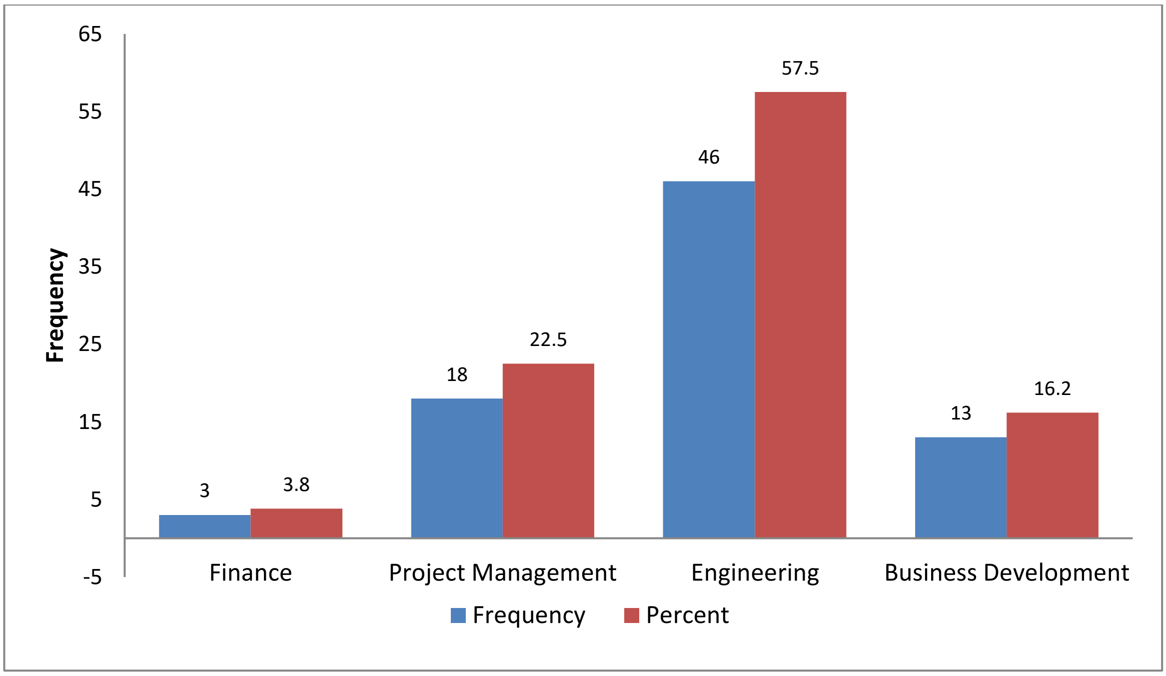
## 4.3 Background information of respondents

To understand the profile of respondents, data was analysed according to the functional department, position at the workplace, experience working in the rooftop solar PV industry, and a number of employees in each organization.

Figure 6 shows the distribution of respondents according to functional department. It can be observed that out of 80 people who participated in this study, the majority (57.5%) declared that they were working in the engineering department, while 22.5% confirmed that they were working in Project Management. On the other hand, about 16.2% were working in the Business Development department while 3.8% declared that they were working in

Finance. Although very few respondents were working in Finance, the distribution shows that respondents were working across diverse functional departments, which helped to have varied opinions and experiences. This is recommended for the study as it aims to gather extensive opinions and experiences on perceived policy impediments and enablers for the uptake of the rooftop solar revolution in the Gauteng Province in South Africa.

**Figure 6: Distribution of respondents according to functional departments**




The distribution of respondents according to position at the workplace is shown in Figure 7. Out of 80 respondents, 37.5% were in general management positions, while 32.5% were in executive management positions within their respective organizations. Senior management personnel accounted for 22.5% of the total number of respondents, while advisors were the least, contributing 7.5% to the total respondents. Engaging executives and senior management in this study was advantageous, as they offered credible and well-informed opinions on the subject matter being investigated.

**Figure 7: Distribution of respondents according to position at work**

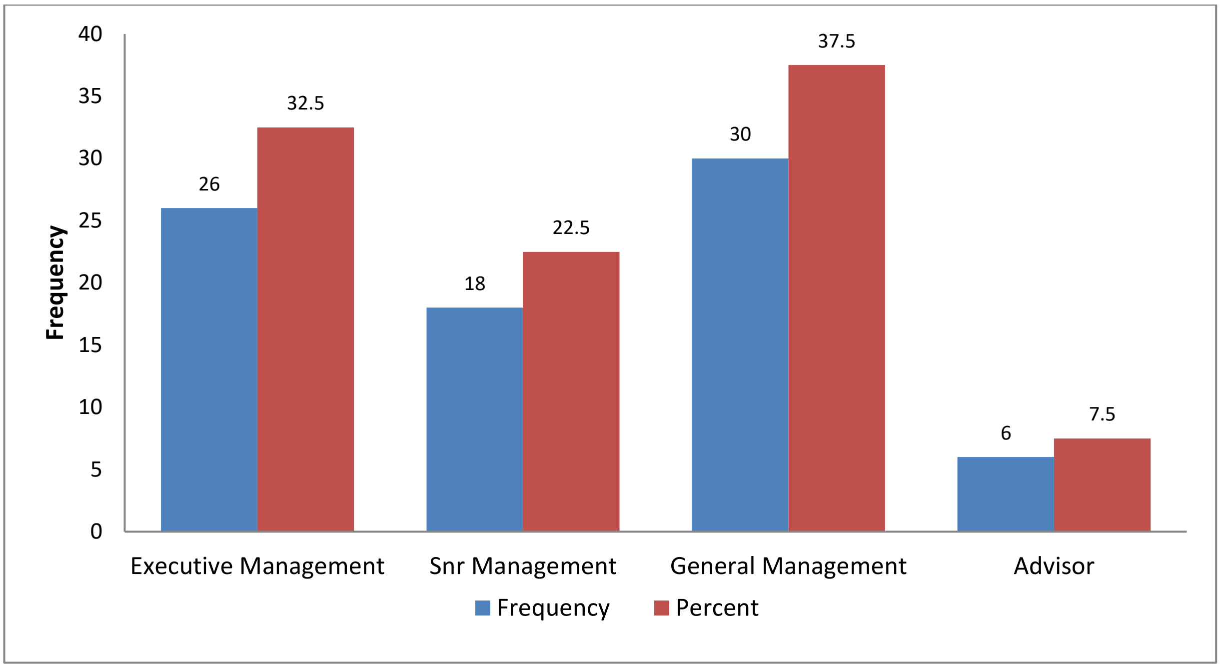



Figure 8 shows the distribution of respondents according to experience working in the rooftop solar PV industry. It can be observed that out of the 80 participants. Among the respondents, 43.8% have accumulated 2 to 5 years of experience in the rooftop solar PV industry, while 37.5% have reported working in the industry for a span of 6 to 10 years. Additionally, 18.8% of the participants indicated a substantial experience of at least ten years in the rooftop solar PV sector. This information is of significant value to the study, as individuals with such extensive experience brought invaluable knowledge to this research endeavor.

**Figure 8: Distribution of respondents according to experience working in rooftop solar PV industry**

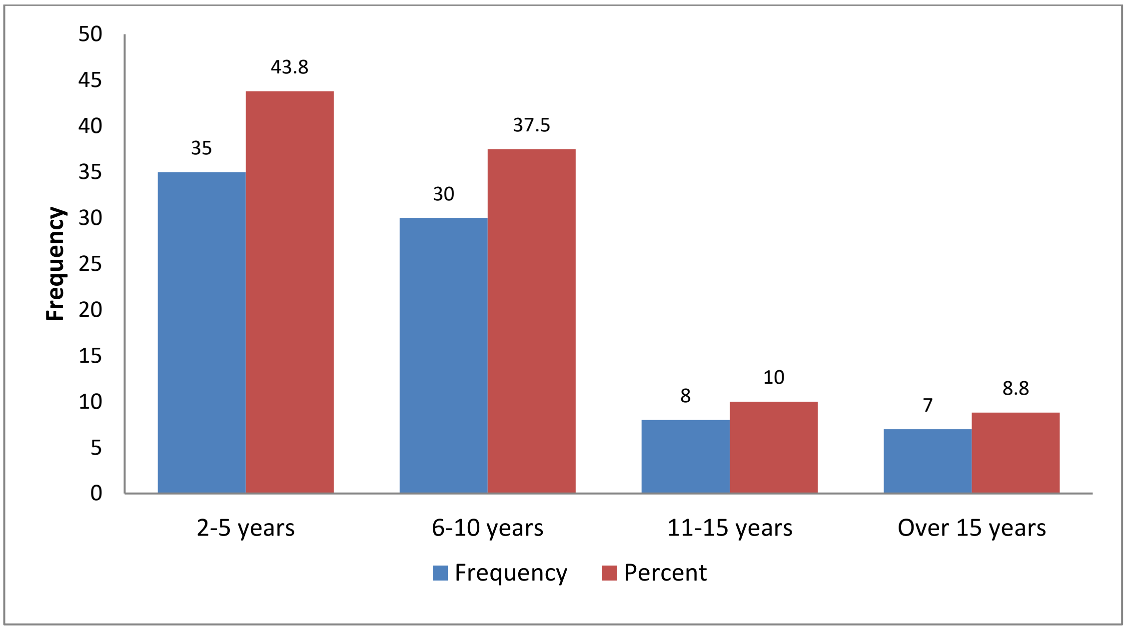
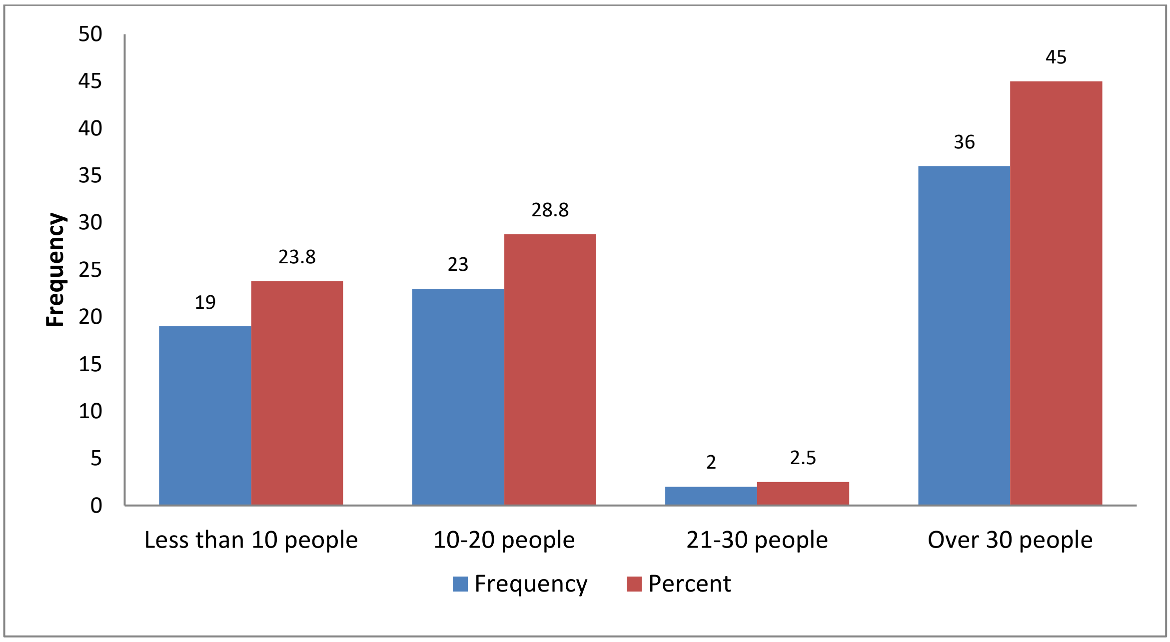



Figure 9 shows employee distribution per organization. About 45% of the respondents suggested that their organizations were employing more than 30 people, while 28.8% of the respondents indicated that their organizations were employing between 10 and 20 people for their operations. However, 23.8% of the respondents stated that their organizations were employing less than ten people. Only 2.5% of the respondents suggested that their organization was employing between 20 and 30 people. This distribution serves to inform that most organizations that respondents represented are small enterprises (SMEs) as defined by The National Small Business Amendment Act (26 of 2003). This act categorizes organizations with about 20 employees as very small.

**Figure 9: Distribution of respondents according to the number of people employed**




## 4.4 Reliability analysis

The reliability of the study's constructs was assessed using Cronbach's Alpha values. Hair Jr et al. (2021) suggested that Cronbach's Alpha values of at least 60% are satisfactory and show that an instrument is reliable and can give dependable results when used repeatedly. However, alpha values under 60%, are regarded as subpar and unsatisfactory.

It can be observed that each construct in Table 7 was found to have Cronbach's alpha values that exceeded a theoretical cutoff point of 60%. In particular, the scales of Policy Enablers and Uptake recorded very high Cronbach's alpha values of 90.0% and 88.6%, respectively, indicating very good levels of internal consistency. The other remaining scales recorded high alpha values that were above 80% each.

The study achieved an overall Cronbach's alpha of 87.6%. This is a very good level of internal consistency, which exceeded the minimal theoretical acceptance ratio of 60%.

**Table 7: Measuring the reliability of the instrument using Cronbach's alpha**

| Attribute | No. of items | Cronbach's Alpha (%) |
|---|---|---|
| Policy enablers | 7 | 90.0 |
| Impediments | 11 | 82.1 |
| Rollout | 4 | 80.4 |
| Uptake | 4 | 88.6 |
| **Overall** | **26** | **87.6** |

### 4.5 Preliminary analysis

The aim was to present the findings as per the calculations.

### 4.5.1 Normality Test Results

It is essential to test if the data gathered is normally distributed or not before making any unsubstantiated assumptions during analysis (Guzik & Więckowska, 2023). Normality tests help in choosing between using parametric statistics or non-parametric statistics to analyze the data gathered for the study (Kvam, Vidakovic, & Kim, 2022). In contrast to parametric statistics, which rely on the normality of the data, non-parametric statistics are strictly used when the data is not normally distributed data (Ghasemi & Zahediasl, 2012).

It is only permissible to employ parametric statistics like mean, standard deviation, mean, skewness, and kurtosis when dealing with normally distributed data (Thode, 2016). The use of inferential statistics like regression analysis, t-tests, correlation, factor analysis, and analysis of variance also implicitly assumes that the data is normally distributed. However, non-parametric statistics like the median, frequencies, percentages, and ranges are only useful if the collected data is not normally distributed (Steinskog, 2014).

The data acquired for this study was examined for normality using the Kolmogorov-Smirnova and Shapiro-Wilk tests shown in Table 8. Kolmogorov-Smirnova, however, was chosen in this instance because it is stable for sample sizes greater than 60 (Cresswell & Clark, 2013). The following hypothesis was formulated to test the normality of data that was gathered in the study;

**$H_0$:** Data gathered for the study is normally distributed

**$H_1$:** Data gathered for the study is NOT normally distributed

Test of normality of data using Kolmogorov-Smirnova is shown in Table 8.

**Table 8: Test of normality of data using Kolmogorov-Smirnova**

| | **Kolmogorov-Smirnov[a]** | | | **Shapiro-Wilk** | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Policy Enablers | .176 | 77 | .074 | .914 | 77 | .096 |
| Impediments | .268 | 77 | .084 | .860 | 77 | .114 |
| Rollout | .210 | 77 | .056 | .915 | 77 | .063 |

Since the p values of Policy Enablers, Impediments, and Rollout were greater than 0.05 ( $p > 0.05$), H0 is not rejected, and it can be concluded that the data gathered for the study is normally distributed.

### 4.5.2 Multicollinearity diagnostics

Multicollinearity occurs when there is a strong correlation between two or more independent variables in a regression model. This correlation can make it challenging to isolate the individual effects of each variable on the dependent variable. Regression analysis should avoid multicollinearity since it leads to unstable regression estimates and excessive standard errors (Cresswell, 2014; Zeng & Zeng, 2021).

Therefore, it is usually advisable to perform a multicollinearity test on a collection of independent variables for multiple regression before generating regression models. Tolerance and Variance Inflation Factor (VIF) statistics are used to assess the degree of multicollinearity in a set of multiple regression variables. Saunders, Lewis, and Thornhill (2019) suggest that multicollinearity is likely present when the VIF is greater than four or the tolerance is lower than 0.25. Furthermore, there is significant multicollinearity that needs to be addressed when VIF is higher than ten, and tolerance is lower than 0.1.

Multicollinearity diagnostic checks (with rollout as a dependent variable) were done, and the results are indicated in Table 9. It is observed that VIF values were lower than a threshold value of 4 (and tolerance levels were above 0.25) in all the attributes except for Q5_5, impediments, and Q6_4. However, VIF values for Q5_5, impediments, and Q6_4 were greater than four but less than 10 (at 4.033, 6.812, and 4.673, respectively). This means that there was no significant multicollinearity that had to be corrected.

**Table 9: Multicollinearity diagnostic checks with rollout as dependent variable**

| **Dependent Variable: Rollout** | | **Collinearity Statistics** | |
|---|---|---|---|
| | | Tolerance | VIF |
| 1 | Q5_5 (solar energy technology roadmap) | .248 | 4.033 |
| | Q5_6 (Impact of the government willingness to rollout solar power initiatives to RSPV uptake) | .335 | 2.990 |
| | Q5_7 (Impact of escalating utility power prices on RSPV uptake) | .509 | 1.965 |
| | Policy Enablers | .253 | 3.950 |
| | Impediments | .147 | 6.812 |
| | Q6_1 (High RSPV capital cost) | .645 | 1.552 |

| | | | |
|---|---|---|---|
| | Q6_2 (Competition for land use) | .470 | 2.126 |
| | Q6_3 (Blockages in transmission line access policy) | .274 | 3.650 |
| | Q6_4 (Blockages to right of access utility infrastructure) | .214 | 4.673 |
| | Q6_5 (High feed-in tariff service charges) | .641 | 1.560 |
| | Q6_6 (Lack of established SSEG procedures) | .419 | 2.384 |
| | Q6_7 (Restrictions based on building safety conditions) | .461 | 2.170 |
| | Q6_8 (RSPV technology unfamiliar among council and regulatory officials) | .342 | 2.921 |
| | Q6_9 (Misinterpretations of existing solar policies) | .325 | 3.073 |
| | Q6_10 (Limited RSPV targeted policies) | .383 | 2.610 |
| | Q6_11 (RSPV height restrictions on building facilities) | .397 | 2.522 |

Multicollinearity diagnostic checks (with Uptake as the dependent variable) were done, and the results are indicated in Table 10. It is observed that VIF values were lower than a threshold value of 4 (and tolerance levels were above 0.25) in all the attributes except for impediments and Q6_4. However, VIF values for impediments and Q6_4 were greater than four but less than 10 (at 5.935 and 4.710, respectively). This means that there was no significant multicollinearity that had to be corrected.

**Table 10: Multicollinearity diagnostic checks with Uptake as dependent variable.**

| **Dependent Variable: UpTake** | | **Collinearity Statistics** | |
|---|---|---|---|
| | | Tolerance | VIF |
| 1 | Q5_5 (solar energy technology roadmap) | .273 | 3.660 |
| | Q5_6 (Impact of the government willingness to rollout solar power initiatives to RSPV uptake) | .343 | 2.919 |

| | | | |
|---|---|---|---|
| | Q5_7 (Impact of escalating utility power prices on RSPV uptake) | .655 | 1.526 |
| | Policy_Enablers | .271 | 3.691 |
| | Impediments | .168 | 5.935 |
| | Q6_1 (High RSPV capital cost) | .711 | 1.406 |
| | Q6_2 (Competition for land use) | .475 | 2.105 |
| | Q6_3 (Blockages in transmission line access policy) | .269 | 3.713 |
| | Q6_4 (Blockages to right of access utility infrastructure) | .212 | 4.710 |
| | Q6_5 (High feed-in tariff service charges) | .624 | 1.604 |
| | Q6_6 (Lack of established SSEG procedures) | .415 | 2.410 |
| | Q6_7 (Restrictions based on building safety conditions) | .461 | 2.170 |
| | Q6_8 (RSPV technology unfamiliar among council and regulatory officials) | .399 | 2.504 |
| | Q6_9 (Misinterpretations of existing solar policies) | .352 | 2.837 |
| | Q6_10 (Limited RSPV targeted policies) | .379 | 2.637 |
| | Q6_11 (RSPV height restrictions on building facilities) | .397 | 2.518 |

### 4.5.3 Homoscedasticity Tests

When the variance of the residual, or error term, in a regression model, is constant, this is referred to as homoscedasticity (Skiera, Reiner, & Albers, 2021). Various tests can be used to test the existence of homoscedasticity. In this study, Levene's Test of Equality of Error Variances was used, as shown in Table 11.

The hypothesis test for homoscedasticity was formulated as follows;

$H_0$: The variances of the errors are constant (homoscedasticity exists).

$H_1$: The variances of the errors are not constant (homoscedasticity does NOT exists).

Since the p-value is greater than 0.05 ($p > 0.05$), it can be concluded that the error variance of the dependent variable is equal across groups. Thus, there is no significant difference in the equality of error variance in the regression model. This suggests that there is no heteroskedasticity requiring attention in the regression analysis. Hence, the condition of homoscedasticity is met.

**Table 11: Testing homoscedasticity using Levene's test of Equality of error variances**

| Dependent Variable: UpTake | | | |
|---|---|---|---|
| F | df1 | df2 | Sig. |
| 1.416 | 23 | 56 | .054 |
| a. Design: Intercept + Policy_Enablers + Impediments + Policy_Enablers * Impediments | | | |

## 4.6 Descriptive Analysis

The results were based on participants' ratings on perceived policy impediments and enablers for the uptake of the rooftop solar revolution in the Gauteng Province in South Africa. Participants' perceptions were measured on a 5-point Likert scale that ranged from very slightly, slightly, medium, high, and very high. While mean scores of between 2.5 and 3.4 indicated medium judgments, mean scores of between 1 and 2.4 indicated unfavourable perceptions (very slight to slight). However, mean scores of at least 3.5 revealed good judgments (high and very high).

Standard deviation and coefficient of variation (CV) were used to measure the extent of the spread of the perceptions of participants from the mean value. A low coefficient of variation of between 0% and 10% indicates some degree of homogeneity in the opinions of participants. In comparison, a coefficient of variation of between 11% and 19% indicates a medium level of homogeneity in the opinions, while a coefficient of variation above 20% indicates a high level of inconsistency or differing opinions on the subject under consideration (Hair Jr et al., 2021).

### 4.6.1 Results Pertaining to Objective 1

Objective 1 was aimed at identifying and quantifying the policy barriers affecting the uptake of RSPV through statistical analysis of survey data. Table 12 shows participants' perceptions of the perceived policy barriers that may be impeding the uptake of RSPV in Gauteng, South Africa. An overall mean score of 3.6 was achieved compared to a maximum possible favourable score of 5. This means that, on the whole, the impediments that were measured in this study were, to a large extent, negatively affecting the uptake of RSPV in Gauteng, South Africa.

However, participants were of the view that the competition for land use with residential, commercial, industrial expansion, recreational, and scenic interests barriers had a minor effect on the uptake of RSPV in Gauteng, South Africa. Rooftop solar PV facilities face slight restrictions based on building heights and noise pollution (Q6_11). The barriers, as mentioned above, recorded low mean scores of 1.7 and 2.2, confirming that (Q6_2) and (Q6_11) have a slight impeding effect on the uptake of RSPV.

On the other hand, high capital cost blockages to the right for access and misinterpretation of solar policies at the municipality level recorded a high mean score of 3.7, 3.5 and 3.6, respectively, confirming that these barriers had a high inhibiting effect on the uptake of RSPV. The rest of the barriers in Table 4.9 recorded medium mean scores that were between 2.5 and 3.4, as shown, confirming that these had a medium adverse effect on the operations of solar companies.

Participants expressed opinions that were highly different on the impediments affecting the PV solar companies in the Gauteng Province in South Africa. This was due to the fact that the overall coefficient of variation was very high at about 35.2%.

**Table 12: Perceptions of participants on the impediments affecting the PV solar companies**

| Attributes | N | Mean | Mode | Std. Dev | CV % |
|---|---|---|---|---|---|
| Q6_1 (High RSPV capital cost) | 80 | 3.7 | 5 | 1.166 | 31.2 |
| Q6_2 (Competition for land use) | 77 | 2.2 | 1 | 1.519 | 68.4 |
| Q6_3 (Blockages in transmission line access policy) | 80 | 3.4 | 4 | 1.311 | 38.1 |
| Q6_4 (Blockages to right of access utility infrastructure) | 76 | 3.5 | 4 | 1.300 | 37.7 |
| Q6_5 (High feed-in tariff service charges) | 80 | 3.4 | 4 | 1.332 | 39.8 |
| Q6_6 (Lack of established SSEG procedures) | 79 | 3.3 | 4 | 1.300 | 39.6 |
| Q6_7 (Restrictions based on building safety conditions) | 80 | 2.6 | 3 | 1.227 | 47.0 |
| Q6_8 (RSPV technology unfamiliar among council and regulatory officials) | 77 | 3.2 | 4 | 1.380 | 43.0 |
| Q6_9 (Misinterpretations of existing solar policies) | 80 | 3.6 | 4 | 1.279 | 35.5 |
| Q6_10 (Limited RSPV targeted policies) | 80 | 3.4 | 4 | 1.391 | 41.2 |
| Q6_11 (RSPV height restrictions on building facilities) | 80 | 1.7 | 1 | 1.479 | 87.0 |
| **Overall Impediments** | **80** | **3.6** | **4** | **1.261** | **35.2** |

### 4.6.2 Results pertaining to objective 2

Objective 2 was aimed at assessing and quantifying the extent of the impact of policy enablers on the uptake of RSPV in South Africa. Table 13 shows participants' perceptions of the policy enablers for rooftop solar PV. An overall mean score of 2.6 was achieved compared to a maximum possible favourable score of 5. This meant that policy enablers have been deployed for rooftop solar PV to a medium extent.

Based on the perceptions of the participants, the enactment of the SA solar energy technology roadmap (SETRM) that promotes the green industry through local development of solar technologies has been deployed to a medium extent (mean = 2.6).

On the other hand, the escalation of utility electricity prices promoting the growth of the Rooftop solar PV business has been highly rated by participants and recorded a high mean score of 4.0 compared to a maximum possible score of 5. This confirms that the escalation of utility electricity prices is in place to enable the growth of RSPV adoption.

The willingness of the South African government to support the rollout of solar power initiatives, such as rooftop solar PV projects that provide households with energy solutions, recorded a low mean score of 2.2. This indicates that this enabler has been slightly put in place to support the growth of RSPV.

Participants expressed contradictory views on the extent of the policy enablers for rooftop solar PV in the Gauteng Province in South Africa. This was due to the fact that the overall coefficient of variation was very high at about 52.

**Table 13: Perceptions of participants on the policy enablers in place for rooftop solar PV**

| Attributes | N | Mean | Mode | Std. Dev. | CV % |
|---|---|---|---|---|---|
| Q5_5 (solar energy technology roadmap) | 78 | 2.6 | 3 | 1.330 | 50.6 |
| Q5_6 (Impact of the government willingness to rollout solar power initiatives to RSPV uptake) | 79 | 2.2 | 1 | 1.398 | 62.4 |
| Q5_7 (Impact of escalating utility power | 80 | 4.0 | 5 | 1.147 | 28.5 |

| | | | | | |
|---|---|---|---|---|---|
| prices on RSPV uptake) | | | | | |
| **Overall Policy Enablers** | **80** | **2.6** | **3** | **1.372** | **52.4** |

### 4.6.3 Results pertaining to objective 3

Objective 3 was aimed at determining the perceived extent of the uptake of RSPV in Gauteng, South Africa. Table 4.9 shows participants' perceptions of the perceived extent of the uptake of rooftop solar.

As shown in Table 14, it was observed that overall, participants were hinted that the extent of rooftop solar PV uptake in the Gauteng Province in South Africa is medium and recorded an overall mean score of 2.8 compared to a maximum possible favourable score of 5. The perceived ratings for the implementation of policies to nurture and grow a good environment for solar projects deployment of government policies to promote the penetration of renewable deployment of the Integrated Resource Plan (IRP) that encourages a shift to the use of renewable energy sources and encouragement by the implementation of the energy policies to combat the effects of power cuts and load-shedding were medium with mean scores of between 2.5 and 3.0.

Participants expressed highly divergent opinions on the extent of the uptake of rooftop solar PV in the Gauteng Province in South Africa. This was observed through an overall coefficient of variation of  43.6%.

**Table 14: Perceptions of participants on uptake of rooftop solar PV in the Gauteng Province**

| Attributes | N | Mean | Mode | Std. Dev. | CV % |
|---|---|---|---|---|---|
| Q5_1 (Existing solar policy enablers) | 80 | 2.6 | 3 | 1.255 | 47.5 |
| Q5_2 (Existing RSPV targeted policy enablers) | 80 | 2.5 | 3 | 1.252 | 51.1 |
| Q5_3 (Integrated resource plan – IRP) | 79 | 2.7 | 3 | 1.384 | 50.7 |
| Q5_4 (New energy policy to combat load-shedding) | 80 | 3.0 | 3 | 1.484 | 49.8 |
| Overall Uptake | **80** | **2.8** | **3** | **1.211** | **43.6** |

### 4.7 Measuring perceptions on the rollout of rooftop solar PV projects

Table 15 shows participants' perceptions on the extent of the rollout of rooftop solar PV projects. An overall mean score of 2.9 was achieved compared to a maximum possible favourable score of 5. This means that, on the whole, the rooftop solar PV projects in Gauteng Province have been moderately rolled out.

However, participants were of the view that there is a highly increased rate of the rollout of rooftop solar PV solutions in South Africa. This attribute recorded a high mean score of 4.1 compared to a maximum possible score of 5.0. However, the other rollout attributes recorded a medium mean score of between 2.5 and 3.0, as shown in Table 15.

Participants expressed opinions that were highly conflicting on the impediments affecting the PV solar companies in the Gauteng Province in South Africa, as observed with a coefficient of 47.1%.

**Table 15: Perceptions of participants on the extent of the rollout of rooftop solar PV projects**

| Attributes | N | Mean | Mode | Std. Dev | CV % |
|---|---|---|---|---|---|
| Q7_1 (RSPV role out rate in RSA) | 80 | 4.1 | 4 | 1.009 | 24.7 |
| Q7_2 (Impact of existing policy on RSPV uptake) | 80 | 2.8 | 2 | 1.332 | 47.4 |
| Q7_3 Effectiveness of government policies relevant to RSPV | 80 | 2.6 | 3 | 1.252 | 49.1 |
| Q7_4 Level of RSPV priority in existing solar policies | 80 | 2.7 | 3 | 1.382 | 51.2 |
| **Overall Rollout** | **77** | **2.9** | **3** | **1.357** | **47.1** |

## 4.8 Hypotheses testing results

This subsection presents tests for the two hypotheses (Hypothesis 1 and Hypothesis 2) that were formulated for the study. A multiple linear regression model was carried out to establish relationships between the identified themes as shown in Table 16. In this case, impediments and policy enablers were independent variables, while the uptake of RSPV was a dependent variable.

**Table 16: Measuring the relationship between impediments, policy enablers and the uptake of RSPV using regression**

| Model | | **Unstandardized Coefficients** | | Standardized Coefficients | **t** | **Sig.** |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | .700 | .188 | | 3.716 | .000 |
| | Policy Enablers | .810 | .041 | .917 | 19.896 | .000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Impediments | -.014 | .044 | -.015 | -.326 | .746 |
| a. Dependent Variable: Uptake | | | | | | |

### 4.8.1 Results Pertaining to Hypothesis 1

Hypothesis 1 was formulated as follows;

**$H_1$**: Impediments negatively influence the uptake of RSPV in Gauteng Province

Based on the results in Table 16, the p-value of the coefficient of Impediments is greater than 0.05 ($p > 0.05$). Hence, the study concludes that there is no statistical evidence to suggest that Impediments influence the uptake of RSPV.

### 4.8.2 Results Pertaining to Hypothesis 2

$H_2$: Policy enablers positively influence the uptake of RSPV in Gauteng Province.

Based on the results in Table 16, the p-value of the Policy Enablers coefficient is less than 0.05 ($p < 0.05$). Therefore, the study finds that Policy Enablers have a positive and significant influence on the uptake of rooftop solar PV projects

## 4.9 Model Validation

The multiple linear regression model above was validated using the Analysis Of Variance shown in Table 17. The p-value of the regression model is less than the 5% level. This means that the model is significant and that the dependent variable, uptake of RSPV, is well defined by two independent variables that include impediments and policy enablers.

**Table 17: Validation of Impediments, Policy Enablers, and Uptake model using ANOVA**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 97.236 | 2 | 48.618 | 200.046 | .000 |
| | Residual | 18.714 | 77 | .243 | | |
| | Total | 115.950 | 79 | | | |
| a. Predictors: (Constant), Impediments, Policy_Enablers | | | | | | |
| b. Dependent Variable: UpTake | | | | | | |

The regression model on the influence of Impediments and Policy Enablers on Uptake was also validated using $R^{2,}$ as shown in Table 18. An adjusted $R^2$ value of 0.834 was achieved using multiple linear regression. The adjusted $R^2$ value achieved in this study is quite high, indicating that impediments and policy enablers explain 83.4% of the variance in the uptake well. This is consistent with the assumptions of Hair Jr et al. (2021).

**Table 18: Validation of model (Impediments, Policy Enablers and Uptake) using $R^2$**

| Model Summary | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | .916[a] | .839 | .834 | .493 |
| a. Predictors: (Constant), Impediments, Policy_Enablers | | | | |

### 4.10 Summary of the results

The study results lead to the conclusion that impediments such as high capital costs, obstacles to access rights, and misinterpretation of solar policies at the municipality level are the primary factors hindering the implementation of rooftop solar PV solutions in South Africa.

The results indicated that the escalation of utility electricity prices, which promoted the growth of the rooftop solar PV business, has been a major enabler for the rollout of rooftop solar systems in South Africa. However, the results showed that the enactment of the SA solar energy technology roadmap (SETRM) that promotes the green industry through local development of solar technologies and the willingness of the South African government were other less significant enablers for the rollout of solar projects in the country particularly in Gauteng Province.

The results indicated that the uptake of rooftop solar PV in South Africa was of medium extent. It was further discovered that the implementation of policies aimed at fostering a favourable environment for solar projects and the deployment of government policies to encourage the penetration of renewable energy were moderately extensive. The findings also indicated that the implementation of the Integrated Resource Plan (IRP), which advocates for a transition to renewable energy sources, and the efforts to address the impacts of power cuts and load-shedding through the implementation of energy policies were also of moderate extent.

Results indicated that policy enablers have a significant and positive influence on the rollout of rooftop solar PV solutions in South Africa. However, there was no statistical evidence to suggest that impediments influence the rollout of rooftop solar PV solutions in Gauteng province, South Africa.

### 4.11 Comparison of literature review and study findings

Table 19 shows a comparison between the findings of the study and the appropriate literature reviewed.

**Table 19: Consistency Table comparing findings with literature**

| **RQ #** | **State Research Question or Objective** | **Prop/hyp #** | **State Proposition or Hypothesis** (literature review response to RQ) | **Findings from own study** |
|---|---|---|---|---|
| | Determine the perceived policy barriers that may be impeding the uptake of RSPV. | | High initial costs are one of the things turning off potential customers from installing rooftop solar PV systems. Policies in place in South Africa help to improve the growth of rooftop solar systems. | High capital cost, blockages to the right of access, and misinterpretation of solar policies at the municipality level are the main factors that are hindering the rollout of rooftop solar PV solutions in South Africa. |
| | Determine the policy enablers currently in place for RSPV in South Africa. | | Literature shows that the South African government has progressively enacted various policies to nurture and grow a conducive environment for rooftop solar projects to flourish. Solar energy technology roadmap is one initiative from the government of South Africa that has been enacted to provide meaningful support to the rollout of solar energy technologies. The theory also revealed that the South African government had shown some willingness to adopt and implement solar technologies. | The findings indicated that the escalation of utility electricity prices, which promoted the growth of the rooftop solar PV business, has been a major enabler for the rollout of rooftop solar systems in South Africa. The findings of the study revealed that enactment of the SA solar energy technology roadmap and the willingness of the South African government were other less significant enablers for the rollout of solar projects in the country, particularly in Gauteng Province. |

| RQ # | State Research Question or Objective | Prop/hyp # | State Proposition or Hypothesis (literature review response to RQ) | Findings from own study |
|---|---|---|---|---|
| | Determine the perceived extent of the uptake of RSPV in Gauteng, South Africa. | | South Africa, especially Gauteng Province, was making tremendous progress in the adoption of rooftop solar PV systems. | The uptake of rooftop solar PV in the Gauteng Province in South Africa is of medium extent. |
| 1 | Hypothesis 1 | 1 | Impediments such as the high cost of capital, policy barriers and lack of awareness and education on the benefits of solar energy technologies have significant effects on the uptake of rooftop solar PV solutions.<br><br>Policy Enablers have a significant influence on the uptake of rooftop solar PV. | The findings of the study showed that impediments have no significant influence on the uptake of RSPV. |
| 1.1 | Hypothesis 2 | | Policy Enablers have a significant influence on the uptake of rooftop solar PV. | The findings revealed that Policy Enablers have a positive and statistically significant influence on the uptake of rooftop solar PV projects in South Africa. |

# CHAPTER 5: DISCUSSION OF THE FINDINGS

## 5.1 Introduction

The purpose of this chapter was to discuss the study's findings, which were reported in the preceding chapter, and compare these to relevant literature which was covered earlier in Chapter 2. This comparative research provides context, credibility, and a solid platform for expanding knowledge about rooftop solar renewables. It also helps in placing findings within the context of broader scholarly discussion. Most significantly, it helps in identifying and explaining any gaps in the study.

## 5.2 Discussion pertaining to Hypothesis 1

Hypothesis 1 was focused on determining the influence of impediments on the uptake of RSPV. The findings of the study showed that there was no statistical evidence to suggest that impediments influenced the uptake of RSPV. According to theory, despite substantial growth in renewable capacity, there are still constraints on the annual installation of new renewable energy systems. Additionally, several impediments, such as high cost of capital, policy barriers, and lack of awareness and education on the benefits of solar energy technologies, are restrictive to the uptake of rooftop solar PV solutions (DRE, 2019). The findings were contradictory to the study findings, which established that impediments show no significant influence on the rollout of rooftop solar PV solutions in South Africa.

Several factors may explain why impediments are not fully halting the rollout of rooftop solar PV solutions in South Africa, despite various challenges. Firstly, South Africa’s ongoing energy crisis, which is characterized by frequent load shedding due to Eskom's unreliable power supply, has driven individuals and businesses to seek alternative energy solutions. This might mean that the urgency to reduce dependence on the national grid overrides many impediments. Furthermore, government policies are gradually becoming more supportive of renewable energy, including rooftop solar. For example, the 2023 budget allowed for tax incentives for businesses and individuals who install solar PV systems, encouraging adoption.

### 5.3 Discussion pertaining to Hypothesis 2

Hypothesis 2 was focused on determining the influence of Policy Enablers on the uptake of RSPV. The findings revealed that Policy Enablers have a positive and statistically significant influence on the uptake of rooftop solar PV projects in South Africa. In support of the findings above, past studies argued that policy enablers have a positive and direct effect on how the rooftop solar PV sub-sector is implemented as well as how it develops (Nel, 2015; DRE, 2019).

The findings indicate that the government is achieving its intended goal of influencing the growth of RSPV adoption through developing and implementing appropriate policies to attract and increase solar PV users. For example, the South African government introduced various tax incentives and rebates aimed at encouraging businesses and homeowners to invest in solar PV systems. For instance, the 2023 budget included an expansion of tax deductions on solar installations for businesses, and households can claim a rebate of 25% on the cost of rooftop solar panels. These financial benefits have to an extent reduced the initial capital burden, making solar more affordable and appealing. The results of this has improved the number of households adopting RSPV.

Furthermore, regulations requiring licenses for power generation below 100 MW have been eased, allowing businesses and homes to install solar PV systems without the lengthy approval processes. This has accelerated the deployment of rooftop solar by reducing bureaucratic red tape. Some municipalities have followed up the national government by implementing policies and programs that promoted solar PV installations, including simplified approval processes and subsidies.

## 5.4 Discussion pertaining to Objective 1

Objective 1 was aimed at determining the perceived policy barriers that may be impeding the uptake of RSPV in Gauteng, South Africa. The study found that high capital cost, blockages to the right of access, and misinterpretation of solar policies at the municipality level were the main factors that hindered the rollout of rooftop solar PV solutions in South Africa.

The findings on the perceived high capital cost of solar to the uptake of solar technologies such as rooftop solar PV solutions in South Africa are supported by past studies of Chidembo, Francis, and Kativhu (2022) and Mulaudzi, Bull, and Makhado (2022), who suggested that many house and business owners are finding the initial cost of buying and installing solar panels and related equipment to be exorbitant. This high capital cost, which is more conspicuous in low-income communities, may be one of the things turning off potential customers (Beck & Martinot, 2016).

Therefore, to ensure that there is an accelerated rollout of rooftop solar PV solutions in South Africa, an effective mechanism has to be put in place for affordable financing outside the government tax incentive system. Many banks and financial institutions in South Africa now offer green loans specifically for renewable energy installations like solar PV. These loans often come with lower interest rates than traditional loans and favourable repayment terms. Furthermore, several solar energy companies now offering in-house financing or partnerships with financial institutions to make solar installations more affordable. These plans allow customers to spread the initial cost of solar PV over several months or years. Crowdfunding and community-based financing models are alternative ways for individuals and businesses to raise funds for solar PV projects and reduce the cost of initial capital.

The study found that blockages to the right of access are some of the issues that are hindering the rollout of rooftop solar PV solutions in South Africa. This finding is well supported by literature, which confirmed that restrictions on the allocation of sites and building construction protocols, as well as the bureaucratic processes of acquiring necessary permits and approvals for rooftop solar installations, also hinder the implementation of rooftop solar PV solutions in South Africa (BRC, 2020; Creamer, 2021).

Literature demonstrated that there are some policies in place in South Africa to regulate rooftop solar systems. However, these regulations have been changed quite often, creating uncertainty for investors and project developers (du Plooy, Brent, and de Kock, 2017). Contrary to the literature above, the study findings indicated that despite the availability of regulated rooftop solar, these policies are often misinterpreted, and this is a hindrance to the rollout of rooftop solar PV. The misinterpretation of policies associated with rooftop solar in South Africa may be attributed to different government departments, business associations, and advocacy groups who often communicate policies in different ways, which can lead to confusion and inconsistencies in the message relayed to target audiences.

### 5.5 Discussion pertaining to Objective 2

Objective 2 was focused on determining the policy enablers currently in place for RSPV in South Africa. The findings indicated that the escalation of utility electricity prices, which promoted the growth of the rooftop solar PV business, has been a major enabler for the rollout of rooftop solar systems in South Africa. This finding was well supported by literature which argued that owing to the erratic electricity supply in South Africa, there has been a rapid escalation of utility electricity prices. Some studies state that this significant increase in utility electricity prices has promoted tremendous growth in semi to off-grid solar projects (SAPVIA, 2020a). Hence, rooftop solar technologies provide a cost-effective alternative energy source for consumers.

The findings of the study also revealed that enactment of the SA solar energy technology roadmap (SETRM) that promotes the green industry through local development of solar technologies and the willingness of the South African government were other less significant enablers for the rollout of solar projects in Gauteng Province. Contrary to these findings, the South African government has put in place various policies to nurture and grow a conducive environment for rooftop solar projects to flourish. Solar energy technology roadmap is one initiative from the government of South Africa that has been enacted to provide meaningful support to the rollout of solar energy technologies (Winkler, 2005). The literature revealed that the South African government had shown some willingness to adopt and implement solar technologies. Additionally, the government has also shown commitment to channel resources towards green technologies, which include rooftop solar projects (DMRE, 2019; DoE, 2019). Hence, it is clear that the willingness of the government to support solar technologies and the implementation of relevant policies is considerably promoting the rollout of solar technologies.

## 5.6 Discussion pertaining to Objective 3

Objective 3 intended to determine the perceived extent of the uptake of RSPV in Gauteng, South Africa. The findings revealed that the uptake of rooftop solar PV in the Gauteng Province in South Africa is at a moderate level.

This finding is aligned with the assertion of the past scholars who established that South Africa, particularly in Gauteng Province, was making tremendous progress in the adoption of rooftop solar PV systems (SAPVIA, 2020a). Supportive government policies, incentives, energy prices, and awareness of the benefits of solar energy has spurred the extent of uptake of rooftop solar PV systems in South Africa. The trend of adopting solar systems is anticipated to persist, driven by the ongoing increase in energy prices and the unreliability of electricity supply, which is characterised by unexpected load shedding.

The overall perception is that rooftop solar PV is being widely adopted in South Africa, particularly in the commercial and residential sectors, as a response to energy insecurity, favourable policies, declining solar costs, and rising electricity prices. While exact statistics on the number of installations are limited, the growth trajectory is evident in urban and industrial areas, supported by government incentives, private sector investments, and innovative financing solutions. The overall outlook is one of continued strong uptake, though some barriers remain, particularly for lower-income households and small businesses.

### 5.7 Conclusion

In conclusion, this study has explored policy enablers and perceived impediments to rooftop solar PV projects in Gauteng, South Africa, using a quantitative method. The study findings indicated that there is no statistical evidence to suggest that impediments influence the uptake of RSPV. This was contrary to the literature, which showed that impediments such as high cost of capital, policy barriers and lack of awareness and education on the benefits of solar energy technologies have an adverse and significant effect on the uptake of rooftop solar PV projects in Gauteng South Africa. The implications of the insignificant influence of Impediments on the uptake of rooftop solar PV projects are diverse and many. This suggests that the demand for rooftop solar solutions is robust enough to offset obstacles like bureaucratic red tape, regulatory barriers, or administrative challenges. It also indicates that the public interest in rooftop solar PV projects is so significant that impediments cannot deter their enthusiasm.

The study established that policy enablers have a positive and statistically significant influence on the uptake of rooftop solar PV projects in South Africa. This was supported by literature that argued that policy enablers have a positive and direct effect on the uptake of rooftop solar systems, such as Mundaca and Samahita (2020) and Collier, House, Connor, and Harris (2023). This may mirror the consistent endeavours of the provincial government to endorse renewable energy, enhance its financial attractiveness, and nurture the advancement of solar energy by formulating and implementing appropriate policies.

The study found that high capital cost, blockages to the right of access, and misinterpretation of solar policies at the municipality level were the main factors that hindered the rollout of rooftop solar PV solutions in Gauteng, South Africa. These findings were supported by literature which argued that potential users are dissuaded from installing solar technologies owing to high initial costs(Tanveer, Zeng, Irfan, & Peng, 2021; Zander, 2021). The provincial government needs to consider affordable financing of rooftop solar PV solutions to accelerate its uptake and achieve its energy plans.

The study also found that the escalation of utility electricity prices was one of the major enablers that have promoted the growth of the rooftop solar PV business in Gauteng. This finding was well supported by the theory which argued that owing to the erratic electricity supply in South Africa, there has been a rapid escalation of utility electricity prices that has encouraged people to install rooftop solar PV solutions as alternatives (Kanhukamwe, 2019; Thenga, 2020). The significance of high electricity prices in facilitating the installation of solar PV systems highlights the role that market forces and economic factors have played in accelerating the switch to renewable energy sources. For individuals and governments, high electricity prices can be a strong incentive to invest in solar technology and help create a more sustainable and affordable energy future.

The study established that the uptake of rooftop solar PV in the Gauteng Province in South Africa is of medium extent. This was in line with the literature, which showed that South Africa, especially Gauteng Province, was making tremendous progress in the adoption of rooftop solar PV systems (Akoon, 2020; Kumba, Akpan, Twite, & Olanrewaju, 2023). This progress in the adoption of rooftop solar PV systems reflects a positive shift towards more sustainable, environmentally friendly, and economically beneficial energy practices. It constitutes a pivotal element in the worldwide initiative to shift towards clean, renewable energy sources and alleviate the impacts of climate change.

# CHAPTER 6: CONCLUSIONS & RECOMMENDATIONS

## 6.1 Introduction

The purpose of the study was to determine policy enablers and perceived impediments for rooftop solar PV projects in Gauteng, South Africa. This chapter presents the conclusion and recommendations. The recommendations in this study were based on the findings of the study and are intended to guide future actions, policies, or decision-making. The chapter also presents areas for future researchers to exploit.

## 6.2 Conclusions Regarding Objective 1

The study concludes that capital cost, blockages to the right of access, and misinterpretation of solar policies at the municipality level are the main factors that hinder the rollout of rooftop solar PV solutions in Gauteng, South Africa. These findings were largely consistent with the past study findings of Chidembo et al. (2022); (Mundaca & Samahita, 2020), and Kumba et al. (2023). However, in contrast to existing literature, the study findings showed that while South Africa has policies in place to control rooftop solar, these policies are frequently misunderstood, which makes it difficult to expand rooftop solar PV systems. Rooftop solar policy misinterpretation in South Africa is linked to various government agencies, business associations, and advocacy groups frequently communicating and explaining policies in different ways, which can cause confusion and inconsistencies in the message delivered to target audiences.

## 6.3 Conclusions Regarding Objective 2

The study concludes that the expansion of rooftop solar PV systems in South Africa has been greatly facilitated by the rise in utility electricity prices and the enactment of the SA solar energy technology roadmap (SETRM) that promotes the green industry through the local development of solar technologies. Such circumstances are regarded as one of the major enablers for the rollout of rooftop solar systems in South Africa. However, the willingness of the South African government to support the rollout of solar power initiatives was not a major enabler for the rollout of rooftop solar systems in South Africa. This was contradictory to past studies' findings, which stressed that governments need to show willingness to support the implementation of solar initiatives to achieve their goals in clean energy. The absence of substantial support from the provincial government in Gauteng may lead to a lost opportunity for transitioning to cleaner and more sustainable energy sources. These sources could provide an affordable alternative for consumers.

## 6.4 Conclusions Regarding Objective 3

The study concludes that the uptake of rooftop solar PV in the Gauteng Province in South Africa is moderate. This finding is contradictory to the theory that showed that South Africa, especially Gauteng Province, was making tremendous progress in the adoption of rooftop solar PV systems. The extent of uptake of rooftop solar PV systems can be attributed to incentives, energy prices, and awareness of the benefits of solar energy. The upward trajectory in the adoption of solar systems is anticipated to persist, driven by the ongoing increase in energy prices and the persistently unreliable electricity supply, marked by unplanned load shedding.

## 6.5 Conclusions Regarding Hypothesis 1

The study concludes that impediments have no significant influence on the uptake of RSPV. Furthermore, it was demonstrated that impediments have an adverse influence on the uptake of RSPV. This finding was consistent with the reviewed literature, which states that impediments such as high cost of capital, policy barriers, and lack of awareness and education on the benefits of solar energy technologies restrain the uptake of RSPV.

The limited impact of impediments on the adoption of RSPV might imply a robust demand for rooftop solar PV in Gauteng, South Africa. This demand appears to overcome various obstacles, including bureaucratic red tape, regulatory hurdles, and administrative challenges. Additionally, this can be attributed to the high level of public desire (as seen by cheap costs, incentives, and effective financing alternatives), which works to balance out the barriers and promote the use of solar energy.

## 6.6 Conclusions regarding Hypothesis 2

The study concludes that policy enablers have a positive and statistically significant influence on the uptake of rooftop solar PV projects in South Africa. The findings were consistent with past studies, which stated that policy enablers have a significant influence on the uptake of rooftop solar PV projects (Collier et al., 2023; Reindl & Palm, 2021; Wilkinson, John, & Morrison, 2021). This may be the result of a coordinated effort on the part of the government to promote renewable energy, make it financially appealing, and foster the expansion of solar energy.

Table 20 displays a consistency table that highlights research questions, conclusions, and contributions to knowledge. The contribution delineates the variance between the initial propositions/hypotheses derived from the literature and the study's findings.

**Table 20: Consistency table: research questions, conclusions, and contribution to knowledge**

| RQ # | Research Objective | State literature-based proposition or hypothesis | State conclusion or answer based on own research | Highlight key differences between your initial propositions/hypotheses and your findings – this is your contribution to knowledge. |
|---|---|---|---|---|
| 1 | Determine the perceived policy barriers that may be impeding the uptake of RSPV. | High initial costs hinder potential customers from installing rooftop solar PV systems. Policies put in place in South Africa help to improve the growth of rooftop solar systems and are not inhibitive to the uptake of solar technologies. | The primary obstacles impeding the implementation of rooftop solar PV solutions in South Africa include high capital costs, barriers to access rights, and misinterpretation of solar policies at the municipality level. | In contrast to the literature, the results revealed that, despite the presence of policies in South Africa governing rooftop solar, these policies are frequently misinterpreted, posing a hindrance to the widespread adoption of rooftop solar PV. |
| 2 | Determine the policy enablers currently in place for RSPV in South Africa. | Literature shows that the South African government has progressively enacted various policies to nurture and grow a conducive environment for rooftop solar projects to succeed. Solar energy technology roadmap is one initiative from the government of South Africa that has been enacted to provide meaningful support to the rollout of solar energy technologies. Literature suggests that the South | The findings indicated that the escalation of utility electricity prices, which promoted the growth of the rooftop solar PV business, has been a major enabler for the rollout of rooftop solar systems in South Africa. The findings of the study established that enactment of the SA solar energy technology roadmap and the willingness of the South African government were other less significant enablers for the rollout of solar projects | Literature suggests that the willingness of the government to support the implementation of solar projects and the enactment of the SA solar energy technology policies are significant enablers for the rollout of solar projects in the country. Nevertheless, the results indicated that the government's willingness to support the implementation of solar projects and the enforcement of South Africa's solar energy technology policies are not significant facilitators for the implementation of rooftop solar PV technologies. |

| RQ # | Research Objective | State literature-based proposition or hypothesis | State conclusion or answer based on own research | Highlight key differences between your initial propositions/hypotheses and your findings – this is your contribution to knowledge. |
|---|---|---|---|---|
| | | African government has shown some willingness to adopt and implement solar technologies. | in the country, particularly in Gauteng Province. | |
| 3 | Determine the perceived extent of the uptake of RSPV in Gauteng, South Africa. | South Africa, especially Gauteng Province, is making tremendous progress in the adoption of rooftop solar PV systems. | The uptake of rooftop solar PV in the Gauteng Province in South Africa is at a moderate level. | The study established that the adoption of rooftop solar systems in South Africa has not reached high levels when compared to other countries, particularly in developed nations with the financial means and political will to support the deployment of solar solutions. |
| 4.1 | Hypothesis 1 | Impediments such as the high cost of capital, policy barriers and lack of awareness and education on the benefits of solar energy technologies have significant effects on the uptake of rooftop solar PV solutions. | The findings of the study showed that impediments such as high capital cost, competition for land use in urban areas, and blockages to transmission infrastructure access have no significant influence on the uptake of RSPV. | The study found that Impediments have no significant influence on the uptake of rooftop solar systems. At the same time, literature contradicts this as it shows that several impediments, such as high cost of capital, policy barriers, and lack of awareness and education on the benefits of solar energy, have a significant and negative influence on the uptake of solar solutions. |
| 4.2 | Hypothesis 2 | Policy Enablers have a significant influence on the uptake of rooftop solar PV. | The study found that Policy Enablers have a positive and statistically significant influence on the uptake of rooftop solar PV projects in Gauteng, South Africa. | Past literature and the study findings were consistent in that Policy Enablers demonstrated significant influence on the uptake of rooftop solar PV. |

## 6.7 Recommendations

Based on the findings and conclusions that were presented above, a comprehensive strategy encompassing government initiatives, regulatory adjustments, financial support, public outreach, and industry collaboration is needed to remove obstacles to the adoption of rooftop solar PV (photovoltaic) solutions in South Africa. Some of the recommendations that can be considered are as follows;

### i. Clear and Supportive Policies

The government should formulate and uphold clear and consistent policies, including net metering, feed-in tariffs, and streamlined permitting processes that support the installation of solar rooftops. Additionally, the implementation of clear policies providing incentives, such as tax credits, rebates, and low-interest loans, can effectively reduce the upfront costs associated with solar installations.

### ii. Streamlined Permitting and Regulation

The government must reduce administrative burdens and costs by streamlining and accelerating the permitting process for solar rooftop projects. It is also appropriate to create a predictable and efficient working environment for installers. Standardizing the regulation is one efficient way.

### iii. Financial Support

Funders must establish accessible and affordable financing options such as solar loans and leasing programs to ensure that solar installations are more affordable to potential users. It can be cost-effective to explore financing mechanisms that can spread the cost over time. This reduces the immediate cost burden to the user.

### iv. Public Education and Awareness

Local authorities must launch public awareness campaigns to educate people about the benefits of solar rooftop systems, including long-term cost savings and environmental benefits. Online resources and information about solar incentives, financing options, and reputable installers should be made available.

### v. Training and Workforce Development

Private investors must invest in the training of solar installers and technicians to ensure the availability of skilled personnel who can perform quality installations. This is one of the aspects that can improve the rollout of solar PV solutions in South Africa.

### vi. Local Government Support

Local governments should adopt and implement regulations that promote rooftop solar installations. Again, local governments should develop local initiatives and incentives to encourage solar adoption.

### vii. Community Solar Programs

Community leaders must develop shared community solar programs that can allow low-income households to purchase or subscribe to shared solar technology. These programs will help to accelerate the rollout of solar PV solutions.

### viii. Collaboration and Partnerships

Several institutions, such as government agencies, utilities, and private sector players, should collaborate to drive the adoption of solar rooftop systems. Solar technology providers must share best practices and lessons learned with other constituencies, regions, and countries to benefit from collective knowledge.

## 6.8 Suggestions for further research

Research in key areas is crucial to navigate the challenges and seize the opportunities of rooftop solar, ultimately leading to a sustainable and resilient energy future. Therefore, future researchers can focus on the following areas to improve on the current research:

- A mixed method approach must be taken into consideration to have high levels of data reliability while also enabling the gathering of more detailed information.
- To accurately predict the impact of various policy factors on the adoption of rooftop solar PV, further research is needed to identify a broader range of potential enablers and impediments. Their influence should then be rigorously evaluated through multiple linear regression analysis.
- A more comprehensive study can be undertaken to analyse the impact of different policy and regulatory frameworks on rooftop solar adoption. A key focus of the research will be evaluating the effectiveness of different policy tools, including incentives, feed-in tariffs, net metering, and streamlined regulations, in boosting solar uptake.

## 7.0 REFERENCES


African Energy. (2021). South Africa: Preferred bidders were announced for the emergency power programme. Retrieved from https://www.africa-energy.com/live-data/article/south-africa-preferred-bidders-announced-emergency-power-programme. https://www.africa-energy.com/live-data/article/south-africa-preferred-bidders-announced-emergency-power-programme

African Union. (2018). Policy Framework and Programme Design for Small Hydropower and Solar Energy Development in Africa Final Report.

Akoon, I. (2020). *The private adoption of solar photovoltaic energy in Ekurhuleni Municipality, South Africa.*

Amankwah-Amoah, J., & Sarpong, D. (2016). Historical pathways to a green economy: the evolution and scaling-up of solar PV in Ghana, 1980–2010. *Technological Forecasting and Social Change, 102*, 90-101. Retrieved from https://doi.org/10.1016/j.techfore.2015.02.017

Amir, M., & Khan, S. Z. (2022). Assessment of renewable energy: Status, challenges, COVID-19 impacts, opportunities, and sustainable energy solutions in Africa. *Energy and Built Environment, 3*(3), 348-362.

Apostol, D., Palmer, J., Pasqualetti, M., Smardon, R., & Sullivan, R. (2016). *The renewable energy landscape: Preserving scenic values in our sustainable future*: Taylor & Francis.

Baker, L. (2015). Renewable energy in South Africa's minerals-energy complex: A 'low carbon' transition? Review of African Political Economy, 42(144), 245-261

Balnaves, M., & Caputi, P. (2001). *Introduction to quantitative research methods: An investigative approach*: Sage.

Bazilian, M., & Pielke, R. (2013). Making Energy Access Meaningful. Issues in Science and Technology, 29(4), 74-81. DOI: 10.1353/tech.2013.0017.

Beck, F., & Martinot, E. (2004). Renewable energy policies and barriers. Retrieved from http://dx.doi.org/10.1016/B0-12-176480-X/00488-5

Beck, F., & Martinot, E. (2016). Renewable energy policies and barriers. Retrieved from http://www.martinot.info/Beck_Martinot_AP.pdf

Bhamidipati, P. L., Haselip, J., & Hansen, U. E. (2019). How do energy policies accelerate sustainable transitions? Unpacking the policy transfer process in the case of GETFiT Uganda. *Energy Policy, 132*, 1320-1332. Retrieved from https://doi.org/10.1016/j.enpol.2019.05.053

Bianco, V., Cascetta, F., & Nardini, S. (2021). Analysis of technology diffusion policies for renewable energy. The case of the Italian solar photovoltaic sector. *Sustainable Energy Technologies and Assessments, 46*, 101250.

Blimpo, M. P., & Cosgrove-Davies, M. (2019). *Electricity access in Sub-Saharan Africa: Uptake, reliability, and complementary factors for economic impact*: World Bank Publications.

BRC. (2020). *South Africa Solar Power Market Outlook*. Retrieved from https://www.blackridgeresearch.com/reports/south-africa-solar-power-market

Brink, H. I. (1993). Validity and reliability in qualitative research. *Curationis, 16*(2), 35-38. Retrieved from https://doi.org/10.4102/curationis.v16i2.1396

Chidembo, R., Francis, J., & Kativhu, S. (2022). Rural Households' Perceptions of the Adoption of Rooftop Solar Photovoltaics in Vhembe District, South Africa. *Energies, 15*(17), 6157.

Collier, S. H., House, J. I., Connor, P. M., & Harris, R. (2023). Distributed local energy: Assessing the determinants of domestic-scale solar photovoltaic uptake at the local level across England and Wales. *Renewable and Sustainable Energy Reviews, 171*, 113036.

Cooke, R., Cripps, A., Irwin, A., & Kolokotroni, M. (2007). Alternative energy technologies in buildings: Stakeholder perceptions. *Renewable energy, 32*(14), 2320-2333. Retrieved from https://doi.org/10.1016/j.renene.2006.12.004

Couture, T. D., Cory, K., Kreycik, C., & Williams, E. (2010). *Policymaker's guide to feed-in tariff policy design*. Retrieved from https://doi.org/10.2172/984987

Creamer, T. (2021). Raising the distributed generator licence-exemption cap to 10 MW 'does not go far enough. *Engineering News*. Retrieved from https://www.engineeringnews.co.za/article/raising-distributed-generator-licence-exemption-cap-to-10-mw-does-not-go-far-enough-2021-05-03

Cresswell, W. (2014). Migratory connectivity of Palaearctic–African migratory birds and their responses to environmental change: the serial residency hypothesis. *Ibis, 156*(3), 493-510.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative*: Prentice Hall Upper Saddle River, NJ.

Creswell, J. W., Plano Clark, V., Gutmann, M. L., & Hanson, W. E. (2003a). An expanded typology for classifying mixed methods research into designs. In

*A. Tashakkori y C. Teddlie, Handbook of mixed methods in social and behavioural research* (pp. 209-240).

Creswell, J. W., Plano Clark, V., Gutmann, M. L., & Hanson, W. E. (2003b). An expanded typology for classifying mixed methods research into designs. *A. Tashakkori y C. Teddlie, Handbook of mixed methods in social and behavioural research*, 209-240. Retrieved from https://us.corwin.com/sites/default/files/upm-binaries/19291_Chapter_7.pdf

CSIR. (2010). *Solar Energy Technology Roadmap of South Africa*. https://pdf4pro.com/cdn/solar-energy-technology-roadmap-of-south-africa-18f33a.pdf

Davies, D., & Dodd, J. (2002). Qualitative research and the question of rigour. *Qualitative health research, 12*(2), 279-289. Retrieved from https://doi.org/10.1177%2F104973230201200211

Davies, M. L. (2021). *South Africa's contested transition to energy democracy: lessons and struggles from the Renewable Energy Independent Power Producer Procurement Programme.* Stellenbosch: Stellenbosch University,

Diamantopoulos, A., Schlegelmilch, B. B., Sinkovics, R. R., & Bohlen, G. M. (2003). Can socio-demographics still play a role in profiling green consumers? A review of the evidence and an empirical investigation. *Journal of Business Research, 56*(6), 465-480. Retrieved from https://doi.org/10.1016/S0148-2963(01)00241-7

DME. (1998). *Energy Policy White Paper*. DME REPUBLIC OF SOUTH AFRICA Retrieved from https://www.gov.za/sites/default/files/gcis_document/201409/whitepaperenergypolicy19980.pdf

DMRE. (2003). *White Paper on Renewable Energy*. DMRE REPUBLIC OF SOUTH AFRICA Retrieved from http://www.energy.gov.za/files/policies/whitepaper_renewables_2003.pdf

DMRE. (2019). *Integrated Resource Plan*. Retrieved from http://www.energy.gov.za/IRP/2019/IRP-2019.pdf

DMRE. (2021). *Mineral Resources and Energy on amended schedule 2 of Electricity Regulation Act 4 of 2006*. Retrieved from http://www.energy.gov.za/files/policies/Gazette44989-Amendment-of-Notice-Licensing-Exemption-and-Registration-Notice.pdf

DoE. (2006). *Electricity Regulation Act 4 of 2006*. Retrieved from https://www.gov.za/documents/electricity-regulation-act

DoE. (2010). *Integrated Resource Plan for Electricity*. Retrieved from http://www.energy.gov.za/IRP/irp%20files/INTEGRATED_RESOURCE_PLAN_ELECTRICITY_2010_v8.pdf

DoE. (2015). *State of Renewable Energy Renewable Energy*. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201510/state-renewable-energy-south-africas.pdf

DoE. (2018). *Draft Integrated Resource Plan*. ECR Newswatch Pretoria Retrieved from http://www.energy.gov.za/IRP/irp-update-draft-report2018/IRP-Update-2018-Draft-for-Comments.pdf

DoE. (2019). *Integrated Resource Plan*. ECR Newswatch Pretoria Retrieved from http://www.energy.gov.za/IRP/2019/IRP-2019.pdf

DPE. (2019). *Roadmap for Eskom in a Reformed Electricity Supply Industry*. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201910/roadmap-eskom.pdf

du Plooy, N. T., Brent, A. C., & de Kock, I. H. (2017). Fostering sustainable energy transitions for South Africa's electricity sector: A set of criteria. *2017 IEEE Technology & Engineering Management Conference (TEMSCON)*, 131-136. Retrieved from https://doi.org/10.1109/TEMSCON.2017.7998366

Edwards, M. R., Holloway, T., Pierce, R. B., Blank, L., Broddle, M., Choi, E., . . . Fritz, M. (2022). Satellite Data Applications for Sustainable Energy Transitions. *Frontiers in Sustainability, 3*, 910924.

Engineering News. (2021). Opinion: New issues with amended amended Schedule 2 of the Electricity Regulation Act for private power generation. *Engineering News*. Retrieved from https://www.engineeringnews.co.za/article/opinion-new-issues-with-amended-amended-schedule-2-of-the-electricity-regulation-act-for-private-power-generation-2021-08-24

Eskom. (2020). *Integrated report 31. March 26–27 (2020). Tariff history*. Retrieved from https://www.eskom.co.za/CustomerCare/TariffsAndCharges/Pages/Tariff_History.aspx

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics, 5*(1), 1-4. Retrieved from https://doi.org/10.11648/j.ajtas.20160501.11

Fagbadebo, O. M., Makiva, M., & Ile, I. (2019). Evaluating transformation progress of historically disadvantaged South Africans: Programme perspective on the downstream petroleum industry. *African Evaluation Journal, 7*(1), 1-12. Retrieved from https://doi.org/10.4102/aej.v7i1.373

Faiers, A., Cook, M., & Neame, C. (2007). Towards a contemporary approach for understanding consumer behaviour in the context of domestic energy use. *Energy Policy, 35*(8), 4381-4390. Retrieved from https://doi.org/10.1016/j.enpol.2007.01.003

Faiers, A., & Neame, C. (2006). Consumer attitudes towards domestic solar power systems. *Energy Policy, 34*(14), 1797-1806. Retrieved from https://doi.org/10.1016/j.enpol.2005.01.001

Fig, D. (2017). Court ruling on Zuma's nuclear deal is a marker of South Africa's political health. *The Times Live*. Retrieved from https://www.timeslive.co.za/politics/2017-05-01-54court-ruling-on-zumas-nuclear-deal-is-a-marker-of-south-africas-political-health/

Fontana, L. (2020). The Law Reviews - The Renewable Energy Law Review. Retrieved from https://thelawreviews.co.uk/title/the-renewable-energy-law-review/south-africa. https://thelawreviews.co.uk/title/the-renewable-energy-law-review/south-africa

Gazette, R. G. (1977). *Petroleum Products Act, 1977 (testimony of RSA)*. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201504/act-120-1977.pdf

Gazette, R. G. (2008). *No. 34 of 2008: National Energy Act, 2008.,*. Retrieved from https://www.gov.za/documents/national-energy-act

Gazette, R. G. (2009). *National Environmental Management: Air Quality Act: National ambient air quality standards*. Retrieved from https://www.environment.gov.za/sites/default/files/legislations/nemaqa_airquality_g32816gon1210_0.pdf

GBA. (2021). Retrieved from https://www.greenbuildingafrica.co.za/south-africa-jacobs-chosen-for-r20-billion-life-extension-programme-at-koeberg-nuclear-plant/. from Green Building Africa https://www.greenbuildingafrica.co.za/south-africa-jacobs-chosen-for-r20-billion-life-extension-programme-at-koeberg-nuclear-plant/

Geh, N., Emuze, F., & Das, D. K. (2023). Solar photovoltaic deployment acceleration model to advance the sustainability of buildings in public universities in South Africa. *Energy and Buildings, 284*, 112855.

Greencape. (2021). *Energy Services 2021 Market Intelligence Report*. Retrieved from https://www.green-cape.co.za/assets/Energy_Services_MIR_2021_31_3_21.pdf

Greenpeace. (2019). Eskom: A roadmap to powering the future. Retrieved from https://www.greenpeace.org/static/planet4-africa-stateless/2019/06/c0fb02b8-eskom-a-road-to-powering-the-future.pdf

Guzik, P., & Więckowska, B. (2023). Data distribution analysis–a preliminary approach to quantitative data in biomedical research. *Journal of Medical Science, 92*(2), e869-e869.

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., Ray, S., . . . Sarstedt, M. (2021). Evaluation of reflective measurement models. *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook*, 75-90.

IEA. (2019). *Africa Energy Outlook 2019*. Retrieved from https://webstore.iea.org/africa-energy-outlook-2019

IEA. (2020). *World Energy Outlook 2020*. Retrieved from https://www.iea.org/reports/world-energy-outlook-2020

Igogo, T., Awuah-Offei, K., Newman, A., Lowder, T., & Engel-Cox, J. (2021). Integrating renewable energy into mining operations: Opportunities, challenges, and enabling approaches. *Applied Energy, 300*, 117375.

Irena. (2019). *Future of solar photovoltaic: deployment, investment, technology, grid integration and socio-economic aspects*. Retrieved from https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Nov/IRENA_Future_of_Solar_PV_2019.pdf

Irena. (2020). *Renewable power generation costs in 2019*. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf

Jain, S., & Jain, P. (2017). The rise of renewable energy implementation in South Africa. *Energy Procedia, 143*, 721-726. Retrieved from https://doi.org/10.1016/j.egypro.2017.12.752

Joubert, E., Hess, S., & Van Niekerk, J. (2016). Large-scale solar water heating in South Africa: Status, barriers and recommendations. *Renewable energy, 97*, 809-822. Retrieved from https://doi.org/10.1016/j.renene.2016.06.029

Juszczyk, O., Juszczyk, J., Juszczyk, S., & Takala, J. (2022). Barriers for renewable energy technologies diffusion: Empirical Evidence from Finland and Poland. *Energies, 15*(2), 527.

Kanhukamwe, F. N. (2019). *Matching renewable energy to the South African electricity system.* Stellenbosch: Stellenbosch University,

Khumalo, M., Fontana, L., & Dladla, Y. (2021). *The Renewable Energy Law Review: South Africa*. Retrieved from https://thelawreviews.co.uk/title/the-renewable-energy-law-review/south-africa

Kim, J., Lee, S., & Lee, C. (2019). Global supply chain dynamics and stability: An empirical study of the solar photovoltaic industry. Energy Policy, 132, 147-158

Krupa, J., & Burch, S. (2011). A new energy future for South Africa: The political ecology of South African renewable energy. *Energy Policy, 39*(10), 6254-6261. Retrieved from https://doi.org/10.1016/j.enpol.2011.07.024

Kumba, H., Akpan, J., Twite, B., & Olanrewaju, O. (2023). Renewable energy adoption and integration in South Africa: an overview.

Kvam, P., Vidakovic, B., & Kim, S.-j. (2022). *Nonparametric statistics with applications to science and engineering with R* (Vol. 1): John Wiley & Sons.

Lawrence, A., & Ballard. (2020). *South Africa's Energy Transition*: Springer.

Leavy, P. (2022). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*: Guilford Publications.

Leedy, P., & Ormrod, J. (2019). Practical research: Planning and design (Twelth ed.). In: Pearson.

Leedy, P., & Ormrod, J. E. (2005). *Practical research* (Vol. 108): Pearson Custom Saddle River, NJ.

Leedy, P., Ormrod, J. E., & Johnson, L. R. (2020). *Practical Research: Planning and Design, Global Edition*: Pearson Higher Education & Professional Group.

Louie, H. (2018). *Off-grid electrical systems in developing countries*: Springer.

Mah, D. N.-y., Wang, G., Lo, K., Leung, M. K., Hills, P., & Lo, A. Y. (2018). Barriers and policy enablers for solar photovoltaics (PV) in cities: Perspectives of potential adopters in Hong Kong. *Renewable and Sustainable Energy Reviews, 92*, 921-936. Retrieved from https://doi.org/10.1016/j.rser.2018.04.041

Maleki, A., Rosen, M. A., & Pourfayaz, F. (2017). Optimal operation of a grid-connected hybrid renewable energy system for residential applications. Energy and Buildings, 149, 467-479

Mendonça, M. (2012). *Feed-in tariffs: accelerating the deployment of renewable energy*: Routledge.

Moksnes, N., Korkovelos, A., Mentis, D., & Howells, M. (2017). Electrification pathways for Kenya–linking spatial electrification analysis and medium to long-term energy planning. Environmental Research Letters, 12(9), 095008

Moolman, S. (2017). Infographic: Eskom tariff increases vs inflation since 1988 (with projections to 2017). *Power Optimal, 20*. Retrieved from https://www.poweroptimal.com/infographic-eskom-tariff-increases-vs-inflation-since-1988-projections-2017/

Moorthy, K., Patwa, N., & Gupta, Y. (2019). Breaking barriers in deployment of renewable energy. *Heliyon, 5*(1), e01166. Retrieved from https://www.green-cape.co.za/assets/Energy_Services_MIR_2021_31_3_21.pdf

Morar, G. S. C. (2017). *Broadening the discourse on small-scale generation: an investigation into public opinion of embedded rooftop photovoltaic systems in Stellenbosch.* Stellenbosch: Stellenbosch University,

Mulaudzi, S. K., Bull, S., & Makhado, R. A. (2022). Potential of households' solar PV consumption in South Africa. *African Journal of Science, Technology, Innovation and Development, 14*(3), 730-739.

Mundaca, L., & Samahita, M. (2020). What drives home solar PV uptake? Subsidies, peer effects and visibility in Sweden. *Energy Research & Social Science, 60*, 101319.

Murombo, T. (2016). Legal and policy barriers to renewable and sustainable energy sources in South Africa. *The Journal of World Energy Law & Business, 9*(2), 142-165. Retrieved from https://doi.org/10.1093/jwelb/jww001

Musango, J. K., Amigun, B., & Brent, A. C. (2011). Sustainable electricity generation technologies in South Africa: Initiatives, challenges and policy implications. *Energy and Environment Research, 1*(1), 124. Retrieved from https://www.ccsenet.org/journal/index.php/eer/article/view/13977

Naicker, P., & Thopil, G. A. (2019). A framework for sustainable utility scale renewable energy selection in South Africa. *Journal of Cleaner Production, 224*, 637-650. Retrieved from https://doi.org/10.1016/j.jclepro.2019.03.257

National Planning Commission. (2013). National Development Plan Vision 2030. Retrieved from http://policyresearch.limpopo.gov.za/bitstream/handle/123456789/941/NDP%20Vision%202030.pdf?s

National Treasury Annual Report 2022/2023: South Africa's financial management, tax policies, public finance, and economic performance for the fiscal year.

Ndanga, G. T., & Gorn, M. (2012). *Requirements for the feasibility of PV net metering in South Africa.* Paper presented at the CIE42 Proceedings Cape Town, South Africa.

Ndlovu, V., & Inglesi-Lotz, R. (2020). The causal relationship between energy and economic growth through research and development (R&D): The case of BRICS and lessons for South Africa. *Energy, 199*, 117428.

Nel, D. (2015). Risks and barriers in renewable energy development in South Africa through independent power production. Retrieved from http://hdl.handle.net/2263/58148

NERSA. (2021). *Media Statement: Amendment to schedule two of the Electricity Regulation Act*. https://www.nersa.org.za/wp-content/uploads/2021/06/Media-Statement-Amendment-to-Schedule-2-of-the-Electricity-Regulation-Act.pdf

Ntsoane, M. (2017). *Rooftop solar PV potential assessment in the city of Johannesburg.* Stellenbosch: Stellenbosch University,

Ntumba, S. (2022). The Scaling up of Renewable Energy Consumption in South Africa; Challenges and Opportunities. *PQDT-Global*.

Obeng, G. Y., & Evers, H.-D. (2009). Solar PV rural electrification and energy poverty: a review and conceptual framework with reference to Ghana. Retrieved from http://nbn-resolving.de/urn:nbn:de:101:1-20090316233

Okharedia, A. A. (2019). A conceptual framework in promoting knowledge management in electricity industry in South Africa: The case of ESKOM. *Journal of Business and Retail Management Research, 13*(3). Retrieved from https://jbrmr.com/cdn/article_file/2019-04-01-12-22-20-PM.pdf

Opoku, R., Obeng, G. Y., Adjei, E. A., Davis, F., & Akuffo, F. O. (2020). Integrated system efficiency in reducing redundancy and promoting residential renewable energy in countries without net-metering: A case study of a SHS in Ghana. *Renewable energy, 155*, 65-78. Retrieved from https://doi.org/10.1016/j.renene.2020.03.099

Oryani, B., Koo, Y., Rezania, S., & Shafiee, A. (2021). Barriers to renewable energy technologies penetration: Perspective in Iran. *Renewable Energy, 174*, 971-983.

Oyewo, A. S., Aghahosseini, A., Ram, M., Lohrmann, A., & Breyer, C. (2019). Pathway towards achieving 100% renewable electricity by 2050 for South Africa. *Solar Energy, 191*, 549-565. Retrieved from https://doi.org/10.1016/j.solener.2019.09.039

Pandarum, A., Lekoloane, G. A., & Milazi, D. B. (2019). Trends and statistics of Solar PV distributed generation in South Africa. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/11033

Parker, V. D. (2016). *Barriers to energy-efficiency implementation: a study of the uptake of energy-efficiency initiatives offered through incentive schemes in South Africa.* University of Cape Town,

Pegels, A. (2010). Renewable energy in South Africa: Potentials, barriers and options for support. *Energy policy, 38*(9), 4945-4954. Retrieved from https://doi.org/10.1016/j.enpol.2010.03.077

Reindl, K., & Palm, J. (2021). Installing PV: Barriers and enablers experienced by non-residential property owners. *Renewable and Sustainable Energy Reviews, 141*, 110829.

Rogers, E. M. (2004). A prospective and retrospective look at the diffusion model. *Journal of Health Communication, 9*(S1), 13-19. Retrieved from https://doi.org/10.1080/10810730490271449

SALGA. (2020). *Status of Small Scale Embedded Generation*. Retrieved from https://www.sseg.org.za/wp-content/uploads/2018/10/SALGA-Status-of-SSEG_2020.pdf

SAPVIA. (2020a). How a minor legislative change could save South Africa from load shedding. Retrieved from https://www.sapvia.co.za/how-a-minor-legislative-change-could-save-south-africa-from-load-shedding/. https://www.sapvia.co.za/how-a-minor-legislative-change-could-save-south-africa-from-load-shedding/

SAPVIA. (2020b). How a minor legislative change could save South Africa from load shedding. Retrieved from https://www.sapvia.co.za/how-a-minor-legislative-change-could-save-south-africa-from-load-shedding/

SAPVIA. (2021). South Africa: SAPVIA reacts to gazetting of ERA Schedule 2 Amendments. Retrieved from https://www.esi-africa.com/industry-sectors/generation/south-africa-sapvia-reacts-to-gazetting-of-era-schedule-2-amendments/. https://www.esi-africa.com/industry-sectors/generation/south-africa-sapvia-reacts-to-gazetting-of-era-schedule-2-amendments/

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). *QualitativeMarket Research: An International Journal*.

SAWS. (2020). Annual State of the Climate of South Africa. Retrieved from https://www.weathersa.co.za/Documents/Corporate/Annual%20State%20of%20the%20Climate%202020_19032021121122.pdf. from South African Weather Service https://www.weathersa.co.za/Documents/Corporate/Annual%20State%20of%20the%20Climate%202020_19032021121122.pdf

Sherry, L., & Gibson, D. (2002). The path to teacher leadership in educational technology. *Contemporary issues in technology and teacher education, 2*(2), 178-203. Retrieved from https://citejournal.org/volume-2/issue-2-02/general/the-path-to-teacher-leadership-in-educational-technology/

Skiera, B., Reiner, J., & Albers, S. (2021). Regression Analysis. In *Handbook of Market Research* (pp. 299-327): Springer.

Sovacool, B. K., & Drupady, I. M. (2011). Examining the Small Renewable Energy Power (SREP) program in Malaysia. Energy Policy, 39(11), 7244-7256

Squier, L., & Venter, K. (2019). *Legal Issues related to solar panels/geysers in sectional title schemes*. Retrieved from https://www.schindlers.co.za/2019/legal-issues-related-to-solar-panels-geysers-in-sectional-title-schemes/?pdf=9487

STATS SA. (2021). Energy Statistics OF South Africa. Retrieved from http://www.statssa.gov.za/?cat=38

Sterl, S. (2021). A Grid for all Seasons: Enhancing the Integration of Variable Solar and Wind Power in Electricity Systems Across Africa. *Current Sustainable/Renewable Energy Reports, 8*(4), 274-281.

Suberu, M. Y., Mustafa, M. W., Bashir, N., Muhamad, N. A., & Mokhtar, A. S. (2013). Power sector renewable energy integration for expanding access to electricity in sub-Saharan Africa. *Renewable and Sustainable Energy Reviews, 25*, 630-642.

Tanveer, A., Zeng, S., Irfan, M., & Peng, R. (2021). Do perceived risk, perception of self-efficacy, and openness to technology matter for solar PV adoption? An application of the extended theory of planned behaviour. *Energies, 14*(16), 5008.

Thenga, S. T. (2020). *A responsive business model for municipal power utilities in a changing electricity market for South Africa: A case study of the City of Ekurhuleni.* University of the Witwatersrand,

Todd, I., & McCauley, D. (2021). Assessing policy barriers to the energy transition in South Africa. *Energy Policy, 158*, 112529.

Tyurina, Y., Frumina, S., Demidova, S., Kairbekuly, A., & Kakaulina, M. (2023). Estimation of Tax Expenditures Stimulating the Energy Sector Development and the Use of Alternative Energy Sources in OECD Countries. *Energies, 16*(6), 2652.

Van Manen, M. (1990). Beyond assumptions: Shifting the limits of action research. *Theory into practice, 29*(3), 152-157. Retrieved from https://doi.org/10.1080/00405849009543448

Walliman, N. (2021). *Research methods: The basics*: Routledge.

Walters, J. P., Kaminsky, J., & Huepe, C. (2018). Factors influencing household solar adoption in Santiago, Chile. *Journal of Construction Engineering and Management, 144*(6), 05018004.

Wani, R. (2015). Population and Sample. Retrieved from http://ddeku.edu.in/Files/2cfa4584-5afe-43ce-aa4b-ad936cc9d3be/Custom/Sampling.pdf

Wilkinson, S., John, M., & Morrison, G. M. (2021). Rooftop PV and the renewable energy transition; a review of driving forces and analytical frameworks. *Sustainability, 13*(10), 5613.

Williams, C. L., Rittman, M. R., Boylstein, C., Faircloth, C., & Haijing, Q. (2005). Qualitative and quantitative measurement of depression in veterans recovering from stroke. *Journal of rehabilitation research & development, 42*(3). Retrieved from https://doi.org/10.1682/jrrd.2004.02.0017

Winkler, H. (2005). Renewable energy policy in South Africa: policy options for renewable electricity. *Energy Policy, 33*(1), 27-38. Retrieved from https://doi.org/10.1016/S0301-4215(03)00195-2

Winkler, H. (2017). Energy policies for sustainable development in South Africa. Energy for Sustainable Development, 11(1), 26-34

World Bank. (2018). Access to Energy is at the Heart of Development. Retrieved from https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7

Wright, J., Calitz, J., & Bischof-Niemz, T. (2017). Formal comments on the Integrated Resource Plan (IRP) 2016 update assumptions, base case and observations. CSIR Energy Centre.

Wu, G. C., Deshmukh, R., Ndhlukula, K., Radojicic, T., Reilly-Moman, J., Phadke, A., . . . Callaway, D. S. (2017). Strategic siting and regional grid interconnections key to low-carbon futures in African countries. *Proceedings of the National Academy of Sciences, 114*(15), E3004-E3012. Retrieved from https://doi.org/10.1073/pnas.1611845114

WWF. (2017). *Energy Facts and Futures*. Retrieved from https://lifeaftercoal.org.za/wp-content/uploads/2017/08/WWF_Energy-Facts-and-Futures_Final-Version.pdf

Yergin, D. (2011). The Quest: Energy, Security, and the Remaking of the Modern World. Penguin Press

Zander, K. K. (2021). Adoption behaviour and the optimal feed-in-tariff for residential solar energy production in Darwin (Australia). *Journal of cleaner production, 299*, 126879.

Zeng, G., & Zeng, E. (2021). On the relationship between multicollinearity and separation in logistic regression. *Communications in Statistics-Simulation and Computation, 50*(7), 1989-1997.

Zhang, X., Shen, L., & Chan, S. Y. (2012). The diffusion of solar energy use in HK: what are the barriers? *Energy Policy, 41*, 241-249. Retrieved from https://doi.org/10.1016/j.enpol.2011.10.043

Zikmund, W., Babin, B., Carr, J., & Griffen, M. (2003). Basic data analysis: Descriptive statistics. *Health Economics Research Method, 2*. Retrieved from http://pioneer.chula.ac.th/~ppongsa/2900600/LMRM02.pdf

## APPENDIX A: Participant Information Sheet

Dear Respondent

My name is Pride Takudzwa Munemo, and I am a student at the University of Witwatersrand Business School. I am a researcher and would like to request your participation in the study as one of the respondents. The study aims to investigate existing policy impediments and enablers for rooftop solar projects and make recommendations that may assist academics, energy practitioners, and regulators to focus their future efforts on the development of such projects and recommend measures that can be taken to create an enabling environment. To conduct this research, it is necessary to acquire data, analyse it and draw conclusions that can be used to improve the performance of learners and educators.

Please note the following:

- This study involves a survey that will take approximately 15-20 minutes of your time.
- Please be assured that your answers will be treated with the utmost confidentiality.
- Your identity cannot be exposed based on the answers you give. The identities of the respondents will not be published or released to anyone.
- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.

- The results of the study will be used for academic purposes only and may be published in an academic journal. On request, we will provide you with a summary of our findings.

If you have any questions regarding the study, please contact me or my supervisor using the below details.

If you would like a summary of the findings, I will gladly let you have it; however, I will need some contact information for that if you are comfortable to provide it.

Many thanks for considering my request for your valuable input.

Yours sincerely,

Taku Munemo

Email: Pride.munemo1@students.wits.ac.za

Phone: 072 451 0717

Supervisor name: Lwazi Ngubevan

Email: lwazi.ngubevana@wits.ac.za

Phone number: 081 785 0492

## APPENDIX B: Participant Agreement Form

Informed consent form

(Form for research respondent permission)

(Must be signed by each research respondent, and must be kept on record by the researcher)

1. Title of the research project*:* **POLICY ENABLERS AND PERCEIVED IMPEDIMENTS FOR ROOFTOP SOLAR PV PROJECTS IN GAUTENG SOUTH AFRICA**

2. I …………………………………………… hereby voluntarily grant my permission for participation in the project as explained to me by ……………………………………………………………………………..
3. The nature, objective, possible safety, and health implications have been explained to me and I understand them.
4. I understand my right to choose whether to participate in the project and that the Information furnished will be handled confidentially.
5. I am aware that the results of the investigation may be used for the purposes of publication.
6. Upon signature of this form, you will be provided with a copy.

Signed: _________________________ Date: _______________

Witness: _________________________ Date: _______________

Researcher:_________________________ Date:_____________

## SECTION A: BACKGROUND INFORMATION OF PARTICIPANTS

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Indicate your functional department | **Finance** | **Supply Chain** | **Project Manage ment** | **Engineeri ng** | **Other** |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | **Executive Management** | **Snr Manageme nt** | **Manage ment** | **Advisor** | **Other** |
| 2 | Indicate your position at work | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | | | | | |
| 3 | How long have you been working with rooftop solar PV technologies? | **Less than 2 years** | **2- 5 years** | **6-10 years** | **+10 years** | |
| | | ☐ | ☐ | ☐ | ☐ | |
| 4 | Indicate the number of people employed in your company | **Less than 10 people** | **10 to 20 people** | **21 to 30** | **More than 30 people** | |
| | | ☐ | ☐ | ☐ | ☐ | ☐ |

**SECTION B: Policy enablers for PV solar projects**

The following statements are based on a 5 point Likert scale. You are requested to provide an opinion on the extent of policy enablers on rooftop solar PV business based on your observation and experiences

| # | Section B: Policy enablers | Very slightly | Slightly | Medium | High | Very High |
|---|---|---|---|---|---|---|
| 1 | Rooftop solar PV uptake is being motivated by the South African government's various policies to nurture and grow a good environment for solar projects to flourish | | | | | |
| 2 | Rooftop solar PV uptake is being driven by government policies in place that promote the penetration of renewable-based electricity such as rooftop solar energy on a least-cost basis | | | | | |
| 3 | Rooftop solar PV uptake is being inspired by the Integrated Resource Plan (IRP) that encourages a shift to the use of renewable energy sources such as solar energy | | | | | |
| 4 | Rooftop solar PV uptake is being encouraged by the implementation of the policy on load-shedding due to constrained capacity | | | | | |
| 5 | Rooftop solar PV roll is being motivated by the enactment of the SA solar energy technology roadmap (SETRM) that promotes the green industry through local development of solar technologies | | | | | |
| 6 | The willingness of the South African government has helped in the rollout of solar power initiatives such as rooftop solar PV projects that provide households energy solutions | | | | | |
| 7 | The rapid escalation of utility electricity prices is promoting the growth of the Rooftop solar PV business | | | | | |

**SECTION C: Impediments on the roll-out of on rooftop solar PV projects**

The following statements are based on a 5 point Likert scale. You are requested to provide an opinion on impediments affecting the PV solar companies based on your observation and experiences

| # | Section C: Impediments | Very slightly | Slightly | Medium | High | Very High |
|---|---|---|---|---|---|---|
| 1 | High capital cost is a barrier to the uptake of solar technologies such as Rooftop solar PV solutions in South Africa | | | | | |
| 2 | Competition for land use with residential, commercial, and industrial expansion, recreational and scenic interests is a barrier for the roll-out of rooftop solar PV projects in South Africa | | | | | |
| 3 | Blockages by transmission access policies are a hindrance to the roll-out of rooftop solar PV projects in South Africa | | | | | |
| 4 | Blockages to the right of access are hampering the potential for new transmission to unlock Rooftop solar PV potential | | | | | |
| 5 | High wheeling charges for transmission access are a barrier to entry to Rooftop solar PV projects in South Africa | | | | | |
| 6 | Lack of established procedures for dealing with Rooftop solar PV business is a barrier to entry to such establishments in South Africa | | | | | |
| 7 | Rooftop solar PV facilities face restrictions based upon building safety conditions | | | | | |
| | Rooftop solar power is an unfamiliar establishment to urban planning custodians, building inspectors, building councils, and regulators in South Africa. | | | | | |
| | Misinterpretation of solar policies at the municipality level is hindering the rollout of rooftop solar PV solutions in South Africa | | | | | |
| | Limited Rooftop solar PV policies are | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | hindering roll out of solar technologies in South Africa | | | | | |
| | Rooftop solar PV facilities face restrictions based upon building heights, noise pollution in South Africa | | | | | |

**SECTION D: Roll out of rooftop solar PV projects**

The following statements are based on a 5-point Likert scale. You are requested to provide an opinion on the rollout of rooftop solar PV projects based on your observation and experiences

| # | Section D: Roll out of Rooftop Solar PV solutions | Very slightly | Slightly | Medium | High | Very High |
|---|---|---|---|---|---|---|
| 1 | There is an increased rate of rollout for rooftop solar PV solutions in South Africa | | | | | |
| 2 | The South African government has provided an enabling environment for rooftop solar PV projects to flourish | | | | | |
| 3 | The South African government has effective policies that promote rooftop solar PV rollout | | | | | |
| 4 | The South African government gives high priority to renewable energy sources such as rooftop solar PV solutions | | | | | |

**Thank you for your participation**

## APPENDIX C: Language Editing Memorandum

# EDITING CONFIRMATION

To whom it may concern:

This memo serves to confirm that the manuscript/research project detailed below has been language-edited and/or proof-read.

Regards,

*-SM001-*
--------------------
SM/FS *(Cert. Lang. Ed.)*
*Language Editors*

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**Manuscript Title:**

POLICY ENABLERS AND PERCEIVED IMPEDIMENTS FOR ROOFTOP SOLAR PV PROJECTS IN GAUTENG, SOUTH AFRICA

**Author:**

PRIDE T. MUNEMO

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