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Solar installation as a solution to sustained load shedding in Gauteng, South Africa

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Research submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in Energy Leadership

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Supervisor: Prof. Frederick Ahwireng-Obeng

ABSTRACT

Background: Due to the lack of generating capacity and the unreliability of Eskom's power stations, South Africa has been experiencing persistent power cuts, with load shedding introduced to manage electricity demand. This situation has prompted households and businesses to seek alternative power sources. This study explores solar installation in households and small businesses. It investigates the factors impeding the uptake of solar systems, evaluates the feasibility of implementing solar PV systems, and provides recommendations and strategic support to enhance the adoption of solar technology.

Methods: A qualitative approach was employed, involving 18 participants selected through purposive sampling. Data were collected using semi-structured in-depth interviews with individuals residing across various regions of Gauteng. An inductive thematic analysis was utilized to analyse the data.

Findings: The findings indicate that both household and small business owners share similar concerns regarding the factors impeding solar PV installation. These include the high costs associated with purchasing and installing solar hardware, doubts about the reliability of solar power during extended cloudy or rainy periods, and limited knowledge of how solar systems function. Regarding the feasibility of solar PV systems, many participants noted that the high costs of hardware and installation render this option impractical. They believe this would only become viable if the government provided financial incentives to lower these costs. Small business owners also unanimously agreed that installing a PV system would only be practical with financial support. These findings lead to recommendations for strategic support to increase solar adoption among small businesses and households, highlighting three key conditions. These are government incentives, education on solar PV systems, and the promotion of grid-tied solar PV systems.

Conclusion: The study highlights key barriers to solar PV adoption among households and small businesses, including high costs, concerns over reliability during low sunlight

periods, and limited knowledge about solar systems. Both household and small business owners agreed that solar PV systems would only be feasible with government incentives to reduce costs. The findings suggest that solar adoption can be advanced through policy interventions focused on providing financial support. The public must be educated about solar technology and grid-tied systems as a practical solution. Such measures would make solar energy more accessible, supporting broader energy security and sustainability goals.

Keywords: consumers, domestic, adoption, loadshedding, renewable energy, Solar Photovoltaic (PV)

DECLARATION

I, Cornilius Makuwerere, declare that this research report is my own work, except as indicated in the references and acknowledgments. 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: Cornilius Makuwerere Signature : 

Signed at Kempton Park

On the 17th day of November 2025

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LIST OF ACRONYMS

CSP	Concentrated Solar Power
DoE	Department of Energy
DRDG	Deployment of renewable distributed generation
GDP	Gross Domestic Product
IEA	International Energy Agency
IPP	Independent Power Producers
IRP	Integrated Resource Plan
LCOE	The Levelized Cost of Electricity
NGOs	Non-Governmental Organisations
PV	Photovoltaic
QLFS	Quarterly Labour Force Survey
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
SA	South Africa
SADC	Southern African Development Community
SAPVIA	South African Photovoltaic Industry Association
SDGs	Sustainable Development Goals
SHS	Solar Heating Systems
TA	Thematic Analysis
UAF	Unit Availability Factor
UN	United Nations

CHAPTER 1: INTRODUCTION

1.1 Context of the study

South Africa has faced a severe energy crisis for over a decade, primarily due to insufficient capacity of Eskom, the national power utility, to meet growing electricity demand (Inglesi-Lotz, 2023). This has resulted in regular load shedding, a practice where electricity supply is intentionally interrupted to stabilize the national grid (Booysen et al., 2023; Erero, 2023). Such frequent disruptions to the power supply are a source of significant frustration for South African households and businesses. Whether these outages are recurrent or extended, they negatively impact the economic well-being of both households and enterprises by reducing the efficiency of existing electrical equipment and discouraging new investments (Inglesi-Lotz, 2023). Erero (2023) estimates that load shedding will reduce economic growth by 2.3%, surpassing the South African Reserve Bank's (SARB) prediction of 0.6%.

Load shedding has had significant economic and social consequences, disrupting daily life, hindering business operations, and affecting the country's overall development (Booysen et al., 2023; Erero, 2023). It has also impacted well-being, compromising both the quality of care and the functionality of health services (Gehringer et al., 2018). Moreover, the effects of power cuts are unevenly distributed across regions and population groups, potentially exacerbating the already historically high levels of income inequality in South Africa (Inglesi-Lotz, 2023). Power outages have also caused significant sales losses across various sectors, including retail, services, manufacturing, and industry (Erero, 2023; Inglesi-Lotz, 2023). Households and small businesses without alternative energy sources are most affected by load shedding, making solar PV adoption a potential solution for them (Calitz & Wright, 2021).

During load-shedding, many businesses are forced to close because their power demands are too high to rely on expensive petrol or diesel generators (Mbomvu et al., 2021). This has resulted in many small and medium-sized enterprises

facing severe difficulties, leading to closures and the loss of thousands of jobs (Inglesi-Lotz, 2023). Small, Medium, and Micro Enterprises (SMMEs) in South Africa represent approximately 97% of businesses, account for nearly 60% of employment, and contribute around 45% to the country's Gross Domestic Product (GDP) (Mbomvu et al., 2021). More reliable energy is therefore required to reduce operating costs and enhance productivity and profitability in businesses (Inglesi-Lotz, 2023).

A solution to this dilemma can be the adoption of solar photovoltaic (PV) systems which convert sunlight into electricity, and which can be installed at both residential and commercial levels. Solar PV technology has the potential to alleviate pressure on the national grid by providing decentralized, renewable energy. However, despite its potential, the uptake of solar PV systems in South Africa has been limited (Ayamolowo et al., 2022; Calitz & Wright, 2021). The large-scale adoption of solar home systems is hindered by several financial and regulatory barriers (Lemaire, 2011). For instance, high upfront costs required to install the solar PV system is the major factor (Chidembo et al., 2022a, 2022b; Conway et al., 2019; Lemaire, 2011).

The ongoing maintenance expenses, especially for solar batteries, present significant financial challenges (Lemaire, 2011). Studies have shown that unsubsidized solar systems are less likely to be adopted among marginalized communities due to their high costs (Chidembo et al., 2022a; Conway et al., 2019). In rural areas, inconsistent income and lack of collateral make it difficult for households to secure loans for solar PV purchases (Lemaire, 2011; Mutumbi et al., 2024). Even high-income households perceive solar PV as an expensive investment with slow returns, further discouraging adoption (Hendricks, 2016). Additionally, the lack of sufficient government-initiated solar subsidy programs intensifies these challenges (Chang et al., 2011; Tang et al., 2022).

Overall, the consensus is that without government intervention and financial support, solar PV adoption will remain limited, especially among low-income and marginalized groups (Mutumbi et al., 2024). These authors also found that personal barriers to solar PV adoption in South African households included lack

of knowledge and personal satisfaction (Mutumbi et al., 2024). Insufficient knowledge and skills for operating and repairing solar PV equipment further contribute to low adoption rates. For example, the failure of a solar energy pilot project in Folovodwe, South Africa was due to households not being trained in operating and maintaining the systems, resulting in disinterest and dissatisfaction (Bikam & Mulaudzi, 2006). Other factors which affect adoption are weak roof structures which may not be able to support the weight of solar panels, leading to potential damage (IEA, 2020). Some electrical distribution systems may struggle to handle the bidirectional flow of power on extended distribution feeder circuits. Thus, even small amounts of PV energy could disrupt system parameters if not properly aligned with the load (Nwaigwe et al., 2019).

The adoption of the solar PV systems will not only solve power cuts in South Africa but will promote a sustainable environment. The bulk of the energy needs of the country are derived from burning coal at Eskom's electricity-generating power plants. South Africa relies on fossil fuels for its energy needs, with approximately 95.6% sourced from low-grade coal (Cowling, 2023). This heavy dependence on fossil fuels results in around 42% of the country’s carbon emissions, which can adversely impact the environment (Eskom, 2023). The IEA (2020) moreover states that residential sectors contribute 22% of gas emissions worldwide. In South Africa, the residential sector not only consumes a significant amount of energy but is also the largest contributor to carbon emissions. This highlights the urgent need for transitioning to solar PV systems to reduce carbon emissions. Therefore, encouraging cleaner energy sources such as solar PV to reduce energy demand and dependence on the grid for residents can significantly reduce emissions. Transitioning to solar PV is also essential for South Africa to achieve its international climate change goals of limiting global warming to 1.5°C (International Energy Agency (IEA), 2019). This will help in fulfilling SDG 7.

Several studies have explored the adoption of solar PV systems in South Africa, emphasizing their potential to mitigate the country's chronic energy shortages. Research has documented the technical feasibility and environmental benefits of solar energy in South Africa, a country endowed with high solar irradiance levels

(Ebhota & Tabakov, 2021; Overen & Meyer, 2022). Previous research has examined financial barriers to solar PV adoption, particularly the high initial costs and the need for government subsidies or incentives to make solar energy more accessible to low- and middle-income households (Geh et al., 2022;Chidembo et al., 2022a, 2022b). Studies have also explored the perceptions of rooftop solar PV in rural households in some parts of the country (Chidembo et al., 2022b). Other studies have examined the acceptance and uptake of rooftop PV in Johannesburg and the financial implications of grid-connected rooftop PV at the household level (Hendricks, 2016; Korsten et al., 2017). While these studies have identified factors influencing the adoption of solar PV in various parts of South Africa, there is a notable gap in research specifically addressing the adoption among small business owners in Gauteng. Existing studies have not thoroughly explored the feasibility of implementing PV systems in both households and small businesses. Nor have they adequately investigated the recommendations and strategic support needed to promote solar PV adoption from key stakeholders, including Eskom employees, government officials, installers, and policymakers. Although the need for government intervention is acknowledged, there is a lack of comprehensive exploration into the strategic support that could be used to foster widespread solar PV adoption.

1.2 Purpose of the study

The purpose of the study was to explore solar installation in households and small businesses in Gauteng province in South Africa as a solution to sustained load shedding. To do this a qualitative approach was used to investigate the factors impeding the uptake of PV solar systems and to assess the feasibility of implementing them in households and small businesses as a backup to load shedding. The study also identified the recommendations and strategic support that can be provided to households and small businesses to promote the adoption of solar PV systems. The study contributes to the growing body of literature on renewable energy adoption, particularly in the context of South Africa. By focusing on solar PV adoption in households and small businesses, it provides localized insights that can inform broader discussions on the challenges faced. In addition, by assessing the feasibility of solar PV systems, the study provides views of small business and household owners on the practicality of

installing solar PV systems made possible when financial assistance and incentives are provided.

1.3 Research problem/motivation

South Africa is currently facing power outages which have seen the introduction of load shedding as a measure to mitigate the impact of power shortages and to prevent total grid failures due to an unreliable power supply system. Eskom is currently unable to generate enough electricity for the country's needs due to ageing power plants, shortage of skills and lack of plant maintenance. This has resulted in frequent and very long hours of load shedding in the country and has seen the adoption of solar PV systems by households and companies (Nogaya et al., 2022). Despite the growing interest in renewable energy as a solution to South Africa's persistent electricity shortages and load shedding, the adoption of solar photovoltaic (PV) systems remains low in households and small businesses across Gauteng.

Various barriers, including high upfront costs, limited awareness, and concerns about the feasibility and reliability of solar systems, continue to impede widespread uptake. The South African government has implemented several initiatives to address its energy challenges, particularly through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). This program aims to increase energy capacity by encouraging private sector investment in solar PV. Under the REIPPPP, South Africa plans to install approximately 8,400 MW of solar PV capacity by 2030, benefiting about 1.5 million households (International Energy Agency, 2022). The government has also introduced a 10-point power crisis plan, which includes easing licensing requirements for private power generation (International Energy Agency, 2022; International Energy Agency (IEA), 2019). This change enables independent power producers to generate up to 100 MW of renewable energy without the requirement of obtaining a license.

The South African Revenue Service (SARS) offers various tax incentives for both households and businesses, such as the renewable energy allowance, employment allowance, and small business allowance (SARS, 2024). While some incentives are permanent, others, like the popular solar tax credits, were temporary (National Treasury, 2023). The incentives were in place to encourage rapid private investment in electricity generation from renewable energy sources to assist in alleviating the recently experienced energy crisis (National Treasury, 2023).

The motivation for conducting this study stems from the ongoing power crisis, which has seen load shedding being carried out in the country to deal with increasing power cuts. The need is to explore alternative energy solutions that are both sustainable and practical for households and small businesses. Given the potential of solar energy to mitigate power shortages and reduce dependence on grid electricity, understanding the specific challenges faced by households in adopting solar PV systems is crucial. Furthermore, assessing the feasibility of solar PV systems as a solution to load shedding and identifying effective recommendations can provide valuable insights for policymakers, businesses, and the public. This study aims to contribute to the growing discourse on renewable energy adoption in South Africa by addressing these critical problems and offering strategies to enhance the uptake of solar PV systems in Gauteng.

1.4 Research objectives

This research study has the following objectives.

1. To determine factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa.
2. To explore the feasibility of implementing solar PV systems in households and small businesses of Gauteng as a solution to load shedding.
3. To provide recommendations and strategic support that can be provided to households and small businesses.

1.5 Research questions

1. What are the factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa?
2. How feasible is the implementation of solar PV systems in households and small businesses in Gauteng as a solution to load shedding?

What recommendations and strategic support can be provided to households and small businesses to promote the adoption of solar PV systems?

1.6 Significance of the study

The study is important in that it provides insights into the adoption of solar PV systems in households in Gauteng, South Africa. By identifying the factors hindering the uptake of solar systems, the research could inform policymakers, businesses, and other stakeholders about the barriers preventing the adoption of solar PV systems in households and small businesses. Assessing the feasibility of implementing solar PV systems as a solution to load shedding is important, as it could offer alternative strategies for energy resilience in the face of ongoing electricity challenges. The study's recommendations and strategic support could guide government interventions, financial programs, and educational initiatives that promote the widespread adoption of solar PV systems. It could further contribute to sustainable energy solutions in South Africa, reduce the burden of load shedding on households, and advance the country's transition toward cleaner energy sources. This will help attain SDG 7 on affordable and clean energy.

Furthermore, this research contributes to the power industry by suggesting viable alternative ways to reduce demand from the grid, which results in load shedding. It also benefits society by highlighting ways to support industries and create more jobs by eliminating power shortages. The South African government could use these findings to balance the socio-economic needs of the population while simultaneously supporting Eskom's projects and ensuring a more stable energy supply. Finally, the study will contribute to the broader body of knowledge by identifying cost-effective approaches for implementing solar projects in South Africa across different income levels, thereby enhancing overall electricity supply.

1.7 Delimitations of the study

The delimitations of this study define its boundaries and scope. The research focuses on the adoption of solar PV systems within households and small businesses specifically in Gauteng province, thus limiting it to one of the country's nine provinces. This intentional restriction, as noted by Theofanidis and Fountouki (2018), confines the results to the unique socio-economic and infrastructural conditions of Gauteng. The study considered the perspectives of households, small businesses, policymakers, government officials, and other relevant stakeholders in Gauteng. While the insights gained may have relevance for other regions, they are not intended to be generalized beyond Gauteng. Moreover, the research did not address the technical aspects of solar PV system design or extensively cover other forms of renewable energy beyond solar PV. Instead, it concentrated on factors influencing the adoption of solar PV systems. The use of purposive sampling, which targets participants with specific knowledge of solar installations, may have introduced bias by excluding individuals who, while not knowledgeable about solar systems, could still provide valuable experiences.

1.8 Definition of terms

Electrical grid: The electrical power system interconnects energy providers to the consumers or load (Kumar et al., 2018).

Fossil Fuels: Fuels made from dead plants embedded in the earth's crust for millions of years (Gerasimchuk et al., 2019).

Load shedding: This is a controlled way of rotating the available electricity between all customers (https://www.eskom.co.za/).

Photovoltaic system (PV): A system that converts sunlight into light and usable electricity (Franklin, 2017). It generates electricity through electronic means of converting sunlight at an atomic level of material known as semiconductors (Johnson & Ogunseye, 2017). The system comprises panels, an inverter, and battery storage to ensure that there is always a power source.

1.9 Assumptions

Several assumptions were made for this study:

- It was assumed that the participants interviewed answered questions honestly and did not just answer without applying their minds cognitively.
- The study assumed that the sample of participants selected sufficiently represented the population from which the conclusions were drawn.
- Finally, it is assumed that domestic or home solar installations within Gauteng could effectively prevent load shedding and free energy for an uninterrupted industrial supply.

1.10 Chapter Outline

Chapter 1: Introduction: This chapter begins by stating the purpose of the study and providing an overview of the current situation in South Africa, particularly regarding power cuts, load shedding, and the adoption of solar PV systems. It then outlines the research problem, offering a justification for conducting the research. The chapter also presents the research objectives and questions and concludes by discussing the significance of the study.

Chapter 2: Literature Review: This chapter addresses the theoretical concepts of the study. It is divided into sections to cover the types of power generation methods, case studies on solar PV installations. It reviews the state of power generation in South Africa and proposes possible answers to the three research questions that were stated in section 1.5. It considers strategies other countries implemented to address the electricity challenges through rooftop solar PV projects.

Chapter 3: Research Approach, Design and Methodology: This chapter details the qualitative approach employed to achieve the study's objectives. It explains the research design and identifies the population, which includes household owners, small business owners, and key stakeholders such as Eskom employees, policymakers, installers, and government officials. The chapter describes the purposive sampling strategy used to select participants and outlines the data collection methods and instruments. The use of thematic data

analysis is also discussed. The chapter concludes by addressing the study's limitations and outlining the ethical considerations applied throughout the research.

Chapter 4: Results and Analysis: This chapter presents the findings of the study, beginning with an overview of how rooftop solar PV systems serve as an effective backup solution for power cuts and load shedding. It addresses the study's objectives. The findings regarding the obstacles to the uptake of solar systems in households and small businesses reveal three main themes. These are the high cost of installation, the impact of weather conditions on solar system performance, and the general lack of knowledge about solar systems. These factors are essential for understanding the challenges faced in adopting solar PV technology in Gauteng. In terms of the feasibility of implementing solar PV systems, the findings reveal that high initial costs make installation economically unfeasible for many consumers. However, government intervention can make it more accessible, and financing options can also improve its feasibility.

Chapter 5: Discussion: This chapter explores the findings in relation to existing literature. It examines how the findings on solar PV as an effective backup solution for load shedding align with previous studies. Guided by the study's objectives, the chapter discusses the themes identified for each objective, highlighting both similarities and inconsistencies with existing literature. It demonstrates that the findings from South Africa are consistent with previous research. The discussion further reveals that adoption challenges identified in South Africa are not unique but are like those observed in other Sub-Saharan countries and beyond. Finally, the chapter provide various suggestions from policymakers, government officials, solar system installers, and Eskom employees, aimed at promoting the adoption of solar PV systems.

Chapter 6: Conclusion and Recommendations: This chapter provides a comprehensive summary of the study’s findings, ensuring that each research question is clearly answered in relation to the study’s objectives. The conclusions drawn highlight key policy implications to enhance the adoption of solar PV systems in South Africa. Additionally, the chapter identifies areas for further research, addressing unresolved challenges and exploring new opportunities for advancing solar energy solutions.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

This Chapter reviews the literature on available methods of electricity generation, as well as case studies of countries that have implemented rooftop solar PV. It determines factors impeding the uptake of solar systems, the challenges faced in implementing solar PV systems, and the strategic support that was provided to install solar PV to ensure uninterrupted access to electricity. The developing countries selected for the case studies are Uganda, the Dominican Republic, Indonesia, and the Philippines. Literature on Eskom history and challenges is also discussed. Lastly, some detail is provided regarding the process followed and the benefits of installing the three different solar PV systems, that is, Off-grid, Grid-tied and Hybrid.

2.2 Methods of Electricity Generation

Electrical generation can either come from renewable or non-renewable energy sources (Benavidev et al., 2021; Phiri & Nyoni, 2023). Wind, hydro, and solar are renewable energy sources, while non-renewable sources are coal, oil, and gas, which are termed fossil fuels. Power plants' methods of generating electricity can be classified as conventional and non-conventional depending on these sources of energy (Ang et al., 2022; Rahman et al., 2022).

It is a prerequisite for any country's sustainable economic development to ensure that there is access to clean energy, such as electricity ("Electricity Access and Economic Development," 2018). Access to electricity improves socio-economic living conditions and promotes equality in developing countries (Benavidev et al., 2021). Nevertheless, the country's economic, environmental, and social growth requires a constant supply of electricity to improve (Xu et al., 2019). Modern society requires electricity as a basic need, and without it living conditions are sub-standard and it becomes difficult to have a smooth business operation (Johnson & Ogunseye, 2017). Figure 2.1 is a diagrammatic presentation of the types of Power Plants according to the source of energy utilised.

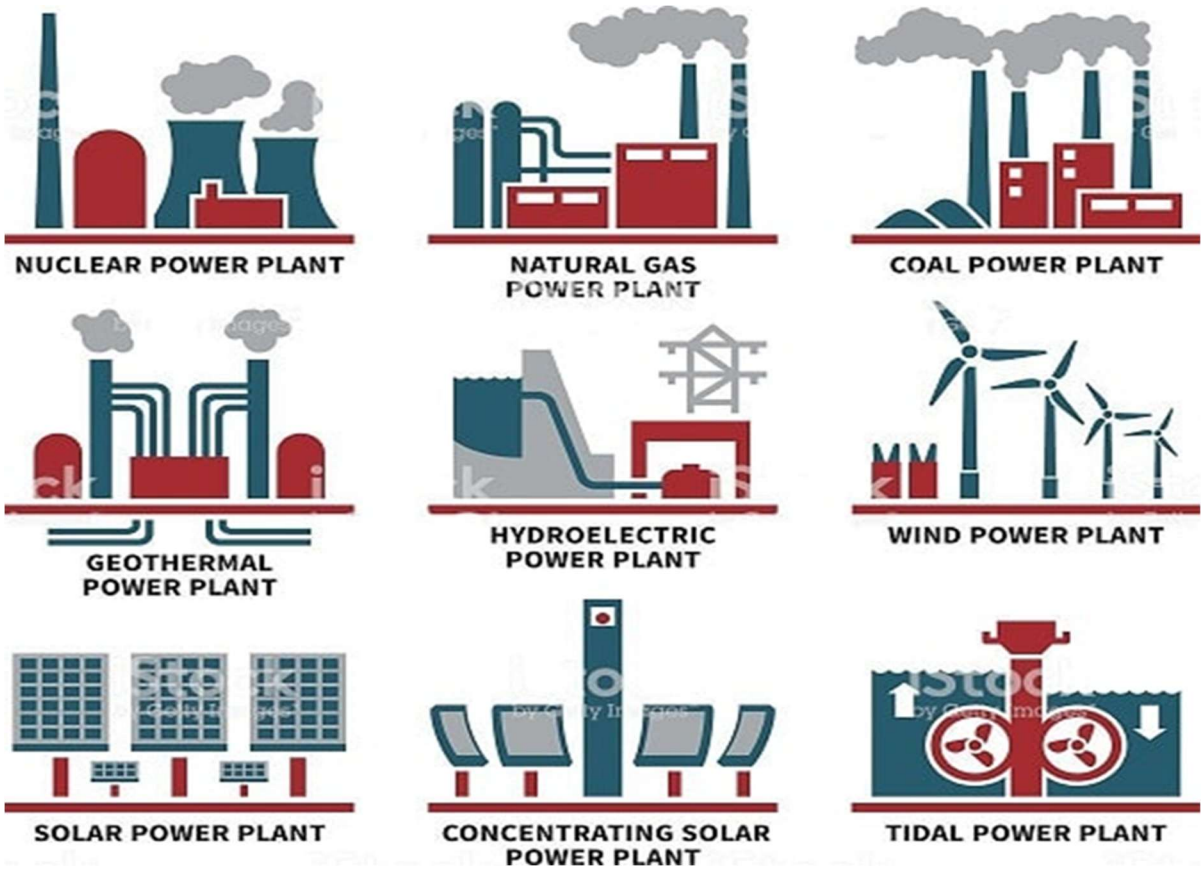


Figure 2.1: Types of Power Plants.

Source: *Study Electrical (2015).*

To come up with possible options viable for SA residents, this investigation considered the experiences of countries which have introduced domestic PV systems, including barriers and enabling factors they faced. In this regard, the use of photovoltaic systems is considered one of the clean methods of energy generation (Maka & Alabid, 2022). Energy demand is increasing, while at the same time it is taking longer to increase power generation, resulting in the grid overloading (Ayamolomo et al., 2022). To meet the current energy demand, other sources of energy must be explored (Nkosi & Govender, 2022). Apart from fossil fuels, PV systems, biogas, biomass, and wind, are alternative power generation technologies that must be harnessed to complement traditional coal-burning power generation (Mathew & Hossain, 2017). Solar energy is favourable as one renewable energy type that generates electricity to replace fossil fuels (Palanca-Tan et al., 2024). Solar power involves energy conversion from sunlight into electricity, by direct reflection as photovoltaic (PV) or indirectly in the form of Concentrated Solar Power (CSP) (Mughal et al., 2018).

Stage 6 load shedding occurs because of 6000MW being cut off grid (du Venage, 2020). When it comes to load shedding, the primary concern is the effect this has on operations of businesses, whether big or small, to the extent that small businesses often close (Nhleko & Inambao, 2020).

To reduce emissions in line with the Paris Agreement, the government is shutting down old fossil fuel power plants, which is expected to lead to temporary difficulties (Todd & McCauley, 2012). However, considering the rate of population growth and expansion of infrastructure in South Africa in comparison to the increase in power generation capacity, it is highly likely that load shedding will persist for some time. For example, a study done in 2021 showed that load shedding was between 1 700 GWh and 1 800 GWh during that year until mid-November (Andreoni et al., 2022). Thus, the need is urgent to accelerate investment to ensure load shedding does not persist or worsen, as the generation capacity gap ranges from 5 000MW to 8 000MW (Andreoni et al., 2022).

This research literature focuses on the three options that can be considered for Solar Power Photovoltaic (PV) systems. To alleviate the negative impact of load shedding on people's lives, livelihoods, and the economy, this review identifies ideal solar panel systems for different income levels and explores possible incentives to support their installation.

2.3 Case Studies

This section examines the adoption of solar PV systems in Uganda, the Dominican Republic, Indonesia and the Philippines. Each case provides insights into the factors that have influenced solar uptake, including financial incentives, policy frameworks and technical support. The analysis highlights both the drivers that have facilitated adoption and the challenges that have hindered widespread implementation. Understanding these experiences can help in drawing lessons to inform strategies for improving solar PV adoption in other regions, particularly in South Africa.

2.3.1 Solar PV Installations in Uganda

Uganda has an annual solar radiation level of up to 2000 kWh/m², making it a highly favourable location for solar energy investments (Gad Mugagga & Baxter Chamdimba, 2021). However, the country's rapidly growing population, estimated to increase by 3.3% per year, has resulted in a rising energy demand of approximately 7–9% annually (Mugagga & Chamdimba, 2021). Meeting this demand has been a significant challenge, as Uganda's reliance on hydroelectric power is often affected by inconsistent rainfall patterns and infrastructural limitations. Recognizing the need for alternative and more sustainable energy solutions, the government has introduced policies and programs aimed at accelerating the adoption of renewable energy, particularly solar photovoltaic (PV) systems (Aarakit et al., 2021). These initiatives focus on expanding access to solar energy in both rural and urban areas where grid electricity remains unreliable or inaccessible.

One of the most impactful strategies for increasing solar adoption in Uganda has been the introduction of flexible payment models, which have made it easier for low-income households to afford solar home systems and kits. The high upfront cost of solar installations has traditionally been a major barrier to adoption, preventing many households from switching to clean energy. However, through mechanisms such as pay-as-you-go (PAYG) financing, microloans, and instalment payment plans, households can spread the cost over time, making solar solutions more financially manageable (Qureshi et al., 2017). These flexible payment schemes allow families to prioritize essential daily expenses while gradually investing in solar energy solutions. As a result, many rural communities that were previously unable to afford solar technology have begun transitioning to renewable energy sources, reducing their reliance on costly and polluting alternatives such as kerosene lamps and diesel generators.

Despite the success of these financial innovations, several challenges persist. High installation costs remain a burden for many households, particularly in remote areas where transportation and logistics add to the expenses. Additionally, Uganda’s solar PV sector faces constraints in research and

development, limiting technological advancements and the availability of high-quality, efficient solar products. A shortage of trained personnel further complicates matters, affecting both the installation and long-term maintenance of solar systems. Weak quality control mechanisms have also allowed substandard solar products to enter the market, leading to frequent system failures and a lack of consumer trust in solar technology ((Abdullah et al., 2019; Gad Mugagga & Baxter Chamdimba, 2021).

Beyond economic and technical barriers, gender dynamics play a crucial role in the adoption of solar energy in Uganda. Studies have shown that the sex of the household head significantly influences the likelihood of adopting solar PV systems. Male-headed households, which typically have greater financial autonomy and decision-making power, are more likely to invest in solar energy when they perceive it as a valuable long-term asset (Aarakit, Ntayi et al., 2021). In contrast, female-headed households often face financial constraints which make it difficult to afford even subsidized solar solutions. Despite recognizing the long-term benefits of solar energy such as cost savings, improved lighting, and enhanced indoor air quality, women are frequently unable to allocate sufficient resources toward purchasing and maintaining solar systems (Cartland et al., 2022). Additionally, cultural norms influence how men and women engage with solar energy providers. Men are generally more likely to interact with solar companies, seek out financing options, and make investment decisions, whereas women tend to prioritize immediate household needs such as food, education, and healthcare (Aarakit, Ntayi et al., 2021).

Despite these challenges, Uganda has made substantial progress in expanding solar energy access. As shown in Figures 2.2 and 2.3, solar PV generation has steadily increased between 2011 and 2020, reflecting the success of government policies and strategic interventions. This growth indicates that well-implemented financial mechanisms, public awareness campaigns, and regulatory improvements can significantly boost solar adoption, leading to broader socio-economic benefits. Increased access to solar energy has improved household productivity, supported small-scale businesses, and enhanced educational opportunities by providing reliable lighting for students in off-grid areas.

Furthermore, the transition to solar energy has contributed to environmental sustainability by reducing reliance on fossil fuels and decreasing carbon emissions.

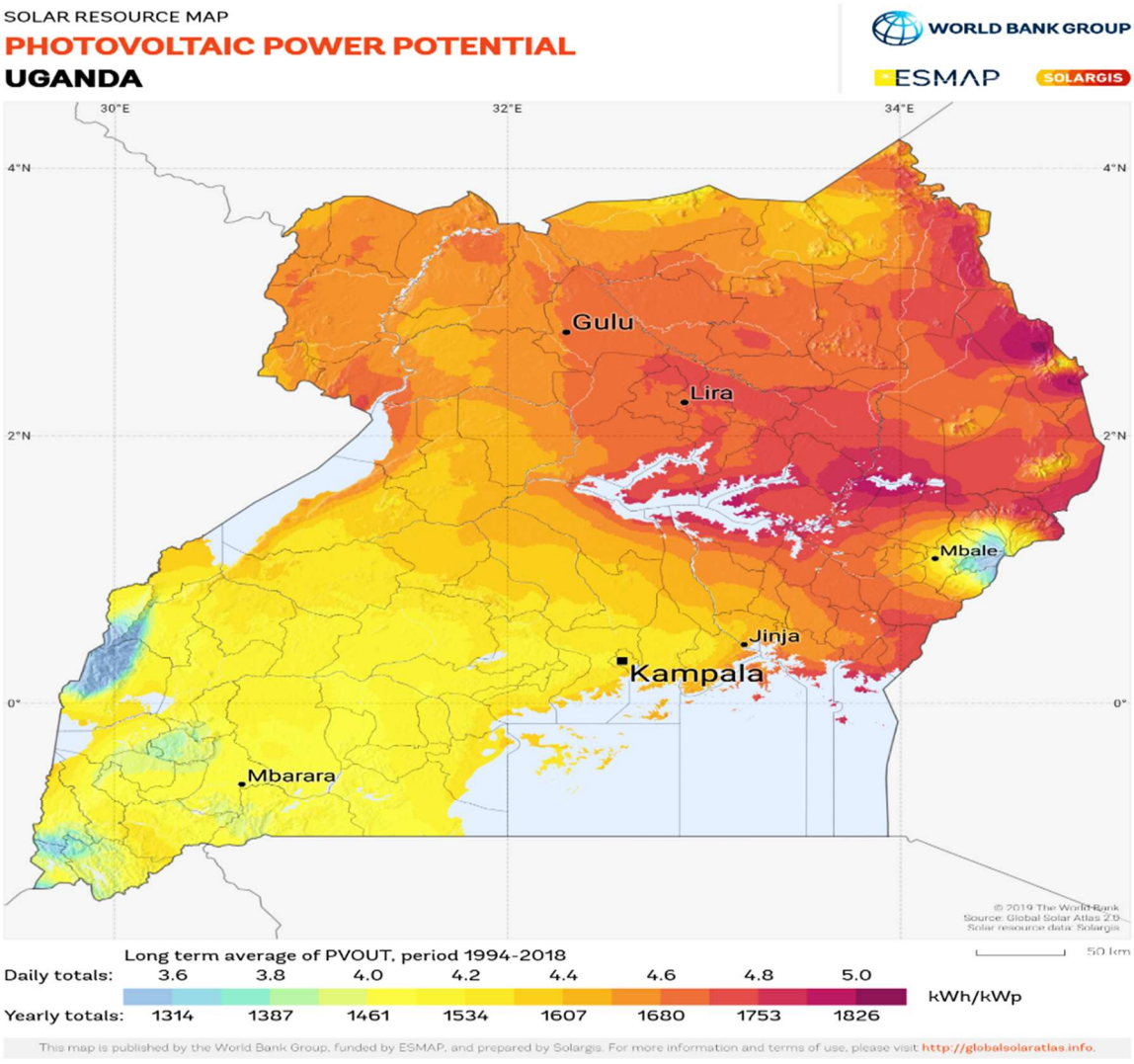


Figure 2.2: Uganda photovoltaic potential map

Source: (*Download solar resource maps and GIS data for 200+ countries and regions*, 2022).

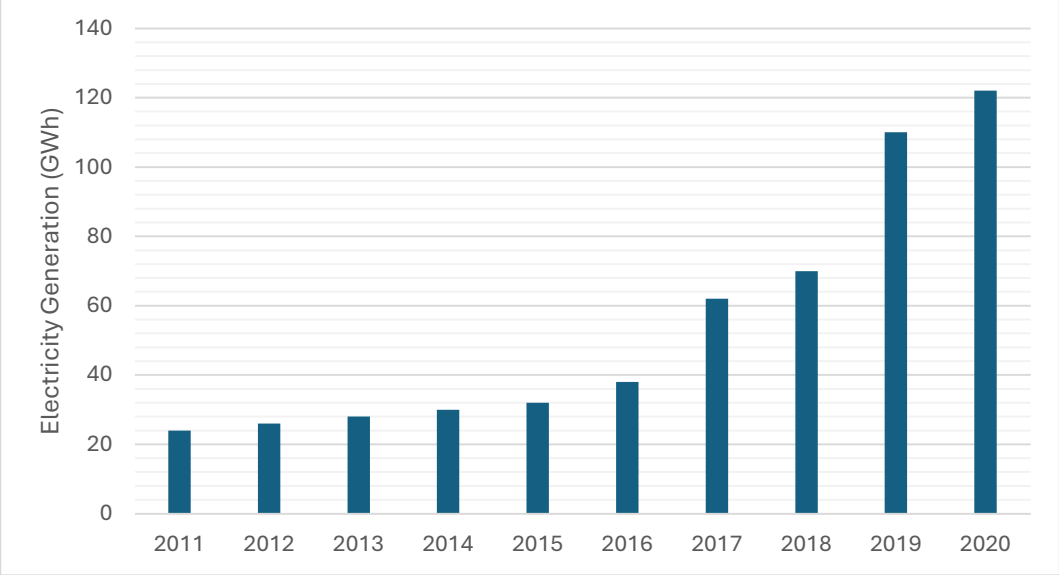


Figure 2.3: Uganda solar PV generation trend

Source: *(Download solar resource maps and GIS data for 200+ countries and regions, 2022).*

2.3.2 Solar PV Installations in the Dominican Republic

The Dominican Republic (DR) is an Island in the Caribbean, Central America, with an estimated average increase of energy consumption of 1% per annum and is regarded as one of the fast-growing economies in the region (Suresh et al., 2020). Fossil fuels are heavily used in the DR and account for about 82% of their energy needs and are imported (Donastorg et al., 2020). In recent years, however, the DR has attempted to generate its energy through clean renewable sources to reduce dependence on fossil fuels and drop GNG emissions (Holechek et al., 2022).

The Dominican Republic's experience highlights key feasibility factors, including government incentives such as Act 57 of 2007, which introduced tax exemptions, subsidies, and feed-in tariffs to promote solar adoption. According to Severino et al. (2023), the government provided a 100% tax exemption and financial incentives to encourage imports of renewable energy equipment. As a result, solar PV has grown significantly, with residents increasingly utilizing net metering as a preferred option. Pena and Gordillo (2020) highlight that solar energy in the Dominican Republic is a viable alternative due to its higher-than-average solar intensity, which enhances energy security. Furthermore, residential and

commercial projects receive funding from both international and national sources, such as the Inter-American Development Bank, while NGOs collaborate with the private sector to facilitate the uptake of solar home systems. These organizations support solar adoption by promoting photovoltaic technologies, offering technical and managerial training, and financing sales through revolving funds. Given these factors, the Dominican Republic serves as a useful comparative case for Gauteng, suggesting that similar financial incentives, policy frameworks, and international funding could enhance the feasibility of solar PV adoption in South Africa.

The success of solar adoption in the Dominican Republic provides valuable insights for South Africa, particularly Gauteng, where load shedding remains a pressing problem. Thus, implementing similar incentives, financing mechanisms, and policy frameworks could make solar PV systems more accessible and feasible for households and small businesses. Additionally, enhanced collaboration between the government, private sector, and NGOs could help address financial and technical barriers. By learning from the Dominican Republic's approach, Gauteng could improve its energy security, reduce its reliance on fossil fuels and promote sustainable energy solutions.

Figure 2.4, 2.5 shows the Dominican Republic's photovoltaic potential at above 5 kWh/kWp, and which is estimated to reach 6kWh/m^2 on a horizontal surface, as evaluated by the Solar and Wind Energy Resource Assessment (Pena & Gordillo, 2020).

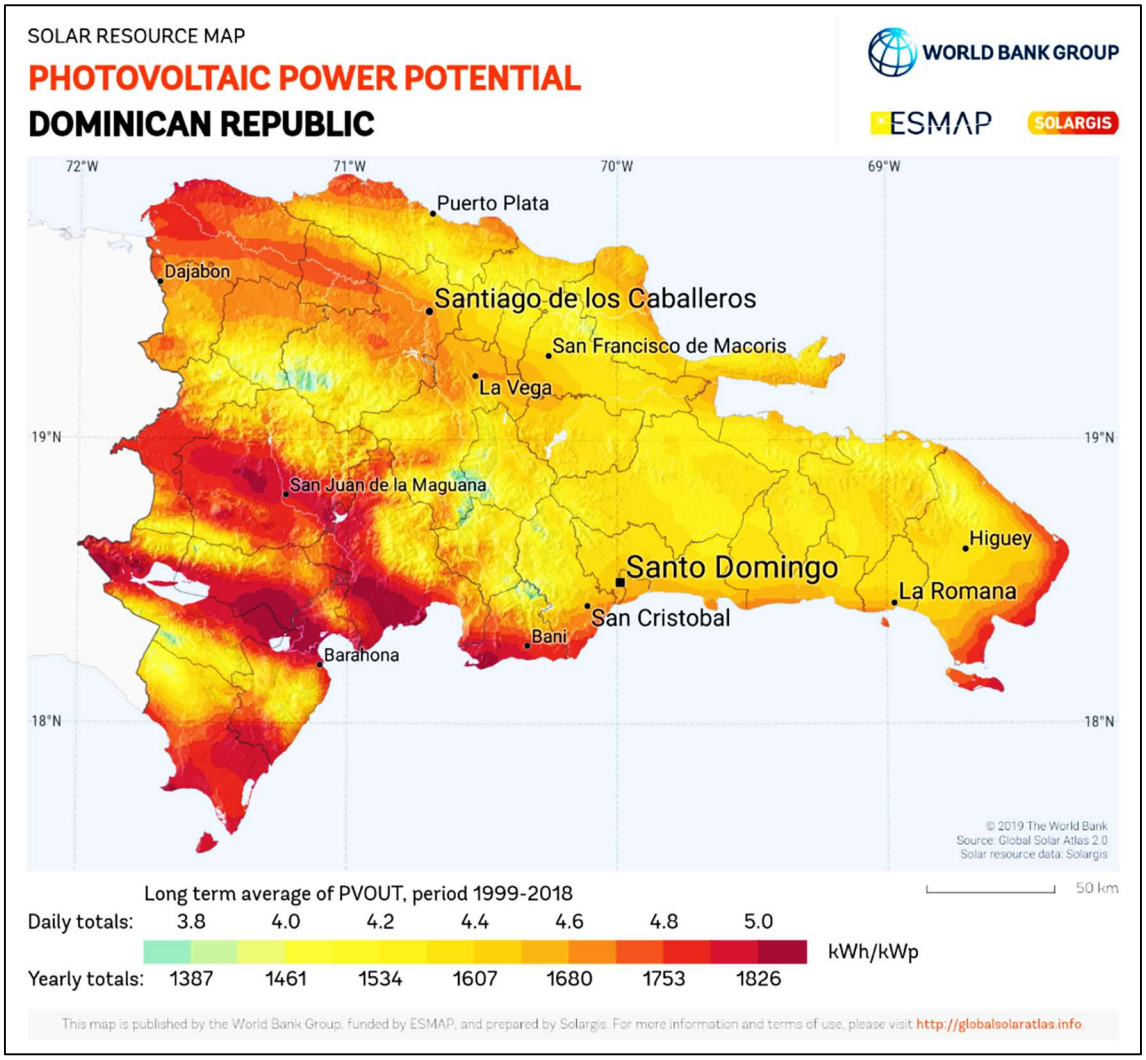


Figure 2.4: Dominican Republic photovoltaic potential

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

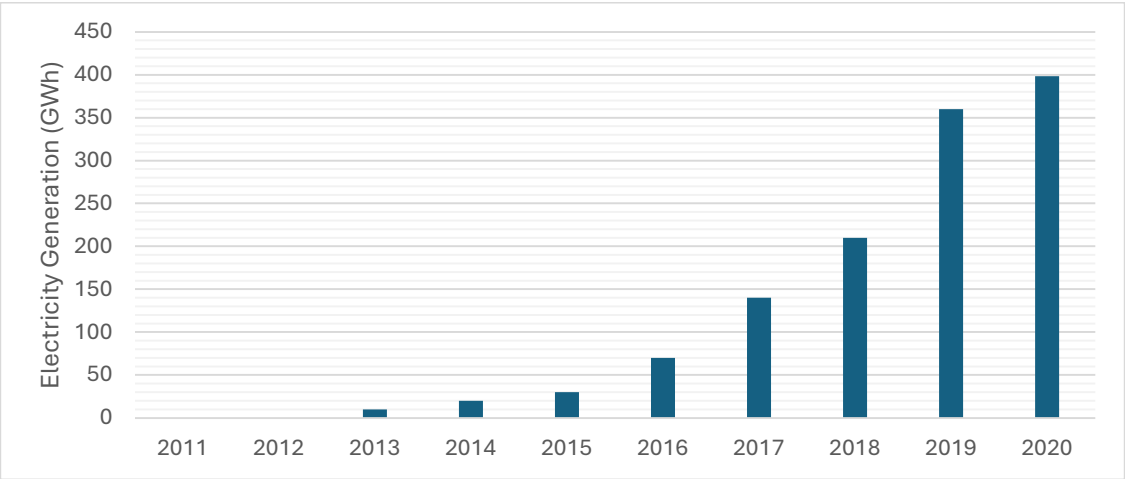


Figure 2.5: Dominican Republic solar PV generation trend

Source:(*Solar energy, 2022*).

2.3.3 Solar PV Installations in Indonesia

Many countries have implemented solar energy policies to reduce reliance on fossil fuels and improve energy production (Solangi et al., 2011). Due to the growing fears of the scarcity of fossil fuels, there is a global interest in considering solar energy (Solangi et al., 2011). Some advantages of using solar energy are that it has no emissions, does not require transmission lines, helps to diversify, and includes energy supply security.

Indonesia is a tropical country that receives high solar energy of around six to seven hours per day (Ho et al., 2019). The country has a solar intensity of 41.8kWh/m^2/day, and plans to install about 45 000MW by 2050, equivalent to 21.65 percent of the total energy the country can generate. This has led to the government implementing incentives such as subsidies, grants, and tax incentives to promote solar PV installations (Ho et al., 2019).

The government has implemented the BANPRES Project, a Presidential initiative which installed more than 3,300 solar home projects in more than thirteen provinces (Retnanestri et al., 2003). The Government of Indonesia began a project to install 1 million solar heating systems (SHS) by 2005 (Retnanestri et al., 2003). They classified potential users according to their level of economic standing in three ways: underdeveloped, more developed, and developed. Responsible authorities were selected and allocated according to the level of these potential users. A payment method was then developed which was more suitable for each level. Those in the underdeveloped category only paid for maintenance fees and battery replacement, while the other two levels were given lease agreements to pay in monthly instalments. If this model is applied in Gauteng, residents can be divided into low, middle, and high-income earning groups.

The project also spawned additional commercially oriented initiatives and government-sponsored programs which have installed nearly 100,000 systems. Participating villages are selected with the help of local governments, and factors such as technical know-how social, economic, and environmental problems must

be considered before rolling out the project (Outhred & Retnanestri, 2015). The selection criteria are based on the community's desire for electricity, lack of access to grid services, household solvency, and the effectiveness of local cooperatives, all of which play a key role in project implementation. Figures 2.6 and 2.7 shows the photovoltaic potential in Indonesia, with about 4.6kWh/kWp solar array capability, which is lower than South Africa's at over 6.2 kWh/kWp. This indicates that South Africa receives more solar radiation compared to Indonesia, making it a more favourable location for solar photovoltaic (PV) energy generation. The higher solar irradiance levels in South Africa suggest that solar panels installed in the country could produce more electricity per unit area, enhancing the overall efficiency and feasibility of solar energy projects. This advantage could contribute to greater energy security, increased adoption of solar PV systems, and reduced reliance on fossil fuels, supporting both environmental sustainability and economic resilience.

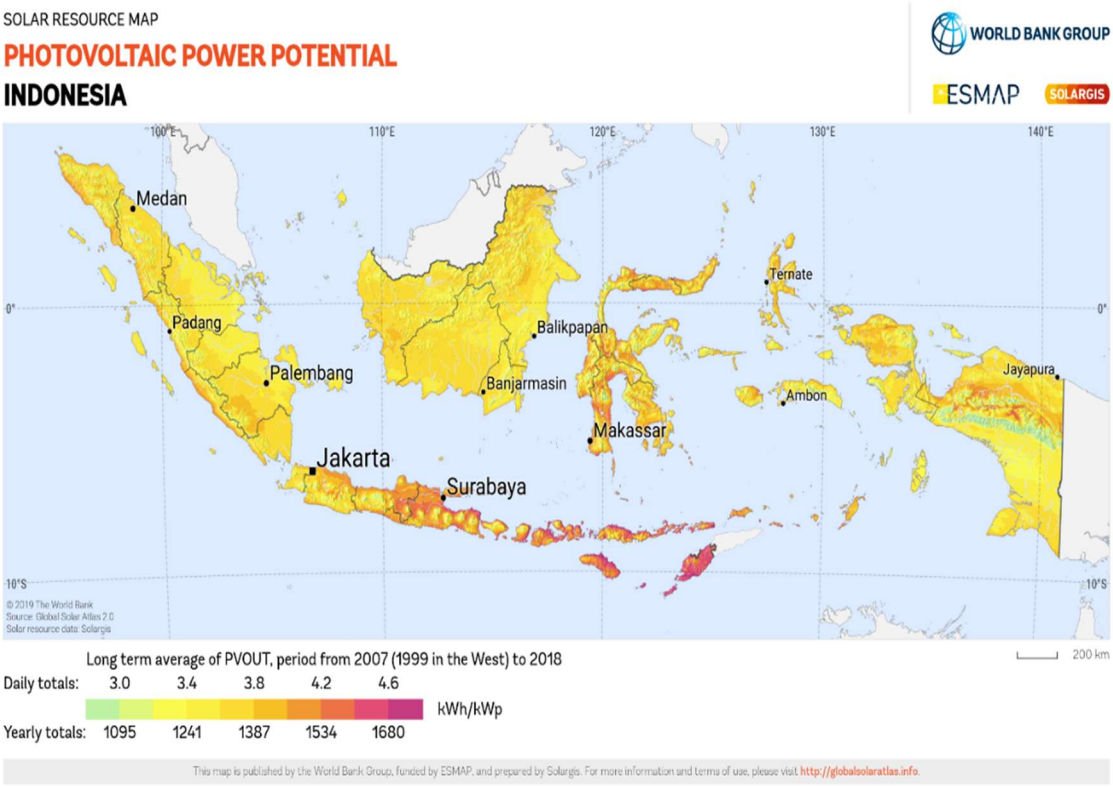


Figure 2.6: Indonesia photovoltaic potential map

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

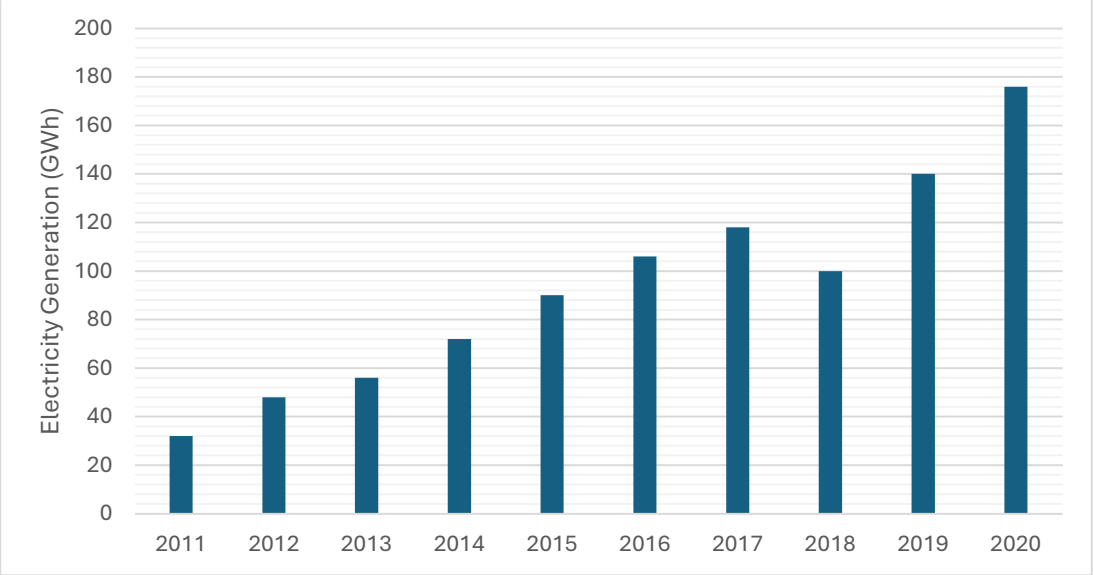


Figure 2.7: Indonesia Solar PV Generation Trend

Source: (*Solar energy, 2022*).

2.3.4 Solar PV Installations in the Philippines

The Philippines is regarded as the fast-growing economy in the world with a population estimated at 102 million (Valančius et al., 2018). In comparison to other Southeast Asian countries the Philippines in 2018 had a 94.9% electrification rate, the third lowest for that region (Benavidev et al., 2021). The country has an average peak solar hours between 4.5-5 hours (Ahmed, 2018) in (Palanca-Tan, 2024).

Heeter et al. (2021) identified that some barriers to use of solar systems are budget constraints among homeowners. They do not have enough information about solar providers, are uncertain about solar as a source of energy, and are unsure of how to use the appliances together. Guno et al. (2021) highlighted that buildings consume about a third of global energy while contributing about 28% of CO_2 emissions. The government therefore introduced the Renewable Energy Act as a way of improving the use of renewable energy in the country (Pacudan, 2018). The Act introduced incentives such as income tax holidays, free duty for imports of renewable energy, zero percent VAT, cash incentives and carry over of net operating loss (Pacudan, 2018).

Moreover, the Philippines uses social media and peer-to-peer information to improve knowledge as a way of promoting social influence (Ragragio, 2024). They have introduced financial incentives such as improved net metering rates, accreditation for providers as a way of reducing risks, and low-cost finance to increase adoption (Palanca-Tan et al., 2024). Only about ten per cent of households can pay for photovoltaic systems in cash. PV systems are therefore bought in bulk to reduce costs for consumers. For the rest, the government has set up revolving funds to finance some programs. Figures 2.8 and 2.9 show the Philippines' photovoltaic potential at just above 4.6 kWh/kWp, just like Indonesia.

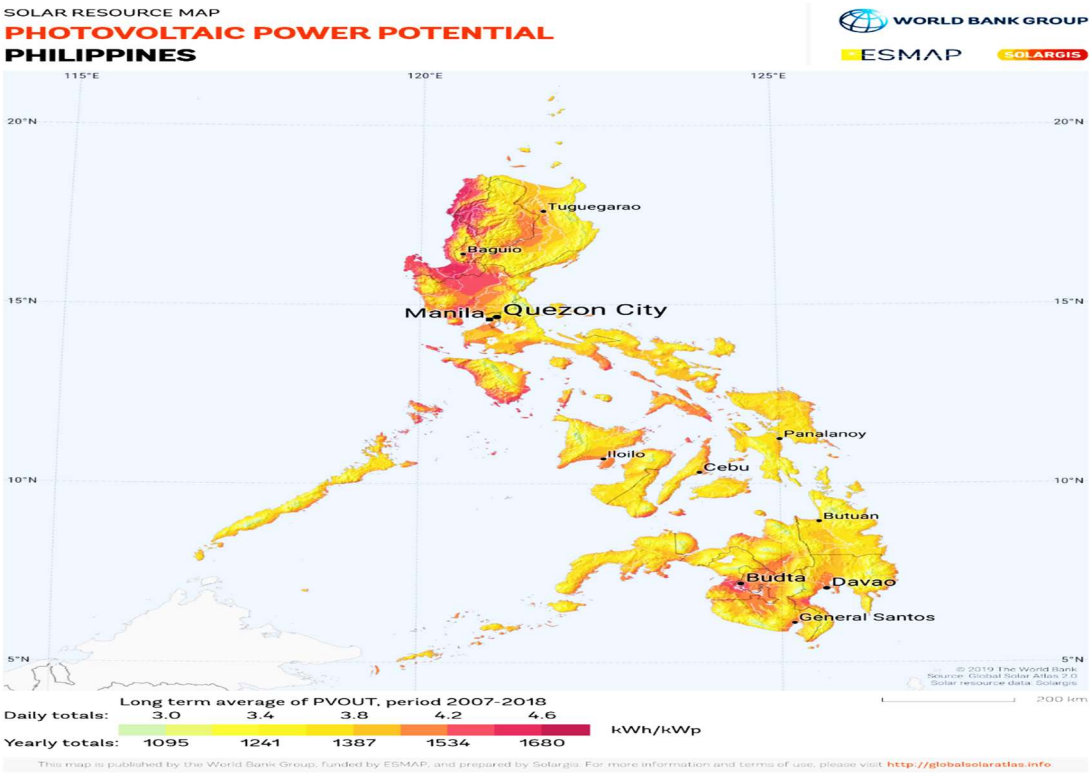


Figure 2.8: Philippines photovoltaic potential

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

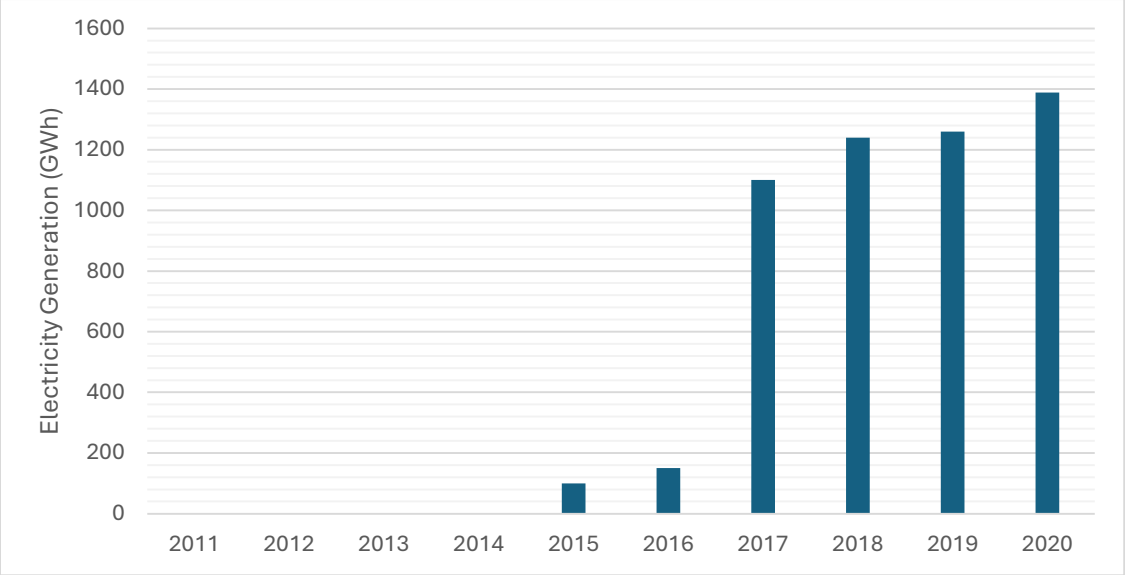


Figure 2.9: Philippines solar PV generation trend

Source: (*Solar energy, 2022*).

2.4 State of power generation in South Africa and challenges

2.4.1 Electricity Challenges

The electricity challenges in SA have continued since 2008, leading to the introduction of the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) to boost plans to implement renewables (Larmuth & Cuelllar, 2019). South Africa is rated as the seventh highest producer of coal in the world (Jain & Jain, 2017). Thus, the programme was not considered viable initially as it showed a cost almost three times greater than coal-based energy power generation methods (Walwyn & Brent, 2015). Nevertheless, in 2010, the South African Department of Energy (DoE) introduced the Integrated Resource Plan (IRP), which is intended to produce 17.8GW of Solar and Wind by 2030 (Larmuth & Cuelllar, 2019).

The REIPPPP boosts investment through tendering by the private sector (called Independent Power Producers (IPP)) for grid-connected renewables (Larmuth & Cuelllar, 2019). The six qualifying technologies under this programme are: PV and CSP Solar, Biomass, Biogas, Onshore wind, and Landfill gas (Eberhard et al., 2014). The first bid started around 2011 and attracted several international and local private investors to these renewable energy technologies to connect their power output to the national grid (Eberhard et al., 2014).

Access to clean, cheap, and reliable energy, particularly electricity, has been identified as a critical indicator in any community for achieving the United Nations (UN) Sustainable Development Goals (SDGs) (Makinde et al., 2021). This is due to numerous problems associated with the conventional power generation of burning fossil fuels, including high costs, environmental degradation, and adverse economic consequences. Many countries are shifting to alternative energy sources for electric power generation (Adewuyi et al., 2019). As a result, there has been an increase in the deployment of renewable distributed generation (DRDG). This is a type of small-scale generation connected to the distribution network and powered by renewable energy sources such as wind or solar power (Zellagui et al., 2014). Nevertheless, despite the abundance of both renewable and non-renewable natural resources, the supply of electricity in South Africa has lagged behind demand (Larmuth & Cuelllar, 2019).

Renewable energy sources such as wind, hydro, solar and biomass are the most predominant in SA, however, solar power has the greatest potential for South Africa (Pegels, 2010). This is because it receives large amounts of sunshine throughout the year because of its geographical location. Winkler (2005) states that "investment in renewable energy and energy efficiency is important to reduce the negative economic, social, and environmental impacts of energy production and consumption in South Africa. Wind as a renewable energy source also has a high potential (Winkler, 2016). Renewable energy however contributes relatively little to primary energy and even less to commercial consumption (Winkler, 2016).

The extent to which renewables should replace coal has been a robust debate for a while in South Africa, especially given the threat of climate change (Winkler, 2018). There is an over-dependency on coal as the source of energy for the country's electricity supply. For instance, the South African electricity landscape can be coupled with an integrated electricity resource plan for up to 2030. This shows that the generated average electricity in South Africa will still be dominated by coal in that energy mix (Msimanga & Sebitosi, 2014). The split of generated electricity by source is such that coal contributes 64%, wind provides 13%, solar

8%, nuclear 4%, and hydro and gas 3% and 1% respectively (Walwyn & Brent, 2015).

The electricity system is monopolised by Eskom, which contributes 95% of electricity generation and distributes 60% of it, while municipalities control about 40% (Baker & Phillips, 2019). About 2.9% of power in SA is contributed by private companies' production, considered Independent Power Producers (IPP) (Baker & Phillips, 2019). While the Integrated Resource Plan (IRP) released in November 2016 allows for solar PV of up to 17,600MW as part of the generation mix by 2050 (Baker & Phillips, 2019), the IRP 2019 retains the annual build limits on renewables (wind and PV) pending the finalisation of a just transition plan (Department of Mineral Resources and Energy, 2019). Table 2.1 shows the planned and installed capacity for different technologies in South Africa.

Table 2.1: SA Planned and Installed Generation Capacity

	Coal	Nuclear	Hydro	Storage (Pumped Storage)	PV	Wind	CSP	Gas / Diesel	Other (CoGen, Biomass, Landfill)	Embedded Generation
2018	39 126	1 860	2 196	2 912	1 474	1 980	300	3 830	499	Unknown
2019	2 155					244	300			200
2020	1 433				114	300				200
2021	1 433				300	818				200
2022	711				400					200
2023	500									200
2024	500									200
2025					670	200				200
2026					1 000	1 500		2 250		200
2027					1 000	1 600		1 200		200
2028					1 000	1 600		1 800		200
2029					1 000	1 600		2 850		200
2030			2 500		1 000	1 600				200
TOTAL INSTALLED	33 847	1 860	4 696	2 912	7 958	11 442	600	11 930	499	2600
Installed Capacity Mix (%)	44.6	2.5	6.2	3.8	10.5	15.1	0.9	15.7	0.7	

Installed Capacity
Committed / Already Contracted Capacity
New Additional Capacity (IRP Update)
Embedded Generation Capacity (Generation for own use allocation)

Source: Department of Mineral Resources and Energy (2019

In the 1970s and 1980s, Eskom overestimated the need for electricity, which created surplus and made South African electricity one of the cheapest in the world, costing as low as 2.5USc/kWh (Eberhard et al., 2014). This led to little revenue collection over the years, and, therefore, not enough money was generated to do significant maintenance of plants.

Figure 2.10 shows the average nominal and real price of electricity generated by Eskom when the exchange rate was at ZA10/USD (Eberhard et al., 2014).

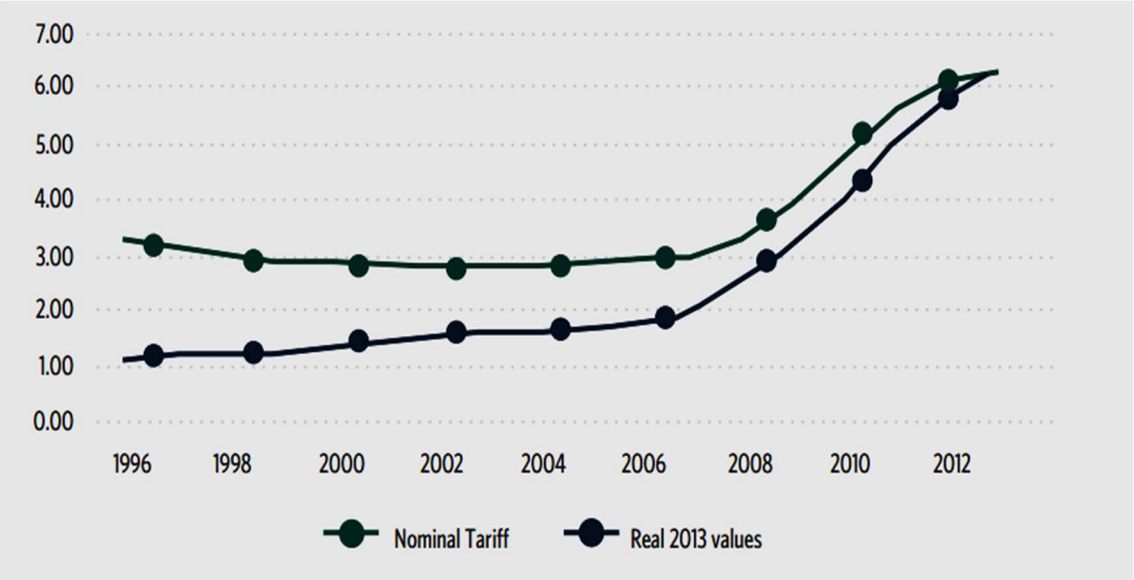


Figure 2.10: Eskom Nominal and Real Tariffs 1996–2012

Source: (*Eberhard et al., 2014*).

The thermal efficiency of the coal-fired power stations for Eskom dropped from 1999 to 2011, as expressed in Figure 2.11, with a range of 34% to around 31% (Pretorius et al., 2015).

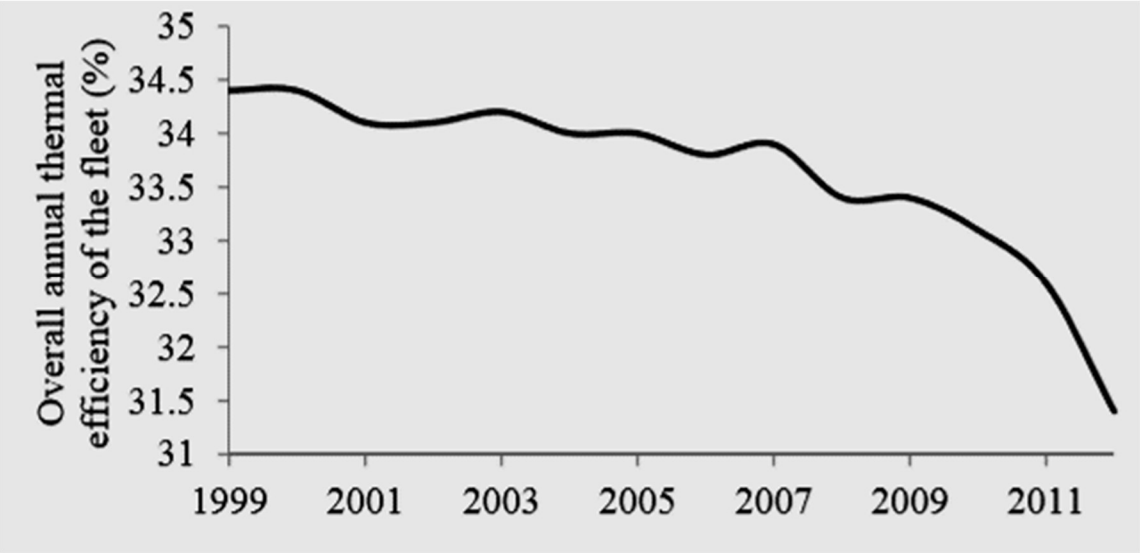


Figure 2.11: Eskom Thermal Efficiency Changes

Source: (*Pretorius et al., 2015*).

2.4.2 The Eskom energy reserve margin

Eskom is struggling to maintain the required electricity reserve margin due to increased electricity demand and the unavailability of generation capacity (Chettiar et al., 2009). Electricity reserve refers to the surplus energy that is available after consumers have received their required supply (Pretorius et al., 2015). This reserve helps to provide backup when there are unplanned outages. Sufficient reserve means there is less pressure on the generation system capacity. Figure 2.12 shows a downward trend in energy reserve margin that happened between 2000 and 2007.

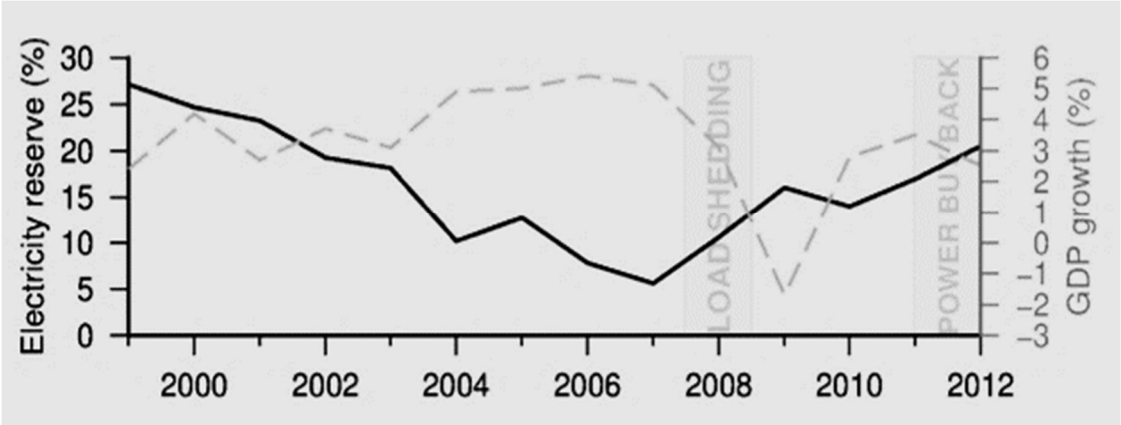


Figure 2.12: Energy Reserve Margin Trend

Source: (*Pretorius et al., 2015*).

The plan to expand generation capacity started in 2005 with two sizeable clean coal power stations, Medupi and Kusile; however, the decision was made too late, leading to rolling blackouts in 2007/2008 (Morris & Martin, 2015). Clean coal refers to coal pollution mitigation efforts via a set of systems and technologies to mitigate coal's health and environmental impacts (Morris & Martin, 2015). It helps to control air pollution from coal-fired power plants and coal burnt by heavy industry.

The power shortages led to SA's drive to introduce renewable energy by implementing the REIPPPP in 2010, which saw seven Concentrating Power Projects up to a capacity of 600MW implemented (Larmuth & Cuelllar, 2019) This resulted in the implementation of a tender process, which led to several

renewable energy projects that increased the total generation capacity, as indicated in Table 2.2.

Table 2.2: Renewable Energy Projects under REIPPPP

	Bid Window 1		Bid Window 2		Bid Window 3		Bid Window 3.5		Bid Window 4		Total	
	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects
Wind	648	8	559	7	787	7			1,362	12	3,356	34
Solar PV	627	18	417	9	435	6			813	12	2,292	45
Solar CSP	150	2	50	1	200	2	200	2			600	7
Landfill GAS					18	1					18	1
Biomass					17	1			25	1	42	2
Small Hydro			14	2					5	1	19	3
Total	**1,425**	**28**	**1,040**	**19**	**1,457**	**17**	**200**	**2**	**2,205**	**26**	**6,327**	**92**

Source: (*Larmuth & Cuelllar, 2019*).

2.4.3 The frequency of load shedding in SA

Improvements in the use of solar PV will minimize the use of diesel and petrol generators, which are very costly to run for small businesses, given the current high prices of diesel, petrol, and the production of undesired gas emissions. The equipment that some businesses use also demands very high-power output, which cannot easily be achieved using solar PV as this requires ample space to connect enough panels to get a high output (*Buying Your Inverter Made Simple - Pricing and Guide*, 2022). In 2019, the highest available residential solar panel output was SunPower 415 watts, with an efficiency of 22.3% (*Buying Your Inverter Made Simple - Pricing and Guide*, 2022). This means five panels must be installed to produce 2kW. Most households require, on average, 5kWhr to 12kWhr to power geysers, stoves, and other smaller power output-rated appliances simultaneously. Therefore, about 30 x 415W panels will be sufficient to produce an output of 12kW if we incorporate days of poor sunshine. These can fit on most medium-income residential rooftops.

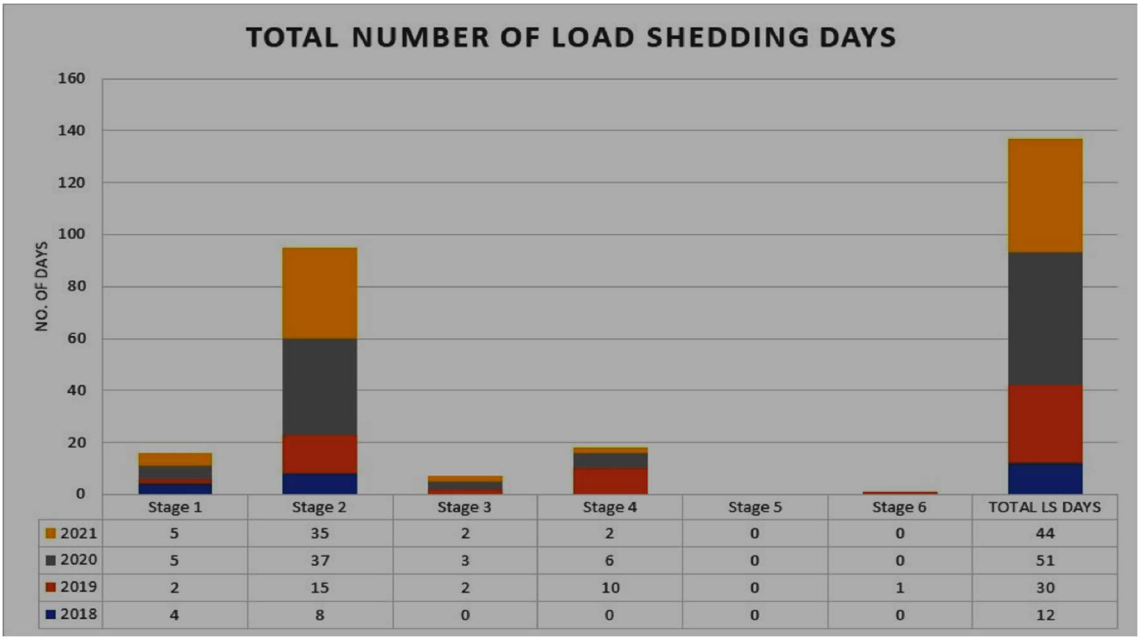
Load shedding was a concern in 2022 as Eskom implemented load shedding as high as stage 6 during some parts of the winter months to maintain grid stability. Work strikes exacerbated this load shedding during wage negotiations between Eskom and the unions. The situation cannot be expected to get better any time soon, as Eskom has a massive backlog of maintenance for its power plants and equipment. Simultaneously, the country plans to meet its commitment to reduce emissions by 348MtCO_2 by 2030. Table 2.3 shows the number of days load shedding was implemented during the energy crisis in 2007. Figure 2.13 shows an increase in the number of days load shedding occurred from 2018 to 2021.

Table 2.3: Frequency of Load shedding in 2007

	October 2007	November 2007	December 2007	Up to 25 January 2007	25 January to 4 February 2007
Number of Days load shedding occurred	4 days intermittently	4 days intermittently	4 days intermittently	15 days continuously	3 days intermittently
Maximum demand shed at a point in time	1500MW	2000MW	2500MW	4000MW	2000MW
Estimated Energy not Served	52 GWhrs	15 GWhrs	56 GWhrs	321 GWhrs	50 GWHrs
Load Factor of Open Cycle Gas Turbines	20 to 40%	10 to 30%	15 to 30%	30 to 60%	15 to 25%

Summary of number of days that load was shedded.

Source: (*Chettiar et al., 2009*).



	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	TOTAL LS DAYS
2021	5	35	2	2	0	0	44
2020	5	37	3	6	0	0	51
2019	2	15	2	10	0	1	30
2018	4	8	0	0	0	0	12

Figure 2.13: Load Shedding Increase since 2018

Source: (*Battery energy storage systems to boost reliability and the adoption of renewable energy. ENCA,2021. Retrieved 25 July 2022*).

A policy shift from non-renewable fossil fuel sources to renewable, cleaner energy sources can help to get funding for new power generation, as investors do not seem keen to invest in fossil fuels. This will not be easy to implement, given SA's abundance of coal as a source of energy and the energy needs are projected to increase. The population in 2010 was 50,850 million. In 2017, the population had increased to 56,522 million, an increase of just over 11%. Gauteng Province was the most populous province in 2017, with about 14 million people and 4,709 million households (StatsSA, 2017).

If, on average, each of these households installs a 5kw solar power system, 23 545MW can be spared from the grid. In 2017, the percentage of Gauteng Province connected to the national grid electricity supply was 80 percent, a decline of 7.2% (StatsSA, 2017). This means that 18 836MW can be saved for industries and businesses where the power is utilised for production which contributes to the GDP of the country and the creation of employment opportunities.

Figure 2.14 indicates that load shedding has been on the rise since 2007-2021, during which period stage six was implemented at some point in 2019 for the first time. Stage 6 load shedding meant that consumers could be affected for up to six hours at a time.

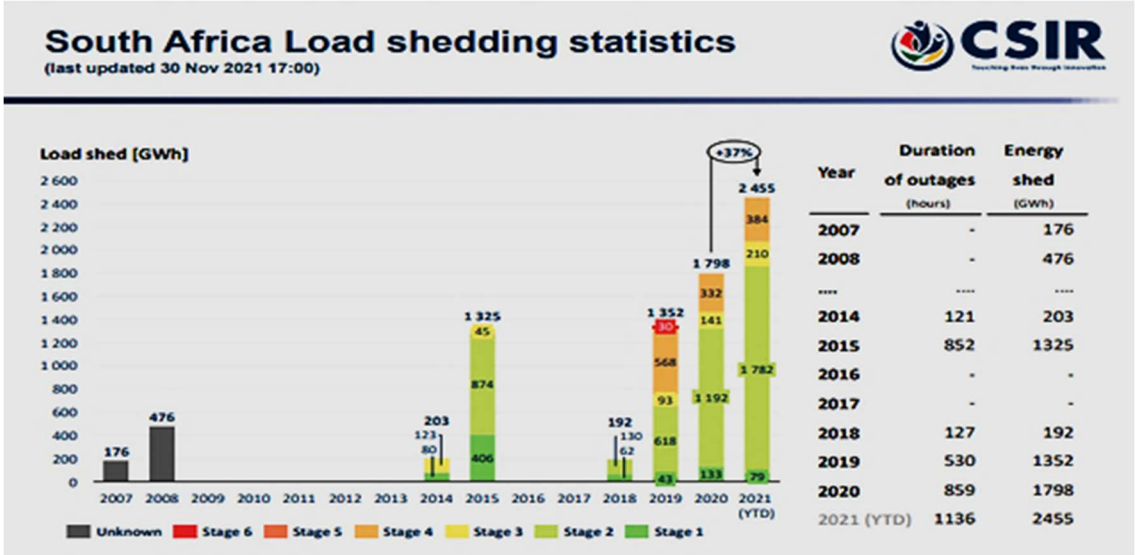
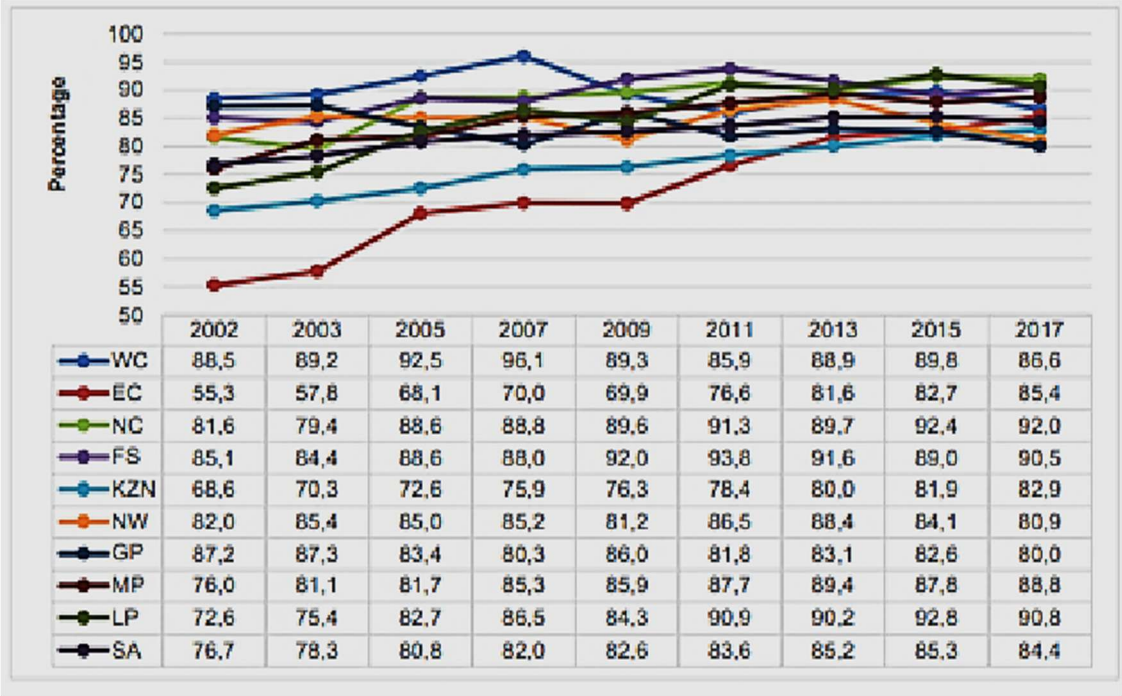


Figure 2.14: Load Shedding Statistics

Source: (*StatsSA, 2017*).

The government should have implemented a system which ensured that each new household was self-supplied through solar PV since 2010, after the power crisis of 2008. This would have meant that load shedding could have been contained to cause a less negative impact on the business or the economy. Figure 2.15 shows an increase in the number of households connected to the grid between 2002 and 2017 in most provinces, which can be directly linked to the increase in load shedding in Figure 2.15.



	2002	2003	2005	2007	2009	2011	2013	2015	2017
WC	88,5	89,2	92,5	96,1	89,3	85,9	88,9	89,8	86,6
EC	55,3	57,8	68,1	70,0	69,9	76,6	81,6	82,7	85,4
NC	81,6	79,4	88,6	88,8	89,6	91,3	89,7	92,4	92,0
FS	85,1	84,4	88,6	88,0	92,0	93,8	91,6	89,0	90,5
KZN	68,6	70,3	72,6	75,9	76,3	78,4	80,0	81,9	82,9
NW	82,0	85,4	85,0	85,2	81,2	86,5	88,4	84,1	80,9
GP	87,2	87,3	83,4	80,3	86,0	81,8	83,1	82,6	80,0
MP	76,0	81,1	81,7	85,3	85,9	87,7	89,4	87,8	88,8
LP	72,6	75,4	82,7	86,5	84,3	90,9	90,2	92,8	90,8
SA	76,7	78,3	80,8	82,0	82,6	83,6	85,2	85,3	84,4

Figure 2.15: Households Connected to Mains Electricity

Source: (*StatsSA, 2017*)

Moreover, Eskom could not maintain its ageing power plants, resulting in significant breakdowns (Kessides, 2020). While the power supply was not so bad in the years before 2017, the worst may lie ahead as old coal-fired plants are shut down and the renewable energy sources delay adding power to the national grid.

Figure 2.16 shows household ratings of the quality of electrical service provided in each province in 2017. Gauteng residents rated the quality of service as good with 64.6%, while 6.1% rated it as poor (StatsSA, 2017).

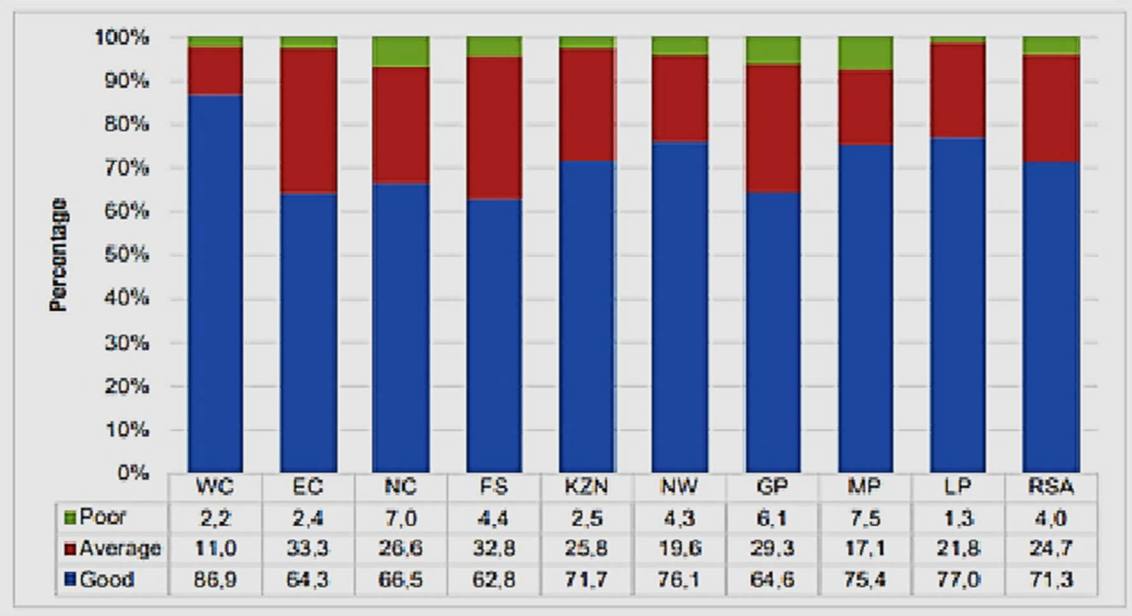


Figure 2.16: Quality of Electricity Household Rating

Source: (*StatsSA, 2017*)

Another objective of this research is to cause the government to implement a strategy that supports Eskom's national solar heating project to promote a reduction of household power utilisation from the national grid. Though the government already offered incentives such as tax rebates to households and businesses (SARS, 2024), the period can be extended, especially to households that can provide proof of approved solar PV project plans and agreements with PV installers to invest in at least a 5kW to 12kW solar system.

2.4.4 Impact of load shedding on consumers

According to the PwC report (2022, p. 17), it is estimated that SA real GDP growth was affected by the adverse impact of load-shedding in 2021 by up to 3.1 percentage points. This could have resulted in up to 400,000 potential jobs for the economy. The report also stated, "Electricity load-shedding, for example, is still the country's number one growth impediment. Power outages increased by an estimated 38% last year, with load-shedding averaging three hours per day".

2.4.5 Effects of load shedding on communities

The degree of unreliable grid connections affects over 200 million families worldwide, and less than 43% of Africa has a dependable electricity supply

(Andreoni et al., 2022). Andreoni et al. (2022) further stated, "it is imperative to ensure electricity supply availability in health centres, to avoid degeneration of patients' health, death, and compromised surgical operations caused by sudden cutting off of electricity supply. The continued load shedding has "unimaginable" effects on the economy and the health sector.

Amon et al. (2012) found that when the power supply is cut off, home electric-powered equipment such as televisions, radios, etc., ceases operating. This negatively impacts the quality of life of household members who rely on these appliances for current information as they do their chores around the house. Furthermore, Amon et al. (2012) found that not being able to watch television or listen to the radio was noted by many participants as an effect of load shedding. The same investigation also found that women took longer to prepare supper with candlelight and found it quite challenging (Amon et al., 2012).

Some effects of load shedding on households include the danger of carbon monoxide poisoning from preparing dinner on an open fire using charcoal or firewood inside their houses, as they do at night. Nursing mothers struggle with childcare at night during load-shedding periods. This creates a major risk for older people and toddlers if they get sick and must be ferried to further health facilities with better infrastructure, like generators.

2.4.6 The effect of population changes on electricity demand

Stas SA (2022) indicates that the SA population is projected to reach 70 million by 2035, increasing the need for more electricity. As the population increases, it will put more pressure on the grid at a time when Eskom would have already shut down most of its old coal-powered plants as planned. Businesses will need all the support they can get to ensure there is enough power supply to avoid shutting down in a country where the unemployment rate is currently estimated at 34.9% (*Quarterly Labour Force Survey (QLFS) – Q3:2021*, 2021).

The fact that the population is increasing and needing more electricity while the electricity generation capacity remains inadequate means there is a great need to come up with an alternative strategy that ensures the stability of the national

grid. For example, domestic lighting can go off the national grid and use solar PV systems, and Eskom focuses on providing power for industries and businesses. The SA population increased from 45.9 million to 56.5 million between 2002 and 2017, as indicated in Table 2.4. Out of this Population, Gauteng is estimated to have the largest number of households (StatsSA, 2017)

Table 2.4: SA Population by Province 2002–2017

	Total population (Thousands)									
	WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
2002	4 756	6 515	1 030	2 645	9 660	3 054	9 764	3 478	5 019	45 921
2003	4 858	6 505	1 040	2 652	9 718	3 097	10 010	3 530	5 050	46 461
2004	4 960	6 498	1 050	2 661	9 783	3 141	10 258	3 586	5 085	47 021
2005	5 063	6 493	1 060	2 670	9 853	3 186	10 511	3 643	5 123	47 602
2006	5 168	6 489	1 071	2 680	9 928	3 232	10 772	3 701	5 165	48 205
2007	5 276	6 484	1 082	2 691	10 005	3 281	11 044	3 760	5 207	48 830
2008	5 388	6 480	1 093	2 704	10 087	3 330	11 325	3 820	5 252	49 479
2009	5 502	6 478	1 105	2 717	10 175	3 382	11 612	3 883	5 299	50 152
2010	5 618	6 477	1 117	2 732	10 268	3 434	11 910	3 947	5 349	50 850
2011	5 738	6 476	1 130	2 748	10 365	3 488	12 219	4 012	5 400	51 574
2012	5 860	6 476	1 143	2 764	10 468	3 545	12 539	4 078	5 453	52 325
2013	5 985	6 477	1 156	2 782	10 576	3 603	12 868	4 147	5 511	53 104
2014	6 112	6 481	1 170	2 802	10 691	3 663	13 203	4 218	5 573	53 912
2015	6 242	6 486	1 184	2 822	10 812	3 726	13 549	4 291	5 638	54 750
2016	6 374	6 492	1 199	2 844	10 941	3 790	13 906	4 367	5 707	55 620
2017	6 510	6 499	1 214	2 867	11 075	3 856	14 278	4 444	5 779	56 522

Source:(*StatsSA, 2017*)

2.5 Proposition 1

It is expected that factors impeding the uptake of solar systems as a backup can be identified.

2.5.1 Factors impeding uptake of solar PV systems

According to Anil Cabraal et al. (1996), case studies on solar PV installations done more than a decade ago in Australia and Indonesia identified critical factors in the success of residential PV programs. These factors included the need for donor support, government support, good infrastructure establishment, and overcoming the first cost barrier (A Cabraal et al., 1996). According to Aguirre

and Ibikunle (2014) factors such as environmental, technological, financial, and policy-related matters were identified to affect the growth in renewable energy. Adebiyi and Moloi (2024) go on to identify two key challenges towards achieving South Africa's energy mix agenda as follows:

- Solar energy production is intermittent and variable due to changes in weather conditions, which affects grid stability and reliability. Upgrading and maintaining the grid is costly and technically demanding; it requires intentionally investing in modernizing and expanding it to accommodate renewable energy inputs, to be stable and reliable (Adebiyi & Moloi, 2024).
- Solar irradiation in South Africa varies significantly, such that solar plant locations are far from major urban centres, which requires efficient transmission systems (Adebiyi & Moloi, 2024).

Solar technology thus has several significant barriers affecting its widespread adoption, such as financial, regulatory, technical, information, social, and psychological (Mathew & Pandian, 2024).

2.5.1.1 Financial barriers

Financial barriers play a dominant role in the decision-making process of adopting solar technologies, as well as uncertainty about return on investment and payoff timelines (Mathew & Pandian, 2024). Despite the long-term financial benefits, high upfront costs of purchasing and installing PV systems deter homeowners from making the initial investment (Adebiyi et al., 2024; Shand et al., 2025).

2.5.1.2 Information barriers

Several studies have identified a lack of information as a barrier that hinders potential adopters from making informed decisions for the widespread adoption of solar technologies (Mathew & Hossain, 2017). There is a need to have targeted awareness campaigns, workshops in communities, and digital interactive platforms to be used to educate the public regarding the benefits and possibilities of solar energy. The dissemination of knowledge on the benefits of

solar energy can impede the adoption rate due to a lack of awareness and information if not done properly (Shand et al., 2025). Lack of awareness and information are social factors among potential adopters, which causes scepticism or hesitation (Shand et al., 2025).

2.5.1.3 Technical barriers

External technical barriers such as insufficient roof space and shading, limitations to building structure, and restrictions of connecting to the grid are obstacles that hinder their widespread adoption of solar PV systems (Mathew & Pandian, 2024). These are barriers caused by architectural and environmental challenges. The need for adequate training and support for system maintenance are technical complexities in regions with limited expertise in solar technologies (Shand et al., 2025). This results in inefficient system operation or maintenance problems that make users dissatisfied.

2.5.1.4 Regulatory and policy barriers

The adoption of solar PV systems is also influenced by regulatory frameworks and policies on the uptake of solar technologies (Mathew & Pandian, 2024). There is thus a need to ensure that there are clear policies and processes that are effective (Mathew & Pandian 2024). Policy inconsistencies or abrupt changes create uncertainty, which discourages long-term commitments to solar PV projects for investors (Shand et al., 2025).

2.5.1.5 Social barriers

Social barriers, particularly peer effects, significantly shape consumer willingness to adopt solar PV systems. For example, if solar PV adoption is viewed as unnecessary, unreliable, or too expensive, these negative perceptions can discourage potential adopters, even when economic or technical benefits exist. Individuals are thus influenced by their social networks, including friends, family and neighbours who may serve as opponents or early adopters for solar technology. If community or social group perceives solar PV as beneficial whether due to cost savings, environmental consciousness or government incentives, this positive perception can create a ripple effect, encouraging others to follow suit (Cartland et al., 2022). Cultural norms and collective beliefs also

play a role, as societies with a strong preference for conventional energy sources may resist transitioning to solar power despite its long-term advantages (Chanda et al., 2025). Thus, social acceptance and perceived credibility of solar PV within a community can either facilitate or hinder widespread adoption, highlighting the importance of awareness campaigns and peer-driven endorsements in promoting renewable energy solutions (Mathew & Pandian, 2024; Shakeel et al., 2023).

2.5.1.6 Psychological barriers

Psychological barriers play a crucial role in shaping consumer attitudes and behaviours toward adopting solar PV systems. These often stem from deeply ingrained traditions, perceived image, and the economic and cognitive costs associated with switching to new technologies (Lin & Kaewkhunok, 2021). Traditional energy consumption patterns such as reliance on fossil fuels or grid electricity create a sense of familiarity and security, making consumers resistant to change (Brown et al., 2023). Additionally, the perceived image of solar PV systems whether viewed as an advanced, elite technology or an unreliable alternative can influence decision-making, especially in communities where renewable energy is not yet mainstream. Economic switching costs, both real and perceived, also contribute to hesitation, as individuals may fear high upfront investments, maintenance complexities, or uncertainty about long-term financial benefits despite available incentives (Zhang et al., 2014). Psychological prejudices such as loss aversion and status quo bias further reinforce resistance, as people tend to overvalue potential risks while undervaluing long-term gains. Overcoming these psychological barriers requires targeted awareness campaigns, trust-building efforts, and policy interventions that highlight the reliability, affordability, and long-term benefits of solar PV adoption (Mathew & Pandian, 2024).

2.5.2 Types of Solar PV Installations

Solar photovoltaic systems can be classified into individual and collective systems (Mohanty et al., 2025). Individual systems involving the use of solar lanterns and solar home systems are limited in what they can do while being

affordable to lower-income groups. Collective systems are centralised and provide electricity to groups, as well as households and commercial consume (Mohanty et al., 2016).

PV modules can also be combined to meet larger energy needs for other household services or productive applications in activities such as agricultural processing or cottage industries (Mohanty et al., 2016). However, formidable obstacles, including the high initial cost of photovoltaic systems, keep this technically and economically viable technology out of the reach of most families. Consumers can install solar PV in three ways: off-grid, grid-tied, and hybrid, as shown in Figures 2.13 to 2.14. These three systems have their advantages and disadvantages when implemented. For example, off-grid systems and hybrid are more expensive to install because they require storage, while grid-tied systems do not need any storage at all and, therefore, are cheaper (*Buying Your Inverter Made Simple - Pricing and Guide*, 2022). The problem with grid-tied is that it needs a power supply for the inverter to work, and when the power goes off, it does not work (*Buying Your Inverter Made Simple - Pricing and Guide*, 2022). The solar photovoltaic system comprises several connected components such as solar panels, a controller, an inverter, batteries, a meter, and AC breakers (Franklin, 2017).

Solar panels/PV modules are placed on rooftops or in direct sunlight to collect radiant heat and supply it to the inverter or charge controller via a combiner box (Franklin, 2017). The combiner box is used to connect several strings into a single parallel circuit (Franklin, 2017). The inverter is used to convert the direct current from the panel to the alternating current used by most residence appliances (Kumar et al., 2018). A charge controller is responsible for controlling the power supplied to the battery to prevent overcharging (Franklin, 2017). The battery is a storage device used to store energy when there is no sunshine. The circuit breaker is a protective device that isolates or allows the flow of power under normal circumstances and switches off when there is a fault. A meter is a device used to monitor electricity inflow and outflow between the solar system and the grid (Kumar et al., 2018).

2.5.2.1 Off-grid System

This is an independent system that uses solar panels connected to an inverter and batteries to supply power to appliances or lights (Karthikeyan et al., 2017). Off-grid systems operate independently from the grid supply, while grid-tied and hybrid systems get power from both the PV array and the grid. In the Philippines, there is an expectation that by 2030, mini-grid and off-grid will be higher (Benavidev et al., 2021). The off-grid system is split into small islands, isolated grids serviced by the government and large islands serviced by private players. The Philippine government created a national policy for total electrification based on the Republic Act 6038, which saw a few laws introduced, such as the Republic Act 9513, also referred to as the Renewable Energy Act, to support off-grid electrification (Benavidev et al., 2021). The Philippine government has also implemented an ambitious renewable energy act to lure private investors to get involved in off-grid areas (Bertheau et al., 2020).

In Indonesia, PV systems started as early as 1997, emphasising off-grid and grid-connected systems for smaller Islands (Outhred & Retnanestri, 2015). In Uganda, this technology is regarded as an important part of rural electrification (Bhamidipati et al., 2019). Off-grid systems are becoming the predominant means of supplying electricity in Uganda due to the high frequency of blackouts. In this country about 30% of the population reported not having electricity but were connected to the grid (Aarakit et al., 2021). Figure 2.17 shows a diagrammatic presentation of household off-grid system components and connections.

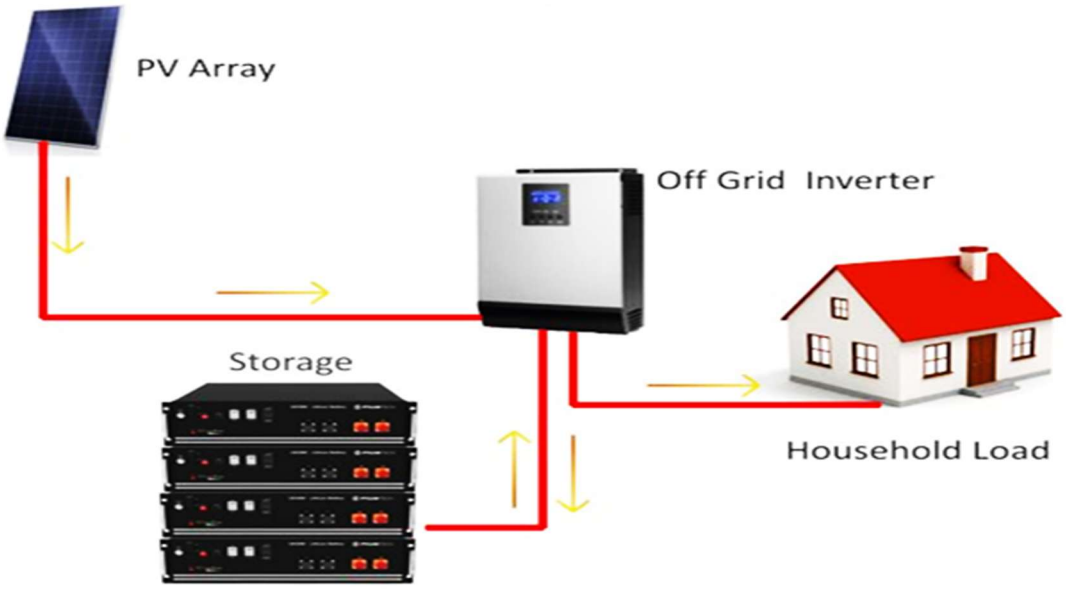


Figure 2.17: Off-grid system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide, 2022*).

2.5.2.1.1 Pros and Cons of off-grid System

Off-grid solar system technology is easy to install (Xu et al., 2019). It provides independence of the power supply in that the household or business does not have to be subjected to any terms and conditions of using grid power (Karthikeyan et al., 2017). Moreover, it helps to provide power in remote areas, and to avoid blackouts due to power failures or plant failures; it acts as a backup system, which helps those with health conditions (Benavidev et al., 2021). When off-grid, no electricity bills are received, which means saving money earned from the salary (Karthikeyan et al., 2017).

On the downside, off-grid solar energy costs quite a substantial amount of money to do the initial installation if disconnected entirely from the grid. There is also a concern about voltage and power fluctuation (Karthikeyan et al., 2017). Furthermore, it requires paying close attention to power usage to avoid draining all the stored power.

2.5.2.2 Grid-tied system

This system is connected to both the grid and the solar panels, which supply appliances via an inverter. If solar radiation is insufficient to meet load demand,

the grid makes up the required power (Karthikeyan et al., 2017). It can also be connected to a generator as a backup via a rectifier, which, however, forms additional costs that households may not be able to afford (Franklin, 2017). The system can supply the excess power back to the grid, and the owner can get paid for that (Bimantoro et al., 2019). Regarding on-grid-connected PV systems, certain factors must be taken into consideration, such as geographical location, installation configuration, and surrounding objects to ensure proper energy production (Mohamed & Zhao, 2010).

This system is being utilised in the Philippines such that consumers are also prosumers, but the scheme compensates for exports below 100kW, therefore benefiting residents mostly, not industries (Jara et al., 2020). Due to the net metering policy, a change in the policy to increase the export limit could encourage additional solar PV installations by the Philippine sub-industries (Jara et al., 2020). For instance, Indonesia's government has implemented a set target to have 23% of renewables by 2025, allowing people to export into the grid, thus encouraging residents to generate using PV systems (Tarigan, 2020). Figure 2.18 shows grid-tied household solar system components and connections.

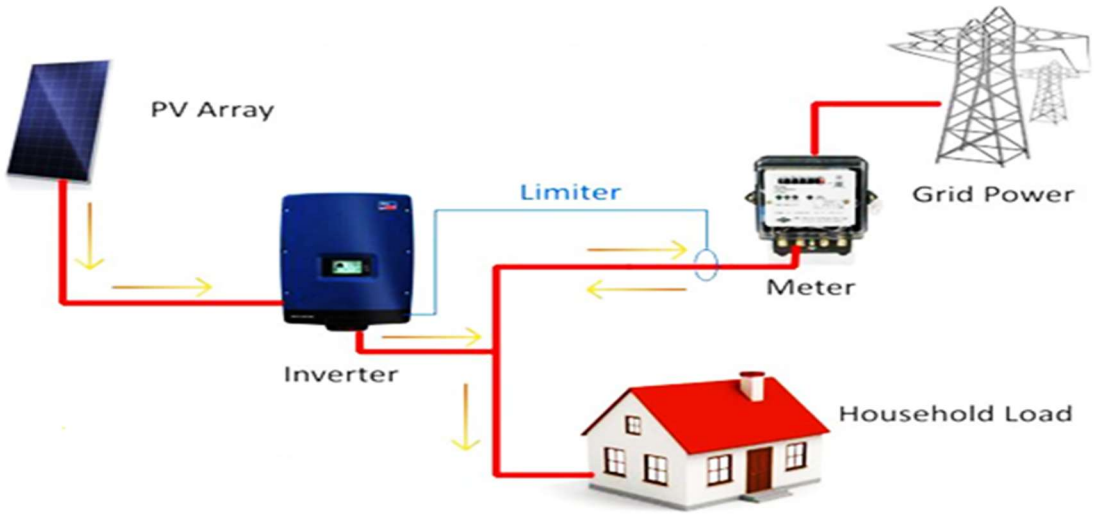


Figure 2.18: Grid tied system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide (SA Home Loans, 2022*).

2.5.2.2.1 Pros and Cons of a grid-tied system

Grid-tied systems do not have to ensure that there is enough supply since they are connected to the grid (Bimantoro et al., 2019). Therefore, they are cheaper as they do not require components such as expensive batteries for storage capability. Since less equipment is needed, the installers have less work, so labour is less expensive. There is also potential to save through net metering, which helps to pay other bills. The payback period for financing is short due to the savings, which makes it cheaper to buy.

The disadvantages of grid ties are that they have some technical requirements which require experts to ensure the safety of people and the grid (M A Eltawil & Z Zhao, 2010). Moreover, they can experience blackouts when there is a power failure or if there is no battery storage. The permits and legal requirements regarding installation can also cost a substantial amount of money and be time-consuming.

2.5.3 Hybrid System

This is a system that relies on more than one energy source to ensure an efficient supply of power (Franklin, 2017). It can be regarded as a combination and an improvement of both the grid-tied and off-grid systems to ensure that there are fewer interruptions. The system can switch automatically from solar panels to grid supply or vice versa (Megantoro et al., 2022). It thus ensures that the end user receives a continuous supply of power by utilising a combination of different energy sources (Rehman, 2021). For instance, Uganda has implemented a hybrid system incorporating both renewable and conventional generating methods such as diesel generators to address fuel challenges and reliability (Kimera et al., 2014). This system has been implemented in the Kalangala district for crop irrigation purposes (Ssenyimba et al., 2020). Its highest annual solar irradiation between 2010 and 2018 was recorded as 10.03kWh in 2013 (Ssenyimba et al., 2020). Figure 2.19 shows the hybrid household solar system components and connections.

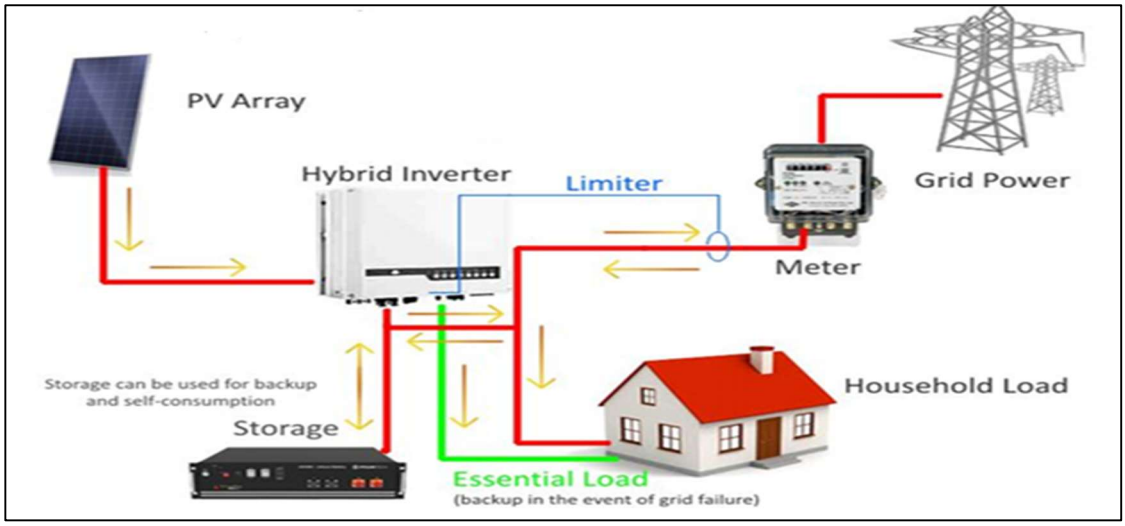


Figure 2.19: Grid tied system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide, 2022*).

2.5.3.1 Pros and Cons of Hybrid System

This system is sound in that it can cater for both off-grid and grid-tied scenarios and is capable of 24-hour supply of electricity (Kimera et al., 2014). The hybrid inverter is reliable compared to the standalone system as it is incorporated with a backup power system and can do load shifting during the evening (Ssenyimba et al., 2020).

The disadvantages are that it also needs battery storage and becomes costly (Adebanji et al., 2021). This means that the financing payback period is longer than the other systems. There are also more components to install, which makes installation costs expensive, and it requires more space (Ssenyimba et al., 2020).

2.6 Proposition 2

The low cost of solar PV hardware makes it feasible for residents to implement solar PV system projects in SA.

2.6.1 Solar PV systems implementation in South Africa

The introduction of green energy in SA has reduced energy production costs and improved job creation, foreign investment, and buy-in from local stakeholders (Jain & Jain, 2017). Furthermore, the levelized cost of electricity (LCOE) from PV

solar installations decreased as the PV module prices dropped over 2011 and 2012 (Jain & Jain, 2017). According to the Department of Energy, LCOE is defined as the price at which the generated electricity should be sold for the system to break even at the end of its lifetime. Table 2.5 shows solar PV as the cheapest option for building a new mega project compared with the LCOE of other energy sources. Figure 2.20 shows the PV module selling prices trend from 2000 to 2020 (Jain & Jain, 2017).

Table 2.5: Building New Generation Capacity Comparative Cost

Technology	Levelized cost of energy	Capital cost	Build time	Eskom position
PV solar	4.1 US$c/kWh	825 US$/kW	18 to 24 months	Identified potential sites to retrofit PV to capitalize on existing infrastructure and available resources
Wind	5.4 US$c/kWh	1,450 US$/kW	24 to 36 months	Leverage sites for wind, with environmental authorizations to capitalize on existing infrastructure and available resources
Gas	7.3 US$c/kWh	1,250 US$/kW	24 to 60 months	Intend to use gas as means to enable renewables, thereby supporting the transition
Nuclear	19.8 US$c/kWh	12,500 US$/kW	12 to 15 years	Supports governments plans to roll out nuclear, will be unable to build due to inadequate balance sheet
New coal	15.9 US$c/kWh	62,250 US$/kW	10 to 12 years	Will own and operate current coal fleet till end of life, will focus on repurposing sites to be decommissioned with renewables. No new coal projects by Eskom

Source: (Andreoni et al., 2022).

These generation costs directly impact electricity tariffs and future affordability. Table 2.5 shows that PV solar is the cheapest at approximately 78c per kWh, followed by wind at R1.03 per kWh, gas at R1.39 per kWh, new coal at R3.03 per kWh, and nuclear at R3.78 per kWh. Integrating more solar and wind energy could help stabilize or even reduce electricity prices in the long run.

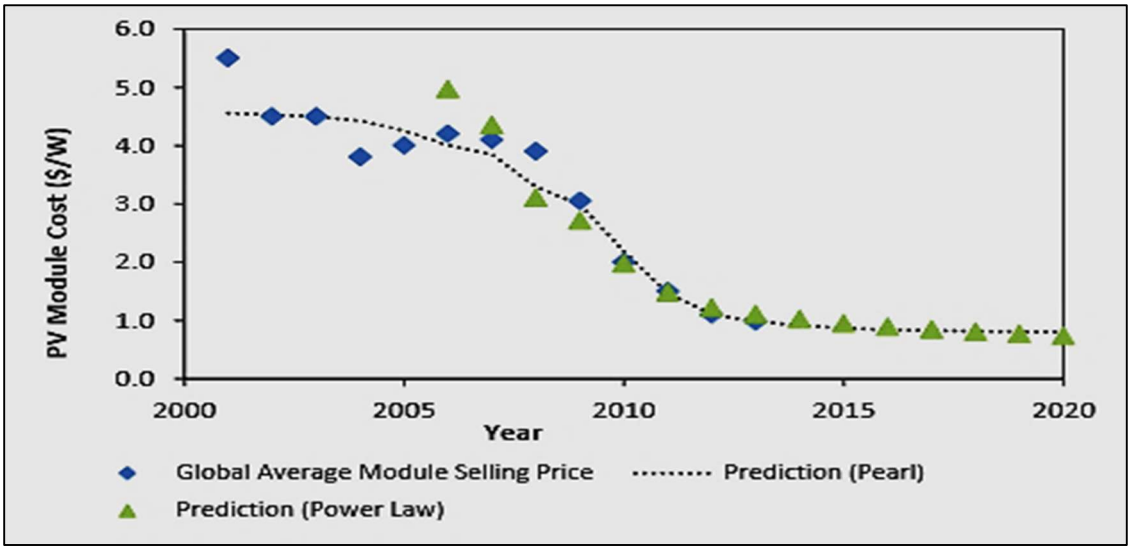


Figure 2.20: Module Selling Price 2000–2020

Source: (*Jain et al., 2020*).

Without energy, economic development will be minimal and will reduce access to basic needs such as medicines, clean water, and refrigerated food, which will negatively impact the populace's quality of life (Taele et al., 2012). However, solar PV costs are expected to continue to decline beyond 2020, resulting in this technology being implemented by consumers in SA (Pandarum et al., 2019).

This reduction in implementation costs due to improved technologies, leading to lower tariffs and a large portion of sunshine per year, is likely to encourage citizens and businesses to consider PV systems as an alternative to meet their electricity needs. In their January 2022 report, the South African Photovoltaic Industry Association (SAPVIA) indicated that the distributed generation market segment experienced substantial growth, with a good improvement in the number of market participants and installed capacity. In the same report, the Chief Operating Officer of SAPVIA, Niveshen Govender, stated, "despite the prevalence of certain barriers, including municipal capacity constraints, processes, policies and regulations, and illicit operators, as well as the upfront costs required to implement solar energy systems that impede the acceleration of growth in sectors, the adoption of solar photovoltaic technology is booming". South Africa has sunshine all year; therefore, it is logical to conclude that, with a proper plan to harness the vast renewable energy resources in South Africa, the

country's power generation problem can be addressed quickly (Gregory, 2020). Solar PV can help South African businesses and households save 15% on electricity costs, with systems paying for themselves within three to twelve years of installation and providing free energy for nearly fifteen years after that (Burke & Stephens, 2018).

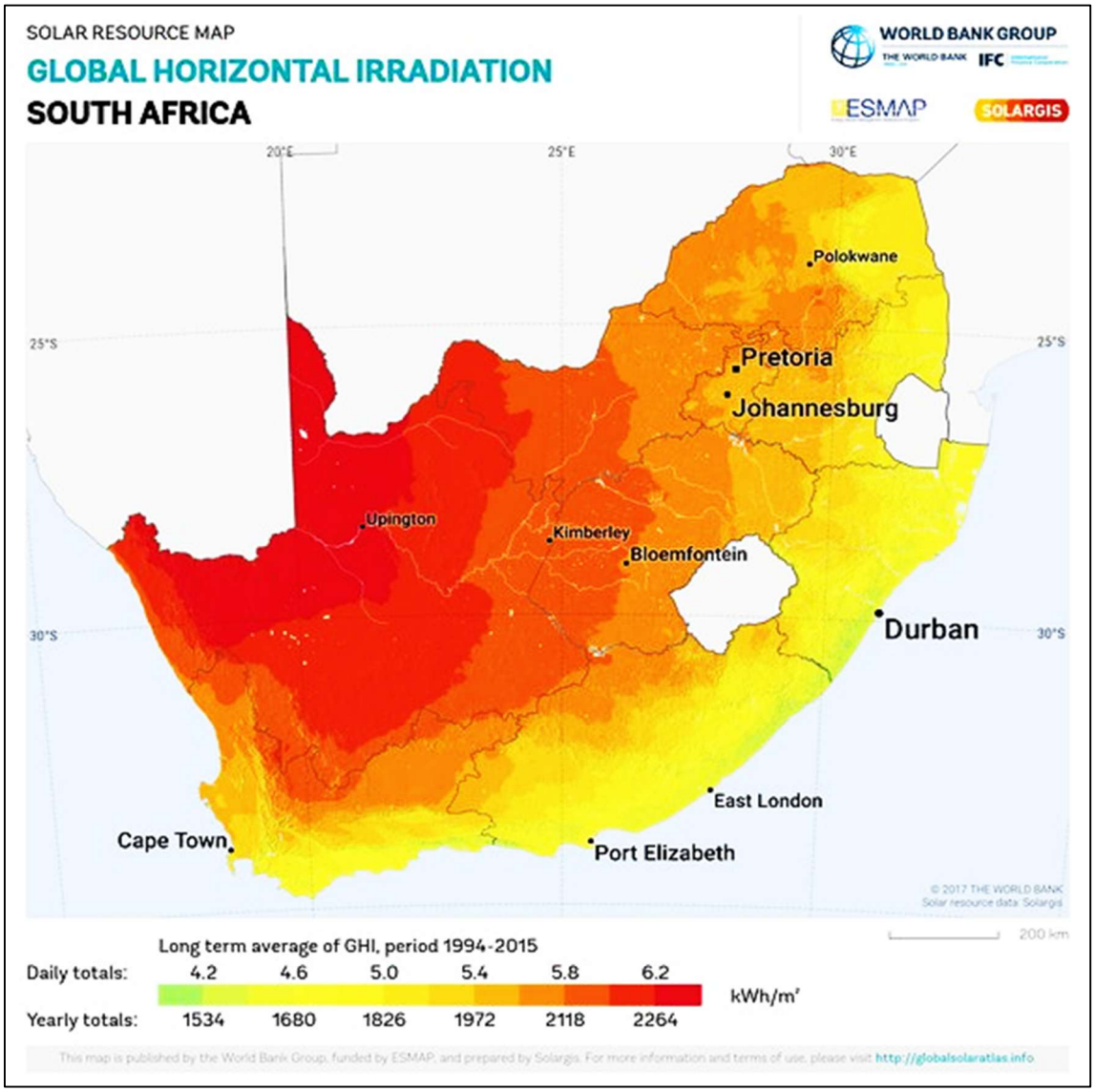


Figure 2.21: South Africa solar photovoltaic potential map

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

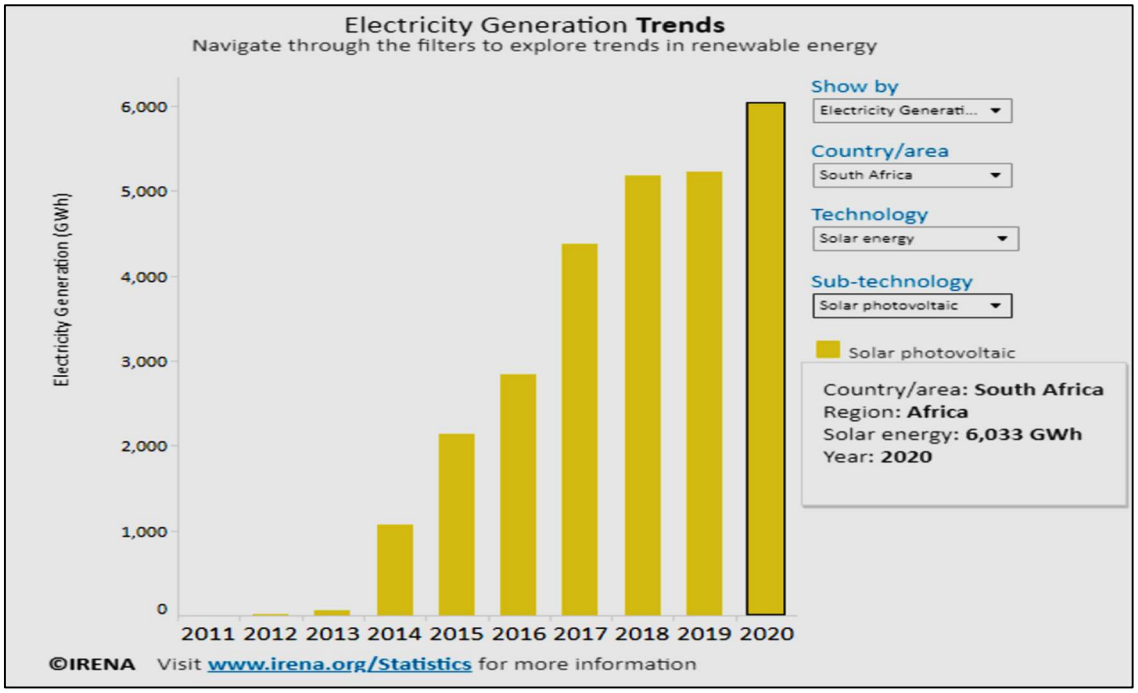


Figure 2.22: South Africa solar generation trend

Source: (*Solar energy, 2022*).

Solar PV has more advantages compared to other power generation technologies such as the short time required for projects to be executed and implemented. Due to the urgent need to address low electricity access rates across South Africa and current electricity supply challenges (frequent blackouts), the capacity to develop photovoltaic solar energy quickly will therefore be advantageous (Winkler, 2016).

2.6.2 Costs of PV hardware and installation in South Africa

While PV solar module costs have decreased by approximately 80% since 2009, reaching between $0.52 and $0.72 per watt in 2015, the overall affordability of solar systems remains a challenge. Although this price reduction makes PV technology a promising solution for meeting energy demands through innovative on-grid and off-grid generation, the high costs of installation, inverters, batteries, and maintenance continue to hinder widespread adoption. In South Africa, additional factors such as import duties, currency fluctuations, and limited financing options further restrict accessibility, contradicting the perception that lower module prices alone make solar PV affordable for households and small businesses. (*Solar energy*, 2022). Solar PV cost was also envisaged to further

decline by 57% between 2015 and 2025 (*Solar energy*, 2022). With such cost reductions, solar PV now offers a rapid, cost-effective pathway to providing modern energy services to the approximately 600 million Africans who lack access to electricity and utility-scale electricity from the grid (*Solar energy*, 2022).

Roof generation is quite popular and has been a significant contributor to solar energy growth in South Africa; nevertheless, high upfront costs limit the market growth. However, this can be countered by targeted financing mechanisms such as price structures, incentives, or specific battery leases. Before any installation can be done, a system design simulation is required to determine the size of the PV system required based on the needs of the household (Bimantoro et al., 2019). Table 2.6 indicates the average cost of installing PV systems in homes in South Africa.

Table 2.6: Average Solar PV System Installation Costs in South Africa

Description	Size	Approximate Price Range
Panels	365w – 420w	R1600 – R2500
Batteries (Lithium)	5kWh – 12kWh	R23000 – R80000
Inverter	5kW – 12kW	R8849 – R55 935
Solar Cable	6mm	R10 – R25/m
Roof Mount Kit	-	R200 – R1000/panel, depending on the type of roof

Source: (*Bimantoro et al., 2019*).

2.6.3 Purchasing versus leasing Solar PV Systems

In recent years, small-scale solar electric generation has steadily increased in developing countries, and micro-generation PV cells have been widely used in residential applications. A licensed distributor can also purchase or lease systems, thus leasing has become a popular option because it does not require high upfront initial costs, and in many cases, the lessor handles equipment maintenance. However, the inability of households to take advantage of any tax breaks associated with the depreciation of solar capital equipment has made

purchasing home systems even less appealing. This means that leasing has a competitive advantage over purchasing (Jordan & Kurtz, 2013).

2.7 Proposition 3

A good government support strategy can encourage residents to install solar PV.

2.7.1 Introduction

Based on the four case studies reviewed in the previous sections, several government support strategies can be considered. These include financial incentives, such as, tax breaks, grants, direct cash incentives, property tax incentives, sales tax incentives, tax credits and subsidies. McKay and Hendricks (2022) highlight that the limited adoption of rooftop solar PV is primarily due to inadequate funding options. Further deterrents are the absence of feed-in tariffs and tax rebates, lack of access to soft loans, stringent credit checks, high interest rates, and inefficient application processing systems. Mutumbi et al. (2024) mention that, households need financial support from credit facilities to improve solar PV adoption as it is expensive to finance.

Key barriers to solar PV adoption can be broadly categorised into financial, personal, institutional, technical, and societal challenges, all of which need to be addressed in a comprehensive and integrated manner (Mutumbi et al.,2024). Financial barriers primarily include the high upfront costs of purchasing and installing solar PV systems, as well as limited access to affordable financing options. These obstacles make it difficult for households and small businesses to invest in solar technology (Ukoba et al., 2024). Click or tap here to enter text.Personal barriers often stem from a lack of awareness, limited technical knowledge, and misconceptions about the reliability and benefits of solar energy. Institutional challenges involve regulatory hurdles, slow policy implementation, and insufficient government support. Technical barriers relate to problems such as inadequate infrastructure, compatibility with existing grid systems, and concerns over the efficiency and durability of solar PV components (Mutumbi et al., 2024). Societal barriers, including cultural perceptions, social acceptance, and resistance to change, further hinder widespread adoption.

Alinaitwe (2023) identified that affordability, financial incentives, and awareness by introducing marketing strategies are critical drivers for increased adoption of solar PV systems. For instance, low- and middle-income groups struggle to get credit facilities compared to high income groups. They occupy small houses with limited roof space, and they lack awareness of solar systems, which makes it difficult for them to adopt solar systems (Mutumbi et al., 2024). It is also noted that due to previous disadvantages resulting from apartheid, low-income groups stay in neighbourhoods that do not have good security systems, which contributes to discouraging them from adopting solar systems.

2.7.2 Proposed Support Strategies

2.7.2.1 Sound Financing Mechanisms

According to Adebiyi et al. (2024), financial incentives, like tax breaks, grants, and subsidies introduced by the government, tend to encourage more investment in renewable energy projects. A focus on Solar PV in South Africa can improve electricity consumption, reduce reliance on the grid, and excess electricity can be supplied back to the grid through net metering and feed-in tariff schemes (Adebiyi et al., 2024).

As an example, the United States uses direct cash incentives, property tax incentives, sales tax incentives, tax credits, and renewable portfolio standards as financing mechanisms that enhance solar PV adoption (Jäger-Waldau, 2019). Jäger-Waldau (2019) further explained that direct cash incentives in the form of rebates, grants, and buy-downs can be implemented on a fixed basis. Property tax incentives such as exemptions and tax credits can be introduced, such that installing solar does not add to the residents' and small businesses' taxable property value. Sales tax incentives in the form of exemptions when purchasing solar hardware can also reduce the total cost of solar installations. Tax credits provided to the owners of solar systems can be introduced to reduce tax payments (Jäger-Waldau, 2024).

The government needs to establish credit schemes that can reduce the burden of upfront costs so that solar is affordable (Alinaitwe, 2023). A network of banks and credit unions can be set up by the government to offer attractive financing options and discounted interest rates (Matisoff, 2022). According to Gad Mugagga and Baxter Chamdimba (2021), solar PV grew from 405 GW in 2017 to 505 GW in 2018 globally, stimulated by tax, carbon credits and government subsidies. The temporary tax incentive of 25% up to a maximum R15 000 given to residents installing solar panels in SA ended and did not cover inverter and batteries that are more expensive to buy (Van Schalkwyk & Scholtz, 2024).

2.7.2.2 Financing Risk Control

When investors identify a risk or perceive that there is a risk, investment does not grow, which requires policy makers and financial institutions to use some fiscal tools that encourage investment (Donastorg et al., 2017). South Africa has started reducing its unfavourable credit risk rating which was considered as sub-investment grade by rating Agencies like Fitch. Nevertheless, political, social, economic and environmental risk negatively affect private investor interest to finance new projects (Mugagga & Chamdimba, 2021). Thus, to mitigate the risks, there is a need to understand the type of risk to devise ways to increase investor confidence and reduce the probability of reoccurrence (Pena & Gordillo, 2020).

2.7.2.3 Sound Energy Policies and Regulatory Framework

The perception and attitude that residents have towards the regulatory and policy framework must be positive as it plays a role in promoting rooftop solar PV adoption (Mathew & Pandian, 2024). In India for instance, rooftop solar PV installations are attractive because of the government incentive of a 40% subsidy on 3kWp (Mathew & Pandian, 2024). Government policies are important to encourage uptake and control resources, and to create high-tech employment opportunities, generate income, and diversify the energy space so that emissions can be reduced (Mughal & Jarial, 2018; Mugagga & Chamdimba, 2021). There is a need to ensure that targets are strictly implemented and achieved within set timelines.

Self-generation of electricity through solar PV is a good option to support. Nevertheless, because it is intermittent, the majority of low to middle income households are forced to use Eskom at some point during the day when they need more than 5kWs for their geysers, stoves and microwaves. These require not less than 8kW when switched on at the same time, which makes it highly unlikely that most of the residents are able to buy big solar systems to go off-grid completely.

2.7.2.4 Feed-in Tariffs and Net Metering Incentives

There has been an increase in electricity costs in the past few years, while the supply of electricity has been unreliable from both Eskom and Municipalities (McKay & Hendricks, 2022). Feed-in tariffs are therefore a good financial tool which can assist as an energy supply side policy to increase the adoption of solar PV by residents and small businesses (Donastorg et al., 2017). Solar PV is an option to reduce electricity consumption from Eskom to control overload on the grid and use residents' excess electricity to back up the grid (Adebiyi, et al., 2024). This is possible mostly during daytime after batteries are full, and residents are not using their excess power. During the day, Eskom could reduce their output and carry out minor routine maintenance activities to avoid unforeseen outages.

Net metering has the potential to lure the right investors as they see it as an opportunity to receive credit for their generated energy as prosumers (Mugagga & Chamdimba, 2021). This is different from feed-in tariffs as it requires only one meter which is bi-directional (Mughal & Jarial, 2018). Net metering ensures that consumers can pay less for their grid electricity consumption as they get billed only for the difference between their production and consumption (Mughal & Jarial, 2018).

2.8 Conclusion of literature review

Based on this literature review, load shedding in South Africa will be present for quite a long time, as most Eskom power plants are old and can no longer achieve their maximum rated output capacity. Furthermore, there is also delays in building

new RE plants, for example, financial close (South African Renewable Energy Council [SAREC], 2014; GreenCape, 2023). Hence, it is crucial and proactive for the government to re-examine at strategic support currently being provided, and to consider adding other incentives like tax credits, property tax incentives, tax breaks, and sales tax incentives to boost solar photovoltaics.

South Africa has one of the highest solar resource potentials globally, with most regions receiving an average of 2,500 hours of sunshine per year and experiencing high solar irradiation levels ranging between 4.5 and 6.5 kWh/m² per day (Smarte Anekwe et al., 2024). The literature reviewed indicates that SA has a good specific yield; the cost of installing solar energy for domestic use is not prohibitive, and it does not require large quantities of electricity compared to industries. Should the government consider providing more assistance in the form of subsidies, credit facilities, microfinance, and tariffs, most people in the middle class upwards may be able to afford to install solar energy in their homes.

Some other funding schemes have been used elsewhere, including in the USA and Uganda, and can be adopted here in South Africa. However, for this residential solar program to succeed, key factors must be considered, including active participation from the private sector. There must be profitability at each stage of the value chain, with a focus on offering a comprehensive package for solar home systems (SHS). Financing options must be tailored to suit different income levels and provide after-sales services to consumers (Philips & Browne, 2001). If more households and small businesses install solar panels, it will help Eskom generate electricity with the required reserve margin and have less pressure to implement load shedding. This will help the economy grow and create more employment opportunities.

Table 2.7: Consistency Table. Research Questions and Propositions

RQ #	Question	Prop #	Proposition
1.	What are the factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa?	1.	It is expected that factors that affect the choice of solar system installation as a backup can be identified.
2.	How feasible is the implementation of solar PV systems in households and small businesses in Gauteng as a solution to load shedding?	2.	The low cost of solar PV hardware makes it feasible for residents to implement solar PV system projects in SA.
3.	What recommendations and strategic support can be provided to households and small businesses to promote the adoption of solar PV systems?	3.	A good government support strategy can encourage more residents to install solar PV for their homes or businesses.

Source (Author)

CHAPTER 3: RESEARCH APPROACH, DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the study's methodology, outlining the strategies employed to achieve its objectives. It begins with a description of the qualitative research approach and explains why it was chosen as the most suitable method for addressing the research questions. The chapter then details the research design, and the instruments used for data collection. It also covers the study's population, sampling method, and sample size. The chapter describes the data analysis method and discusses the study's limitations. Finally, it addresses problems of trustworthiness and outlines ethical considerations.

3.2 Research approach

A qualitative research approach was employed to address the objectives of this study. This allowed for an in-depth exploration of the reasons why households and small businesses may be hesitant or unable to adopt solar systems. It offered the flexibility to uncover factors that may not be immediately evident or measurable through quantitative methods, such as cultural beliefs, social dynamics, or personal experiences. Qualitative research focuses on understanding individuals from their own perspectives and experiencing reality as they perceive it, and interpreting the meaning people attach to aspects of their lives(Corbin & Strauss, 2015;Taylor et al., 2015). This approach was chosen because it provided deeper insights into the opinions of households and small businesses regarding the feasibility of implementing solar PV systems. It was deemed suitable for investigating human subjectivity—capturing feelings, beliefs, frustrations, thoughts, and the financial considerations of installing solar photovoltaic systems (Bansal & Corley, 2011).

3.3 Research design

The research design was structured into three main components: data collection, measurement, and analysis. Research designs typically take one of three forms—exploratory, descriptive, or explanatory (Robson, 2002). This study

adopted an exploratory qualitative research design, which sought to uncover underlying facts and insights. Specifically, it investigated the participants' views on factors impeding uptake of solar systems and the feasibility of implementing solar PV systems in households and small businesses.

The focus of this qualitative research design was to address the "why" and "how" questions related to the research objectives. It served as a framework of methods and techniques chosen by the researcher to logically integrate different components of the study, ensuring the research problem was effectively addressed (Bhatt, 2016). This design facilitated an in-depth investigation into the feasibility of implementing solar PV systems in households and small businesses. Ultimately, it ensured that the findings were aligned with and answered the primary research question.

3.4 Data collection methods

An interview guide was used to collect data from the participants, consisting of semi-structured in-depth interviews. Semi-structured interviews are widely used due to their flexibility, allowing participants to freely share their perspectives (Barrett & Twycross, 2018). These interviews gathered detailed insights into participants' views on the factors hindering the adoption of solar systems. They investigated the feasibility of implementing PV systems in households as a solution to load shedding, and their perspectives on the recommendations and strategic support needed to promote the adoption of solar PV systems. Through semi-structured interviews, the researcher used a pre-planned guide with open-ended questions, focusing on specific aspects (Smith & Sparkes, 2016). This study designed the interview guide around the study's objectives and used it to facilitate discussions with the participants.

Semi-structured in-depth interviews are valuable when a researcher aims to understand complex behaviours, social processes, or the meanings individuals attach to certain phenomena. This approach allows flexibility in gathering information, enabling concepts and theories to emerge naturally from the data (Bryman, 2016). This study employed semi-structured interviews to provide participants with the opportunity to explain what was hindering the adoption of

solar PV systems in their households and small businesses. These interviews revealed that the high initial costs associated with purchasing solar PV systems prevented many participants from affording them. The semi-structured format also enabled the researcher to probe for additional information as needed.

The data were collected by the researcher, through face-to-face interviews with 6 participants, while the remaining 12 participants were interviewed virtually. Of these, 4 were interviewed via MS Teams, and 8 were interviewed over the phone. The in-person interviews took place at Kelvin Power Offices in Kempton Park and lasted between 15 to 30 minutes. A challenge encountered was scheduling conflicts, which prevented some participants from attending in-person interviews, necessitating virtual alternatives. There were minor difficulties during the virtual interviews, such as occasional problems with audibility, requiring questions to be repeated.

3.5 Population and sample

3.5.1 Population

The population refers to the group of objects, or participants, who possess specific characteristics of interest and relevance, and to whom the research findings are intended to apply (Asiamah et al., 2017). The target population for this study included household owners and small business owners residing in Gauteng province, as well as PV system installers, government officials, Eskom engineers, and energy policymakers in the area. This target population was appropriate for the study because they were best positioned to provide insights related to the installation of solar PV systems in households and small businesses.

3.5.2 Sample size and sampling method

Purposive, also known as judgmental sampling, was employed in this study as a non-probability sampling technique, allowing the researcher to select participants based on their expertise. Purposive sampling is used to ensure that the sample aligns closely with the research aims and objectives, thereby enhancing the study's rigor and the trustworthiness of the data and results (Campbell et al.,

2020). This method enabled the researcher to intentionally choose participants with specialized knowledge of solar systems. The selected participants included household owners, small business owners, government officials, policymakers, and installers. By targeting these knowledgeable individuals, the study gained deeper insights into the factors hindering adoption and the feasibility of solar systems as a solution to load shedding. This sampling approach ensured that the data collected were relevant, detailed, and strategically useful, which was critical for meeting the study's objectives and providing meaningful recommendations.

A minimum sample size of 12 participants is typically recommended to achieve data saturation in qualitative studies (Clarke & Braun, 2013; Guest et al., 2006). The sample size for this study comprised 18 participants, including household owners, PV system installers, small business owners, government officials, Eskom engineers, and energy policymakers in Gauteng Province. Data saturation was not achieved because participants continued to provide varying information due to the diverse range of their perspectives. Participants were identified through LinkedIn, social media platforms, and referrals from energy experts. The following were the inclusion criteria for sampling purposes:

1) The participants selected resided in the Gauteng province.
2) Participants selected were household owners, installers of PV systems, business owners, government officials, Eskom Engineers, and energy policymakers.
3) Participants were both male and female.
4) Participants had resided in Gauteng for at least one year.
5) Participants were required to be prepared to get involved in this research.

Gauteng province was chosen as the area of concern for this research because it is regarded as the country's national powerhouse and is the most populous, generating over a third of the country's national GDP. Therefore, there is a need to ensure a stable electricity supply for the industry to ensure that people do not suffer from power shortages resulting in unrest. Furthermore, it is the most urbanized province in the country, with a high concentration of both residential and commercial buildings. This urban environment makes it a suitable research

site for studying the implementation of solar PV systems, as urban areas often have better access to the necessary infrastructure for solar energy installation and use. (Table 3.1)

Table 3. 1: Classification of Participants

Participant Type and Description	Number sampled
Homeowners within townships, low-class, middle- and upper-class suburbs in the province of Gauteng – Consumers.	3
Business owners in Gauteng	3
Energy policymakers	3
Government Officials	3
Eskom Officials	3
Solar Installers in Gauteng.	3
Total number of participants	**18**

Source: Author's computations

3.5.3 The research instrument

Interview guides were used to collect data from participants (see Appendices A1, A2, A3, A4, A5, & A6). Six different guides were created, each tailored to specific participant groups: small business owners, household owners, government officials, policymakers, Eskom workers, and installers. Although each guide contained similar questions relevant to the participants' roles, they were designed to address the unique perspectives of each group. The guides were pilot tested with two participants to check that the questions were clear to the participants. ensure the clarity of the questions. The effectiveness of the interview guides was crucial in shaping the study's outcomes. The questions were designed to align with the research objectives, ensuring that they contributed to addressing the study's objectives. The guides provided a structured framework for guiding interview discussions but were flexible enough to accommodate probing questions. An interview guide is not meant to be rigidly adhered to (Kallio et al., 2016). This flexibility allowed for the exploration of unanticipated problems related to the factors impeding solar system adoption in households in Gauteng. The objective was to gather comparable information from each participant while

offering prompts on key topics for discussion (Gill et al., 2008; Holloway & Galvin, 2023).

3.6 Procedure for data collection

E-mails and WhatsApp messages were sent to selected prospective participants to inquire if they were interested in participating in the study. The interviewer explained the purpose of the research. Once participants agreed, they were asked to complete and sign a consent form. Though face-to-face interviews were scheduled, some participants had to be interviewed online via MS Teams or telephonically due to conflicting schedules. Handwritten notes were not taken during the interviews; instead, notes were recorded and compiled after each interview to save time. Participants were given the opportunity to voluntarily express their interest in participating and were informed that their identity would be anonymous. They were also advised that a recording device would be used. After obtaining their agreement, the interviews proceeded. Immediately following each interview, the data were transcribed.

3.7 Data analysis and interpretation

The collected data were first transcribed verbatim to prepare for analysis, ensuring that they accurately reflected the participants' spoken responses. This was important to ensure an accurate representation of the participants' verbal content and to preserve the originality of the data (Braun & Clarke, 2006). This study employed an inductive approach to analyse the data, focusing on participants' views to generate data-driven recommendations. Inductive thematic analysis involves a strong link between the data and themes (Braun & Clarke, 2006). Therefore, coding and theme development were based on the actual content from the participants. To analyse the data, the researcher re-read all the transcripts to ensure that all information shared by participants was accurately captured. This was easier to remember considering that the researcher had collected the data themselves and transcribed it. This process was conducted for the researcher to familiarize himself with the data and to identify themes within the data. After familiarising himself with the data, relevant ideas were then

considered to produce codes. This process involved organising the data into meaningful groups by identifying features of interest (Braun & Clarke, 2006).

Using the inductive approach, the researcher developed codes directly from the data. These codes include barriers to solar adoption, feasibility of solar PV systems, and context-specific recommendations to support the adoption of solar systems. This approach ensured that the data collected were rich and diverse, capturing a broad range of perspectives from households, small business owners, solar energy professionals, and policymakers in Gauteng. It allowed the researcher to uncover factors influencing solar adoption, such as financial constraints, high costs of the solar hardware and lack of knowledge. After coding the data, the researcher grouped similar codes to form broader themes. This process involved analysing and combining codes to create overarching themes (Braun & Clarke, 2006). For example, codes related to high costs, knowledge of solar systems and solar systems with weather concerns were combined under the theme of factors impeding the uptake of solar systems. Codes related to feasibility, government interventions, and financing options were grouped to form the second theme, the feasibility of implementing solar PV systems. The final theme called recommendations for solar adoption, was developed from codes such as government assistance, financial incentives, government-led education initiatives, bank finance, and securing funding from donors. By combining inductive reasoning with thematic analysis, the study generated practical, data-driven recommendations tailored to the context of households and small businesses in Gauteng.

3.8 Limitations of the study

The study focused on some areas located in Gauteng province, thus the findings cannot be generalized to the province or the entire country. The use of the judgemental sampling method might have led to biased results, since it might not have included the diversity of households and small businesses in Gauteng. The investigation of the feasibility of implementing solar PV systems might have relied on assumptions which did not account for all real-world solutions to the adoption of solar PV systems.

3.9 Trustworthiness

Although qualitative research has inherent limitations, such as potential subjectivity and scarce resources, the careful application of strategies to ensure trustworthiness significantly enhances the accuracy and reliability of the research (Ahmed, 2024). Establishing trustworthiness is crucial for validating the credibility and dependability of qualitative findings, given their inherently subjective nature (Dodgson, 2019). The concept of trustworthiness in qualitative research includes key components such as credibility, transferability, dependability, and confirmability (Amin et al., 2020; Rawhani, 2023). Grounded in trustworthiness, qualitative research plays a vital role in shaping and implementing policies, guiding policy decisions and enhancing service delivery across different sectors (Hendren et al., 2023; Ahmed, 2024). Policymakers rely on strong evidence to develop informed and flexible policies that address social problems and promote equitable outcomes (Ahmed, 2024). Therefore, trustworthy qualitative research findings, strengthened by a deep understanding of the context and diverse perspectives, provide essential evidence for guiding policy decisions (Ahmed, 2024).

3.9.1 Transferability

Transferability refers to applying insights gained from specific individuals, settings, and time periods to other contexts that have not been directly studied (Drisko, 2024). Transferability and generalization share similarities but differ in key aspects. For instance, generalization is often automatic or probability-based and universally applicable to similar situations, whereas transferability involves an abstract process of applying findings from specific contexts to other unstudied contexts (Drisko, 2024). To ensure transferability, the researcher provides a detailed explanation of the findings, emphasizing problems specific to the South African context, such as how high costs of the solar hardware and installation impede the uptake of solar systems. The researcher further explains that providing financial assistance, and incentives could make it feasible to implement solar PV systems in households and small businesses. The study also includes profiles of the sample from which data were collected, offering a clear understanding of the data source. By documenting the specific factors affecting

solar system adoption in Gauteng, the researcher provides detailed contextual information that can help others evaluate whether these findings might be relevant in different provinces or countries with similar energy challenges. Although these findings are context-specific to Gauteng and may not be generalizable to other provinces, a similar methodology can be applied in other contexts to gather views from different regions.

3.9.2 Credibility

To ensure credibility in this study, a clear methodology outlining the strategies used for data collection and analysis is provided. Guba and Lincoln (1981), and Guba (1989) recommend enhancing the credibility of qualitative findings by maintaining an "audit trail," which allows another researcher to review the decisions made during data analysis. In this study, providing detailed information on the data analysis approach, including inductive and thematic analysis, is part of establishing this audit trail. During interviews, the researcher repeated some of the participants' responses to verify accuracy and ensure alignment with the original information shared. This practice helped confirm that the recorded data was consistent with participants' accounts. The study included interviews with stakeholders from various sectors to gather diverse perspectives on the adoption of solar systems, leading to a comprehensive view of recommendations for increasing solar PV adoption in households and small businesses. Efforts were also made to ensure that the transcription accurately reflected participants' responses, with data transcribed verbatim to preserve its original meaning. Collecting data from a range of stakeholders provided a clear understanding of the necessary actions to promote solar adoption. Results highlighted the fact that high costs were a major barrier affecting the uptake of solar systems.

3.9.3 Dependability

Dependability refers to the consistency of research findings and their replicability by other researchers. For another researcher to replicate the study and achieve similar results, the research report must provide sufficient information (Goertz & Mahoney, 2013). To ensure dependability, this study includes a detailed methodology outlining how data were collected and analysed. This transparency allows others to follow the research process and understand how the findings

were derived. Throughout the study, the researcher's background in renewable energy was managed to prevent any potential bias from influencing the findings. Moreover, the researcher actively probed for additional information from participants, even though he had knowledge of effective solar systems. Participants were encouraged to share their experiences and opinions, leading to a consensus that the grid-tied option was most recommended.

3.9.4 Confirmability

Confirmability is akin to objectivity in quantitative research and refers to the extent to which the findings are shaped by the participants and the data, rather than by researcher bias, motivation, or interest. In this study, confirmability was ensured by presenting the findings based solely on the data collected from participants, with no personal biases introduced during transcription. The data were reported verbatim as shared by the participants. During the interview process, the researcher took measures to ensure that his knowledge of solar systems did not influence the participants' responses. An interview guide was used to ask questions, and probing was employed to clarify responses. The researcher allowed participants to share their experiences without judgment or correction. This approach is consistent with Bruyn's (1966) advice for qualitative researchers to approach situations as if experiencing them for the first time. This methodology helped the researcher gain deeper insights into participants' scepticism about solar systems operating in cloudy or rainy weather.

3.10 Ethical considerations

Ethics approval for this study was granted by the University of Witwatersrand's Ethics Committee (see Appendix C2: Ethics Approval Certificate), and the purpose of the study was explained to all the interested participants. A participant information letter was sent to all identified participants, providing them with all the required details about the research (see Appendix B1). Participants provided verbal and written consent before taking part in the study. They voluntarily agreed to participate by completing and signing an informed consent form (see Appendix B2). Permission to audio-record the interviews was obtained from participants prior to recording. To protect participants' identities, pseudonyms were used during the interviews and in the presentation of findings. Participants were

informed that their participation was entirely voluntary and that they could withdraw from the study at any time without consequences. They were assured that their information would be kept confidential and that their anonymity would be maintained throughout the research process.

Table 3.2: Consistency Matrix (Research Questions, Data Collection and Data Analysis)

RQ #	Research Question	Prop / hyp #	State Proposition	Data collection detail	Data analysis method
1.	What are the factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa?	1.	The factors impeding the uptake of solar systems in households and small businesses include financial barriers, information barriers, technical barriers, regulatory and policy barriers, social barriers and psychological barriers.	Interview guide one[1] questions 11, 12, 14, 15, 16, 17 & 19 Interview guide two[2] questions 10, 12, 13, 16, 18	Inductive thematic analysis
2.	How feasible is the implementation of solar PV systems in households and small businesses in Gauteng as a solution to load shedding?	2.	The feasibility of the implementation of solar PV systems in households and small businesses depends on the cost of hardware for installations and level of support from the government.	Interview guide one questions 6, 7, 8, 10, 11, 12, 13, 14, 16, 17 & 20 Interview guide two questions 7, 8, 9, 10, 11, 13, 16, 17, 19 & 20	Inductive thematic analysis

[1] Interview guide one was used to collect data among household owners
[2] Interview guide two was used to collect data among small business owners

RQ #	Research Question	Prop / hyp #	State Proposition	Data collection detail	Data analysis method
3.	What recommendations and strategic support can be provided to households and small businesses to promote the adoption of solar PV systems?	3.	Recommendations and strategies that support the adoption of solar PV systems include having sound financing mechanisms, control of finance risks, sound energy policies and regulatory frameworks, provision of benefits such as feed-in tariffs and net metering incentives.	Interview guide three[3] questions 7, 8, 9, 10, 11 & 15 Interview guide four[4] questions 7, 8, 9, 11 &14 Interview guide five[5] questions 10, 11 & 18 Interview guide six[6] questions 8, 9, 10, 11, 15, 16, 17, 18 & 19	Inductive thematic analysis

[3] Interview guide three was used to collect data from government officials
[4] Interview guide four was used to collect data from policy makers
[5] Interview guide five was used to collect data from Eskom employees
[6] Interview guide six was used to collect data from installers

CHAPTER 4 RESULTS AND ANALYSIS

4.1 Introduction

The chapter presents results from household and business owners in Gauteng regarding the installation of solar PV systems. It begins by detailing participants' views on rooftop solar PV as a backup solution, then proceeds to explore the factors impeding the uptake of solar systems. The major theme emerging from the participants' narratives was the high cost of purchasing solar hardware and installation. The chapter further examines participants' perspectives on the feasibility of implementing solar PV systems in households and small businesses. Finally, it discusses the recommendations and strategic support to increase solar installations in households and small businesses.

4.2 Profile of the participants

Table 4.3: Profile of the participants

	Name of the participant	**Sex**	**Age**	**Ethnicity**	**Occupation**	**Residential location**
1.	Joseph	Male	52	White	Engineer	Rubber Club
2.	Thandi	Female	44	African	Primary Energy Engineer	Mohali city West Rand
3.	Nkosinathi	Male	43	African	Mechanical Engineer	Bez Valley
4.	Charlotte	Female	42	African	Business owner	Brakpan
5.	Kunutu	Male	50	African	Business owner	Midrand
6.	Lesebe	Male	53	African	Business owner	Kempton Park
7.	Lebo	Female	43	African	Policy maker - Energy Specialist	Kempton Park
8.	Philip	Male	45	African	Policy maker – Strategist Dept of Energy	Pretoria

	Name of the participant	Sex	Age	Ethnicity	Occupation	Residential location
9.	Melinda	Female	43	African	Policy maker – Energy Specialist	Johannesburg
10.	Charles	Male	45	African	Government official - DMR	East Rand
11.	Mpho	Male	45	African	Government official – Department of Energy	Southern Pretoria
12.	Mphahlele	Male	35	African	Government official - DMR	Southern Pretoria
13.	Peter	Male	46	African	Installer	Johannesburg
14.	James	Male	40	African	Lecturer and Solar Installer	Lombardy East
15.	Eric	Male	41	African	Installer	Lombardy East
16.	Siyabonga	Male	42	African	Eskom (Electrical engineer)	Benoni
17.	Themba	Male	40	African	Eskom (Electrical engineer)	Morning side
18.	Kgothatso	Male	39	African	Eskom (Electrical engineer)	Brakpan

Source: Author

Most participants were male; of the eighteen individuals interviewed, four were female. The participants' ages varied by group: household owners ranged from 43 to 52 years, small business owners from 42 to 53, policymakers from 43 to 45, government officials from 35 to 45, installers from 40 to 46, and Eskom employees from 39 to 42. Most participants were Black, with only one being White. The majority resided in suburbs located in the eastern part of Johannesburg, with a few living in northern Johannesburg and the southern parts of Pretoria (Table 4.1).

4.3 Rooftop solar PV is a good backup solution

The section highlights participants' views on the installation of rooftop solar PV systems as a backup solution. It also provides context by illustrating the participants' views on load shedding in the country and why installing solar panels would be the best solution given their circumstances. The narratives of household owners indicated that they recognized the installation of solar PV as a good backup solution to the continuous power cuts, which have seen the introduction of loadshedding. They described how solar panels can generate electricity during the day, which can then be used to power homes during load shedding. Joseph, a fifty-two-year-old male, an engineer stated that installing rooftop solar would reduce his reliance on Eskom and help save on electricity bills. However, some participants noted that rooftop solar panels were not a viable solution for many ordinary South Africans who cannot afford them. This is highlighted by Thandi, a forty-four-year-old female, an administrator who said, *"They are meant for the few who can afford who are in the higher tax bracket, not any ordinary average South African".* Similarly, Nkosinathi, a forty-three-year-old mechanical engineer, supported the idea that rooftop solar could reduce reliance on the grid but acknowledged the financial challenges for most households. The above perspectives show a significant barrier to adopting solar PV systems, that is the substantial upfront costs that put them out of reach for many South Africans, despite their potential benefits as a reliable backup power source.

According to the narratives of the household owners, solar PV installation is viewed as a good backup solution due to the unreliability of Eskom, which frequently experiences power cuts leading to loadshedding. Load shedding has caused challenges for households and small businesses. Most participants from households mentioned that load shedding inconvenienced them, forcing them to plan their day around the load shedding schedule. Some participants mentioned that loadshedding dictates their daily routines, making it difficult to cook, keep food cold, and work from home. They found themselves spending more on takeaways since time is spent stuck in traffic due to non-functioning traffic lights caused by load shedding. Participants mentioned no longer buying perishable food in bulk that requires refrigeration. Thandi provided a detailed explanation of how she was spending more on petrol because of the increased time spent on the road, starting and stopping for long periods due to

traffic congestion caused by non-working traffic lights. Based on the participants narratives, they had devised various backup strategies to cope with load shedding. Some used candles or generators for lighting. One participant relied on a generator, another had a gas stove, a gas geyser, a battery-powered fridge and a few flashlights, while another only had rechargeable lights. Those using generators mentioned that they had to be cautious not to use too much electricity to avoid running out of power. The participant with only a rechargeable light intended to have a solar panel, a gas stove, and solar geyser, but could not afford them.

The narratives from homeowners showed that none of them had installed solar panels as part of their backup plans. Participants in their narratives indicated that installing solar PV was beneficial as a long-term solution to load shedding, reducing dependence on Eskom. They believed that with solar PV, they would have increased energy independence and be less vulnerable to power outages. Thandi shared similar views, stating "…*you will be able to plan your life when you have those solar panels because when there is load shedding, you are not affected. You will still have your electricity in your house, then your life will continue as normal."* While the participants expressed the benefits of installing solar PV, some, participants like Thandi, demonstrated a lack of knowledge about the appropriate size of solar panels needed to run a geyser, stove, and washing machine. They mentioned that using solar PV would help them save on high electricity bills. Interestingly, they were also aware that using green energy protected the environment. For instance, Joseph stated that using solar PV reduced carbon emissions, while Nkosinathi mentioned that it improved the environment by reducing reliance on fossil fuels.

Interestingly, the participants were quite aware that the installation of solar PV was beneficial not only for themselves but also for Eskom. They believed that solar installations could ease pressure on the National Grid. Nkosinathi noted that the installation of solar panels would reduce reliance on the grid, leading to lower electricity demand during peak hours on the grid. Although some participants were not fully aware of the exact consumption levels of households, they believed that solar panel installations would benefit Eskom. Thandi said:

"They will assist the Grid as much as I cannot really quantify how much the households use. For now, almost 90% of South Africans use electricity, so if

households can put solar panels, that will ease the pressure on the national grid (Thandi, household owner).

Like household owners, the majority of the small business owners highlighted that it was good to install solar PV systems. They linked the advantages of solar installation to the potential savings for their businesses from excessive power cuts. Some believed that using solar energy would be cheaper because the energy would be coming directly from the sun. They viewed solar panels as a viable solution to expand their businesses and reduce reliance on Eskom's electricity, which is unreliable due to frequent load shedding. They believed that installing solar panels would lower their operating costs. From the participants' narratives, it can be noticed that load shedding inconvenienced them and created a sense of hopelessness. Small business owners mentioned being inconvenienced in various ways, including not being able to access virtual platforms to conduct their work and being unable to make phone calls. Both small business owners and homeowners shared a common challenge of struggling to plan their days effectively due to load shedding, as they were forced to schedule their activities around power outages. Lesebe, a business owner said:

"In the past, you could plan your day from 7:30 to 4:00 or 5:00. sometime. Then you would work long hours. Now we can't do things at a certain time" (Lesebe, small business owner).

Load shedding has presented numerous challenges for these individuals, affecting their businesses. The participants described a scenario where operations came to a standstill due to power outages. Both small business owners and household owners alike reported increased travel times due to load shedding-induced traffic congestion from non-functional traffic lights. Some of the small business owners highlighted problems with the water supply, as electricity is essential for pumping water. They expressed concerns of how as small business owners who are operating small supermarkets are having some of their products like meat, getting rotten and having to throw it away. Furthermore, the need to use costly generators during load shedding has forced businesses to increase product prices, straining budgets and productivity. Some stated that loadshedding had let their business down, for instance, Charlotte said:

"Firstly, load shedding has affected our productivity. Secondly, it has thrown us out of budget, and being a small business, it is an extra cost" (Charlotte, small business owner).

Participants whose business relied on Wi-Fi expressed concerns about experiencing delays due to load shedding, which affected the Wi-Fi speed. They struggled to access essential websites, causing work that normally took a day to extend to four days to be completed. One small business owner emphasized that tax-related problems were at the core of their business operations. During load shedding, websites like SARS e-filing and government portals such as CIPC which they dealt with, were often down the whole day. This affected productivity, as they could no longer guarantee delivery times to their customers. This led to customers not paying once off for their work to be done, like they used to before, instead they paid in instalments until they had received their work. The instability caused by load shedding made it challenging for small businesses to retain customers, further impacting their ability to attract new ones. Most of the small business owners mentioned that their businesses are small and lack resources, putting up a generator during loadshedding would be costly. Spending money on petrol during these periods was seen as a significant financial drain. Some reported running generators during load shedding hours without making any sales, effectively losing money. Only a few small business owners used generators for backup during load shedding. For instance, one business owner who previously used an inverter saw their batteries weaken from frequent power cuts and resorted to using a generator to power the inverter, which proved costly to maintain and operate.

Some small business owners mentioned their inability to afford a generator during load shedding, forcing them to schedule their days around power outages, which resulted in numerous customer complaints, especially among those running printing businesses. Lesebe expressed: "*I must always apologize to my customers that what I need to do for them might not be delivered on time."* Despite financial constraints preventing them from investing in backup power solutions, many recognized the value of owning a generator or installing solar panels. They noted that while generators require ongoing expenses such as diesel and maintenance, solar panels offered a more cost-effective solution over time. Interestingly, some of the business owners

knew the installation costs of the solar panels for their business. One of the businessmen, Kunutu said:

"If it's a solar, you may spend R150 000 for the installation, but you can forget about costs for the next 5 years or so, depending on the type of batteries. But if it's a generator, every time you must buy diesel and service the engine. Solar will be the first option because there are no day-to-day operating costs, it's a once-off payment for the next 5- 6 years" (Kunutu, small business owner).

Policy makers, along with household and small business owners, agreed that installing solar panels was a good idea to address the power cuts challenges faced in the country. They all pointed out that the solar PV installations could reduce electricity demand from the grid and lower electricity bills. For instance, Melinda, a 43-year-old female policymaker, stated: *"Solar PV systems can help to reduce power demand from the grid, which can ease load shedding."* The consensus on solar panels' potential to reduce electricity costs was echoed by household owners, small business owners, and government officials alike. Policy makers also shared the belief with some households that solar energy is a clean and renewable energy source, contributing to a reduction in reliance on fossil fuels. They highlighted how solar systems could positively impact the environment by decreasing reliance on coal-fired energy, thereby reducing greenhouse gas and carbon emissions and improving air quality. Some policymakers, like Melinda, noted the potential for increased energy independence and property value due to solar installation.

All participants interviewed in this study, except for Eskom workers, shared the belief that widespread adoption of solar panels could reduce demand on the grid and alleviate load shedding. For example, government officials like Charles, a 45-year-old male, advocated for supporting the installation of solar panels in households and small businesses, arguing that even though these entities consume less energy compared to large companies, their cumulative impact could make a significant difference in reducing overall consumption. In contrast, Eskom workers expressed scepticism about the effectiveness of solar panel installations as a solution to power cuts. They argued that solar panels only provide energy during load shedding periods and do not address the underlying problems causing power interruptions. According to them, the primary solution lies in repairing the infrastructure of power stations to ensure reliable

electricity supply to the country. Despite this scepticism, some Eskom workers acknowledged the benefits of solar PV systems, contingent on favourable weather conditions. This concern about energy storage during load shedding was also shared by small business owner Charlotte, who wondered if the energy could be stored to sustain operations during power outages.

Government officials, like household owners, small business, and installers, acknowledged that installing solar panels involves a high upfront cost but highlighted that this cost is one-time investment compared to the ongoing expense of using generators fuelled by diesel. They also emphasized that adopting solar panels can reduce electricity bills. These sentiments were echoed by household owners, small business owners, and policy makers. Some government officials suggested that supporting widespread solar panel installations could help the economy, mitigating the impact of load shedding. One of the officials pointed out potential job creation opportunities through solar system installations, a perspective not raised by small business owners, household owners, and policy makers. They shared the belief with small business owners that installing solar systems was beneficial for business continuity during load shedding, ensuring uninterrupted operations.

In a nutshell, while participants acknowledged the benefits of solar PV such as reducing reliance on Eskom, lowering electricity bills, and easing pressure on the national grid, many cited the high upfront costs as a significant barrier to adoption. Small business owners also emphasized the potential economic advantages, including lower operating costs and uninterrupted operations during power cuts. Policymakers and government officials supported these views, noting the environmental benefits of solar energy and its potential to promote energy independence and job creation. However, Eskom workers expressed doubts about the effectiveness of solar PV as a comprehensive solution, arguing that resolving the underlying infrastructure problems at power stations is crucial for reliable electricity supply.

4.4 Factors impeding the uptake of solar systems in households and small businesses

This section presents the narratives of participants regarding the first objective of the study: to identify factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa. A common recurring theme in the participants narratives was the concern over the costs involved in purchasing solar hardware and the installation.

4.4.1 Installing solar PV is costly

Based on the narratives of the participants, the high costs associated with purchasing and installing solar hardware explain the slow uptake of solar panels. All participants in the study noted the expense involved in acquiring solar PV hardware and arranging for its installation. They highlighted the high prices of solar PV systems and the costly installation processes. Most of them expressed interest in adopting solar panels but cited financial constraints as a barrier. For instance, Thandi, a homeowner, stated: *"…I can use solar panels if they were very cheap, but as it is I don't have them because I can't afford them, not because I doubt their effectiveness…"* In the participants narratives it was clear that the initial cost of installing the solar system was costly not only for them but for the majority of ordinary South Africans. Despite these challenges, some household owners observed that the prices of solar hardware and installation were gradually decreasing in the country. Some participants like Peter were quite knowledgeable about the prices, he described how the costs of a solar system are determined by the size of the system, type of the solar panels and labour costs.

Small business owners shared similar views with household owners regarding the high costs of purchasing and installing solar systems. Most participants described these costs as exorbitant, noting that installing a 12 kW PV system required a one-time payment of R250,000. They all agreed that this amount was substantial for small business owners, given the nature of their businesses, which could not easily raise such a large sum upfront, Kunutu said:

"…R250 000 is not an amount that someone can pay in cash unless the business is doing very well. So, the main problem is the cost. Maybe we need to follow the strategy used by Muammar Gaddafi in Libya, where people didn't have to pay for electricity.

However, we don't know how he was compensating for it" (Kunutu, small business owner)

Some small business owners felt that the upfront costs required to install a PV system did not make financial sense for their operations. They mentioned that using a generator was more practical, as during stage 6 load shedding, which involved staying 10 hours without power, they incurred monthly costs of R28 000. They also noted that the costs of one lithium battery alone was almost the same as the total cost of solar panels. Thus, they found using a generator more feasible than paying R80,000 upfront for solar panels. However, the same participants acknowledged that installing a PV system is cost-effective in the long run. Despite viewing the installation costs as exorbitant, their primary concern was the high upfront cost, which they could not afford. Only one small business owner stated that it was not just the costs of the PV system that stopped him from installing the system but also the fact that he was renting the premises where he operated his business. He mentioned that he initially relied on a generator but later stopped due to the high costs of diesel. Other tenants who also rented the premises were unwilling to pay extra for diesel. Further explaining his situation, Kunutu said:

"The cost of diesel is the problem because we are tenants. Some agree, and others do not agree to pay extra on the rental to cover the diesel costs" (Kunutu, small business owner).

All the participants interviewed in this study mentioned that high costs were a significant factor in the slow adoption of solar installations in households and small businesses. Installers also emphasized that the high costs of solar hardware and installation labour posed a barrier to the widespread installation of solar panels. Most of the installers described the hardware costs as overpriced. Peter, a 46-year-old male, solar installer, mentioned that the average cost to install a 5kW rooftop solar PV system is around R70,000 while a 8kW rooftop solar PV system is around R140,000. Eskom workers shared similar views, stating that the costs of solar PV systems were too high. However, they noted that in the long run, people would be relieved from paying tariffs. For instance, Themba a 40-year-old male, Eskom worker, said:

“In the long run, they don’t pay tariffs, so it will be a saving for them if they install a good solar system that can sustain them for long periods, not only during load shedding but all the time” (Themba, Eskom employee).

However, one of the installers mentioned that the cost of solar hardware is slowly decreasing, which might make it more affordable in the future. These views were also shared by household owners, policy makers and government officials.

4.4.2 Solar systems and weather concerns

Some participants had concerns about the reliability of solar power, particularly during extended periods of cloudy or rainy weather or at night when no sunlight is available. They lacked confidence in the performance and dependability of solar systems, worrying about their ability to generate sufficient electricity under various weather conditions. They were all aware that solar panels depend on sunlight to produce electricity, and small business owners, such as Kunutu, mentioned that Gauteng often experiences cloudy or rainy weather, which might affect solar panel users. A homeowner, Charlotte, expressed similar concerns about the sustainability of solar systems during bad weather. Participants also noted that during the winter months, shorter daylight hours and lower sunlight levels can lead to reduced energy output, contributing to doubts about the reliability of solar systems. These views highlight the concerns potential users have about the ability of solar panels to consistently produce adequate power.

4.4.3 Lack of knowledge of solar systems

The installers also highlighted other factors impeding the installation of solar panels, such as a lack of awareness about solar PV and insufficient financing options. Most homeowners and small business owners lacked knowledge about how solar systems work and their reliability. This lack of awareness about the benefits and limitations of solar power contributed to the scepticism among some participants. Charlotte, for example, believed that installing solar was a good option to deal with load shedding but had limited knowledge of how it would perform under unfavourable weather conditions common in Gauteng in summer, such as cloudy or rainy days. Her concerns centred on its reliability and sustainability, questioning whether it could provide continuous power during bad weather and if it would frequently require system upgrades. Some participants believed it was wise to have both solar panels and

generators, considering that bad weather could disrupt solar energy supply. For instance, Kunutu, a 50-year-old business owner with eight years of experience, said: *“…solar will be one of the options, and on the other side, have other options like generators. But when the weather is bad, you go back to zero unless you have a power backup system, which becomes pricey” (Kunutu, small business owner)*

The problem of reliability in unfavorable weather conditions indicates that some participants, particularly homeowners and small business owners, were not well-informed about how solar systems operate, and the advancements in energy storage technology. This lack of knowledge includes understanding how solar energy can be stored for use during load shedding and the possibility of relying solely on solar systems without needing Eskom. This is evident when some participants questioned whether one could solely rely on solar panels without any other form of backup. They mentioned that households using solar panels also relied on Eskom. This uncertainty is highlighted by Thandi, who said" *…my concern is I have not heard of anyone who has used the system without a backup*." Although participants were aware of the benefits of solar panels, they had misconceptions about their effectiveness during cloudy or rainy days, particularly regarding energy storage capabilities. One of the participants suggested having a generator as a backup plan for solar panels. Installers mentioned that conducting awareness campaigns on solar systems in the country could help address this knowledge gap.

This section highlighted the narratives of the participants concerning factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa. The primary barrier, as expressed by participants, is the high cost of purchasing and installing solar photovoltaic (PV) hardware. Many participants, including both homeowners and small business owners, cited the significant upfront financial burden as a key barrier. Household owners unanimously stated that the expense of both the hardware and installation was prohibitive, stopping many from investing in solar panels despite recognizing their benefits. Small business owners shared these sentiments, describing the costs as exorbitant and highlighting that the initial outlay required for solar installation was beyond the financial reach of many small enterprises. Even though some noted that prices are gradually decreasing, the initial costs remain prohibitive for many. Concerns about the reliability of solar power, particularly during

cloudy or rainy weather, also contribute to hesitation. Participants expressed doubts about the consistent performance of solar systems under varying weather conditions, reflecting a lack of confidence in their reliability. Additionally, there is a noticeable lack of knowledge and awareness about how solar systems work, their benefits, and advancements in energy storage technology. This lack of understanding further contributes to scepticism and reluctance to invest in solar solutions.

4.5 Feasibility of implementing solar PV systems

This section answers the second objective of the study, which was to determine the feasibility of implementing solar PV systems in households and small businesses of Gauteng.

4.5.1 High costs make installation not feasible

The participants' narratives highlight their shared views on the feasibility of installing solar PV systems. When asked about the practicality and effectiveness of installing solar photovoltaic (PV) systems as a solution to load shedding for households and small businesses, most participants acknowledged its effectiveness but doubted its practicality due to economic challenges affecting affordability. They mentioned that the high prices of PV solar hardware and installation made it an impractical solution for many households and businesses. Thandi and Joseph had this to say:

"… I do not afford them, so they are not a viable solution. They are meant for the few who can afford, who are in the higher tax bracket, not any ordinary average South African" (Thandi, household owner).

"In my opinion, the costs for PV solar hardware and installation in SA are still relatively high" (Joseph, household owner).

In agreement with the views expressed by the household owners, Eskom workers stated that the installation of solar PV systems is impossible for the poor because of the high costs which ordinary South Africans cannot afford. Siyabonga, a male worker at Eskom said: "*It is not feasible for the poor; it is the middle class and industrial customers who can afford it*". Government officials also highlighted the installation costs, specifying that the price for a typical residential solar PV system range between R50,000 and R300,000, depending on the size and components required. They

attributed these high costs to the importation of hardware such as batteries, panels and inverters, noting that local manufacturing of these components could significantly reduce prices.

Interestingly, policymakers shared similar sentiments with household and small business owners regarding the feasibility of installing solar PV systems. They acknowledged that high installation costs were a significant barrier for households and small businesses. Lebo, a 43-year-old female policymaker, pointed out that the lack of regulation in South Africa allows market forces to drive up costs, despite expectations that solar panel prices would decrease. She emphasized that high costs continue to hinder widespread installation at the household level. Policy makers believed that without additional incentives, installations would be limited. Melinda mentioned existing government incentives aimed at making costs more affordable, but another policymaker noted that these incentives may primarily benefit high-income individuals. For instance, Lebo said: "*I think technically, when they put together that incentive package, they are mostly thinking about high-income and high net worth individuals who had already planned".* Contrary to the policymakers' perspectives, household and small business owners expressed a lack of awareness regarding such incentives. They suggested that if the government could incentivize solar panel installations, it would assist them.

4.5.2 The government's intervention can make it feasible

Some installers emphasized that the feasibility of implementing solar panels depends on government intervention. They suggested that incentivizing the costs of solar PV hardware and installation could benefit households and small business owners. Similarly, some household owners believed that practicality in installing solar PV systems will only come about if the government subsidizes prices. Some participants expressed that government encouragement could be pivotal, proposing financial incentives like tax breaks or rebates to promote solar PV adoption. Joseph, for instance, advocated for a reduction of import duties on solar PV hardware. Participants also stressed the importance of government-led awareness campaigns about the benefits of solar PV systems. Others suggested that technical assistance should be provided to households interested in installing solar systems.

They believed that if the government could facilitate easier access to loans for financing solar PV installations, it would encourage more households to adopt solar systems. Participants also identified public education about the benefits of solar PV and its installation process as crucial government interventions. However, some participants suggested that providing solar panels for free could be particularly beneficial. Nevertheless, the participants acknowledged that obtaining free solar panels was unrealistic due to government budget constraints. Thandi explained:
“If these solar panels were free, but nothing is free, right? Or the government subsidized them, maybe then we could afford them. But in terms of buying them outright, that's out of reach for us. So, the only way we could have them is if the government says, 'Here are solar panels,' but can the government afford to do that? I don’t know. (Thandi, household owner).

Surprisingly, later in the interview, Thandi expressed that she believed it was the government's responsibility to roll out solar systems to every household. She emphasized the government's role in ensuring protection from thieves who might target solar panels. This stance appears contradictory to her earlier statement where she mentioned the government assisting with installation but dismissed the idea due to perceived costs. However, she later expressed confidence in the government's potential to assist with both installation and security. Furthermore, Thandi suggested that the government should focus on ensuring high energy consumers, such as platinum users and miners, adopt alternative power sources like solar panels. She stated that ordinary citizens consume comparatively little power even with various luxuries, implying that government policies should prioritize addressing high energy consumption sectors. Thandi's viewpoint was as follows:
“The focus should be on high energy consumers to get alternative sources of power, like installing solar panels, such as platinum users and miners, because we as consumers do not have the millions and billions that they are generating. An ordinary citizen consumes very little power, even with all the luxuries that I have. The government must create a policy to deal with high energy users,” (Thandi, household owner).

Interestingly, some of the government officials were quite aware that only the affluent in South Africa can afford solar panels, which they have installed in their homes and

businesses. They acknowledged that many South Africans, particularly small businesses operated by black individuals, struggle with financial constraints. To address this disparity, government officials like Mpho proposed interventions aimed at narrowing the energy inequality gap in the country. Mpho suggested that the government could provide financial guarantees or backing (surety) to consumers interested in installing solar PV systems. Mphahlele, another government official, supported this idea, stating, *"I think the government should provide consumers with support in the form of surety. This would help to make solar PV systems more affordable and accessible to more people."* It is interesting to note that some government officials recognized their role in making solar system installations feasible for households and small businesses.

4.5.3 Affordable financing options make it feasible

All small business owners unanimously agreed that installing a PV system would only be practical with financial assistance. Their narratives clearly expressed a need for support to enable them to afford solar panel installations. They emphasized that access to loans, subsidies, or instalment plans would influence their decision to adopt solar systems. Without such financial assistance, they believed the high upfront costs would make installing solar systems unfeasible. They saw the value of solar panels in improving business operations, especially in mitigating the impacts of load shedding.

However, some small business owners expressed a preference for receiving donations to install solar panels rather than taking out loans. They cited the uncertainty of business income as a barrier to borrowing money. Kunutu specifically mentioned that repaying a loan would add to their financial burden, given their current struggles to generate sufficient income. Some participants indicated that even assistance with the installation of PV systems, without direct financial support, would be beneficial.

Small business owners like Charlotte emphasized that due to load shedding, predicting the future of their businesses has become increasingly difficult. Some suggested that government intervention through the installation of PV systems with low-interest financing, allowing for monthly instalments over a period of two years or more, would greatly enhance business reliability. However, Charlotte also expressed scepticism about government assistance, fearing that changes in government leadership could lead to policy reversals and abandonment of energy crisis solutions.

Despite political uncertainties, she believed that having PV systems installed would ensure continued business operations even during ongoing electricity challenges.

According to policy makers, providing financial support was deemed crucial to making solar system installations feasible. Some advocated prioritizing small business owners and proposed options such as low-interest loans or grants. Given the persistent nature of load shedding, attributed to challenges like aging infrastructure, high debt levels, and insufficient investment in new generation capacity by the South African government, policy makers acknowledged that Eskom would require several years to improve capacity and reduce load shedding.

This section highlights the findings of the study which answers the second objective of the study. The findings reveal mixed perspectives on the feasibility of implementing solar PV systems in households and small businesses in Gauteng, emphasizing economic challenges and the high costs of solar hardware and installation as significant barriers. Participants, including household owners, small business owners, and Eskom workers, noted that the high prices make solar PV systems impractical for many, especially the poor. They suggested that government intervention, such as subsidies, and financial incentives could enhance affordability. Additionally, policy makers and installers highlighted the need for financial support mechanisms, like loans and tax breaks, to encourage solar adoption. Government officials also recognized the importance of public education on solar benefits and proposed collaborations with banks and donors to reduce costs. Ultimately, the feasibility of solar PV systems depends on substantial government support and financial assistance to overcome the economic barriers faced by households and small businesses.

4.6 Recommendations and strategic support on solar adoption

This section presents findings aimed at addressing the third objective of the study: to provide recommendations and strategic support to assist in the installation of solar panels in households and small businesses in Gauteng.

4.6.1 Policy makers views

There were varying opinions among policy makers regarding the government's potential role in assisting households and small business owners with solar PV systems. Philip, a 45-year-old male policy maker, believed that the government could support households in installing solar PV systems. Others emphasized the need for government assistance specifically targeting small business owners. Interestingly, some policy makers shared similar views with small business owners on how the government could provide support. This includes offering financial incentives like tax breaks or rebates to make solar systems more affordable. In addition, some municipalities in the country are offering services to assist in the installation of solar systems, which can alleviate the financial burden for individuals looking to go completely off the grid. Policy makers also highlighted the importance of government-led initiatives to educate households about the benefits of solar energy and facilitate easier access to quotations from solar installers. Philip suggested that this could be achieved through the creation of a database of solar installers or the provision of a comparison tool.

Apart from the government providing financial assistance, policy makers suggested several measures to enhance the generation capacity. These include expanding renewable energy projects such as solar and wind farms, upgrading the transmission and distribution network, and promoting energy efficiency. Regarding solar installation options, one policy maker discussed the choices available: off-grid, grid-tied, or hybrid systems. He advised that grid-tied solar systems are generally the most cost-effective option. Off-grid systems, on the other hand, are suitable for households or businesses not connected to the grid, while hybrid systems combine both grid-tied and off-grid capabilities, offering greater self-sufficiency. Melinda, another policy maker, recommended grid-tied solar PV systems to households, citing their affordability and practicality. She emphasized that grid-tied systems can power homes during the day and allow for the export of excess electricity back to the grid, providing potential financial benefits to users.

4.6.2 Government officials' views

Government officials presented varied perspectives on how the government could support the installation of solar systems, contingent upon the willingness and capability

of the government to assist. These views contrasted with those expressed by policy makers and small business owners, who cited numerous governmental challenges and constraints hindering assistance. One government official stressed an existing intervention demonstrating the government's supportive role: the Energy Efficiency and Demand Side Management (EEDSM) programme. Managed by the Department of Energy, this programme optimizes energy use and enhances efficiency nationwide. It supports municipalities in reducing electricity consumption through initiatives such as upgrading traffic and street lighting, improving energy efficiency in buildings, and enhancing water service infrastructure. Grants are provided for these projects, with goals including rapid relief to the power system, reducing greenhouse gas emissions, and lowering energy costs for users. Moreover, the government officials emphasized that the government underscores its commitment to transitioning to renewable energy sources through this program. They cited initiatives such as electrifying villages with solar panels for lighting and charging, thereby creating households less reliant on Eskom for electricity.

Government officials highlighted the potential role of banks in facilitating the financing of consumers interested in installing solar panels. They suggested that if banks could collaborate with the government, the government could subsidize a portion of the financing. This approach would help keep interest rates manageable, thereby reducing the burden of higher monthly installments for consumers. The government officials emphasized that the subsidies were important, particularly given the high cost of living, which might otherwise discourage households and small businesses from taking out loans to install solar energy. Moreover, government officials shared common ground with small business owners in exploring partnerships, with donors interested in promoting green energy. They acknowledged that securing funding from donors committed to transitioning to cleaner energy sources could contribute to the widespread installation of solar panels in households and small businesses. For example, Charles illustrated how banks are already facilitating such initiatives:
“I know of a program from Nedbank that offers consumers funding for installation, with repayments spread over five years. This is beneficial because many people cannot afford, for instance, a 5kW system costing 150K” (Charles, government official).

Government officials emphasized that promoting the use of clean energy through the installation of solar panels in households and small businesses addresses two critical problems. Firstly, it reduces the impact of load shedding by lowering electricity demand. Secondly, it helps stabilize the economy, as prolonged power cuts during load shedding severely affect businesses, especially small enterprises lacking backup systems. They also highlighted that advancing clean energy aligns with South Africa's Integrated Resource Plan (IRP), which sets targets to be achieved by 2030, including decommissioning coal plants and increasing renewable energy sources. To advance this agenda, government officials discussed the need to explore ways to support the installation of solar systems, addressing the prevalent concern about high costs that currently hinder many households and small businesses. Views among government officials varied regarding the optimal solar installation options available—off-grid, grid-tied, and hybrid systems. Mpho favoured grid-tied systems for businesses, noting their ability to integrate with the grid and provide continuity during power outages. Meanwhile, households could consider off-grid systems, though sufficient energy storage is essential for nighttime use. Charles proposed hybrid systems, citing their versatility with inverters, though he acknowledged the costliness of storage. Ultimately, the choice of solar installation, according to Charles, should align with specific energy needs and usage patterns.

4.6.3 Installers views

In supporting both household and small business owners, installers emphasized the importance of specifying appropriate solar PV system sizes tailored to different needs. According to most installers, a 3 kW-5 kW system is suitable for households in townships, while a 5 kW-8 kW system is recommended for small businesses and middle to upper-class residential households. These systems are deemed capable of meeting basic domestic needs such as lighting and refrigeration, with power supplies lasting for at least 12 hours after a power cut. Installers generally advocated for grid-tied solar PV systems across townships and middle to upper-class residential areas due to their affordability and effectiveness. Peter highlighted this perspective, stating: *“I would recommend a 3 kW-5 kW system for townships and a 5 kW-8 kW system for small businesses and middle to upper-class residential houses. These systems are more affordable and can still provide enough power. However, households needing*

power for pumping boreholes or operating electric gates would require a 5 kW system" (Peter, Installer).

They also emphasized the importance of educating households and small business owners about solar PV hardware, as choosing an inappropriate system like a 3KVA could fail to support their appliances effectively. Most of the installers proposed that the government could facilitate the widespread installation of solar panels in households and small businesses by offering support in the form of surety. This approach, they argued, would make solar PV more affordable and accessible. For example, Eric explained how surety could function:
"If the government can provide surety between the installer and the consumer, ensuring that if the system does not perform as expected for a specified period, the government compensates the installer partially, allowing the installer to pay monthly instalments to the government while resolving the problem" (Eric, installer).

The installers echoed the sentiments of policy makers regarding the potential benefits of providing tax breaks and other incentives to encourage the installation of solar PV systems. James, a 40-year-old male installer, suggested an additional idea: *"The government could also consider constructing one or two solar plants that can integrate into the grid when the coal-powered system is offline."*

4.6.4 Eskom's recommendations

Based on the narratives of Eskom workers, it is evident that they do not see the installation of solar systems as a comprehensive solution to the country's power cuts. Instead, they advocate for infrastructure maintenance at Eskom as the primary solution. They emphasized that, while households can use temporary measures such as gas and portable solar for basic lighting, the fundamental problem lies in repairing and maintaining Eskom power stations. Kgothatso, a 39-year-old male Eskom worker, explained why fixing the power stations is the best approach:
"I think the best and most viable option for now, or the quickest solution, is fixing the power stations. The reason I'm saying this is because to develop a project from scratch and get it connected to the grid is not going to be as quick as everyone hopes. So, if given the options, you put a wind turbine or repairing a unit, repairing a unit is going to

be quicker and provides an immediate solution. I think the better and quickest solution is to fix or take some units on an outage and fix them" (Kgothatso, Eskom employee).

Most of the Eskom workers expressed scepticism about nuclear energy as a solution. Kgothatso clearly stated, "*Well, I wouldn't build a Nuclear Power Station, that's for sure, at Eskom*." They emphasized that Eskom lacks interventions to support the repair of its power stations. Additionally, they suggested making use of the abundant wind resources in South Africa by installing more wind turbines along the coastlines. Kgothatso proposed a strategic approach involving neighboring Mozambique to harness natural gas resources: Kgothatso explained how the country can make use of the wind:
"Given the intermittency of wind, I'm of the view that South Africa must maybe approach Mozambique to see what portion of the gas can be obtained, especially given Mozambique's proximity to Mpumalanga, maybe with a chance of converting one or two of the power plants of Eskom from coal to gas" (Kgothatso, Eskom employee).

Interestingly, some of the Eskom workers highlighted the benefits of grid-tied solar systems. They explained the financial and practical advantages of connecting solar PV systems to the grid in South Africa, emphasizing that this approach could lead to quicker financial returns and more efficient use of solar-generated electricity. For instance, Siyabonga suggested that the most effective approach for using solar PV systems would be to connect them to the national electricity grid. The Eskom workers stated that a grid-tied solar PV system is connected to the public electricity grid so that when the solar panels produce more electricity than is needed, the excess can be sent back to the grid. Based on the Eskom workers' narratives; by being grid-tied, household and small business owners can sell excess electricity back to the grid, thus earning money or receiving credits on their electricity bills. This additional income would help them recover the initial investment costs more quickly.

This section presented findings on the third objective of the study. Overall, the findings highlight diverse perspectives on supporting the installation of solar panels in households and small businesses in Gauteng. Policy makers suggested various government roles, including financial incentives, educational initiatives, and municipal

support services, to facilitate solar PV adoption. They emphasized expanding renewable energy projects, upgrading infrastructure, and promoting energy efficiency, recommending grid-tied systems for cost-effectiveness. Government officials discussed leveraging existing programs like the Energy Efficiency and Demand Side Management (EEDSM) and collaborating with banks and donors to make solar PV more affordable. Installers underscored the importance of appropriately sizing systems and suggested making government surety to ensure system performance. Eskom workers, however, argued that fixing power stations is the immediate solution to power cuts, though they acknowledged the benefits of grid-tied solar systems for financial returns and efficient electricity use. They also dismissed nuclear energy as a viable solution, suggesting wind and natural gas as alternative resources.

4.7 Conclusion

The findings from this study highlight the factors impeding the uptake of solar systems in households and small businesses in Gauteng. Primarily, the high costs associated with purchasing and installing the hardware were identified as a major obstacle for both household owners and small business owners. Additionally, concerns about the reliability of solar power during adverse weather conditions and a lack of knowledge about solar technology contribute to scepticism and reluctance to invest in these systems.

The chapter also presented the diverse viewpoints on the feasibility and implementation of solar PV systems in households and small businesses across Gauteng, amidst the challenges posed by load shedding. The findings revealed mixed views on the feasibility of implementing solar PV systems in households and small businesses pointing out that the high costs of solar hardware made it impractical to install solar systems. Participants, including household owners, small business owners, and Eskom workers, pointed out that these high prices render solar PV systems impractical for many, particularly lower-income individuals. They highlighted that that affordability remains within reach primarily for wealthier individuals rather than ordinary South Africans. Participants suggested that government intervention, such as subsidies, and financial incentives, could enhance affordability and make solar systems feasible. From the findings it is evident that the feasibility of solar PV systems

in Gauteng depends on substantial government support and financial assistance to overcome economic barriers. These findings highlight the role that government support and financial assistance can play in overcoming economic barriers to the adoption of solar PV systems in Gauteng.

The study offered recommendations and strategic support aimed at facilitating the installation of solar panels in households and small businesses across Gauteng. Participants proposed that effective government intervention, including financial incentives, subsidies, public education campaigns, and partnerships with financial institutions, would enhance the feasibility of solar PV installations. Policy makers and installers advocated for mechanisms such as loans and tax breaks, while government officials emphasized the importance of educational initiatives and municipal support services to promote widespread adoption of solar systems. They highlighted that such initiatives could ease strain on the national grid and advance renewable energy goals. However, Eskom workers cautioned that while solar PV systems offer benefits, they are not a comprehensive solution to the power crisis, stressing the essential need for infrastructure improvements at power stations to ensure reliable electricity supply.

CHAPTER 5: DISCUSSION

5.1 Introduction

Off-grid generation systems like solar photovoltaics (PV) are increasingly recognised as a viable option for supplying electricity to off-grid and under-electrified households (Ntayi, et al., 2021). Solar PV installations have traditionally been associated with rural areas, where many households are not connected to the grid. Urban areas are connected to the national grid, which supplies them with electricity. However, due to frequent power outages and the unreliability of Eskom's supply, South Africa has been facing persistent power cuts, with load shedding introduced to manage electricity

demand. The introduction of load shedding has led both households and businesses to seek alternative electricity sources, such as installing solar PV systems. While households in South Africa are investing in sustainable energy technologies like rooftop solar PV systems, such adoption is still not widespread (Korsten et al., 2017). This study explored the views of households and small business owners regarding the installation of solar PV systems. This chapter presents the themes identified in the study and discusses them in relation to existing literature. A dominant theme that emerged is the high cost of solar PV systems, which affects installation decisions.

5.2 Solar PV: A good backup solution for loadshedding

This study explored the perspectives of household owners and small business owners regarding the installation of solar systems. The responses from the participants showed that rooftop solar PV systems are beneficial in reducing their reliance on Eskom and promoting savings on electricity costs. This is in line with studies that have shown how using solar PV systems can result in savings on electricity purchased from municipalities (Korsten et al., 2017). Households connected to the grid often adopt solar systems either to reduce electricity expenses or as a backup for an unreliable power supply (Aklin et al., 2018; Ngonda et al., 2023).

Participants believed that by installing solar PV, they could achieve energy independence while also helping to ease the burden on the national grid. This is consistent with a study in Malawi that highlights the benefits of off-grid solar adoption, including energy independence, reliability, and cost savings (Ngonda et al., 2023). However, Eskom workers expressed scepticism about whether solar PV installations could effectively reduce pressure on the national grid. This scepticism likely stems from their preference for focusing on infrastructure development or repairs at Eskom to address the country's power problems, rather than relying on alternative energy solutions. Their reluctance could also be attributed to concerns about job security and maintaining Eskom's role as the primary electricity provider. Similar concerns have been noted in studies in South Africa, where it is believed that widespread solar PV adoption could negatively impact municipal revenues (Korsten et al., 2017). Nevertheless, the idea that increasing the uptake of solar PV could alleviate pressure

on the national grid is supported by studies indicating this potential benefit (Eberhard & Naude, 2016).

The findings highlight how policymakers and government officials perceived solar PV installations as beneficial for reducing electricity bills while also promoting renewable energy and environmental sustainability. These perspectives are consistent with the literature that encourages the use of solar PV as a clean energy source that supports environmental sustainability (Njoku & Omeke, 2020). Moreover, solar PV contributes to mitigating the effects of climate change, supports decentralized energy systems, reduces reliance on energy imports, and minimizes the need for extensive grid infrastructure (Ebhota & Tabakov, 2021). Increasing access to affordable and clean energy through solar PV systems is anticipated to advance the achievement of the seventh Sustainable Development Goal (SDG 7) in many developing countries (Dagnachew et al., 2017). While participants viewed solar PV as an effective backup solution for load shedding, they recognized that it remains unaffordable for most ordinary South Africans.

The problem of solar PV affordability for households and small businesses is a widespread challenge across many Sub-Saharan African countries (Kizilcec et al., 2021; Ngonda et al., 2023). In Uganda, for instance, over 70% of the population lacks access to electricity (Ssennono, et al., 2021). Participants believed that once they installed solar PV, they would no longer need to plan their daily activities around load-shedding schedules. This experience is common across Sub-Saharan Africa, where those who cannot afford alternative energy sources must plan their day based on electricity availability (International Energy Agency (IEA), 2019). South Africa, once known for reliable electricity provision, now faces similar challenges to those encountered in other countries struggling with electricity reliability (Ebhota & Tabakov, 2021).

The findings show that load shedding negatively impacts small business productivity, with some businesses forced to close and others incurring additional costs to run fuel-powered generators. Small business owners reported financial losses due to the high costs of operating generators, which in turn led to increased product prices and difficulties in meeting delivery deadlines. Although they had not yet installed solar PV

systems, many business owners recognized the potential economic benefits of solar PV in reducing operational costs and maintaining productivity during power outages. This is consistent with a study in rural Malawi, which found that businesses using solar energy for irrigation spent less compared to those relying on expensive fuel-powered engines (Ngonda et al., 2023). Considering that fuel expenses can be high without guaranteeing good crop yields, while those with solar energy can irrigate more efficiently and achieve better results (Ngonda et al., 2023). In Malawi, business owners also noted that solar PV increased productivity by allowing them to operate for longer hours after dark.

5.3 What is impeding solar PV installation in South Africa?

The study findings indicate that various factors impede the adoption of solar systems in households and small businesses. These include the high costs of solar hardware, concerns about the reliability of solar power during extended cloudy or rainy periods, at night when sunlight is unavailable, and a lack of knowledge about solar systems. These findings are consistent with other studies that have identified installation costs (Fashina et al., 2018; Qureshi et al., 2017; Rai et al., 2016); information and awareness (Jan et al., 2020; Ondraczek, 2013; Qureshi et al., 2017); and access to finance as key factors that influence the uptake of solar PV (Fashina et al., 2018). A study on the emerging solar market in East Africa (Kenya and Tanzania) found that awareness, availability, and affordability are the primary factors driving the adoption of off-grid solar technology (Ondraczek, 2013). Other studies highlight the importance of demographic and socio-economic factors, including age, gender, education level, household income, household size, assets, housing conditions and type, and rural residence in shaping residential adoption of solar PV in African countries (Guta, 2018; Rahut et al., 2018). For example, a study in rural Ethiopia found that wealthier and more educated households are more likely to adopt solar energy technology, while male-headed households are less likely to do so compared to female-headed households (Guta, 2018).

In rural India, households with access to electricity were more willing to invest in solar systems than those without electricity (Urpelainen & Yoon, 2015). The findings suggest that the affordability of solar PV systems is a barrier to adoption among households

and small businesses in South Africa. The findings indicate that solar PV is not affordable for ordinary South Africans, which is in line with existing literature showing that the middle-income group has largely driven the growth of the solar home system market in several countries (Hansen et al., 2015). The problem of affordability is a major problem not only in South Africa but in most parts of Sub-Saharan Africa. In many parts of the region, a large proportion of households remain without electricity due to governments lacking the capacity to electrify their countries, especially in rural areas (International Energy Agency (IEA), 2019; Ngonda et al., 2023). Even in areas with grid electricity, power outages are common, with over 30% of households reporting they rarely have access to electricity despite being connected to the grid (Blimpo & Cosgrove-Davies, 2019). Urban areas are also affected by blackouts due to the inability of electricity providers to deliver reliable power (Blimpo & Cosgrove-Davies, 2019). Recognizing the need for widespread deployment of solar PV systems at various scales across Sub-Saharan Africa could significantly help mitigate frequent blackouts and inadequate power supply (Ebhota & Tabakov, 2021).

The study's findings show that while household and small business owners are interested in installing solar PV, they are hindered by the high cost of both the systems and installation. Participants described the prices as exorbitant, noting that installing a PV system could require a one-time payment of up to R250,000—a substantial amount for both households and small businesses. Small business owners highlighted that their businesses could not easily raise such a large sum upfront, making rooftop solar panels an unrealistic option for many ordinary South Africans. This aligns with other studies showing that the high cost of solar hardware is a major barrier to adoption (Kurata et al., 2018; Palm, 2017; Qureshi et al., 2017; Shah et al., 2019; Sindhu et al., 2016). Overall, solar energy requires a significant initial capital investment, which individuals living in poverty often cannot afford (Adwek et al., 2020; Guta, 2018; Nygaard et al., 2017). Consequently, wealthier households are more likely to adopt the technology compared to poorer ones (Hansen et al., 2015).

The findings indicate that a lack of awareness is one of the factors impeding the installation of solar panels. Some household owners and small business owners were unfamiliar with how solar systems operate and their reliability. This lack of awareness about the benefits and limitations of solar power contributed to the scepticism among

some household and small business owners. For example, they lacked knowledge about the operation of solar systems and advancements in energy storage technology. They were also unaware of how solar energy can be stored for use during load shedding and the potential for relying entirely on solar systems without depending on Eskom. These findings are consistent with studies showing that slow adoption of solar PV is often due to insufficient understanding of how solar energy works (Vasseur & Kemp, 2015). Common concerns include whether the solar system will perform as expected (Vasseur & Kemp, 2015); fears about system reliability and potential breakdowns (Kurata et al., 2018); and doubts regarding durability (Palm, 2018; Walters et al., 2018). Social influence has a major impact on consumer behaviour when it comes to buying new products (Bollinger & Gillingham, 2012). The uptake of solar PV often depends on information and advice from trusted sources such as neighbours with solar PV systems, opinion leaders, and third-party agencies (Bollinger & Gillingham, 2012; Palm, 2017; Wolske et al., 2017). Neighbours who already have PV systems can motivate others to consider solar installation (Rai et al., 2016). Adoption by opinion leaders may also signal social acceptance and validate the suitability of the system (Curtius et al., 2018; Parkins et al., 2018). In some rural areas of Malawi, inadequate training has led to improvised and potentially hazardous solar PV installations. Participants in this study suggested that the government should provide public education about the benefits of solar PV and the installation process. Increasing awareness and understanding of solar technology can enhance adoption rates (Jan et al., 2020; Zander et al., 2019). These findings highlight the need for awareness campaigns and information dissemination to promote solar system adoption in urban areas.

5.4 Feasibility of implementing solar PV systems

The findings indicate that the feasibility of installing solar PV systems for households and small businesses largely depends on receiving financial assistance due to the high costs of purchasing and installation. Participants believed that if the government facilitated easier access to loans for financing solar PV installations, it would encourage more households to adopt solar systems. Access to financing is vital for the adoption of solar PV, as the initial costs can be prohibitive for many households (Fashina et al., 2018; Zander et al., 2019). However, microfinance loans for solar home

systems (SHSs) are often limited and, when available, come with high servicing costs (Adwek et al., 2020). The study found that small business and household owners emphasized that access to loans, subsidies, or instalment payment plans would influence their decision to adopt solar systems.

This is consistent with research showing that financing options make solar adoption more feasible given the high costs involved (Kizilcec & Parikh, 2020; Ngonda, 2022; Wassie et al., 2021). Offering affordable and flexible credit options could improve the ability of low-income households to afford solar PV systems (Barry & Creti, 2020; Hyun et al., 2021; Kizilcec et al., 2021). Flexible payment mechanisms have been shown to positively impact the adoption of solar home systems and solar kits by making costly solar PV systems more accessible to income-constrained households (Aarakit, Ntayi, et al., 2021). In Malawi, the availability of credit has facilitated the purchase and installation of solar PV systems in rural areas (Ngonda et al., 2023). A flexible payment mechanism is an innovative financing model that enables customers to make a small initial payment and then pay the remaining amount in flexible instalments over an agreed period of time (Hyun et al., 2021).

Many developing countries have implemented flexible payment mechanisms to help income-constrained households and businesses afford relatively costly solar PV systems (Aarakit, Ntayi, et al., 2021). Introducing similar flexible payment options in South Africa could potentially increase the uptake of solar systems. For example, in Uganda, flexible payment options are prevalent, making solar PV systems more accessible and attractive to consumers (Sanyal et al., 2016; Yadav et al., 2019).The findings indicate that government incentives for solar panel installations would benefit both households and small business owners. They proposed that government interventions, such as subsidies and financial incentives, could improve affordability. Some policymakers agreed with this view, supporting the idea of providing financial incentives like tax breaks or rebates to make solar systems more accessible.

Other studies have shown that government incentives impact the adoption of solar PV. For instance, a study on state policy incentives in the U.S. found that financial incentives positively influenced solar PV demand by lowering the initial costs, aligning with pro-environmental preferences, and enforcing solar-specific mandates

(Chernyakhovskiy, 2015). Another US study showed a positive effect of state policy incentives on solar PV adoption (Crago & Chernyakhovskiy, 2014). Similarly, in Pakistan, government financial support for small solar PV systems played a crucial role in influencing adoption decisions (Qureshi et al., 2017). In China, incentives such as feed-in tariffs were identified as key drivers behind the expansion of domestic PV solar technology (Zhang & He, 2013). However, insufficient fiscal incentives, such as the lack of feed-in tariffs, rebates, and tax credits, along with inadequate regulatory frameworks, have negatively impacted the spread of PV technology in various countries (Pode, 2010; Qureshi et al., 2017; Shah et al., 2019; Sindhu et al., 2016).

Key problems such as a lack of incentives, low demand from project financiers, and insufficient infrastructure funding need to be addressed to enhance solar PV deployment (Geh et al., 2022). These findings suggest that if the South African government were to implement incentives for solar PV costs, it could increase adoption rates among households and small businesses that currently cannot afford these systems.

The findings suggest that reducing solar PV costs and providing financial support would make implementing solar PV systems more feasible. Government officials and small business owners agreed on the need to explore partnerships with donors focused on promoting green energy. They recognized that securing funding from donors committed to cleaner energy transitions could help expand solar panel installations in households and small businesses. This is consistent with existing literature, which emphasizes that donor support is a key factor influencing the adoption of solar PV.

For example, a study examining Kenya, Tanzania, and Uganda in East Africa identified three primary drivers of rapid solar home system adoption. These were: the decreasing global market prices for solar PV technology, sustained support from international donors, and favourable conditions established by national governments (Hansen et al., 2015). World Bank (WB) loans are available in various countries for solar home system (SHS) programs, and bilateral donors have successfully financed large-scale projects, such as the AusAID initiative in Indonesia, where the Australian government funded 36,000 SHSs (Adwek et al., 2020). A study on rural residents in

China found that financial assistance, subsidies, technical support, and effective communication are crucial factors in the adoption of renewable energy technologies by households (Zhu et al., 2011). The study's findings suggest that financial support from donors can go a long way in assisting the adoption of solar PV. The government officials' mention of existing programs like the Energy Efficiency and Demand Side Management (EEDSM) initiative, and the potential for collaboration with banks and donors to make solar PV systems more affordable, highlights the need for financial assistance for households and small business owners.

The findings show that homeowners, installers, policymakers, and government officials have observed a gradual decrease in the prices of solar hardware and installation. Despite this decline, the initial costs remain prohibitively high for many individuals. This is consistent with literature showing that the cost of solar photovoltaics (PV) is decreasing, contributing to the growing popularity of solar home systems in developing countries (Ellabban et al., 2014). However, the substantial upfront expenses are a barrier to the adoption of solar PV. Although there is optimism about future affordability, the prohibitive upfront expenses remain a barrier to the uptake of solar PV.

5.5 Recommendations and strategic support on solar adoption

The findings provide recommendations and strategic insights for increasing solar adoption among small businesses and households, highlighting three key problems: the need for government incentives, education on solar PV systems, and promoting grid-tied solar PV as the most practical solution. However, some Eskom workers argue that solar installations alone are not a complete solution to power outages, emphasizing the need to maintain and repair Eskom's infrastructure. The reluctance to fully support solar PV adoption may stem from the fact that municipalities and Eskom depend on revenue from traditional grid energy sales, so a widespread shift to solar could threaten their income (Mutumbi et al., 2024). For instance, a study that examined the impact of grid-connected solar PV on municipal revenue in Stellenbosch found that if households transitioned to solar PV, the municipality could face a revenue loss of approximately 0.6% to 2.4% (Korsten et al., 2017). As more households

generate their own electricity with rooftop PV systems, their dependence on grid energy decreases, posing a challenge to traditional utility sales.

Rooftop PV is viewed as a disruptive technology that challenges the conventional centralized utility model. This is driven by declining rooftop PV costs, supportive policies for distributed generation, and in South Africa, rising conventional grid electricity prices (Kirsch & Morey, 2015; Walwyn & Brent, 2015). Utilities in various countries resist the growth of rooftop solar PV due to concerns over revenue loss, even though the shift from centralized, fossil fuel-based electricity is a positive step (Korsten et al., 2017). However, some countries outside Africa, such as China, Germany, Japan, and potentially the United States, are addressing this problem by offering financial incentives for grid-tied rooftop installations (Mukisa et al., 2021; Mutumbi et al., 2025).

5.5.1 Educating Households and Small Businesses on Solar PV Hardware

The findings emphasize the importance of providing education about solar PV systems. Installers highlighted the need to inform households and small businesses about selecting appropriate solar PV hardware, noting that choosing an inadequate system, like a 3kVA, may not sufficiently power their devices. Policymakers similarly suggested that government-led initiatives could educate households on the benefits of solar energy and make it easier to obtain quotes from solar installers. These findings support existing literature, which underscores the need for governments in sub-Saharan Africa to offer training and guidance on the proper installation, operation, and maintenance of solar PV systems to ensure safe and efficient use.

Governments could promote solar energy adoption through education and awareness campaigns that highlight the cost savings, convenience, and productivity benefits associated with solar PV systems (Ngonda et al., 2023). For instance, governments could collaborate with skilled solar technicians to develop community-based training initiatives aimed at equipping people with the skills and knowledge required to install and maintain solar PV systems (Ngonda et al., 2023). Access to information about solar PV is vital (Ngonda et al., 2023; Schelly, 2014). Such information can be disseminated through various channels, including community meetings, workshops,

radio broadcasts, mobile video vans, door-to-door campaigns, dramas, and visual posters (Ngonda et al., 2023).

5.5.2 Providing incentives to improve Solar PV Accessibility

Stakeholders—including government officials, installers, and policymakers—recommended interventions such as tax rebates, subsidies, and other financial incentives as essential measures to improve accessibility to solar PV systems. Participants suggested that tax breaks, grants, or low-interest loans could alleviate the financial burden of solar installations. This finding was supported by Ngonda et al. (2023) who recommended that governments could stimulate private investment in solar infrastructure through such incentives. Introducing these inducements in South Africa could significantly increase adoption rates, as seen in other countries like the U.S., China, and Pakistan. In the absence of such incentives, the adoption of solar PV by households and small businesses will remain limited. Therefore, government policies and regulatory frameworks would play a decisive role in expanding access to solar energy in South Africa. This is consistent with literature which has shown that government incentives have assisted in the adoption of solar PV systems**.**

5.5.3 Grid-Tied Systems: The recommended option

The findings suggest that policymakers and government officials support grid-tied solar PV systems for both households and businesses. This is due to their affordability, practicality, and the potential to earn financial benefits by exporting excess electricity back to the grid. Installers also recommend these systems for their cost-effectiveness and efficiency, particularly in townships and middle to upper-class areas. Some Eskom workers highlighted that grid-tied systems could provide faster financial returns and more efficient energy use by allowing users to feed excess electricity back into the grid, which can help offset installation costs. This is consistent with literature showing that incentives for grid-tied systems can enhance the adoption of solar PV. For example, Germany saw significant growth in photovoltaic adoption due to financial incentives for rooftop installations connected to the utility grid (Bayer et al., 2018). Similarly, in Australia, compensating prosumers for surplus electricity fed into the grid has been a major factor driving the widespread adoption of residential PV systems (Ellabban & Alassi, 2019). In Brazil, the implementation of net metering policies led to a rapid increase in solar PV adoption (Hallack et al., 2018). In South Africa, concerns

that connecting rooftop solar PV systems to the grid might reduce electricity sales and revenue for local governments could be hindering solar PV adoption (Korsten et al., 2017). These concerns may explain the reluctance of some governments in Sub-Saharan Africa. However, some studies show that some governments in the region are supporting the adoption of solar PV systems. For instance, Ghana is among countries that has introduced net metering a billing mechanism that allows homeowners or businesses with solar photovoltaic (PV) systems to receive credit for the excess electricity they generate and feed back into the grid (Afonaa-Mensah et al., 2024).

5.6 Contribution of the study

The study has shown important insights into the socioeconomic barriers hindering the adoption of rooftop solar PV systems in South Africa, particularly the impact of high installation costs on low- and middle-income households. While financial barriers have been acknowledged in previous research, this study has provided a more detailed understanding of how the reliance on imported components like batteries, panels, and inverters significantly inflates costs. Participants suggested that local manufacturing of these components could substantially reduce prices, a perspective that has not been thoroughly explored in existing literature. Additionally, the findings show that current policy frameworks may disproportionately benefit wealthier households and industrial customers, leaving ordinary South Africans unable to afford solar installations despite their potential benefits. This distinction between different income groups' ability to adopt solar energy highlights the need for more inclusive policies and financial support mechanisms.

Another significant finding is the widespread lack of knowledge about the practical aspects of solar PV systems among homeowners and small business owners. Although participants recognised the potential of solar energy to reduce reliance on Eskom and lower electricity bills, many were unaware of the appropriate system sizes required for essential appliances or the long-term cost savings. Small business owners reported severe disruptions due to load shedding but lacked the financial resources to invest in backup solutions such as generators or solar installations. This knowledge gap suggests that informational and educational campaigns are urgently needed to help potential adopters make informed decisions about solar energy. Moreover, the

study highlights the potential for adopting alternative financing models, such as pay-as-you-go schemes or cooperatives, which have been successful in other developing countries but remain underutilized in South Africa.

The study is very important in shaping targeted policy interventions to promote solar PV adoption in South Africa. Encouraging local manufacturing of solar components could lower installation costs and create jobs, thereby stimulating the local economy. Additionally, restructuring government subsidies to focus on low- and middle-income households could make solar systems more accessible, addressing the financial barriers identified. The study's insights into the information gap also emphasize the need for comprehensive educational programs to raise awareness about the benefits and requirements of solar PV systems. Implementing these strategies could significantly enhance solar adoption rates, reduce the impact of load shedding, and contribute to South Africa's broader energy security and sustainability goals.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusion of the study on the research questions regarding the factors impeding solar PV installation and the feasibility of implementing solar systems. It provides recommendations and strategic support for enhancing solar adoption among small businesses and households in South Africa. It also incorporates insights from government officials, installers, policymakers, Eskom workers, and households and small businesses in Gauteng.

This study provides insights into the installation of solar PV systems in households and small businesses in Gauteng province in South Africa. It reveals that both household and small business owners view solar PV systems as beneficial, primarily for reducing reliance on Eskom which is always facing power cuts. The ability of solar PV systems to offer backup power during load shedding and its potential to achieve energy independence were identified as benefits. Despite these advantages, high costs, concerns about reliability during adverse weather, and a general lack of understanding about how solar systems function impede widespread adoption.

Thus, the primary barrier to the widespread adoption of solar PV systems for households and small businesses is the high initial cost of purchasing and installation. It is clear from the findings that financial assistance in the form of accessible loans, subsidies, and flexible payment options is crucial. Without such support, many low-income households and small businesses are unable to afford the upfront costs. This is in line with global studies showing that financial mechanisms like microfinance, flexible payment plans, and donor support are effective in enabling solar adoption in income-constrained communities.

6.2 Conclusion regarding research question 1

The adoption of solar PV systems in households and small businesses is primarily hindered by three key factors which are high installation costs, concerns over reliability during periods of low sunlight, and a lack of knowledge about solar technology. The upfront capital investment required to purchase and install solar PV systems is beyond the financial reach of most households and small business owners. While solar energy offers long-term cost savings, the initial expenditure remains a significant deterrent. This problem is exacerbated by the lack of accessible financing options, as many participants highlighted the difficulty of securing loans or financial assistance for solar installation. Reliability concerns further discourage adoption, particularly in a region like Gauteng, where cloudy and rainy weather is frequent in summer. Many potential users are uncertain whether solar PV systems can generate sufficient electricity during winter months, when shorter daylight hours and reduced sunlight intensity may limit energy output. This scepticism is further reinforced by the misconception that solar panels alone can provide continuous power without the need for supplementary systems, such as battery storage or grid-tied solutions.

Additionally, limited public awareness and knowledge about solar technology pose another major barrier. Many individuals lack an understanding of how solar PV systems operate, the available financial support mechanisms, and the long-term benefits of switching to solar energy. This knowledge gap leads to uncertainty and hesitation, preventing potential users from making informed decisions about solar adoption. Addressing these barriers requires targeted interventions that reduce financial constraints, improve system reliability through technological advancements, and increase awareness through educational initiatives.

6.3 Conclusion regarding research question 2

The feasibility of implementing solar PV systems as a solution to load shedding in Gauteng depends on financial accessibility, technological reliability, and supportive policy frameworks. While solar PV technology has the potential to alleviate power shortages, its adoption remains impractical for many due to cost constraints. Without financial incentives such as subsidies, tax rebates, or affordable loan schemes, solar PV systems remain out of reach for low- and middle-income households, as well as

small businesses struggling with operational costs. Participants emphasized that government intervention is crucial in bridging this financial gap and making solar installations a viable option. Beyond financial considerations, the success of solar PV adoption is also linked to system efficiency and adaptability to local climatic conditions. The study finds that while solar PV can significantly reduce dependence on the national grid, its effectiveness depends on proper system design, including the integration of backup power solutions such as batteries or grid-tied configurations. Grid-tied systems, which allow users to supplement their power supply with electricity from the national grid when solar generation is low, present the most feasible alternative for widespread adoption. These systems eliminate the need for expensive battery storage while ensuring continuous energy availability.

Furthermore, raising public awareness about financing options, maintenance requirements, and system efficiency is essential to improving adoption rates. Many participants acknowledged that they would be more willing to invest in solar PV if they had access to accurate information about system costs, performance, and long-term benefits. Therefore, the feasibility of solar PV implementation in Gauteng hinges not only on financial and technical factors but also on comprehensive awareness campaigns that address common misconceptions and educate users on available solutions.

6.4 Conclusion regarding research question 3

To enhance the adoption of solar PV systems among households and small businesses in Gauteng, a combination of financial, educational, and policy-driven strategies must be implemented. The study recommends that the government introduce targeted financial incentives, such as subsidies, tax breaks, and low-interest financing schemes, to reduce the high initial costs of solar installations. These financial interventions would make solar PV more accessible, particularly for low- and middle-income groups who currently find it unaffordable. Additionally, partnerships between the private sector, financial institutions, and energy providers could facilitate innovative financing models, such as pay-as-you-go solar systems or leasing arrangements, which have been successfully implemented in other countries.

The findings reveal various views of policymakers regarding the government's role in supporting the installation of solar PV systems. There is consensus over the need for government assistance to make solar systems more accessible, with suggestions including financial incentives such as tax breaks or rebates. Policy makers also propose creating initiatives to educate households about solar energy and improve access to installation services. While some advocate for financial support for both households and small business owners, others emphasize the importance of expanding renewable energy projects and upgrading infrastructure to enhance generation capacity. Recommendations for solar installation include promoting grid-tied systems due to their cost-effectiveness and practicality. Overall, the findings suggest that a combination of financial support, educational initiatives, and infrastructure improvements is essential for increasing solar PV adoption and addressing load shedding faced by households and small businesses.

The findings reveal that government officials have diverse perspectives on supporting the installation of solar systems, reflecting both existing initiatives and proposed strategies. The Energy Efficiency and Demand Side Management (EEDSM) programme, managed by the Department of Energy, showcases the government’s commitment to optimizing energy use and supporting renewable energy transitions, including electrifying villages with solar panels. However, challenges remain, with officials acknowledging constraints that may limit broader assistance.

Proposed solutions include subsidizing financing through collaboration with banks to make loans more affordable and partnering with donors to promote green energy. Government officials also discussed various solar installation options—grid-tied, off-grid, and hybrid. These efforts align with South Africa's Integrated Resource Plan, which aims to reduce reliance on coal and increase renewable energy. Addressing the high costs associated with solar systems and expanding support mechanisms are critical to overcoming current barriers and advancing clean energy adoption.

6.5 Recommendations

It is recommended that the National Treasury provide tax breaks or rebates for those who install solar PV systems, to reduce the financial burden and encourage broader

adoption. The findings suggest that such tax incentives could make solar PV more affordable, promoting its adoption among households and small businesses. The Department of National Treasury should develop targeted subsidies, grants, and tax incentives to further reduce the costs of solar PV systems for these groups. The findings indicate that these measures would contribute to lowering the costs associated with purchasing and installing solar PV systems, making them more accessible. Eskom and Municipal Electricity providers are recommended to develop programs that encourage households and businesses to install grid-tied solar PV systems. These programs should enable users to sell excess electricity back to the grid, thereby reducing their energy costs. The findings indicate that grid-tied solar PV systems are favoured for their affordability, practicality, and the financial benefits of exporting excess electricity. To raise public awareness, Eskom can work with municipalities to educate the public on the benefits and feasibility of solar PV systems in efforts to provide solutions to the power outages.

The South African Photovoltaic Industry Association (SAPVIA), a non-profit organization dedicated to renewable energy, could collaborate with the South African Local Government Association (SALGA) to educate households and small business owners about solar PV systems. This partnership should focus on informing the public about different types of solar PV systems, their benefits, and proper usage. Local programs should be implemented to offer technical assistance, information, and resources for those interested in solar PV installations. This recommendation addresses the findings that some participants lacked understanding of how solar systems operate and their reliability.

Based on the findings, government officials and small business owners both expressed interest in exploring partnerships with donors focused on promoting green energy. Therefore, it is recommended that Non-Governmental Organizations (NGOs) and Civil Society Groups advocate for policy changes that support solar adoption and educate communities about the benefits and feasibility of solar PV systems. They should facilitate community solar projects that pool resources for shared solar systems, making solar energy more accessible to a broader population.

6.6 Suggestions for further research

Future research should address this study's limitations by using mixed methods to enhance the generalizability of findings on solar PV adoption in Gauteng. A cost-benefit analysis of different solar PV systems could help identify the most cost-effective solutions for various income groups. Additionally, research on the impact of government incentives and financing models, such as pay-as-you-go systems, would provide insights into effective policy interventions. Longitudinal studies assessing user satisfaction and system performance over time would further clarify the sustainability of solar PV. Finally, exploring social and psychological barriers, including peer influence and cultural perceptions, could deepen understanding of adoption challenges.

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APPENDICES

Appendix A1: Interview Questionnaire – Household

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

1. How old are you?

2. What is your gender?

3. What is your ethnicity?

4. What is your occupation?

5. Where is your residential property in Gauteng Province?

6. What is your average electricity bill in a day or week or in a month?

7. What are the most energy consumers in your premises?

8. What challenges have you experienced due to sustained load shedding?

9. Can you briefly comment of effects of load shedding?

10. What do you think about using rooftop solar PV in your home as a viable backup solution to address load shedding?

11. Following up on question 5 above, what do you suggest needs to be done to ensure that more solar PV installations can be installed by households?
12. What do you think are the benefits to consumers of installing solar systems as a solution to loadshedding?

13. How do you think installations of solar systems in dwellings may easy pressure on the National Grid and reduce severity of load shedding?

14. What back up strategy do you have in the event of sustained load shedding by Eskom?

15. As a follow up to the previous question, what plans/ advise can you provide to prevent power interruption?
16. In your opinion what can you say about the costs for PV solar hardware and installation in SA?
17. In your opinion, do you think it will cost you less to get electricity from solar PV systems than Eskom as a solution to load shedding?

18. Approximately, how is the frequency of load shedding in your area?

19. In your opinion, how can the government provide support or assistance to households to encourage more solar power installation projects?

20. What do you prefer, to go off grid of partially off grid? Please briefly explain why you choose that option.

Appendix A2: Interview Questionnaire – Business Owner

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

1. How old are you?

2. What is your gender?

3. What is your ethnicity?

4. What is your occupation?

5. How long have you been operating this business?

6. Where is the business located?

7. How much electricity do you consume in a day or week or in a month rather, you know, how much would you say is an estimate in a month, how much electricity do you pay for?

8. What challenges have you faced due to load shading?

9. How feasible is it to put solar PV as an option to mitigate the effects of load shedding?

10. Why do you think that solar PV could be a good option to mitigate the effect of load sharing?

11. What are your average power requirements to keep your most critical equipment of the business going during load shedding?

12. What back up strategy do you have for power supply in the event of load sharing?

13. What do you prefer to be installed for your backup system?

14. Why would you say it is the most preferred?

15. What are the most difficult challenges you experience in your business due to load shedding?

16. And what is the reason you failed to buy or install solar PV as a backup system?

17. How are the costs of solar PV hardware and installation in South Africa?

18. As a business, what options do you offer to consumers to improve their buying power, if any? Are there any incentives that you provide for your customers, you know, as a way of either lowering customers' prices or making them able to utilize your business?

19. And what assistance do you need to install a backup system for a business.

20. How would you want the assistance provided or what payment options would you like, are you saying just donation or what?

21. And in your opinion, what would you prefer to install as a backup if you were given some assistance between going off grid or partially off grid?

Appendix A3: Interview Questionnaire – Government Official

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

1. How old are you?

2. What is your gender?

3. What is your ethnicity?

4. Where do you reside in the in Gauteng Province, may you please indicate the area?

5. What back up system do you have for electricity supply?

6. How often do you experience load shedding in your area?

7. What do you suggest as a solution to curb sustained load shedding?

8. Following up on question 2 above, what can you say about households and small businesses in the Gauteng Province focusing on rooftop solar PV installations as part of the solution to reduce power demand from the grid?

9. In your opinion, as government officials what support do you suggest can be provided to households, and small businesses to install solar systems to curb the current high levels of loadshedding?
10. Following up on question 4 above, how do you think this can easily put pressure on the government to address load shedding, In your opinion?

11. Following up on question 6 above, what do you suggest as the best viable options to consider increasing rooftop solar installations for households and small businesses?

12. In your opinion, apart from the government giving Eskom financial assistance to improve their generation capacity what other options have you considered to reduce pressure on Eskom generating plants so that they can do planned maintenance?

13. In your opinion, what would you say government prioritize to replace fossil fired plants as a solution to increase generation capacity and reduce emissions?

14. As a follow up to the previous question, what is the realistic time period these new technologies can be operational?

15. In your opinion what do you think about the costs of PV solar hardware and installation in SA?

16. In your opinion, what advantages can solar PV give apart from being a solution to load shedding if households in Gauteng Province get their electricity from solar systems?

17. In your opinion when do you think load shedding is going to end? What is your estimated period to end?

18. In your opinion which option do you recommend between the three options of solar installations, off grid, grid tied and hybrid? What is the reason for choosing this option?

Appendix A4: Interview Questionnaire – Policy Maker

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

Question 1: How old are you?

Question 2: What is your gender?

Question 3: What is your ethnicity?

Question 4: What is your occupation?

Question 5: Do you reside in the in Gauteng Province and if yes, may you please indicate the area?

Question 6: On average how much electricity do you consume in a day or week or in a month at your premises or household?

Question 7: Do you experience load shedding? If so, what do you suggest as a solution to curb sustained load shedding?

Question 8: Following up on question 7 above, what is your opinion about households and small businesses in the Gauteng Province focusing on rooftop solar PV installations as part of the solution to reduce power demand from the grid?

Question 9: In your opinion, do you think the government is able to support households, and small businesses to install solar systems to curb high levels of loadshedding?

Question 10: Following up on question 9 above, how can this easy pressure on the National Grid and reduce severity of load shedding?

Question 11: Following up on question 9 above, what do you suggest as viable options to consider increasing rooftop solar installations for households and small businesses?

Question 12: In your opinion, apart from the government giving Eskom financial assistance to improve their generation capacity what other options have been considered as policy makers to reduce pressure on Eskom generating plants so that they can do planned maintenance?

Question 13: What back up strategy do you have in the event of sustained load shedding by Eskom for your house?

Question 14: As a follow up to the previous question, what is the total cost you incurred to put this system in place, if any?

Question 15: In your opinion how are the costs of PV solar hardware and installation in SA?

Question 16: In your opinion, what advantages do you think are there is households in Gauteng Province get their electricity from solar systems apart from being a solution to load shedding?

Question 17: Do you think load shedding is going to end any time soon? What is your estimated period to end?

Question 18: In your opinion which option do you recommend between the three options of solar installations, off grid, grid tied and hybrid?

Appendix A5: Interview Questionnaire – Eskom Engineer

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

1. How old are you?

2. What is your gender?

3. What is your ethnicity?

4. What is your occupation?

5. How long have you been working as engineer at Eskom?

6. Where is your office location stationed located?

7. What Engineering section or profession are you?

8. What back up system do you have for electricity supply?

9. How often do you experience load shedding in your area?

10. What do you suggest as a solution to curb sustained load shedding? To minimize the impact.

11. Following up on question 10 above, what do you think about households and small businesses in the Gauteng Province focusing on rooftop solar PV installations as part of the solution to reduce power demand from the grid?

12. In your opinion, as an Eskom Engineer what do you think are the challenges Eskom is facing?
13. Following up on question 12 above, how do you think this can easy pressure on Eskom?

14. Following up on question 13 above, what do you suggest as the best viable options to consider reducing demand from the grid and load shedding? Why

15. In your opinion, what do you recommend if Eskom is given financial assistance to improve their generation capacity what other options can you considered?

16. In your opinion, what do you suggest needs to be done to ensure the current fossil fired plants are properly maintained?

17. In your opinion, as a follow up to the previous question, what is the realistic time period needed to improve Eskom capacity?

18. In your opinion what do you think about the cost of PV solar hardware and installation in SA compared to the current tariffs?

19. In your opinion, what advantages can solar PV give apart from being a solution to load shedding if households in Gauteng Province get their electricity from solar systems?

20. In your opinion when do you think load shedding is going to end? What is your estimated period to end?

21. In your opinion which option do you recommend between the three options of solar installations, off grid, grid tied and hybrid? What is the reason for choosing this option?

Appendix A6: Interview Questionnaire – Installers

Topic: Solar installation as a solution to sustained load shedding in Gauteng, South Africa.

Interview Guide to the interviewer: In carrying out the semi-structured interviews, it is important that you adhere closely to the following interview instructions, namely,

i) Ensure that you prepare for interviews.

ii) Before explain anything, must introduce yourself. Then give a briefing of the purpose of the study to so that the respondent understands and feels comfortable.

iii) Mention to the respondent that the study will be treated confidential, and they will be anonymous, no identities will be revealed in the gathered findings.

iv) Ensure to follow the questions in their correct order.

v) Ensure that you are systematic and consistent when interacting with the respondents and avoid personal opinions.

vi) Get permission to record the interview before starting to conduct the interview and write down responses in full.

Questions

1. How old are you?

2. What is your gender?

3. What is your ethnicity?

4. What is your occupation?

5. What solar installation business enterprise do you own in Gauteng or SA, and where is it located?

6. How many solar PV installations have you done roughly and up to what power output?

7. In what type of suburbs is your business enterprise located, in the townships medium density or low-density suburbs?

8. As a solar installer, please briefly comment on whether you have experienced a business boom since the advent of load shedding.

9. How do customers pay for installations, and do you experience any challenges with payments?

10. In your opinion, how much appetite do you think is there to install solar PV? And how many installations do you do in a month?

11. In your opinion, what do you think about solar hardware and installation labour costs in relation to affording?

12. Following up on question 11 above, what are the average costs involved to install a 5kW and 12kW rooftop solar PV system?

13. What contingencies measures did you put in place to mitigate the impact of load shedding?

14. How much time does it take on average to install a 5kW rooftop solar system and what about a 12kW system in a house?

15. What solar PV output package would you recommend for townships and middle to upper-class residential houses? Why do you choose that option?

16. What solar installation option would you recommend for townships and middle to upper-class residential houses? Why do you choose that option?

17. Should the government provide consumers with support in the form of surety how do you think it will help your business to grow? What other options do you suggest should be considered?

18. How feasible is it to implement solar PV system projects for most households in the Gauteng province, given the cost of both solar PV hardware and installation in South Africa? Please explain your reason/s.

19. What challenges do your clients normally highlight as difficulties they face, and which prevent them from putting solar PV systems as a backup or even go off grid completely?

APPENDIX B1 PARTICIPANT INFORMATION

Dear Sir/Madam,

My name is Cornilius Makuwerere. I am studying for a Master of Management in Energy Leadership with Wits Business School.

It is a requirement as part of my studies to complete a research report and therefore would like to kindly invite you to take part in a face-to-face or Ms Teams interview for my research. My topic of research is, **"Solar installation as a solution to sustained load shedding in Gauteng, South Africa",** under the supervision of Professor Frederick Ahwireng-Obeng.

Load shedding has been on the rise in South Africa over the past decade and requires a different approach to reduce further episodes of power cuts. This research will help to identify a suitable solution to promote solar PV installation as a solution to sustained load shedding.

With your permission, I would like to audio/video record the interview. This data will be in an external hard drive for 5 years and deleted thereafter. Only the researcher will have access to the data.

During the research activity, I will need to ask for some personal information about you, including your residential location or area. The interview will be confidential and when I share the results of the research study your name will not be included. With your permission, other researchers may use the data collected from this study but will not use your name and any personal information.

Taking part in the research study is voluntary, you do not have to take part. You can stop participating at any time and do not have to answer questions you do not want to. Taking part in the study will not cost anything and there are no direct benefits for joining the research study. The risks of this study are part of what happens in everyday life and nothing more.

This research study will be written as a research report available on the university library website. I will be happy to send it to you if you would like to receive a summary of this report.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27 11 717 1408, email hrecnon-medical@wits.ac.za

Yours Sincerely

Cornilius Makuwerere

Research Details

Cornilius Makuwerere, **Wits Email** - 2494905@students.wits.ac.za, **Cell No**. +27 83 859 86 56.

Supervisor: Professor Frederick Ahwireng-Obeng

Email Address: Frederick.ahwireng-obeng@wits.ac.za, **Wits Telephone** - +27 11 717 3727

APPENDIX B2 CONSENT FORM

Title of Project: Solar installation as a solution to sustained load shedding in Gauteng, South Africa

Name of Researcher: Cornilius Makuwerere

I…….. agree/do not agree to participate in this research project.

Please indicate yes or no on the options below.

	Description	**Yes/No (select appropriate)**	**Special request if any**
1.	To conduct the interview face to face or via Ms Teams		
2.	To record the interview		
3.	To provide personal details		
4.	To provide my location or area of residence		
5.	Researchers to use the data		

Signature: …….. Date:…….

APPENDIX C ETHICS APPROVAL CERTIFICATE



CERTIFICATE OF COMPETENCE IN RESEARCH ETHICS

Name: Cornilius Makuwerere

Student/Staff No: 2494905

Date of Certification: 19 January 2022- 18 January 2025 (This certificate is valid for a period of three years)

TRAINED BY:

PROFESSOR JASPER KNIGHT (RESEARCH ETHICS)

SIGNATURE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

ISSUED BY:

DR ROBIN DRENNAN (DIRECTOR: RESEARCH OFFICE)

SIGNATURE

This certificate is confirmation of successful completion of a training course in Research Ethics for Non-Medical human research, based upon achieving a minimum level of competence in different assessment tasks.

APPENDIX D ANALYSIS TABLES AND CHARTS

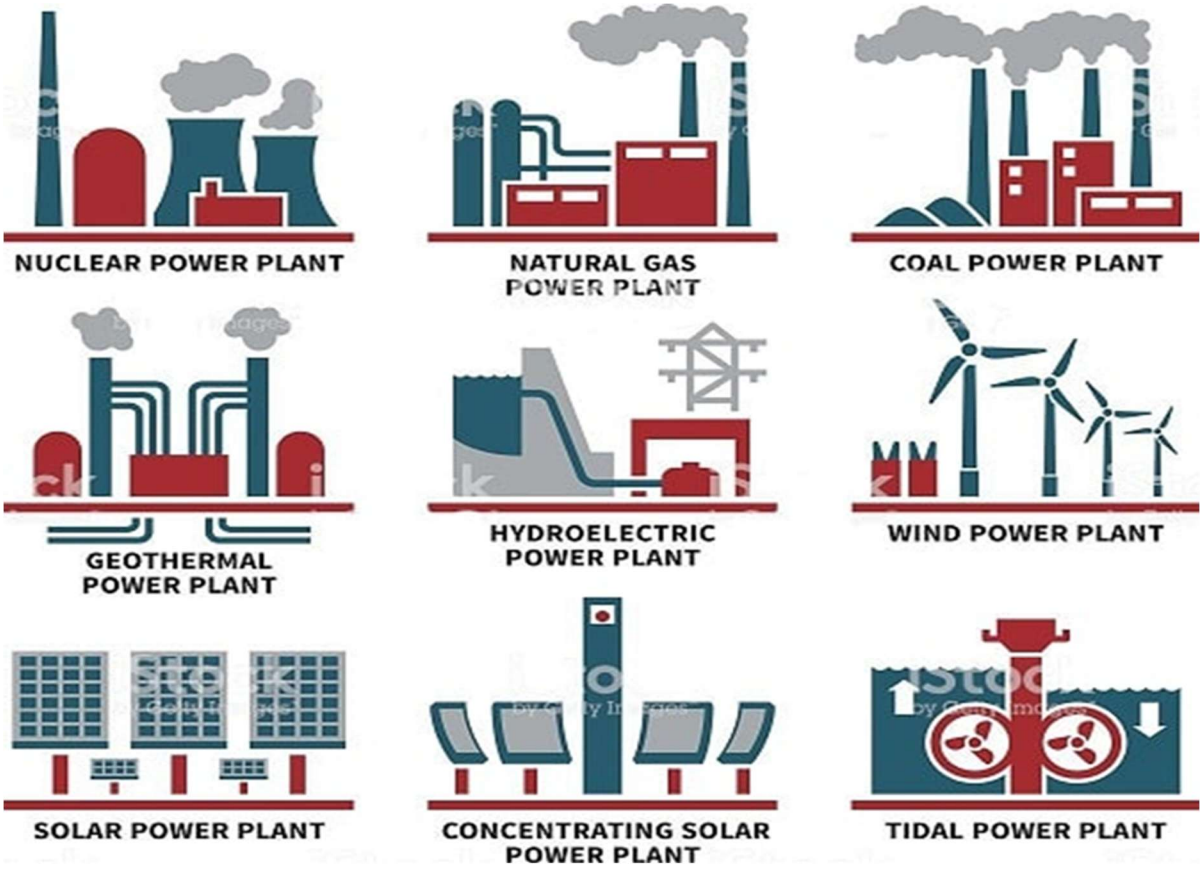


Figure 2.1: Types of Power Plants (StudyEletcrical, 2015).

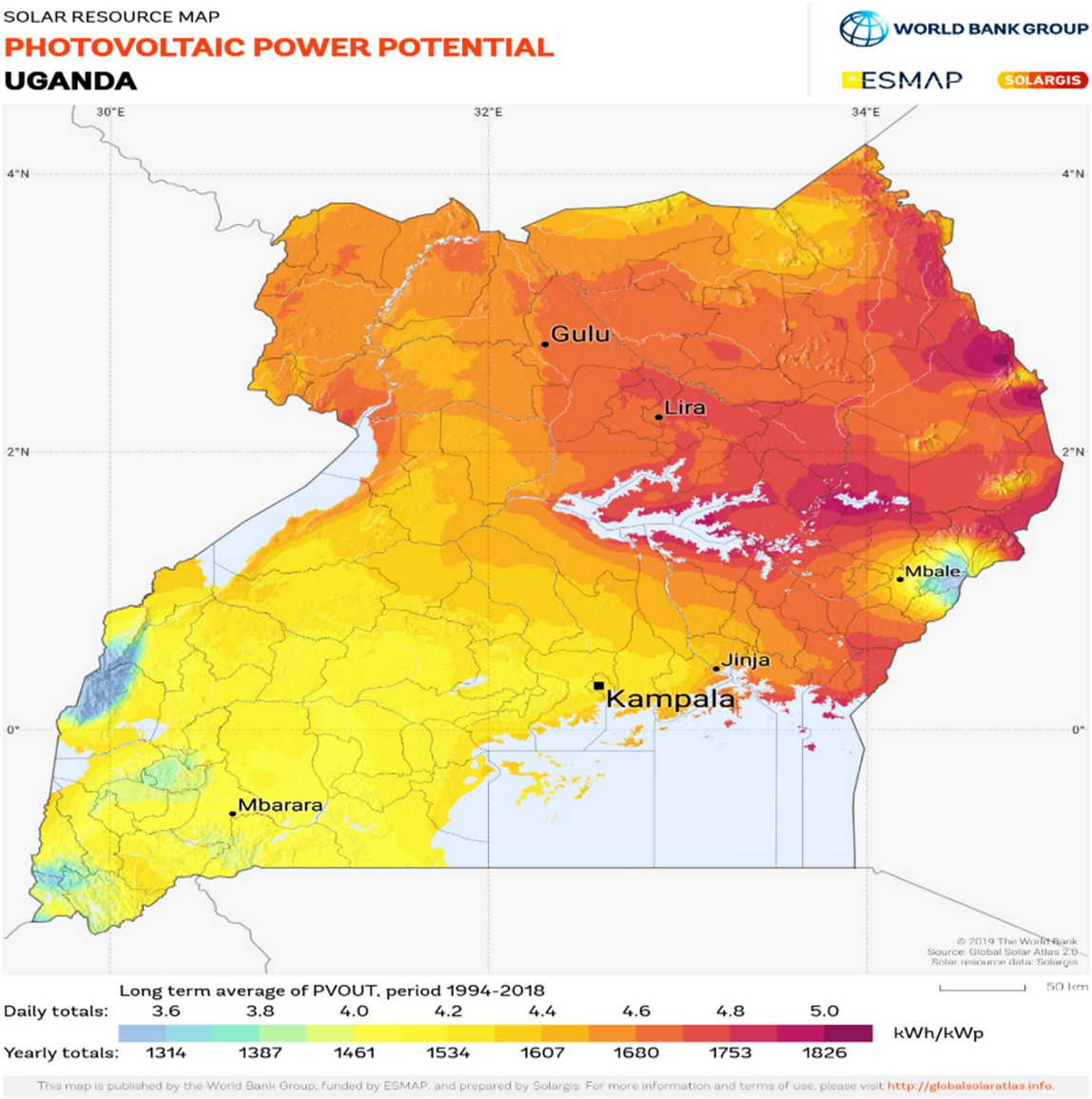


Figure 2.2: Uganda photovoltaic potential map

Source: (*Download solar resource maps and GIS data for 200+ countries and regions*, 2022).

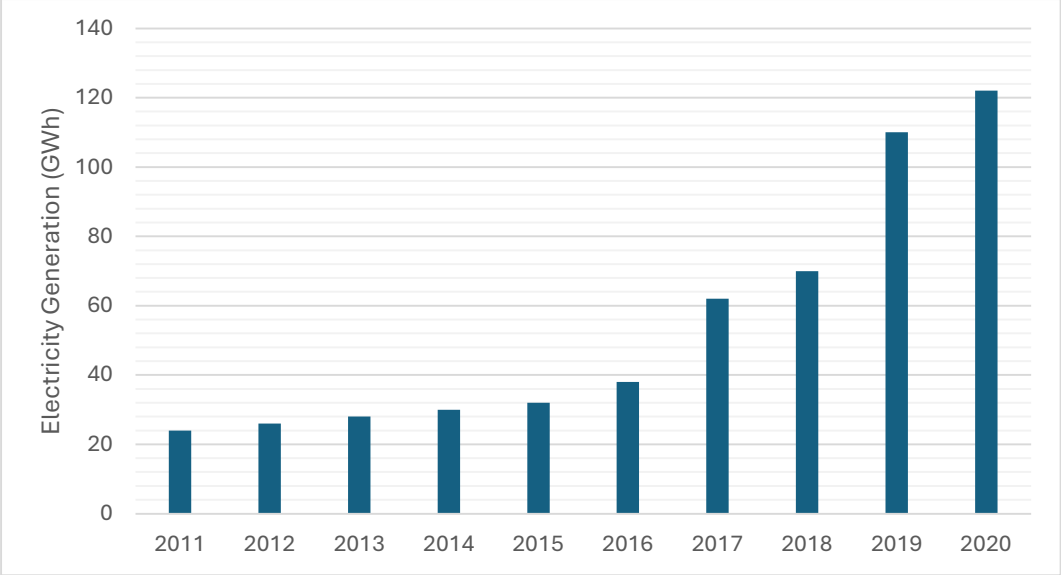


Figure 2.3: Uganda solar PV generation trend

Source: *(Download solar resource maps and GIS data for 200+ countries and regions, 2022).*

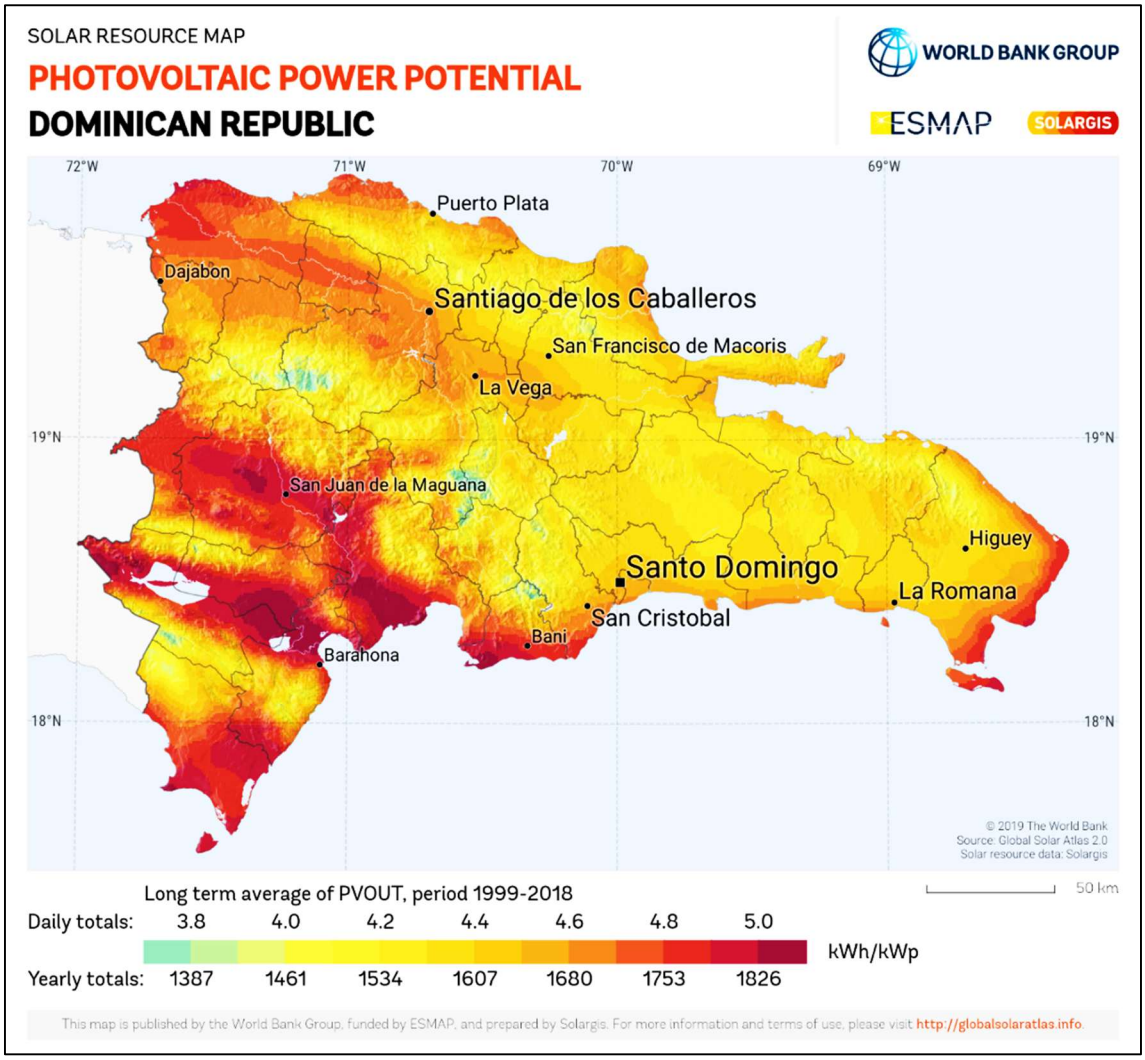


Figure 2.4: Dominican Republic photovoltaic potential

Source: (Download solar resource maps and GIS data for 200+ countries and regions, 2022).

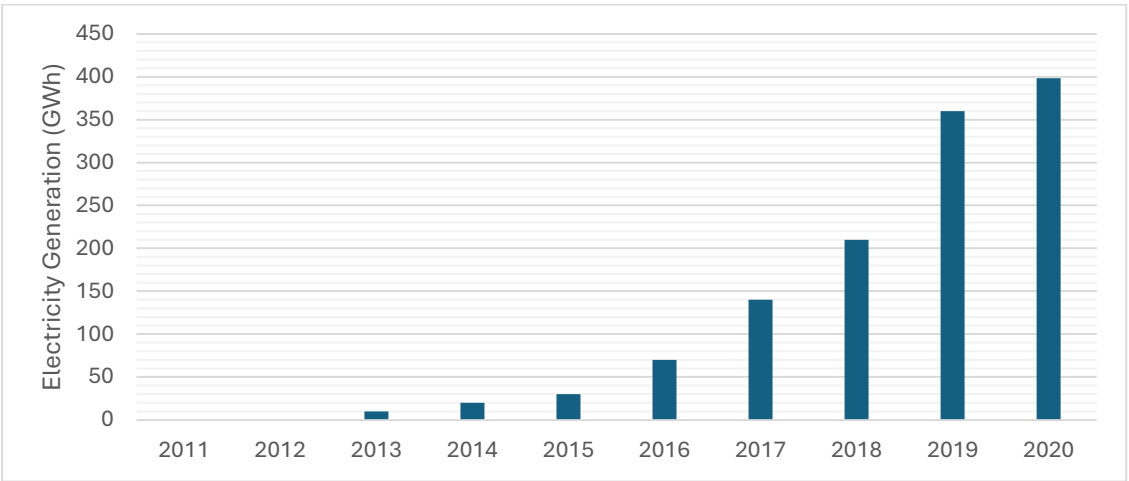


Figure 2.5: Dominican Republic solar PV generation trend

Source:(Solar energy, 2022).

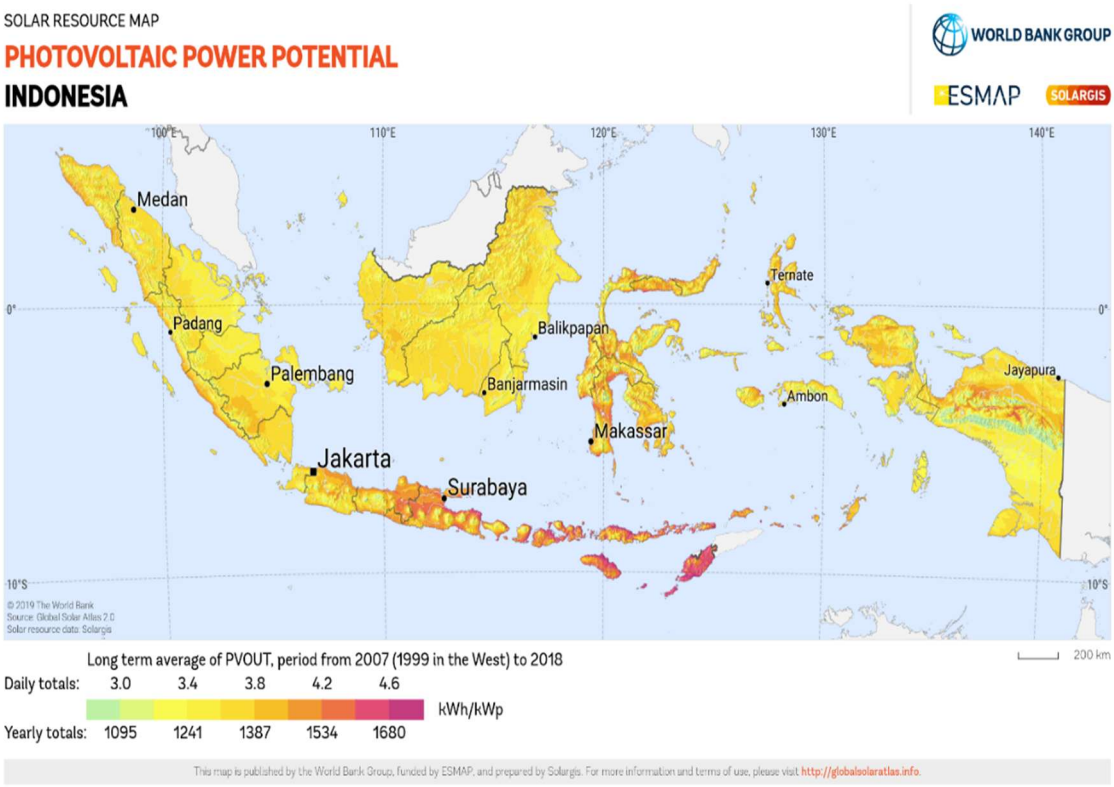


Figure 2.6: Indonesia photovoltaic potential map

Source: (Download solar resource maps and GIS data for 200+ countries and regions, 2022).

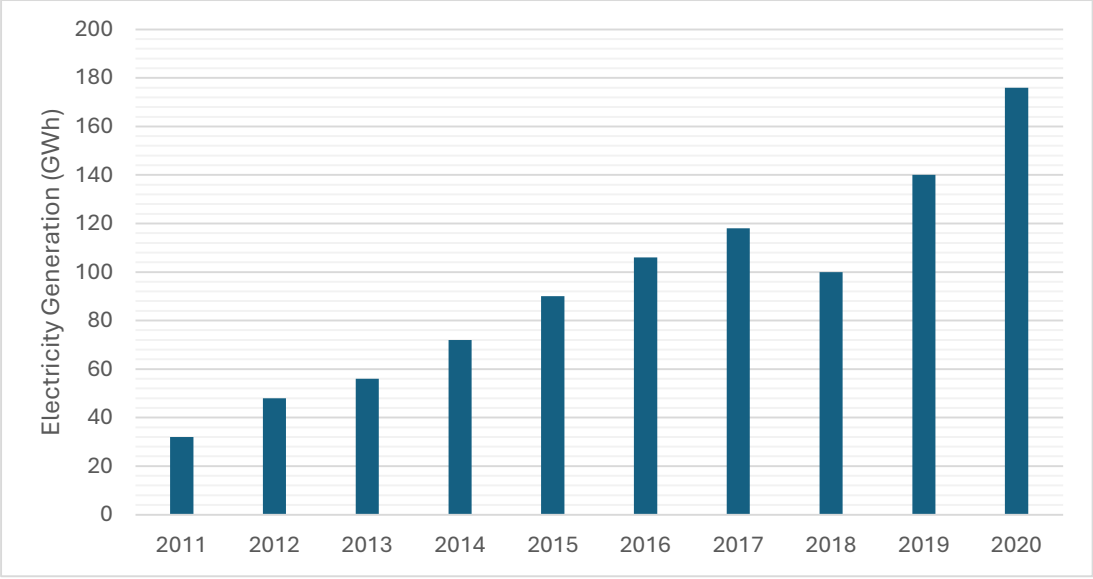


Figure 2.7: Indonesia Solar PV Generation Trend

Source: (*Solar energy, 2022*).

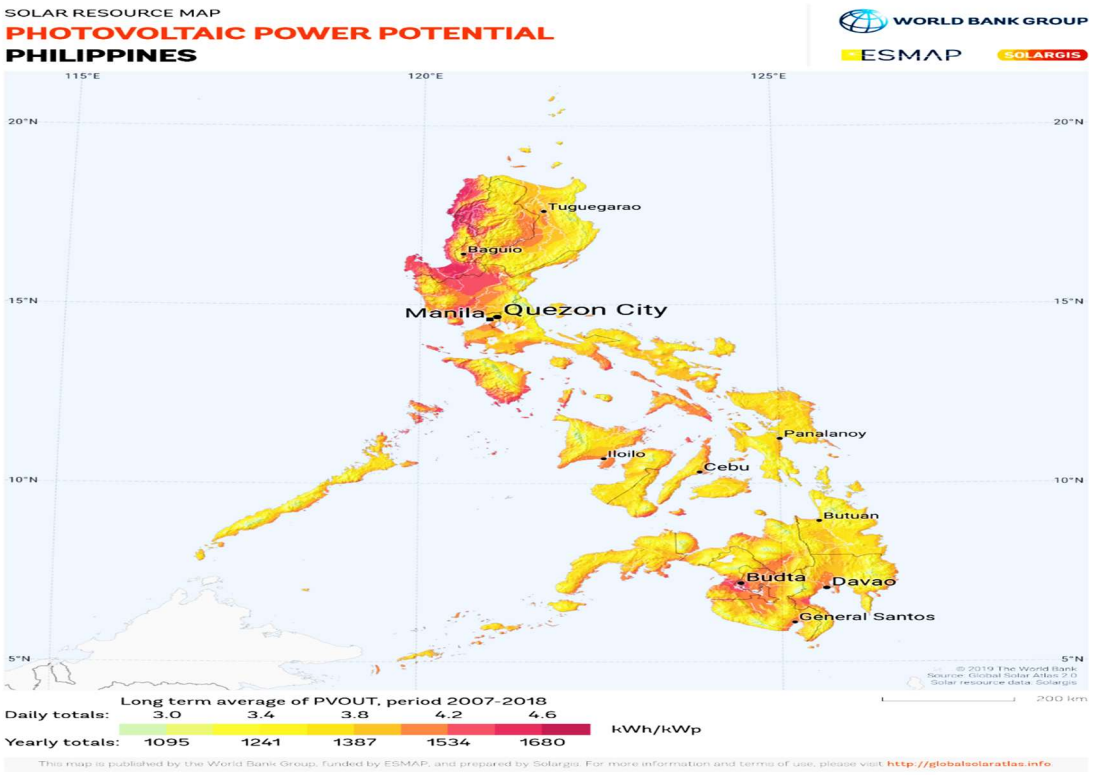


Figure 2.8: Philippines photovoltaic potential

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

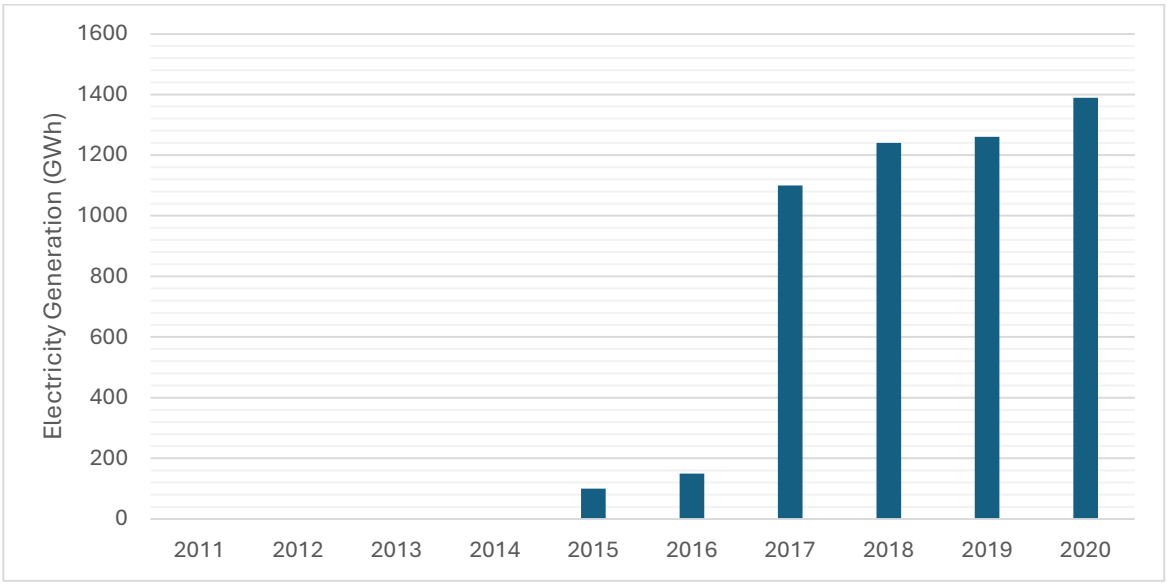


Figure 2.9: Philippines solar PV generation trend

Source: (*Solar energy, 2022*).

Table 2.1: SA Planned and Installed Generation Capacity

	Coal	Nuclear	Hydro	Storage (Pumped Storage)	PV	Wind	CSP	Gas / Diesel	Other (CoGen, Biomass, Landfill)	Embedded Generation
2018	39 126	1 860	2 196	2 912	1 474	1 980	300	3 830	499	Unknown
2019	2 155					244	300			200
2020	1 433				114	300				200
2021	1 433				300	818				200
2022	711				400					200
2023	500									200
2024	500									200
2025					670	200				200
2026					1 000	1 500		2 250		200
2027					1 000	1 600		1 200		200
2028					1 000	1 600		1 800		200
2029					1 000	1 600		2 850		200
2030			2 500		1 000	1 600				200
TOTAL INSTALLED	33 847	1 860	4 696	2 912	7 958	11 442	600	11 930	499	2600
Installed Capacity Mix (%)	44.6	2.5	6.2	3.8	10.5	15.1	0.9	15.7	0.7	

Installed Capacity
Committed / Already Contracted Capacity
New Additional Capacity (IRP Update)
Embedded Generation Capacity (Generation for own use allocation)

Source: *Larmuth and Cuelllar(2019).*

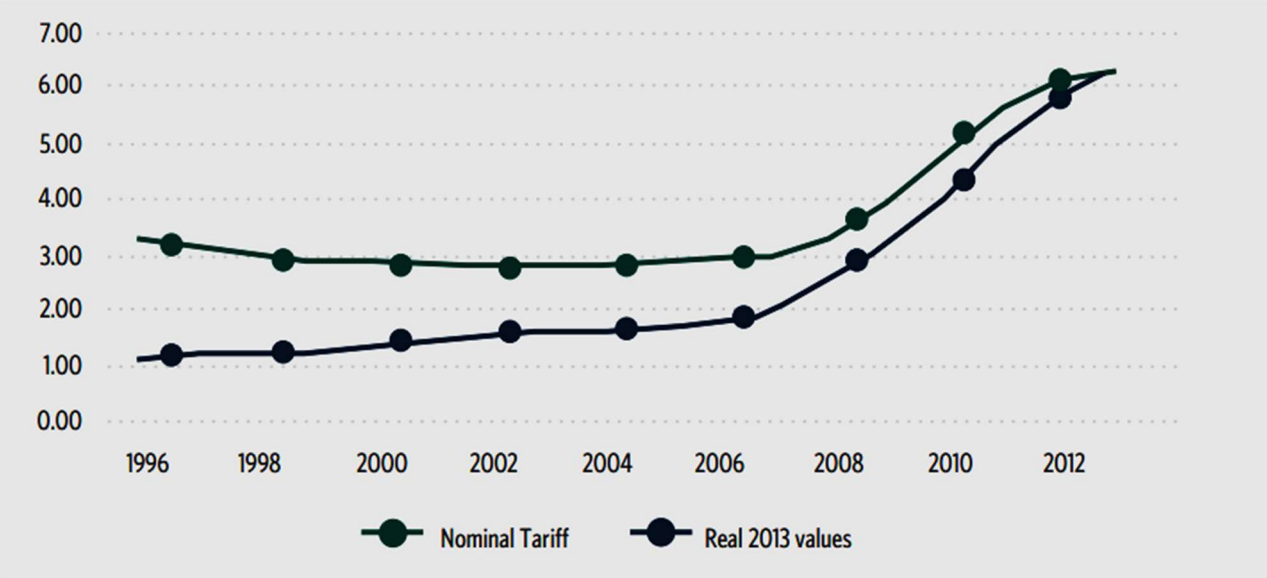


Figure 2.10: Eskom Nominal and Real Tariffs 1996–2012

Source: (*Eberhard et al., 2014*).

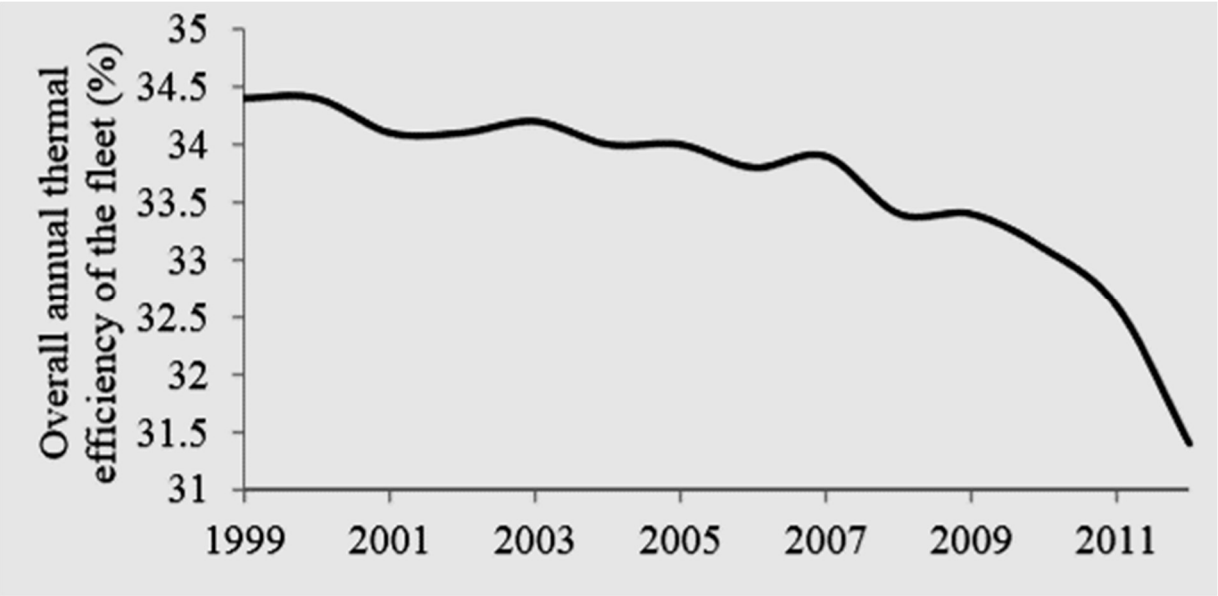


Figure 2.11: Eskom Thermal Efficiency Changes

Source: (*Pretorius et al., 2015*).

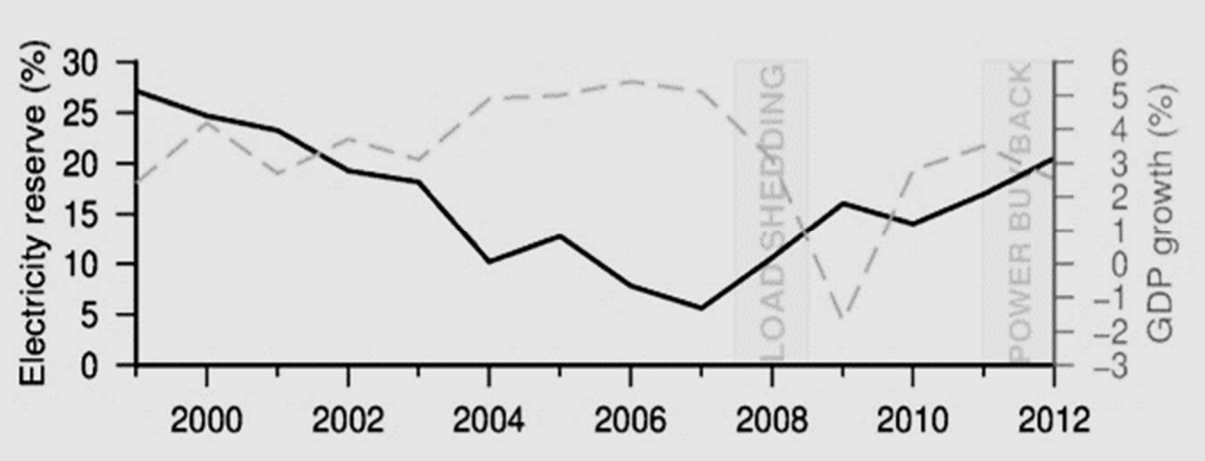


Figure 2.12: Energy Reserve Margin Trend

Source: (*Pretorius et al., 2015*).

Table 2.2: Renewable Energy Projects under REIPPPP

	Bid Window 1		Bid Window 2		Bid Window 3		Bid Window 3.5		Bid Window 4		Total	
	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects	Capacity [MW]	QTY Projects
Wind	648	8	559	7	787	7			1,362	12	3,356	34
Solar PV	627	18	417	9	435	6			813	12	2,292	45
Solar CSP	150	2	50	1	200	2	200	2			600	7
Landfill GAS					18	1					18	1
Biomass					17	1			25	1	42	2
Small Hydro			14	2					5	1	19	3
Total	**1,425**	**28**	**1,040**	**19**	**1,457**	**17**	**200**	**2**	**2,205**	**26**	**6,327**	**92**

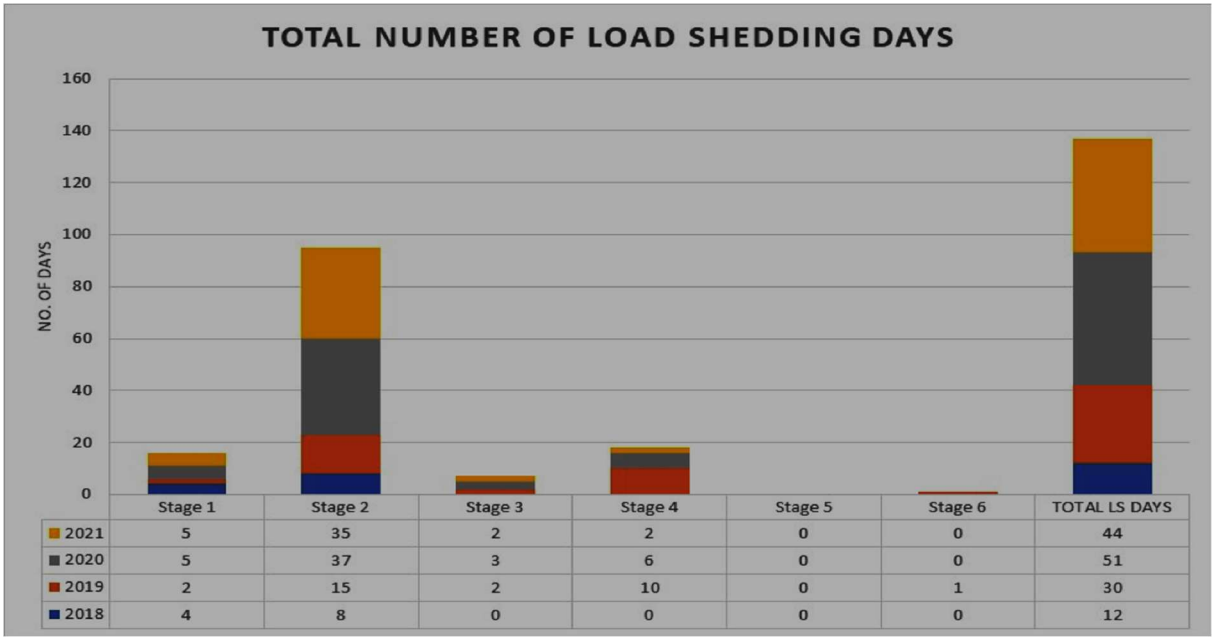
Source: (*Larmuth & Cuelllar, 2019*).

Table 2.3: Frequency of Load shedding in 2007

	October 2007	November 2007	December 2007	Up to 25 January 2007	25 January to 4 February 2007
Number of Days load shedding occurred	4 days intermittently	4 days intermittently	4 days intermittently	15 days continuously	3 days intermittently
Maximum demand shed at a point in time	1500MW	2000MW	2500MW	4000MW	2000MW
Estimated Energy not Served	52 GWhrs	15 GWhrs	56 GWhrs	321 GWhrs	50 GWHrs
Load Factor of Open Cycle Gas Turbines	20 to 40%	10 to 30%	15 to 30%	30 to 60%	15 to 25%

Summary of number of days that load was shedded.

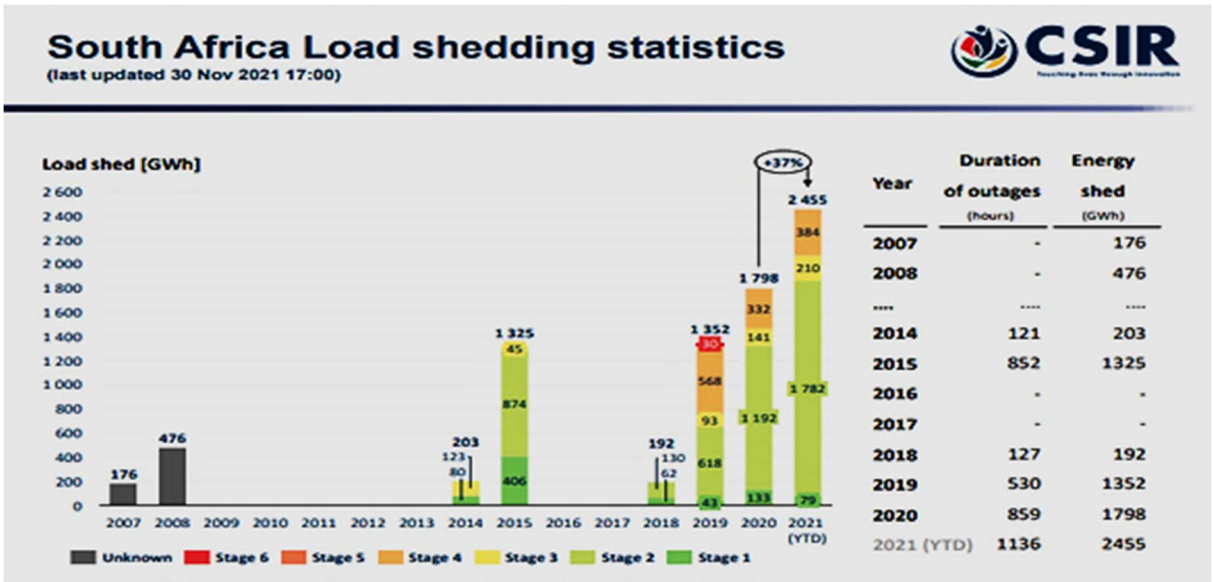
Source: (*Chettiar et al., 2009*).



	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	TOTAL LS DAYS
2021	5	35	2	2	0	0	44
2020	5	37	3	6	0	0	51
2019	2	15	2	10	0	1	30
2018	4	8	0	0	0	0	12

Figure 2.13: Load Shedding Increase since 2018

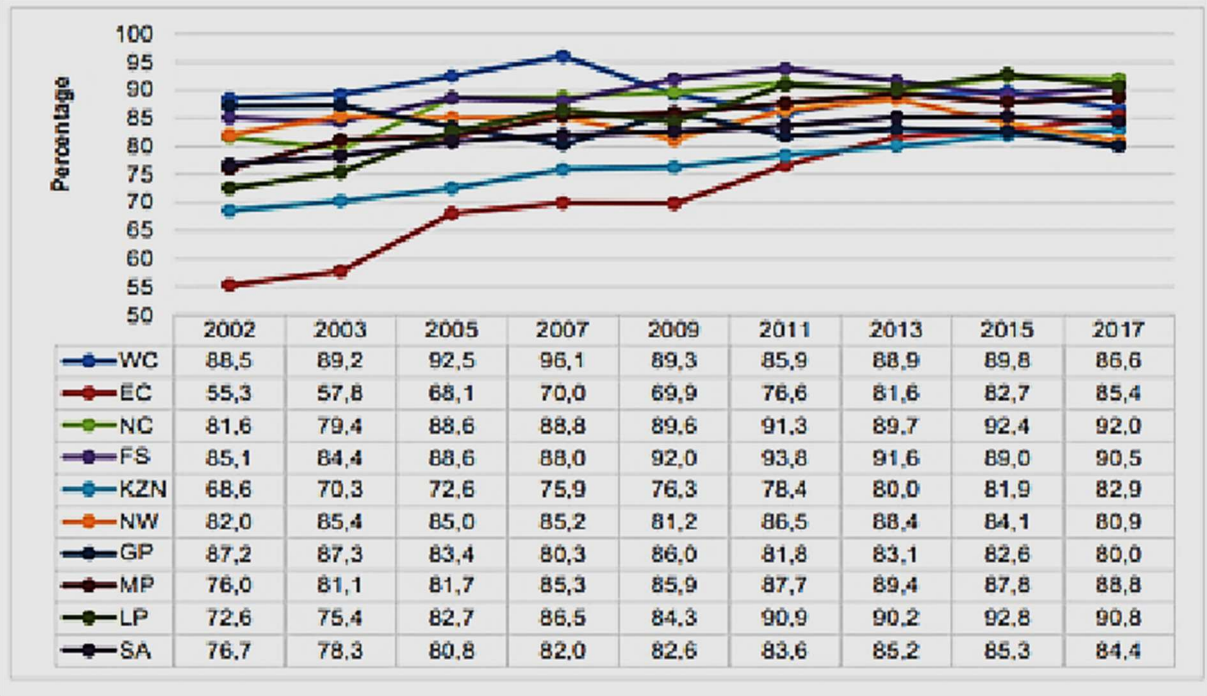
Source: (*Battery energy storage systems to boost reliability and the adoption of renewable energy. ENCA,2021. Retrieved 25 July 2022*).



Year	Duration of outages (hours)	Energy shed (GWh)
2007	-	176
2008	-	476
....	....	....
2014	121	203
2015	852	1325
2016	-	-
2017	-	-
2018	127	192
2019	530	1352
2020	859	1798
2021 (YTD)	1136	2455

Figure 2.14: Load Shedding Statistics

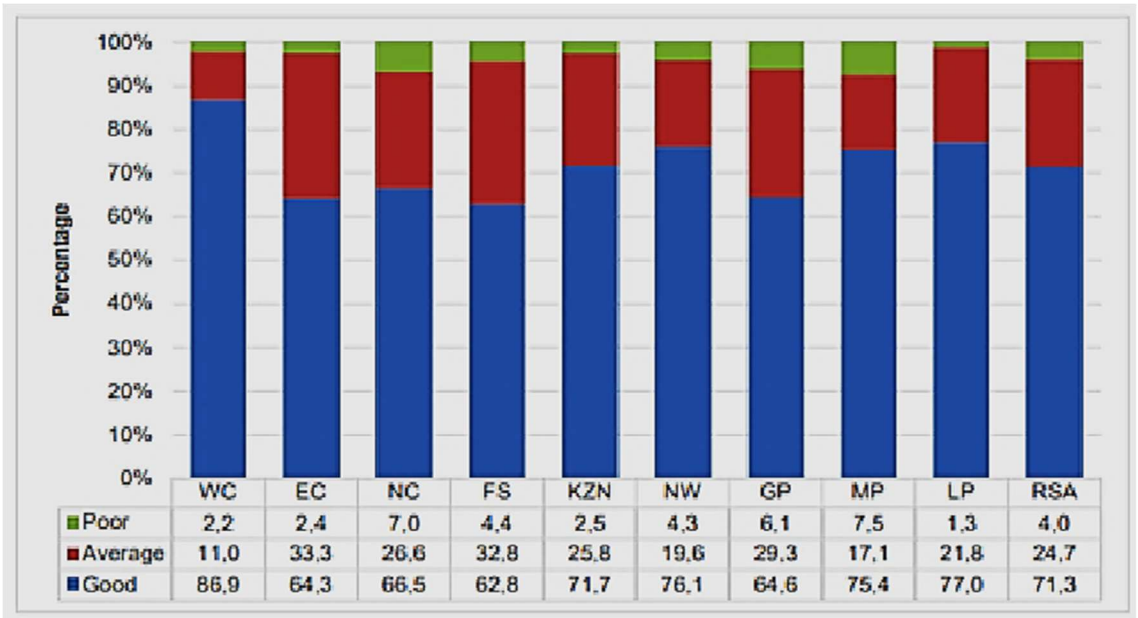
Source: (*StatsSA, 2017*).



	2002	2003	2005	2007	2009	2011	2013	2015	2017
WC	88,5	89,2	92,5	96,1	89,3	85,9	88,9	89,8	86,6
EC	55,3	57,8	68,1	70,0	69,9	76,6	81,6	82,7	85,4
NC	81,6	79,4	88,6	88,8	89,6	91,3	89,7	92,4	92,0
FS	85,1	84,4	88,6	88,0	92,0	93,8	91,6	89,0	90,5
KZN	68,6	70,3	72,6	75,9	76,3	78,4	80,0	81,9	82,9
NW	82,0	85,4	85,0	85,2	81,2	86,5	88,4	84,1	80,9
GP	87,2	87,3	83,4	80,3	86,0	81,8	83,1	82,6	80,0
MP	76,0	81,1	81,7	85,3	85,9	87,7	89,4	87,8	88,8
LP	72,6	75,4	82,7	86,5	84,3	90,9	90,2	92,8	90,8
SA	76,7	78,3	80,8	82,0	82,6	83,6	85,2	85,3	84,4

Figure 2.15: Households Connected to Mains Electricity

Source: (*StatsSA, 2017*)



	WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
Poor	2,2	2,4	7,0	4,4	2,5	4,3	6,1	7,5	1,3	4,0
Average	11,0	33,3	26,6	32,8	25,8	19,6	29,3	17,1	21,8	24,7
Good	86,9	64,3	66,5	62,8	71,7	76,1	64,6	75,4	77,0	71,3

Figure 2.16: Quality of Electricity Household Rating

Source: (*StatsSA, 2017*)

Table 2.4: SA Population by Province 2002–2017

	Total population (Thousands)									
	WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
2002	4 756	6 515	1 030	2 645	9 660	3 054	9 764	3 478	5 019	45 921
2003	4 858	6 505	1 040	2 652	9 718	3 097	10 010	3 530	5 050	46 461
2004	4 960	6 498	1 050	2 661	9 783	3 141	10 258	3 586	5 085	47 021
2005	5 063	6 493	1 060	2 670	9 853	3 186	10 511	3 643	5 123	47 602
2006	5 168	6 489	1 071	2 680	9 928	3 232	10 772	3 701	5 165	48 205
2007	5 276	6 484	1 082	2 691	10 005	3 281	11 044	3 760	5 207	48 830
2008	5 388	6 480	1 093	2 704	10 087	3 330	11 325	3 820	5 252	49 479
2009	5 502	6 478	1 105	2 717	10 175	3 382	11 612	3 883	5 299	50 152
2010	5 618	6 477	1 117	2 732	10 268	3 434	11 910	3 947	5 349	50 850
2011	5 738	6 476	1 130	2 748	10 365	3 488	12 219	4 012	5 400	51 574
2012	5 860	6 476	1 143	2 764	10 468	3 545	12 539	4 078	5 453	52 325
2013	5 985	6 477	1 156	2 782	10 576	3 603	12 868	4 147	5 511	53 104
2014	6 112	6 481	1 170	2 802	10 691	3 663	13 203	4 218	5 573	53 912
2015	6 242	6 486	1 184	2 822	10 812	3 726	13 549	4 291	5 638	54 750
2016	6 374	6 492	1 199	2 844	10 941	3 790	13 906	4 367	5 707	55 620
2017	6 510	6 499	1 214	2 867	11 075	3 856	14 278	4 444	5 779	56 522

Source:(*StatsSA, 2017*)

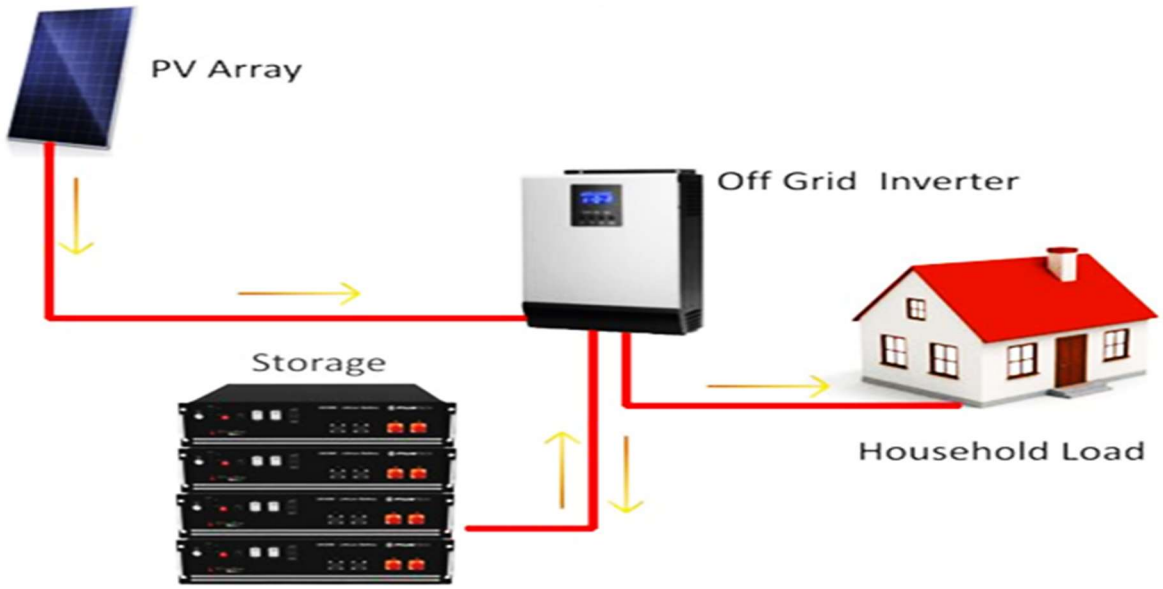


Figure 2.17: Off-grid system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide, 2022*).

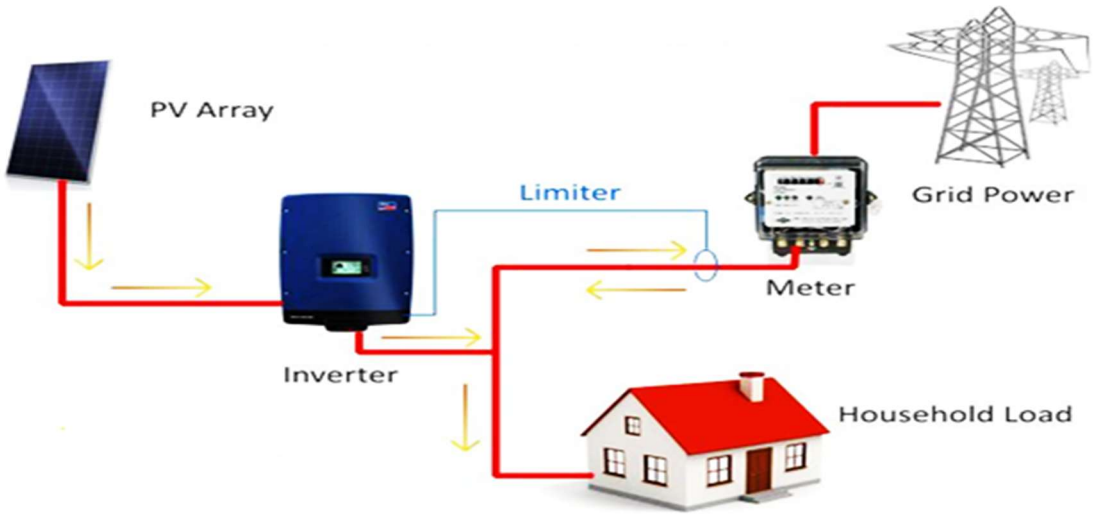


Figure 2.18: Grid tied system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide (SA Home Loans, 2022*).

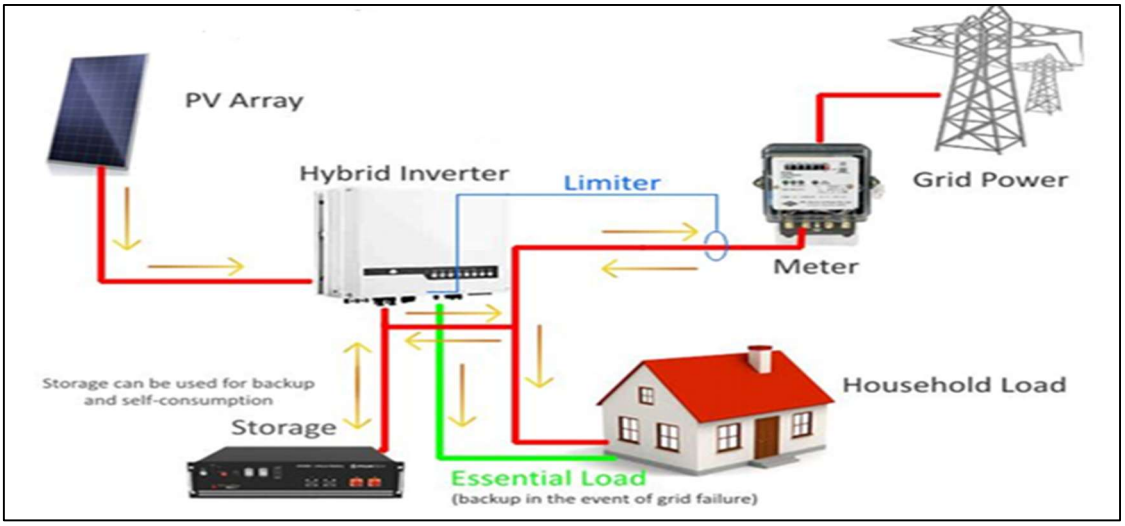


Figure 2.19: Grid tied system

Source: (*Buying Your Inverter Made Simple - Pricing and Guide, 2022*).

Table 2.5: Building New Generation Capacity Comparative Cost

Technology	Levelized cost of energy	Capital cost	Build time	Eskom position
PV solar	4.1 US$c/kWh	825 US$/kW	18 to 24 months	Identified potential sites to retrofit PV to capitalize on existing infrastructure and available resources
Wind	5.4 US$c/kWh	1,450 US$/kW	24 to 36 months	Leverage sites for wind, with environmental authorizations to capitalize on existing infrastructure and available resources
Gas	7.3 US$c/kWh	1,250 US$/kW	24 to 60 months	Intend to use gas as means to enable renewables, thereby supporting the transition
Nuclear	19.8 US$c/kWh	12,500 US$/kW	12 to 15 years	Supports governments plans to roll out nuclear, will be unable to build due to inadequate balance sheet
New coal	15.9 US$c/kWh	62,250 US$/kW	10 to 12 years	Will own and operate current coal fleet till end of life, will focus on repurposing sites to be decommissioned with renewables. No new coal projects by Eskom

Source: (Andreoni et al., 2022).



Figure 2.20: Module Selling Price 2000–2020

Source: (*Jain et al., 2020*).

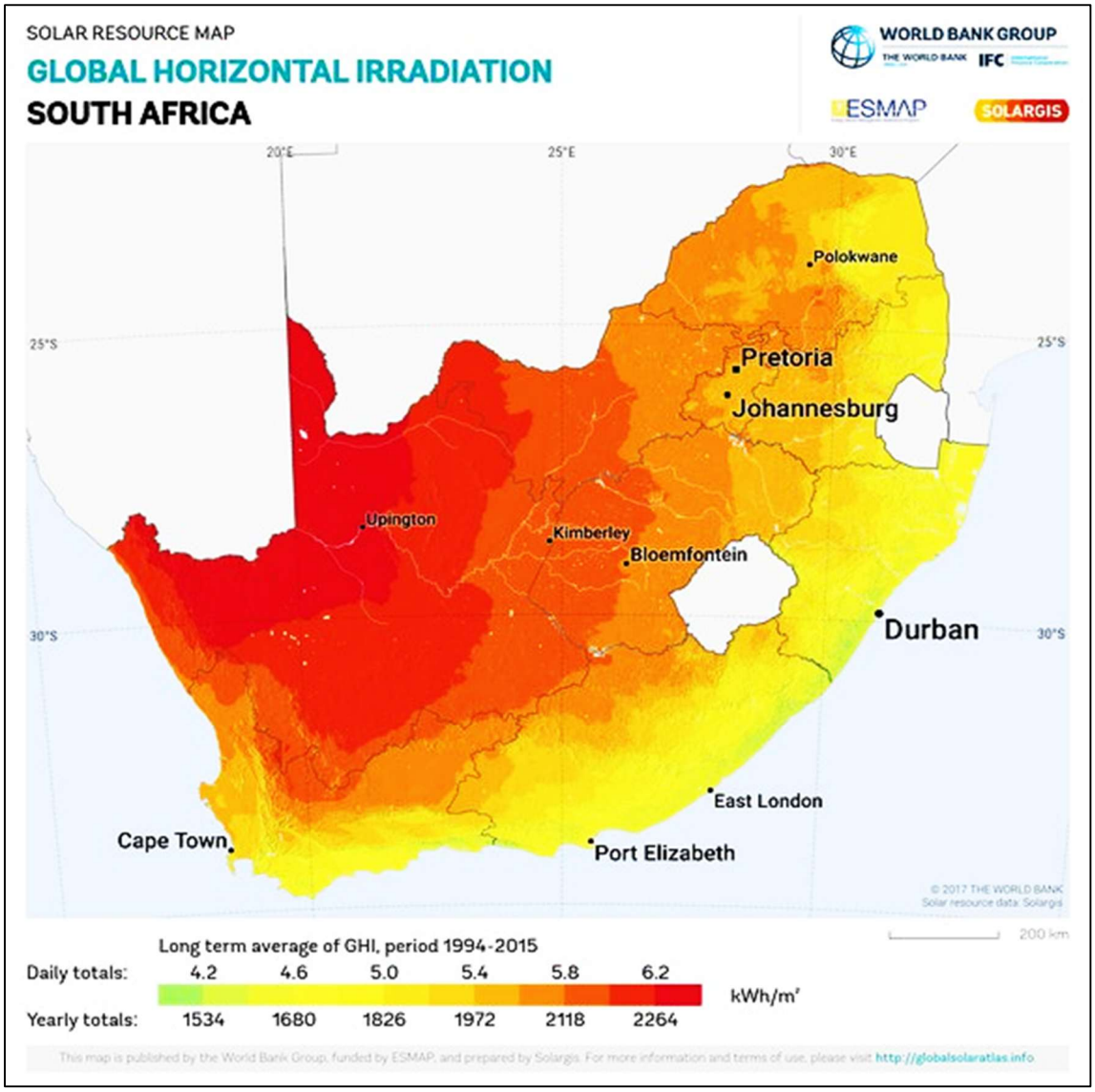


Figure 2.21: South Africa solar photovoltaic potential map

Source: (*Download solar resource maps and GIS data for 200+ countries and regions, 2022*).

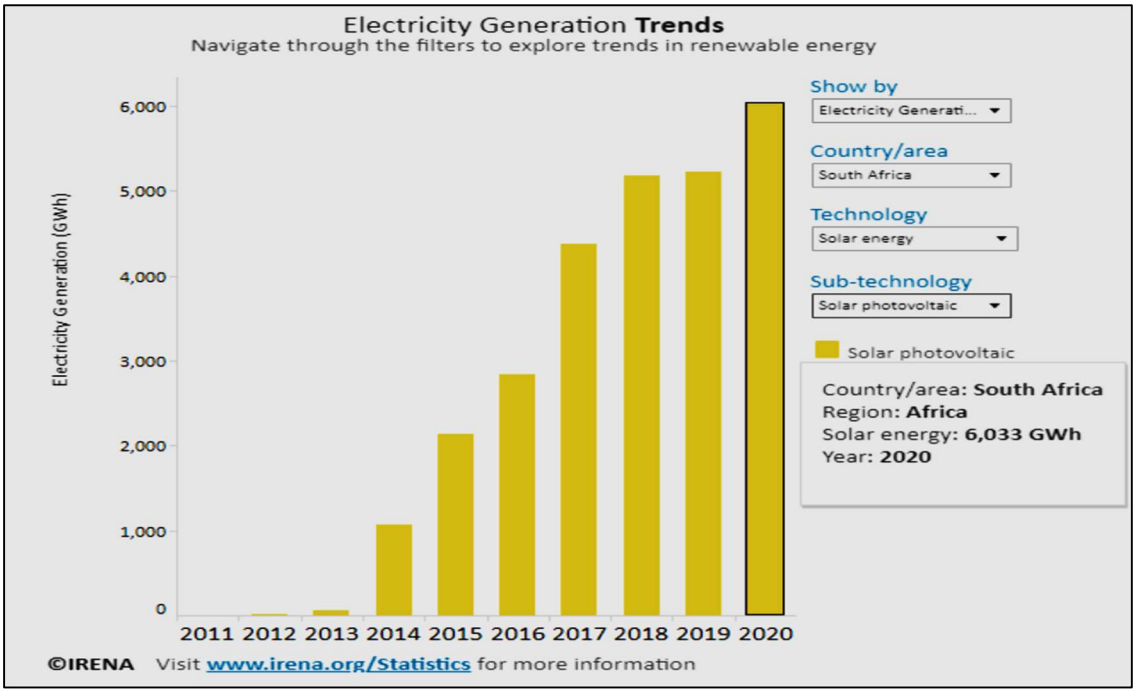


Figure 2.22: South Africa solar generation trend

Source: (*Solar energy, 2022*).

Table 2.6: Average Solar PV System Installation Costs in South Africa

Description	Size	Approximate Price Range
Panels	365w – 420w	R1600 – R2500
Batteries (Lithium)	5kWh – 12kWh	R23000 – R80000
Inverter	5kW – 12kW	R8849 – R55 935
Solar Cable	6mm	R10 – R25/m
Roof Mount Kit	-	R200 – R1000/panel, depending on the type of roof

Source: (*Bimantoro et al., 2019*).

Table 2.7: Consistency Table. Research Questions and Propositions

RQ #	Question	Prop #	Proposition
1.	What are the factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa?	1.	It is expected that factors that affect the choice of solar system installation as a backup can be identified.

RQ #	Question	Prop #	Proposition
2.	How feasible is the implementation of solar PV systems in households and small businesses in Gauteng as a solution to load shedding?	2.	The low cost of solar PV hardware makes it feasible for residents to implement solar PV system projects in SA.
3.	What recommendations and strategic support can be provided to households and small businesses to promote the adoption of solar PV systems?	3.	A good government support strategy can encourage more residents to install solar PV for their homes or businesses.

Source (Author)

Table 3.1: Profile of Participants

Participant Type and Description	Number sampled
Homeowners within townships, low-class, middle- and upper-class suburbs in the province of Gauteng – Consumers.	3
Business owners in Gauteng	3
Energy policymakers	3
Government Officials	3
Eskom Officials	3
Solar Installers in Gauteng.	3
Total number of participants	**18**

Source: Author's computations

Table 3.2: Consistency Matrix (Research Questions, Data Collection and Data Analysis)

RQ #	Research Question	Prop / hyp #	State Proposition	Data collection detail	Data analysis method
1.	What are the factors impeding the uptake of solar systems in households and small businesses in Gauteng, South Africa?	1.	The factors impeding the uptake of solar systems in households and small businesses include financial barriers, information barriers, technical barriers, regulatory and policy barriers, social barriers and psychological barriers.	Interview guide one[7] questions 11, 12, 14, 15, 16, 17 & 19 Interview guide two[8] questions 10, 12, 13, 16, 18	Inductive thematic analysis
2.	How feasible is the implementation of solar PV systems in households and small businesses in Gauteng as a solution to load shedding?	2.	The feasibility of the implementation of solar PV systems in households and small businesses depends on the cost of hardware for installations and level of support from the government.	Interview guide one questions 6, 7, 8, 10, 11, 12, 13, 14, 16, 17 & 20 Interview guide two questions 7, 8, 9, 10, 11, 13, 16, 17, 19 & 20	Inductive thematic analysis

[7] Interview guide one was used to collect data among household owners
[8] Interview guide two was used to collect data among small business owners

RQ #	Research Question	Prop / hyp #	State Proposition	Data collection detail	Data analysis method
3.	What recommendations and strategic support can be provided to households and small businesses to promote the adoption of solar PV systems?	3.	Recommendations and strategies that support the adoption of solar PV systems includes having sound financing mechanisms, control of finance risks, sound energy policies and regulatory frameworks, provision of benefits such as feed-in tariffs and net metering incentives.	Interview guide three[9] questions 7, 8, 9, 10, 11 & 15 Interview guide four[10] questions 7, 8, 9, 11 &14 Interview guide five[11] questions 10, 11 & 18 Interview guide six[12] questions 8, 9, 10, 11, 15, 16, 17, 18 & 19	Inductive thematic analysis

[9] Interview guide three was used to collect data from government officials
[10] Interview guide four was used to collect data from policy makers
[11] Interview guide five was used to collect data from Eskom employees
[12] Interview guide six was used to collect data from installers

Table 4.1: Profile of the participants

	Name of the participant	Sex	Age	Ethnicity	Occupation	Residential location
1.	Joseph	Male	52	White	Engineer	Rubber Club
2.	Thandi	Female	44	African	Primary Energy Engineer	Mohali city West Rand
3.	Nkosinathi	Male	43	African	Mechanical Engineer	Bez Valley
4.	Charlotte	Female	42	African	Business owner	Brakpan
5.	Kunutu	Male	50	African	Business owner	Midrand
6.	Lesebe	Male	53	African	Business owner	Kempton Park
7.	Lebo	Female	43	African	Policy maker - Energy Specialist	Kempton Park
8.	Philip	Male	45	African	Policy maker – Strategist Dept of Energy	Pretoria
9.	Melinda	Female	43	African	Policy maker – Energy Specialist	Johannesburg
10.	Charles	Male	45	African	Government official - DMR	East Rand
11.	Mpho	Male	45	African	Government official – Department of Energy	Southern Pretoria
12.	Mphahlele	Male	35	African	Government official - DMR	Southern Pretoria
13.	Peter	Male	46	African	Installer	Johannesburg
14.	James	Male	40	African	Lecturer and Solar Installer	Lombardy East

	Name of the participant	Sex	Age	Ethnicity	Occupation	Residential location
15.	Eric	Male	41	African	Installer	Lombardy East
16.	Siyabonga	Male	42	African	Eskom (Electrical engineer)	Benoni
17.	Themba	Male	40	African	Eskom (Electrical engineer)	Morning side
18.	Kgothatso	Male	39	African	Eskom (Electrical engineer)	Brakpan

Source: *Author*