Adoption of Solar Photovoltaic (PV) Technology in Residential Sectional-Title and Townhouse Community Schemes Market in South Africa

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DECLARATION

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

Name: Howard Siboniso Nkuna Signature:

Signed at Alberton, Gauteng

On the 31st day of May 2024

DEDICATION

To the Divine, the source of infinite wisdom, I offer my deepest gratitude. For the gift of knowledge and the enduring capacity to grow, all glory is Yours.

To my cherished partner, Sthando, whose love and support know no bounds, you are the beacon that guides my journey. Your unwavering belief in me is my most incredible fortune.

In honour of my ancestors and family, whose interest in my scholarly pursuits has never waned, I extend my heartfelt thanks. Your prayers and words of encouragement have endowed me with the fortitude and resilience necessary to triumph over adversity.

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I am forever grateful to the Divine and my ancestors for endowing me with the perseverance to see this endeavour to its completion.

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ABSTRACT

The research was undertaken based on the experienced load-shedding and power outages in South Africa. It was observed that other market segments, such as commercial real estate, businesses, industries, and residential customers with standalone houses, have adopted solar PV technology to mitigate the impact of load-shedding and power outages. The research was undertaken to identify and analyse the factors hindering or facilitating solar PV technology adoption and identify activities of responsive business model elements that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa. A qualitative research approach was used to undertake the study.

The research conducted on the factors hindering and facilitating solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa has revealed significant insights. The study identified many barriers that impede the widespread adoption of solar PV systems in these community schemes. These barriers encompass social and stakeholder collaboration challenges, institutional, policy, and legislative hurdles, financial constraints, limitations in land, building, and roof resources, technical and technological obstacles, as well as company resources and operational barriers.

On the contrary, the study also sheds light on various factors that facilitate the adoption of solar PV technology in these residential communities. These facilitating factors include the impact of load-shedding on the demand for backup solutions like solar PV, the influence of social, stakeholder, and industry players in driving awareness and engagement, the role of incentives, policy, and legislative instruments in promoting solar PV investment, the principle of economies of scale in driving adoption in larger communities, and the perceived benefits of solar PV adoption across economic, environmental, social, and energy security domains.

The research question focused on exploring the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa. The study findings revealed two business models, i.e., the customer-owned business model (COBM) and the third-party-owned business model (TPOBM).

Keywords: Renewable Energy, Solar Photovoltaic (PV), Small Scale Embedded Generation, Business Model, Solar PV Installers, Body Corporate

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List of Abbreviations

BMs	Business Models
COP21	21st Conference of Parties
COP26	26th Conference of Parties
DOI	Diffusion of Innovation
DG	Distributed Generation
DSO	Distribution System Operator
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
ESCOs	Energy Service Companies
FIPs	Feed-in Premiums
FITs	Feed-in-Tariffs
GDP	Gross Domestic Product
GW	Gigawatt
GWh	Gigawatt-hour
HOA	Homeowners Association
IDC	Industrial Development Corporation
IEA	International Energy Agency
IPPs	Independent Power Producers
IRENA	International Renewal Energy Agency
IRP	Integrated Resource Plan
IT	Information and Technology
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelized Cost of Electricity
M^2	Metres squared
MW	Megawatt
MWh	Megawatt hour
NERSA	National Energy Regulator of South Africa
NPV	Net Present Value
O&M	Operating & Maintenance
PPAs	Power Purchase Agreements
PPP	Public Private Partnership
PV	Photovoltaic

R&D	Research and development
RE	Renewable Energy
RET	Renewable Energy Technologies
REIPPP	Renewable Energy Independent Power Procurement Program
SLA	Service Level Agreements
SSEG	Small-Scale Embedded Generation
TAM	Technology Acceptance Model
TOE	Technology-Organisation-Environment
UN	United Nations
UTAUT	Unified Theory of Acceptance and Use of Technology Model

1 INTRODUCTION

1.1 Purpose of the Study

The adoption of solar photovoltaic (PV) technology in the Sectional-title and Townhouse Community Schemes of the residential market is beneficial and critical for attaining sustainable living and a secure energy future for South Africa. However, several factors influence the adoption of the technology to assist in tailormade solutions to boost adoption. Thus, this study aims to explore a business model perspective of the factors that hamper and engender the adoption of solar PV technology in the Sectional-title and Townhouse Community Schemes segment in the residential market in South Africa.

1.2 Context of the Study

1.2.1 Global Context

The Renewable Energy Policy Network for the 21st Century (REN 21) report emphasises that the growth of renewable energy has been occurring in tandem with global energy consumption, positioning it as a mainstream energy resource (REN21, 2022). Furthermore, the report acknowledges the United Nations (UN) Secretary-General’s Sustainable Energy for All (SE4ALL 2014-2024) initiative, which, among other objectives, aims to triple the proportion of renewable energy in the world's energy mix by 2030 (REN21, 2022). At the 21st Conference of Parties (COP21) in Paris in December 2015, 195 countries committed to achieving zero net emissions in the latter half of the century, demonstrating a global pledge to address climate change (Ourbak & Magnan, 2017).

The International Energy Agency’s (IEA) publication of the Net Zero by 2050 scenario in May 2021 marked a significant turning point in global climate ambitions, prompting governments and corporations to set even more ambitious targets (IEA, 2021). The change in attitude was noticeable at the 26th Conference of Parties (COP26) in Glasgow, Scotland, in November 2021. During this event, 17 countries pledged to achieve net-zero emissions by 2050 or later, with some aiming for 2025 (Cohen et al., 2022). Concurrently, the European Commission increased its 2030 renewables target in total final energy consumption (TFEC) to 40% in 2021 and 45% in early 2022 (European Commission, n.d).

Several nations have demonstrated their commitment to addressing climate change by submitting revised or new Nationally Determined Contributions (NDCs) to decrease greenhouse gas emissions under the Paris Agreement in anticipation of the COP26 summit (Cohen et al., 2022). The Glasgow Climate Pact, which emerged from COP26, called for countries to increase their climate ambitions annually rather than every five years and, for the first time in UN climate agreement history, explicitly recognised the necessity of reducing fossil fuel usage (Cohen et al., 2022).

A significant milestone during COP26 was the agreement by 140 countries to “phase down” unabated coal power, alongside numerous companies, countries, and public finance institutions pledging to terminate public support and funding for unabated fossil fuels (Global Energy Monitor, 2021). Over 40 countries vowed to discontinue financing new coal plants. However, it is essential to note that commitments to close existing capacity were conspicuously absent from Australia, China, India, and the United States. As of 2021, they collectively possessed two-thirds of the world’s coal plants (Global Energy Monitor, 2021). Furthermore, the UN High-Level Dialogue on Energy in September 2021 saw the UN Secretary-General unveil a roadmap for “global clean energy for all, " attracting government and private sector commitments exceeding USD 400 billion (REN21, 2022, p. 36). This substantial financial backing highlights the growing global recognition of the urgent need to transition to cleaner energy sources.

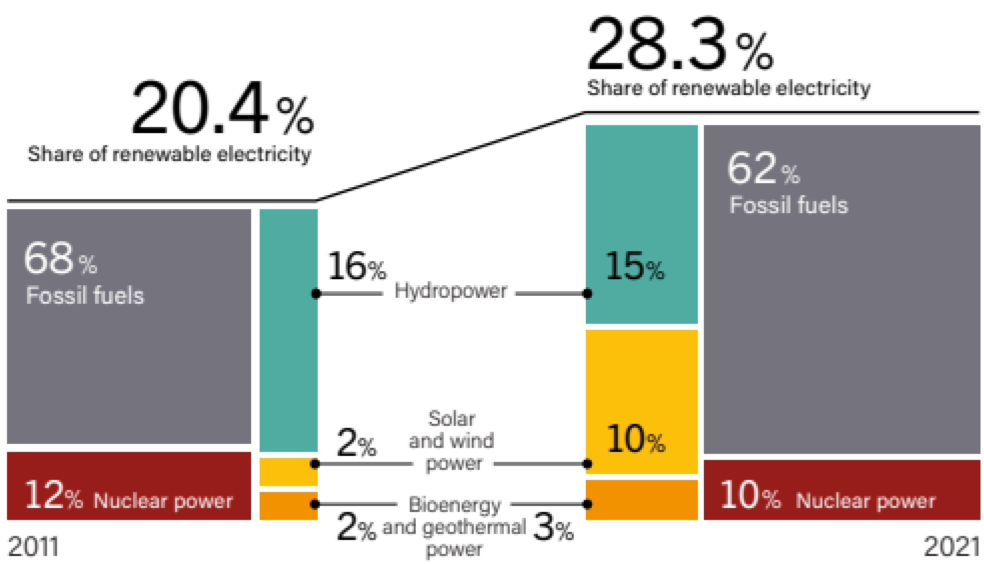


Figure 1: Share of Renewable Energy in Electricity Generation (REN21, 2022, p. 44)

The renewable energy sector encountered obstacles in 2021 due to the ongoing Coronavirus disease (COVID-19) pandemic, its consequences, and economic and geopolitical changes (REN21, 2022). The pandemic’s aftershocks and a surge in commodity prices disrupted renewable energy supply chains and led to project delays (REN21, 2022). Furthermore, the sharp increase in energy prices in late 2021 and Russia’s invasion of Ukraine in early 2022 ignited a growing discourse on the role of renewable energy in enhancing energy security and sovereignty by replacing fossil fuels (REN21, 2022). Despite these challenges, the renewable energy sector experienced record growth in power capacity, with investment in renewable power and fuels increasing for the fourth consecutive year

(REN21, 2022). Consequently, solar and wind power contributed more than 10% of global electricity generation for the first time, as shown in Figure 1 (REN21, 2022). Figure 2 depicts the total additional capacity, the growth and the country's contribution to the renewable energy generated by solar PV (REN21, 2022).

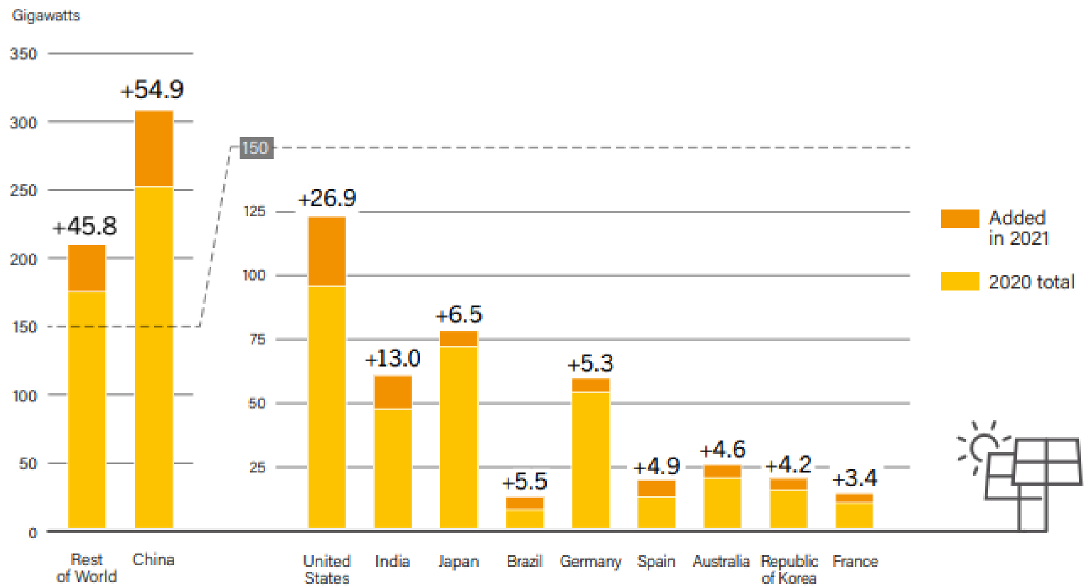


Figure 2: Top 10 Countries for Solar PV Capacity and Additions in 2021 (REN21, 2022, p. 127)

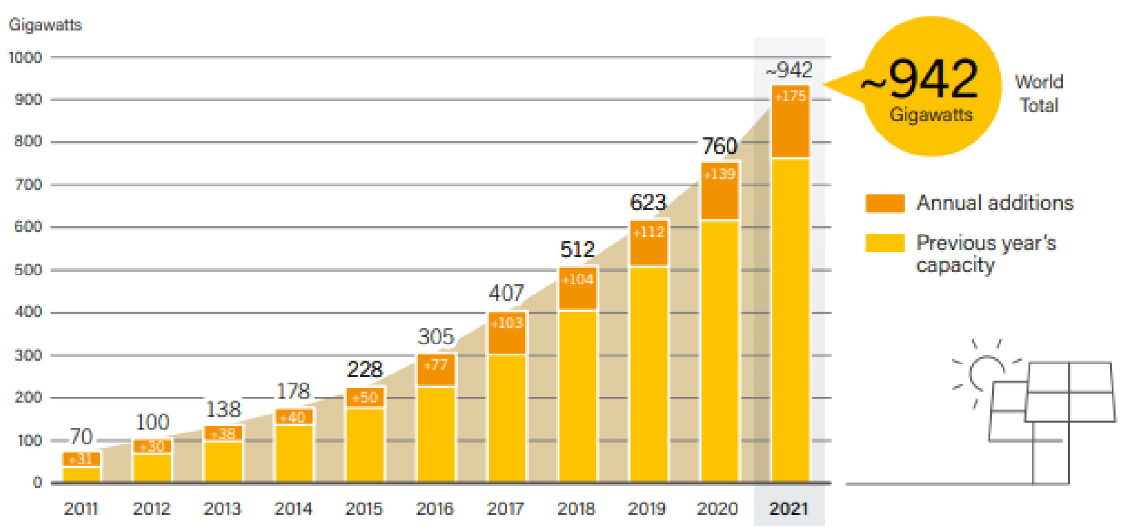


Figure 3: Solar PV Global Capacity and Annual Additions between 2011-2021 (REN21, 2022, p. 126)

Solar PV grew with an estimated 175 Gigawatt (GW) added capacity in 2021, for a total global capacity of approximately 942 GW (REN21, 2022). Although global capacities have increased (as depicted in Figure 3), this growth has primarily overlooked Africa, despite solar radiation in African countries being reported to be 52% to 117% higher than in Germany (IRENA, 2016; REN21, 2022). Nevertheless, this trend shifted due to technological advancements and reduced solar PV costs. Solar PV is already making a significant contribution to decentralised electricity generation in many countries, particularly as rapidly falling costs have rendered solar PV-generated electricity cost-competitive compared to conventional sources, thereby attracting private-sector investments (REN21, 2022). These factors have encouraged numerous local, international, and social entrepreneurs to enter the pico-solar products, solar home systems (SHS) market, and renewable-based mini-grids markets while support policies for utility-scale systems - higher than 1 megawatt (MW) - are starting to yield results (IRENA, 2016; IRENA et al., 2022).

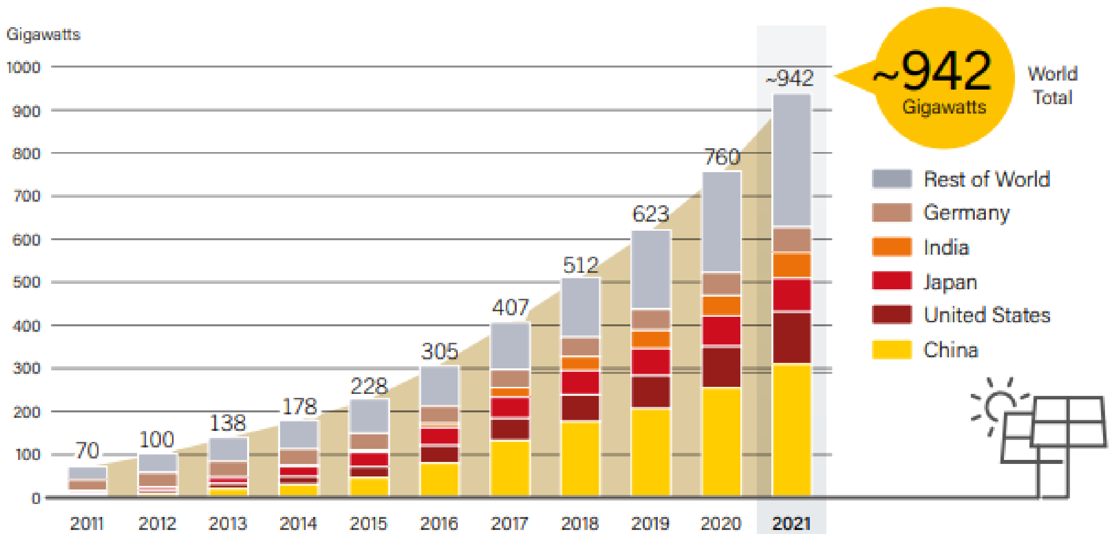


Figure 4: Solar PV Global Capacity by Country and Region between 2011-2021 (REN21, 2022, p. 127)

1.2.2 State of Electricity Industry in South Africa

The electricity market industry in South Africa has its roots in the early 20th century, with the establishment of the Electricity Supply Commission (Eskom) in 1923 (Eskom, 2023). Eskom, a state-owned entity, was granted a monopoly over electricity generation, transmission, and distribution in the country (Eskom, 2023). Eskom dominates the South African electricity market industry, responsible for over 80% of the country's electricity generation (Department of Energy, 2019; Eskom, 2023). With a total nominal capacity of 47,145 MW, Eskom predominantly depends on coal-fired power stations for its electricity generation (Eskom, 2022a). A staggering 83% of Eskom's electricity is sourced from coal, highlighting its significant reliance on this fossil fuel (Eskom, 2022a).

The South African electricity market industry faces several challenges, including ageing infrastructure, financial instability, and inadequate investment in the sector. Since 2007, the electricity market industry has faced an urgent challenge of generating enough capacity to meet social and economic development (Van der Nest, 2015). The challenges mentioned above have resulted in a decrease in the dependability of the electrical supply. Consequently, Eskom has been compelled to introduce load limitations, colloquially called load shedding, which involves intentionally switching off electricity in specific regions to manage power generation capacity (Agbenyo Folly, 2021). This strategy has given rise to power outages and various socio-economic issues (Zhang et al., 2008). South Africans have experienced the worst power outages since 2014, reaching new records in 2022 and 2023, with stage 6 load shedding being implemented. South Africa's inability to meet its electricity demand has led to downward revisions of the economic growth forecast to below 2% for the next two to three years (Burger, 2022).

Despite the present dependence on coal-generated electricity, the electricity industry in South Africa is experiencing substantial transformations. These shifts have been prompted by the challenges encountered by Eskom, including financial struggles, capacity limitations, escalating electricity costs, and downgrades by credit rating agencies (Baker et al., 2014). Additionally, the energy sector is confronted with transitioning towards a low-carbon electricity generation mix, encompassing decentralisation, digitisation, and democratisation (Department of Energy, 2019). This shift is crucial for complying with the nation's commitments under the Paris Agreement on climate change, illustrating a dedication to sustainable and responsible energy production (Department of Energy, 2019).

Naicker and Thopil (2019) argue that transitioning from coal dependency will help South Africa meet the Renewable Energy Independent Power Producer Programme (REIPPP) targets of 39,730MW new generation capacity by 2030. However, Independent Power Producers (IPPs) have been introduced recently to diversify the electricity generation mix and reduce the country's reliance on Eskom. As a result, the country has seen the introduction of renewable energy through the REIPPP, coordinated by the Independent Power Producer Office (IPP) of the Department of Mineral Resources and Energy (DMRE) (Baker et al., 2014). As of 2019, there were 112 operational IPPs in South Africa, contributing to approximately 6,422 MW of installed capacity, and earlier in 2024, this number increased to 140 IPPs with an installed capacity of 13,266 MW (Britz, 2024; Department of Energy, 2019).

The utility provides electricity to industrial, mining, commercial, agricultural, and residential customers in South Africa and municipalities (Eskom, 2022a), who redistribute electricity to businesses and households within their areas, as shown in Figure 5 (Eskom, 2022a; Ratshomo & Nembahe, 2019). Eskom also purchases electricity from Independent Power Producers (IPPs) in terms of various agreement schemes as well as electricity generating facilities beyond the country's borders (Eskom, 2022a; Ratshomo & Nembahe, 2019) and has played a crucial role in South Africa's and the Southern Africa region's economic development.

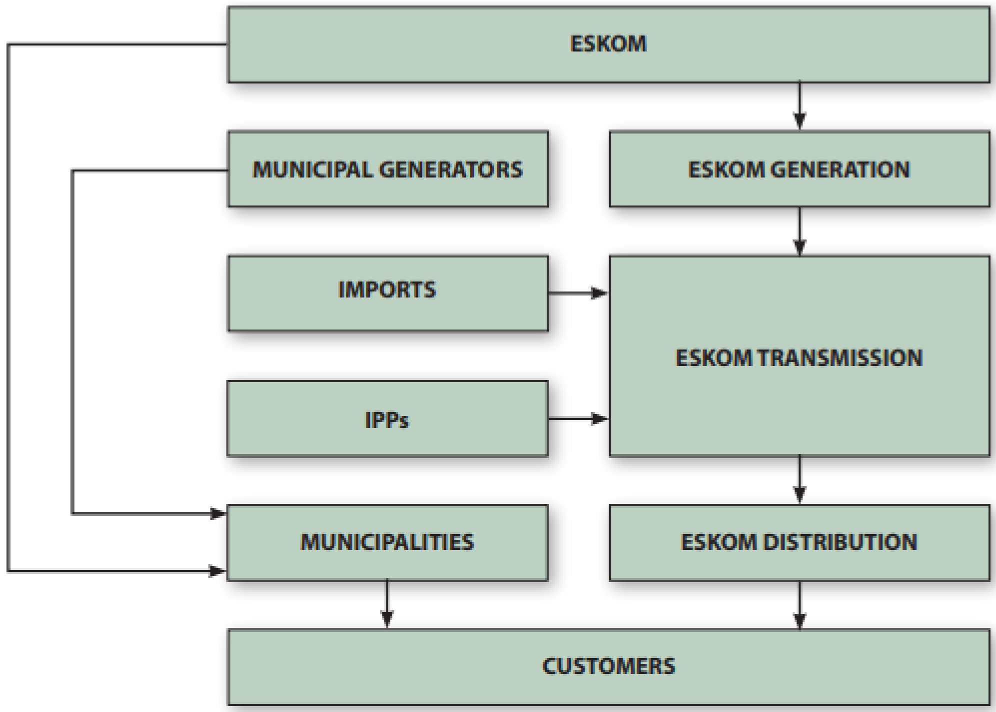


Figure 5: Electricity Generation, Transmission and Distribution (Ratshomo & Nembahe, 2019, p. 16)

Eskom's operating costs are rising, spending massively on building new plants. It appears unable to prevent corruption in its supply chain management (Stone, 2021). Eskom seeks to satisfy by employing tariff increases, increased state guarantees, more long-term loans, and issuing equity to raise capital. For South African residential consumers, electricity costs have increased by 425% between 2007 and 2022, or five times over 15 years (Eskom, 2022b). The Energy regulator NERSA has also approved an 18.65% electricity tariff increase effective April 1, 2023, and 12.74% effective April 1, 2024 (Stoddard, 2023). The price increase is primarily due to Eskom's overspending and colossal debt, which led to a funding deficit of about R400 billion (Bloomberg, 2023; Stoddard, 2023).

1.2.3 Effects on South African Demographic

The effects of electricity supply disruptions, i.e., load-shedding and prolonged power outages, have been felt by many, especially by residential households, small businesses, malls and shopping centres, corporations, public services, and industries. These effects include, but are not limited to:

- Residential households are unable to prepare meals, and food impoverished in the fridge, causing disruption of night studies, reduced entertainment for families, and risk of their electrical appliances being damaged when power is switched on, and an increase in crime rates (Bwalya Umar & Kunda-Wamuwi, 2019);

- Small businesses that depend on electricity to operate are unable to provide services and resort to closing and losing out on sales (Mbhele, 2022);
- Corporates experiencing failing internet connections reduced productivity, missed deadlines by employees and reduced output due to supply chain disruptions (BusinessTech, 2022b);
- Malls and shopping centres lose trading hours, resorting to closing early (Mhlanga, 2022);
- Public services, such as hospitals and clinics, are crippled and pose a risk to patients, resulting in loss of life (Ndaguba, 2018);
- Industries such as mining have experienced a drop in production as they are 'forced to shutdown operations" during load shedding, and the industry as the largest employer may be led to retrenchment (BusinessTech, 2022a).

1.2.4 The Future of South Africa's Electricity Industry

Despite the challenges of Eskom meeting electricity needs, the number of consumers who cannot afford electricity services in South Africa is increasing due to high unemployment, low wages, rising inflation, and electricity tariffs (Stoddard, 2023). The future of the South African electricity market industry depends on addressing the challenges mentioned above and embracing new growth opportunities. Several institutions have called for the introduction of alternative methods of power generation that can reduce power shortages and alleviate energy poverty (National Treasury, 2019). The South African government has demonstrated its political commitment to transition to a green economy by adopting a diversified energy mix away from dependence on coal (Department of Public Enterprises, 2019). The government has outlined plans for restructuring Eskom and introducing further competition in the electricity market by unbundling the utility into separate generation, transmission, and distribution entities (Department of Energy, 2019; Eskom, 2022a). Furthermore, the government's Integrated Resource Plan (IRP) aims to develop 22,000 MW of new renewable energy capacity by 2030, reflecting a growing emphasis on renewable energy sources (Department of Energy, 2019).

Although renewable energy is not yet ready to become baseload electricity due to constraints such as technological development and the optimal design of renewable energy systems (Naicker & Thopil, 2019), the country's electricity challenges have catalysed the REIPPP and the emergence of embedded generation such as rooftop solar PV (Baker et al., 2014; Bloem et al., 2021). These changes have been acknowledged by Eskom, which has recognised the pressure and competition faced by traditionally vertically integrated utilities due to the advent of the decentralised electricity industry business model (Eskom, 2022a). With these reforms, a new business model will emerge in the electricity distribution market. Eskom will procure power from Eskom transmission, licenced generators, and embedded generation (Department of Public Enterprises, 2019). Embedded generation includes renewable energy sources suitable for integration into the country's energy mix (Department of Public Enterprises, 2019).

1.2.5 Embedded Renewable Energy in South Africa

Among renewable sources (i.e. solar power from the sun, wind power from wind and hydropower from water), solar energy is considered one of the most abundant and significant potential energy sources (Kluger, 2019; McKay & Hendricks, 2022; Semelane et al., 2021). Specifically, South Africa has the third-largest solar resources (i.e. solar radiation) globally (Kaluba, 2018; McKay & Hendricks, 2022; Semelane et al., 2021), as depicted in Figure 6.

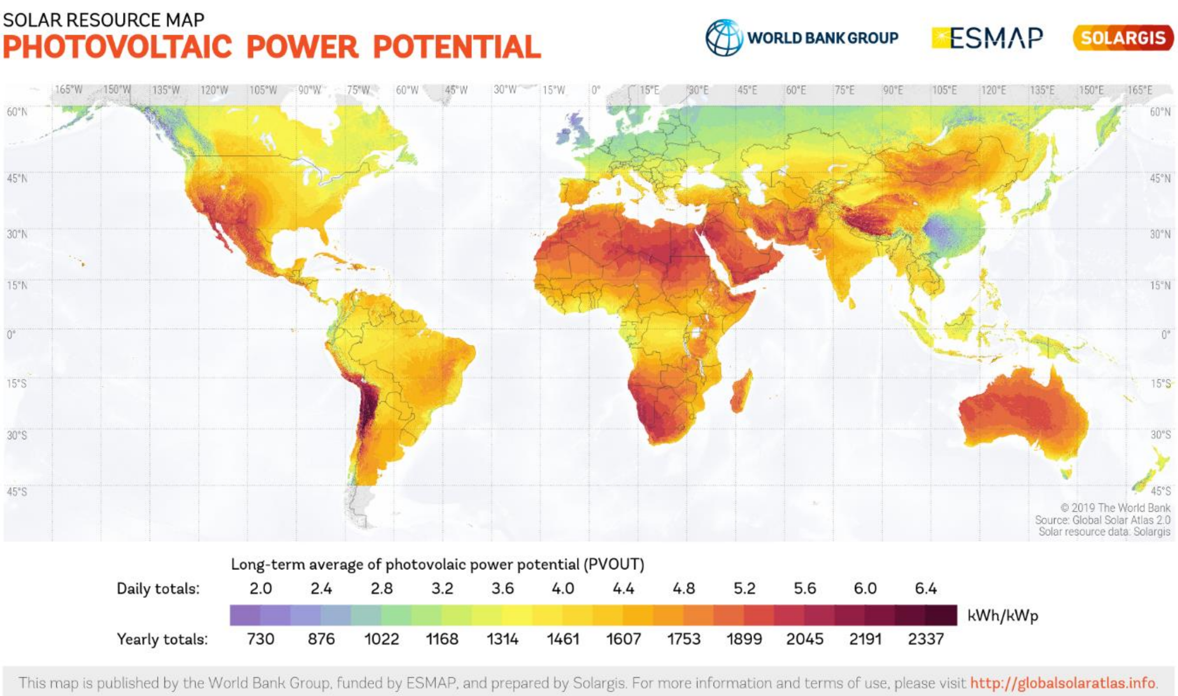


Figure 6: Global Solar Photovoltaic Power Potential (Solargis, 2023)

As depicted in Figure 6, South Africa's solar radiation equals a mean of 4.5kWh to 6.5kWh per m^2 per day, which indicates a potential for solar energy generation. The South African electricity sector has been characterised by a growing demand for energy and a need to transition towards more sustainable and environmentally friendly power generation sources (Eberhard et al., 2014). Solar PV technology has emerged as a viable solution for embedded generations to address these challenges, offering a clean and renewable energy source that consumers can harness (Naicker & Thopil, 2019; Pegels, 2010). Embedded renewable energy, also known as distributed generation or embedded generation, refers to the production of electricity from small-scale renewable energy sources connected to the national grid, near the point of consumption, or used for self-consumption.

Embedded renewable energy has gained significant traction in South Africa, with the country's abundant solar energy potential making it an ideal location for deploying solar PV technology (Pegels, 2010). The South African government has recognised the potential of solar PV. It has implemented various policies and initiatives to support its adoption, such as the REIPPP (Akinbami et al., 2021; Eberhard et al., 2014; Kluger, 2019). These efforts have led to a steady increase in the number of solar PV installations across the country, both at the utility-scale (greater than 1MW with a license) and in Small-Scale Embedded Generation (SSEG), which refers to power generation under 1MW (where a license is not required) that are grid-tied or off-grid application near a residential, commercial or industrial site (Akinbami et al., 2021; Bloem et al., 2021; Pegels, 2010).

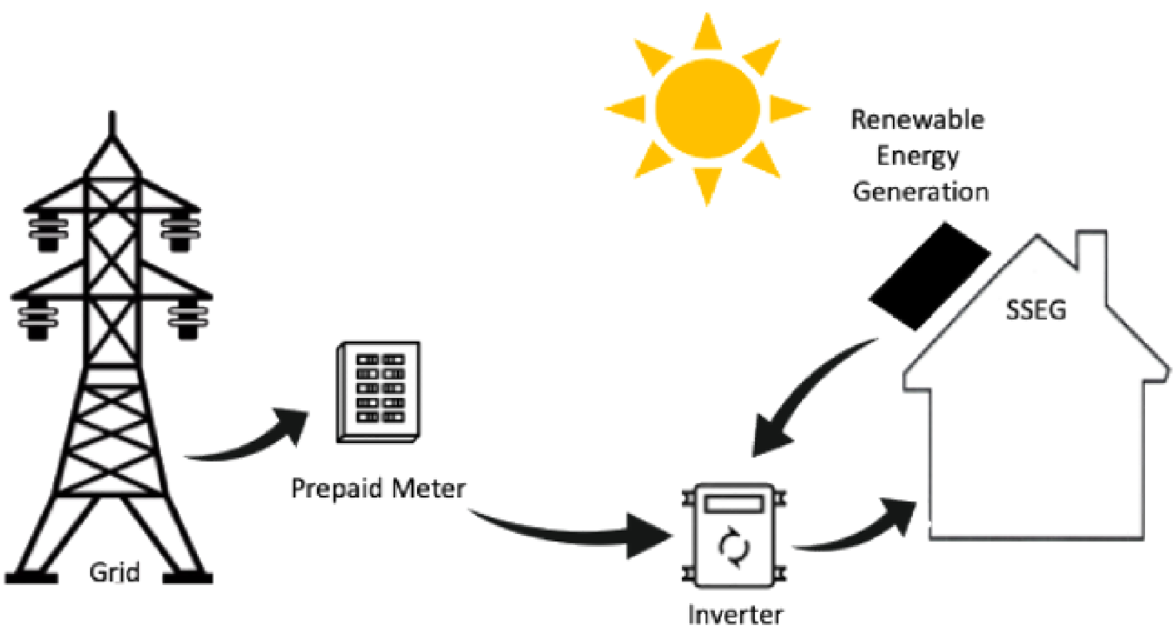


Figure 7: Small Scale Embedded Generation (SSEG) based on Solar PV technology, inverter and battery systems (Bloem et al., 2021, p. 5)

SSEGs using Solar PV tend to generate electricity on the customer side of the Eskom or municipal electricity meter, mainly for self-consumption, as shown in Figure 7 (Bloem et al., 2021). Solar PV systems can be combined with inverters and batteries for energy storage. The arrangement can be programmed to prioritise energy usage from solar PVs and switch to grid energy if solar energy is insufficient. Additionally, the system can draw energy from the batteries if both solar and grid power are inadequate. This setup ensures that the user can benefit from solar power during the day, grid and battery power at night, and battery power in the event of power outages or load shedding. Moreover, the grid can charge the battery during cloudy and shorter winter days (Bloem et al., 2021).

Key role players in the South African electricity industry include Eskom, the national utility responsible for power generation, transmission, and distribution. The National Energy Regulator of South Africa (NERSA) oversees licences for electricity generation, transmission, distribution, and trading and determines electricity tariffs and prices in the energy sector. The Department of Energy (DoE) is responsible for policy development and implementation in the energy sector. The South African National Energy Development Institute (SANEDI) has been entrusted with overseeing, supervising, and carrying out energy research and development activities. Additionally, SANEDI is tasked with fostering advancements in energy research and technology and implementing strategies to enhance energy efficiency across various sectors of the economy (Eberhard et al., 2014; Eberhard & Naude, 2017; Filipova et al., 2019).

The South African Photovoltaic Industry Association (SAPVIA) works closely with government agencies, regulatory bodies, and other stakeholders to promote the adoption of solar PV technology in South Africa and to ensure that the industry operates sustainably and responsibly. These organisations play a crucial role in facilitating the adoption of solar PV technology within the residential market by developing appropriate regulations, tariffs, and incentives (Eberhard et al., 2014; Eberhard & Naude, 2017; Filipova et al., 2019).

1.3 Research Problem

South Africa has experienced significant growth in adopting solar PV systems due to increasing demand for renewable energy sources, driven by concerns over climate change, fossil fuel depletion, and decreasing solar PV technology prices. These systems offer numerous advantages, such as a life cycle of 25 to 30 years, minimal maintenance requirements, and independence from additional fuel sources. Barriers to the widespread adoption of solar PV systems in South Africa include high upfront installation costs and low efficiency, which affect the performance of the solar PV installation, amongst the financial, technological, political, and social barriers, which economically render the Solar PV technology expensive and unviable (Caruana et al., 2021; Esram et al., 2006). However, recent advancements in solar power efficiency (Khan & Arsalan, 2016) and annual declines in solar PV costs by 20% to 30% (Borenstein, 2012) have made solar energy more attractive, considering the high electricity tariffs charged by Eskom and South African municipalities as well as an intermittent and unreliable electricity supply (Semelane et al., 2021; Strydom, 2020).

The benefits of PV installations gained popularity recently when South Africa's PV market ranked as one of the highest for solar technology in the world (Akinbami et al., 2021). Drivers for adopting solar PV systems in South Africa include the potential for rooftop solar photovoltaic systems, which typically have payback periods of 3 to 7 years of investment costs (Muchunku et al., 2018). To further encourage the adoption of solar PV technology, policy reforms and incentives such as subsidies, tax credits, interest-free loans, and feed-in-tariffs (FIT) policy, which encourage consumers and investors to switch to solar power and sell additional electricity generated to the utility grid, which has been proposed and implemented in various countries, including the US, Germany, Portugal, and Italy (Mukisa et al., 2021; Pegels, 2010; J. P. Walters et al., 2018). Although these reforms and incentives have been lacking in the South African context, there are calls by industry players to push towards a FIT policy in the residential market, which enables customers to export excess power to the grid from a solar installation and be paid at a specific rate (Knight & Mahlalela, 2017; National Treasury, 2019; Strydom, 2020).

Within the broader research problem, this study explicitly addresses the relatively low adoption of solar PV technology in the residential market, especially in medium-density housing, such as sectional-title properties and townhouses. A study conducted by McKay and Hendricks (2022) to establish the drivers and barriers for the middle-income population in the residential market in adopting rooftop PV in South Africa found that South African households prefer demand-side management tools, such as energy-efficient lights and inverters trolleys, and opt for gas or generators instead of rooftop solar photovoltaic (PV) systems. This preference is attributed to the high costs of rooftop PV, the lack of supportive measures like feed-in tariffs, tax rebates, and subsidies, and the reluctance of banks to finance such projects due to long-term return on investment and the absence of accredited suppliers (McKay & Hendricks, 2022). Additionally, middle-income consumers face challenges in understanding PV technology and trusting suppliers, who often fail to market themselves effectively or offer adequate maintenance and credit services.

In South Africa, the relatively low adoption of solar PV technology in the residential market, especially in medium-density housing, such as townhouses, necessitates further investigation, as McKay and Hendricks (2022) suggested. These townhouse complexes, typically found in suburban areas of major cities, have experienced significant growth since the country's political transition due to their affordability, security, and changing family structures (Du Toit et al., 2017). Therefore, understanding and addressing the barriers to solar PV adoption in this housing sector is crucial for promoting pro-environmental consciousness in the country.

From a solar energy company perspective, anecdotal evidence indicates limited literature on businesses that provide services to customers in the Sectional-Title and Townhouse segment of the residential market. This gap presents an opportunity to explore a business model perspective to overcome the barriers and capitalise on the drivers for solar PV adoption in South Africa. There are emerging business models for deploying solar PV systems in residential settings, such as multi-story buildings, sectional-title, and townhouse community schemes, including initiatives from retailers, developers, and community energy organisations (Roberts et al., 2019; Trotter & Brophy, 2022).

Several scholars (Cabanero et al., 2020; Guajardo, 2021; Moner-Girona et al., 2018; Trotter & Brophy, 2022; Yang & Yang, 2018) suggest that the business model should aim to create, deliver, and capture social, economic, and environmental value in the changing market conditions, emerging opportunities, and evolving regulations. Such a business model can also include innovative financing for integrating solar PV in the townhouses (Kaluba, 2018) and deploying solar photovoltaics in apartments through initiatives with developers (Roberts et al., 2019) and community structures such as homeowners' associations (HOAs) and Body Corporates in the case of townhouse schemes (Bloem et al., 2021). Solar PV technology can supply electricity to common property, individual apartments, or shared resources between multiple apartments through embedded networks, local energy trading, or 'behind the meter' deployment models (Kaluba, 2018). These systems can be implemented to reduce reliance on the national grid and mitigate the impact of electricity tariff hikes (Sewchurran & Davidson, 2021).

1.4 The Rationale of the Study

This study addresses a significant gap in the empirical studies on responsive business models for solar energy companies and factors influencing adopting solar PV technology in the sectional-title and townhouse community scheme development in South Africa's residential market. Given the scarcity of such studies, the findings of this research are poised to enhance understanding of the factors that drive the adoption of solar PV technology in these residential settings.

It seeks to identify effective strategies that stakeholders can implement to overcome existing challenges in this sector. Doing so will empower and support representatives of sectional-title and townhouse community schemes to adopt solar PV technology further. Moreover, this study aims to provide valuable insights into the development of responsive business models for solar energy companies.

This research is significant for its contribution to academic literature and practical implications for solar energy companies and residential sectional-title and townhouse communities in South Africa.

1.5 Objectives of the Study

The study is guided by the primary research objective and sub-objectives as follows:

1.5.1 Main objective

To explore a business model gap that can enable increased adoption of solar PV technology in the sectional title and townhouse community schemes segment of the residential market in South Africa, which is further divided into two sub-objectives.

1.5.2 Sub-objectives

- To identify and analyse the factors hindering or facilitating solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa.
- To explore and evaluate responsive business model elements that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa.

1.6 Research Questions

1.6.1 Research Question One

What are the factors that hinder or facilitate solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa?

1.6.2 Research Question Two

What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa?

1.7 Delimitations of the study

The delimitations of a study refer to the boundaries or limitations that the researcher has set to narrow down the scope of the research. In this study, there are three primary delimitations:

- **Scale of Generation:** This study is focused explicitly on small-scale embedded generation systems with a capacity of up to 1 MW. It excludes larger generation stations above 1 MW, meaning that this research does not cover large-scale renewable energy generation systems, such as IPPs, that supply power to Eskom and Municipalities' transmission and distribution networks. The emphasis is on small-scale systems embedded within the community (IRENA, 2019; IRENA et al., 2022).

- **Type of Renewable Energy:** This study explicitly examines small-scale embedded generation systems that utilise solar PV technology. Other renewable technologies, such as wind energy, are not included in the scope of this research (Eberhard et al., 2014).
- **Market Segment:** The study is focused explicitly on the sectional title and townhouse community schemes segment of the residential market in South Africa, implying that other market segments, including commercial, industrial, mining, and other residential segments like single-family homes, are not covered in the research.

These delimitations ensure that the research remains focused and manageable while addressing the research questions.

1.8 Definition of key concepts

The fundamental concepts used in the study are defined as follows:

Business Model – refers to a plan that outlines how a company generates revenue, delivers value to its customers, and sustains profitability. The existing literature on renewable energy business models can be categorised into two primary types: utility-side and customer-side models (Huijben & Verbong, 2013; Richter, 2012). These classifications provide a comprehensive overview of the current state of research in renewable energy business models.

Utility-side business models revolve around large-scale renewable energy systems that generate energy on a massive scale and feed it into the central grid (Huijben & Verbong, 2013; Richter, 2012). In these models, there is no self-consumption of energy or direct interaction with the end user. Examples of utility-side business models include large-scale solar farms and wind farms (Sarasini & Linder, 2018).

On the other hand, customer-side business models primarily focus on off-grid or on-grid renewable energy systems located on the customer's property or near the end user (Richter, 2012; Wainstein & Bumpus, 2016). These models emphasise the direct benefits to the consumer, such as energy self-consumption and increased interaction with the energy generation process. Examples of customer-side business models include solar PV panels and small-scale wind turbines (Sarasini & Linder, 2018). In this study, a focus will be on the customer-side business model based on solar PV Panels.

Feed-in-Tariff (FiT) Policy - allows utility consumers to generate energy through Renewable Energy Technology (RET) projects and supply surplus energy to the grid network. This policy enables prosumers to gain financial benefits by receiving a FiT rate for the power fed into the grid while also experiencing a decrease in their regular energy bills from the utility. The FiT rate provided under this scheme is either facilitated by the utility operator via ratepayers or by the government through taxpayers (Barbosa et al., 2018; Couture et al., 2010). FiT policies can be divided into two main categories. The first category is the market-independent FiT scheme, in which the regulatory authority, separate from the electricity market retail rate, determines remuneration. This type of FiT scheme is also referred to as the fixed-price FiT scheme, which comprises the generation cost (levelized cost of electricity (LCOE)) (Barbosa et al., 2018). The second category is the market-dependent FiT policy, where a premium payment, serving as a supplement, is incorporated into the standard retail rate of the electricity market. This type of FiT policy is also known as the premium-price (bonus) FiT scheme (Barbosa et al., 2018).

Net Metering (NM) - is a billing method that rewards prosumers for the electricity they contribute to the grid from their installed systems. Throughout the billing cycle, prosumers receive credit in the form of kilowatt-hours for the energy they supply to the grid. In cases where prosumers' systems produce more electricity than they consume, their electric meters effectively "run backwards," as the excess energy is directed to the grid. Hence, the prosumers acquire reduced electricity from the utility provider (Augustine & McGavisk, 2016; IRENA, 2019; REN21, 2022; Zhang, 2016).

Net present value (NPV) – is a financial evaluation method employed in this research to ascertain the overall worth of investing in rooftop solar photovoltaic (PV) systems for the selected case study, taking into account a series of cost and revenue flows throughout a specified time frame (Le, 2021; Semelane et al., 2021). By converting future expenses and revenues into their present monetary value in South African Rand, NPV enables a compelling analysis of an investment's profitability, considering the project's future cash flows about the social discount rate (Le, 2021; Semelane et al., 2021).

Payback Period – refers to the amount of time it takes for the initial investment deployed for the installation of a solar PV system to be paid back through revenue generated from the sale of electricity generated from the solar system for self-consumption and the excess electricity feed-back to the grid (Sewchurran & Davidson, 2021). It is essential for evaluating investment options (Kuang et al., 2022; Simin, 2021).

Sectional-Title and Townhouse Community Schemes – refer to residential development where individual units are grouped on one erf or site with shared facilities such as parking areas or gardens, and this development can take various forms and functions depending on the size, layout, design, location, and management of the schemes (Landman & Badenhorst, 2012).

Small Scale Embedded Generation (SSEG) – refers to a power generation facility under 1MW (where a license is not required) that is connected at low voltage to a Distribution System near a residential, commercial, or industrial site (Akinbami et al., 2021; Bloem et al., 2021; NERSA, 2021; Pegels, 2010).

The Researcher – pertains to the student who is carrying out the research.

1.9 Assumptions

The assumptions of the study are the following:

- availability and willingness of participants of the research to be interviewed; and
- research participants will provide an honest, authentic, and factual response to the interview questions.

1.10 Outline of the Research Report

The report is structured into six chapters, including this introductory chapter. The subsequent chapters are organised as follows:

Chapter 2 - Literature Review: This chapter comprehensively reviews the existing literature, setting the stage for the study by discussing key concepts. It delves into the factors influencing the adoption of solar PV technology and the current understanding of solar photovoltaic (PV) business models. Additionally, it introduces a conceptual framework that connects related theories and sub-themes.

Chapter 3 - Research Methodology: This chapter outlines the research methodology, detailing the steps to investigate the research problem, the data collection process, and the rationale for the chosen techniques for identifying, processing, and analysing data. It also discusses the establishment of rigour, the limitations of the chosen methods, and ethical considerations.

Chapter 4 - Presentation of Research Findings: This chapter presents in-depth interviews and data analysis results. It highlights the key emerging themes and presents the research questions' findings.

Chapter 5 - Discussion of the Research Findings: This chapter offers a discussion on the results and findings of the study, contrasting them against the existing literature to provide a comprehensive understanding of the research problem.

Chapter 6 - Conclusions and Recommendations: This final chapter summarises the discussions in Chapters 4 and 5. It presents recommendations for various stakeholders in the solar energy industry, including entrepreneurs, financial service providers, policymakers, regulators, and representatives of sectional-title and townhouse community schemes such as managing agents, Body Corporates, and Homeowners' Associations (HOAs). Lastly, it provides suggestions for further research in this area.

2 LITERATURE REVIEW

2.1 Introduction

This chapter explores the literature on the key concepts, theories and research gaps related to the research problem. A comprehensive exploration of pertinent literature was carried out utilising key terms such as "Embedded energy generation," "Small-Scale Embedded Generation," "Distributed Power System," "Solar PV," "Rooftop solar PV," "Solar Business Model," "barriers,” “drivers” and “benefits," and "Residential market".

The study begins by providing a background discussion on the sectional title and townhouse community schemes segment in the residential market, solar photovoltaic (PV) adoption and the various solar business models.

Subsequently, the chapter delves into a robust and nuanced understanding of the factors influencing the adoption of Small-Scale Embedded Generation (SSEG), especially rooftop solar photovoltaic (PV) technology, within the global context and in South Africa.

It then presents the theoretical framework of the research, which forms the basis for examining various solar business models and their capacity to promote the adoption of solar PV technology within the specified market. This framework draws upon established theories and concepts within technology acceptance, innovation diffusion, and business model innovation.

Lastly, the chapter outlines the study’s conceptual framework, which serves as the foundation for establishing factors influencing the adoption of solar PV technology and analysing solar business models and their potential for driving the adoption of solar PV technology in the targeted residential market.

In summary, this literature review seeks to offer a thorough understanding of the electricity industry in South Africa, the renewable energy landscape, and the potential for solar business models to drive the adoption of solar PV technology in the sectional-title and townhouse community schemes residential market.

2.2 Background Discussion

2.2.1 Sectional-Title and Townhouse Community Schemes

In recent years, South Africa has witnessed a proliferation of medium-density housing and cluster developments, catering to a wide range of income groups and household types, not only in large metropolitan areas such as Johannesburg and Tshwane but also in provincial cities across the country (Ferreira & Visser, 2015; Landman & Badenhorst, 2012). This growth in sectional-title and townhouse development is due to the growing need for secure living environments, efficient land use, and the desire for affordable yet comfortable housing options.

There are numerous types of cluster developments in South Africa, encompassing a wide range of forms and functions. These include large security estates, townhouse complexes, and apartment block developments (Landman & Badenhorst, 2014). The various types differ in size, spatial arrangement, facilities, amenities, and their primary function, ranging from predominantly residential (e.g., smaller gated townhouse complexes and apartment blocks) to mixed-use gated developments (Landman & Badenhorst, 2014).

One of the critical reasons for the growing preference for townhouse developments is the enhanced security they offer. In South Africa, where crime rates are relatively high, the demand for secure living environments has led to the popularity of gated communities and townhouse complexes. Additionally, these developments often provide residents with access to shared facilities and amenities, such as swimming pools, gyms, and communal gardens, which contribute to the overall appeal of this type of housing (Landman & Badenhorst, 2012, 2014; Makhale & Landman, 2018).

The popularity of townhouse developments in South Africa can be attributed to their well-organised management structure. The management of these large, gated estates is typically overseen by Body Corporates and Homeowners Associations (HOAs), which are responsible for the day-to-day management of the estate and includes the management and maintenance of shared facilities and amenities, as well as the provision of security services. The complexes are governed by the Sectional Titles Act and the Sectional Title Management Schemes (STMS) Act, which defines common property as that part of a sectional title scheme which does not form part of any section (Paddocks, n.d). “Examples of common property are driveways, parking bays and garages, private gardens and gardens, swimming pools, corridors, lifts, and entrance foyers, to name a few. Some parts of the common property can be designated for exclusive use areas under section 27 or section 27a and allocated to a particular owner for exclusive use” (Paddocks, n.d).

The government has established a Community Scheme Ombud Service (CSOS) with a mandate to “regulate the conduct of parties within community schemes” as well as “to provide a dispute resolution service and also provide stakeholder training, consumer education and awareness for property owners, occupiers and other stakeholders” (CSOS, 2022, p. 6) due to several issues about the management of schemes and disputes between different stakeholders involved, such as the homeowners, occupiers or tenants, estate agents, trustees, Body Corporates and homeowner’s association, as well as employees employed by the schemes. According to CSOS (2022), about 30,438 community schemes have been registered. However, according to the Associations of

Residential Communities ARC (n.d), there are 56,000 sectional-title schemes and 3,000 homeowners' associations. These indicate that the number of community schemes registered with CSOS is less than expected.

The benefits and drawbacks of townhouse development for residents, communities, and cities have been widely debated in the literature (Schuur, 2005). On the one hand, townhouse development can offer advantages such as security, affordability, convenience, access to shared facilities and amenities, social interaction, community cohesion, efficient land use, increased property values, and reduced infrastructure costs (Ferreira & Visser, 2015; Landman & Badenhorst, 2014). On the other hand, townhouse development can also pose challenges such as spatial fragmentation, social exclusion, environmental degradation, loss of privacy, conflict over management, maintenance, and governance issues, and limited opportunities for customisation and personalisation (Ferreira & Visser, 2015; Landman & Badenhorst, 2014).

One of the emerging themes in the literature is the potential for enhancing sustainability and energy efficiency in communities (Funkhouser et al., 2015; Izadpanahi et al., 2021; Nolden et al., 2020; Ptak et al., 2018; Stauch & Vuichard, 2019), for example, in a townhouse development in the South African context (Bloem et al., 2021). Townhouse developments offer a unique opportunity for solar PV adoption compared to other residential segments, such as free-standing homes, due to economies of scale, shared infrastructure, and collective decision-making. Due to the shared nature of these developments, the implementation of solar PV systems can be more cost-effective and efficient, as the benefits of the technology can be distributed among multiple households (Bloem et al., 2021). Installing solar PV systems on rooftops or communal areas of townhouse complexes such as solar carports (Rigo et al., 2022), residents can reduce their dependence on grid electricity, lower their electricity bills, and increase their energy security.

This benefit encourages the adoption of renewable energy sources and contributes to the community's overall sustainability and energy efficiency. Furthermore, they can contribute to the national goals of increasing renewable energy generation and reducing carbon emissions. However, some barriers and challenges hinder the uptake of solar PV technology in a townhouse development, such as lack of awareness, knowledge, and skills, high upfront costs, complex legal and regulatory frameworks, and resistance from developers, Body Corporates, and Homeowners Associations (HOAs) (Ferreira & Visser, 2015).

2.2.2 Solar Photovoltaic (PV) Technology Adoption

Solar PV is a renewable energy technology that converts sunlight into electricity using photovoltaic cells. Solar PV has many benefits for the environment and the economy, such as reducing greenhouse gas emissions, diversifying the energy mix, creating jobs, and lowering electricity costs (World Bank, 2019). South Africa has a high solar potential, with an average of 2,500 hours of sunshine per year and a solar radiation level of about 4.5 to 6.5 kWh/m2 per day (IRENA, 2019). According to the Integrated Resource Plan (IRP) 2019, the South African government has mandated 600 MW of solar PV procurement by 2022. It aims to increase the country's total solar PV capacity to 6,000 MW by 2030 (World Bank, 2019).

Some examples of recent solar PV projects in South Africa include the De Aar project in the Northern Cape, which is the largest solar farm in Sub-Saharan Africa with a capacity of 175 MW (Jiang, 2022); the Lesedi Solar PV project near Kimberly, which has a capacity of 75 MW (Jiang, 2022); and the New Solar Energy's floating solar farm in Gauteng, which has a capacity of 0.06 MW and is the first of its kind in Africa (Jiang, 2022). These projects demonstrate the feasibility and viability of solar PV technology in South Africa's diverse climatic and geographic conditions. Moreover, they illustrate how solar PV can be integrated into different types of developments, such as ground-mounted, rooftop-mounted, or floating systems.

The South African government has recognised the potential of solar PV. It has implemented various policies and initiatives to support its adoption, such as the Renewable Energy Independent Power Producer Procurement Programme (Akinbami et al., 2021; Eberhard et al., 2014; Kluger, 2019). These efforts have led to a steady increase in the number of solar PV installations across the country, both at the utility-scale (greater than 1MW with a license) and in Small-Scale Embedded Generation (SSEG), which refers to power generation under 1MW (where a license is not required) that are grid-tied or off-grid application near a residential, commercial or industrial site (Akinbami et al., 2021; Bloem et al., 2021; Pegels, 2010). These Solar PV installations used to be mainly off-grid and located in rural regions where grid connection was expensive. However, as technology advances quickly and costs drop, more urban areas are adopting SSEG solar PV installations.

Akoon (2020) conducted a study investigating the uptake of PV panels in urban spaces during 2010-2019 and its impact on energy security in single-dwelling households, shopping centres and industries. Akoon (2020) conducted a study investigating the uptake of PV panels in urban spaces during 2010-2019 and its impact on energy security in single-dwelling households, shopping centres and industries. The study found that there has been an increase in energy security in these areas due to the uptake of PV panels. However, the uptake was low for single-dwelling households. Pandarum et al. (2019) echoed the same. They estimated that about 285 MW of SSEG solar PV rooftop and ground were installed in South Africa as of December 2017 and projected that the uptake growth increases from 2018 until 2025, as shown in Figure 8. In contrast, Mulaudzi Silas et al. (2022) found substantial potential for solar PV in the middle- and high-income groups. The study revealed that 2 million middle-income and 523,301 high-income households consume 9.6 and 3.1 TWh/year, respectively, and are interested in paying for electricity based on green sources, such as solar PV systems.

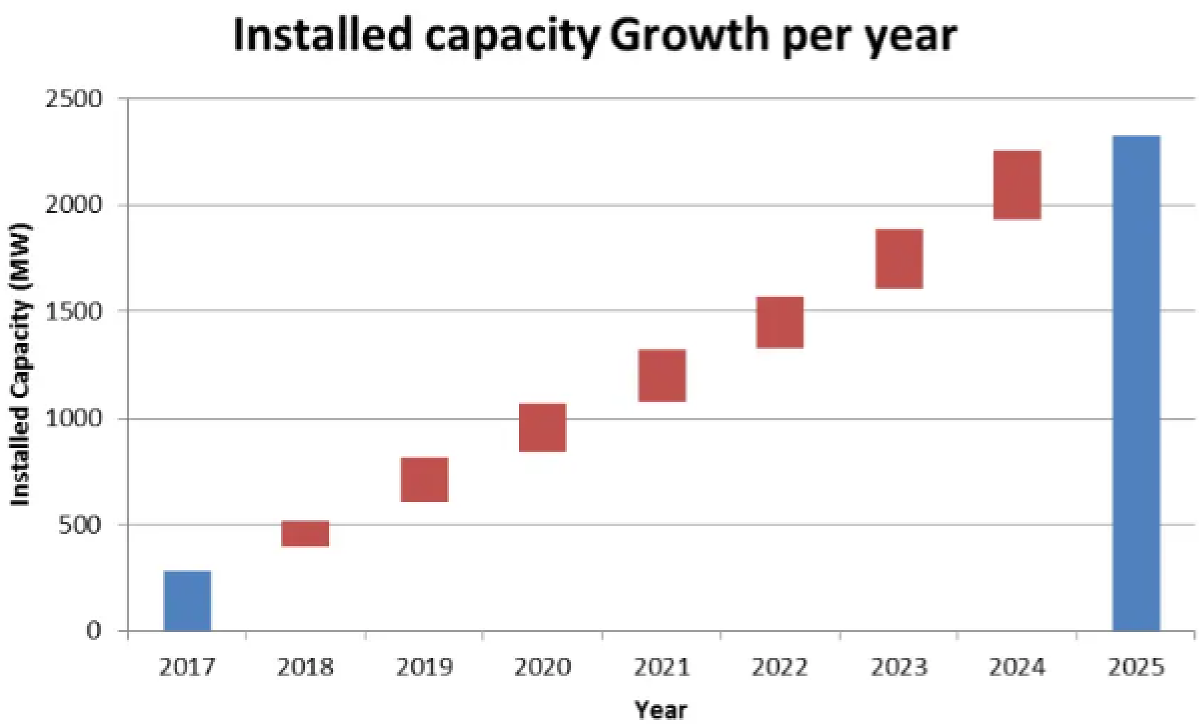


Figure 8: SSEG Solar PV estimated growth in capacity from 2018 to 2025. Adopted from Pandarum et al. (2019)

On the other hand, Hendricks (2016) conducted a study in Parkhurst to determine the levels of acceptance and uptake of rooftop solar PV. The study found that the uptake of solar was low, which could be due to various reasons. The studies emphasise the need to comprehend the factors influencing the uptake of PV panels and the potential for solar PV in different income groups to promote a sustainable and secure energy future.

According to the literature (Akinbami et al., 2021; Etongo & Naidu, 2022; Kizilcec & Parikh, 2020; Ngonda, 2022), some of the potential social and economic impacts of solar PV adoption in South Africa include:

a) The improvement of energy access and security for households and businesses, especially in rural and remote areas, can enhance their quality of life, well-being, productivity, and income generation (Etongo & Naidu, 2022; Kizilcec & Parikh, 2020; Ngonda, 2022).

b) Reducing reliance on fossil fuels and grid electricity can lower the exposure to volatile fuel prices, power outages, and load shedding and increase resilience to energy shocks and disruptions (Etongo & Naidu, 2022; Kizilcec & Parikh, 2020; Ngonda, 2022).

c) The solar PV value chain offers local communities employment and economic opportunities in manufacturing, installation, operation, maintenance, and service provision (Akinbami et al., 2021; Kizilcec & Parikh, 2020; Ngonda, 2022).

d) Promoting social unity and empowerment among individuals who adopt and use solar PV systems can be particularly beneficial in townhouse development and rural electrification settings. In these contexts, solar PV systems have the potential to facilitate collective action, active participation, shared ownership, and effective management (Ferreira & Visser, 2015; Kizilcec & Parikh, 2020; Ngonda, 2022).

e) Mitigating greenhouse gas emissions and environmental impacts from fossil fuel-based power generation can contribute to climate change adaptation and sustainable development goals (Etongo & Naidu, 2022; Kizilcec & Parikh, 2020; Ngonda, 2022).

2.2.3 Energy (Solar PV) Business Models

Before liberalising the energy market, the focus on Energy Business Models (EBM) was minimal, as monopolistic utility companies primarily offered a standardised commodity to a wide range of consumers. However, the unbundling of the market and the growth of renewable-based decentralised generation have led to significant changes in the traditional utility business models, enabling smaller energy retailers to emerge and provide innovative electricity supply packages (Ferreira, 2018). Consequently, new EBMs have surfaced, which tend to be predominantly service-oriented, encompassing electricity supply, energy management, and energy efficiency services (Ferreira, 2018). Presently, both large utilities and small energy retailers are competing to offer tailored energy solutions that increasingly concentrate on local generation and consumption (Ferreira, 2018).

Two main types of energy business models (EBMs) exist for renewable energy technologies (RETs): utility and customer-side business models, as shown in Figure 9. Utility-side models involve large-scale projects that produce and deliver electricity to the grid, similar to traditional power plants (Richter, 2012). Customer-side EBM involves small-scale systems installed near the end-users, also known as distributed generation (DG) (Richter, 2012). The customer-side systems have a different position in the power system, as they generate electricity at the point of consumption. Since this study focuses on distributed generation, the customer-side EBMs are discussed as the potential solar PV business models to drive the adoption of solar PV technology in the residential market of the sectional-title and townhouse community schemes. These customer-side EBMs include the customer-owned business model (COBM), Third-party Owned Business Model (TPOBM) and Community-Shared Business Model (CSBM).

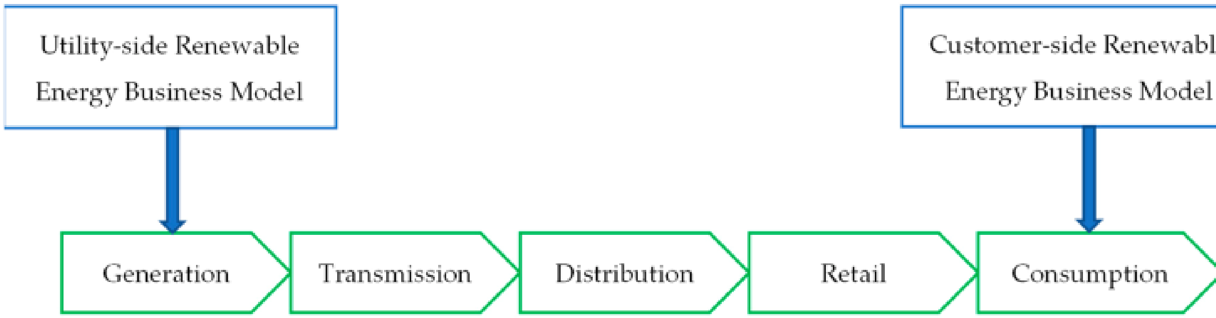


Figure 9: Energy Business Models and their location in the power system (Richter, 2012)

2.2.3.1.1 Customer-Owned Business Model (COBM)

The predominant photovoltaic (PV) business model found in the literature is the host-owned model, which is referred to by several different names, such as customer-owned (Huijben & Verbong, 2013; Mukisa et al., 2022), host-owned feed-in (Bankel & Mignon, 2022; Strupeit & Palm, 2016), customer-sited (Mukisa et al., 2022; Strupeit & Palm, 2016), plug-and-play (Mukoro et al., 2022; Van Opstal & Smeets, 2022a), and end-user owner PV (Huijben & Verbong, 2013). In this model, the building owner where the PV system is installed is the primary user of the energy generated. The term "Customer-Owned Business Model" (COBM) will be employed to ensure uniformity throughout the study (Huijben & Verbong, 2013; Mukisa et al., 2022), while a company offering services to the customer under this business model will be designated as a "solar energy company".

COBM projects are initiated by customers who invest in energy generation and storage assets to take advantage of self-consumption and reduce energy bills. Long-term power purchase agreements (PPAs) are established with energy retailers or last-resort traders, who purchase the prosumers' excess generation and compensate them through feed-in tariffs while supplying the upstream power needed. The modes of 'all sold to the grid' or 'self-consumption with surplus sold to the grid' can be utilised, allowing for the complete injection of generated power into the grid or self-consumption with surplus injection, respectively (Hamwi & Lizarralde, 2017). The primary market segment for COBM projects is the residential sector, along with small and medium enterprises that typically have suitable property space for solar PV systems, particularly building rooftops.

The low deployment of RETs, particularly solar PV, has led to the development of energy business policy schemes (discussed in section 2.3.2.2) and niche markets intended to enhance the diffusion of RETs and their valuation. COBM projects have significantly benefited from these schemes, especially the FiT and NM schemes (Mukisa et al., 2021; Pang et al., 2019). Generally, COBM projects have high upfront investment costs and long payback periods, which impede deployment from the customer's perspective. Therefore, from the entrepreneur's perspective, the COBM has a deficient potential responsive business model for adopting Solar PV technology in the residential market's sectional-title and townhouse community schemes segment.

2.2.3.1.2 Third-Party Owned Business Model (TPOBM)

The third-party ownership business model (TPOBM) refers to an energy project initiated by a developer to generate electricity from renewable energy sources (RES), where all costs and benefits are allocated to the developer (Augustine & McGavisk, 2016; Zhang, 2016). The third-party developer manages all aspects, including financing, designing, installing, and maintaining rooftop solar photovoltaic (PV) systems in the customer's building (Huijben & Verbong, 2013; Klein et al., 2021; Zhang, 2016). In this arrangement, customers, typically building owners or tenants, can use the energy-generating system without bearing the initial expenses (Burger, 2022; Horváth & Szabó, 2018).

TPOBM initiatives present an appealing option for electricity consumers who prefer not to assume risks associated with owning a solar PV system by making substantial upfront payments but instead choose to make minimal initial payments for solar PV systems (Davidson et al., 2015). The third-party developer could be a utility company or another individual or company (Garg et al., 2014). Suppose the utility is not a third-party developer. In that case, it plays a more active role in TPOBM initiatives as the project facilitator (Huijben & Verbong, 2013).

The TPOBM project can be designed so that the rooftop solar PV system does not need to supply any generated energy to the grid network, with the host customer consuming all the produced energy. Alternatively, the TPOBM project can be designed to allow the rooftop solar PV system to feed excess energy into the grid network, with the utility operator transacting with the third-party developer (Garg et al., 2014). A power purchase agreement (PPA) or lease governs the relationship between the third-party developer and the host customer for 10-25 years to purchase some or all the energy generated from the installed system (Burger & Luke, 2017; Garg et al., 2014; Horváth & Szabó, 2018). In both PPA and lease agreements, the host client makes a single, minimal deposit payment to the developer and then continues to make periodic payments as agreed. After the upfront down payment, the host customer pays a predetermined monthly (R/month) amount for the lease contract. In contrast, for the PPA contract, the host customer pays a predetermined amount per unit (R/kWh) for the monthly energy generated (Davidson et al., 2015; Zhang, 2016).

Significantly, TPOBM projects have been implemented in the residential sector and expanded to include community-shared solar photovoltaic (PV) projects in developed countries. Community-shared solar PV projects, which vary significantly in size and are connected to distribution grid networks operated by either the utility or a third-party entity (i.e. developer), reportedly provide a compromise for meeting stakeholders' interests (Chan et al., 2017). Some Community-Shared Business Model (CSBM) projects are known to be based on third-party ownership structures (Augustine & McGavisk, 2016). Regarding third-party ownership of community-shared solar PV projects, developers work with utility operators to establish, oversee, and maintain solar PV systems. Developers then sell the energy they generate to utility operators through Power Purchase Agreements (PPAs). Consequently, utility operators are responsible for handling billing procedures, interconnection services, and managing the electricity distribution system (Chan et al., 2017). Therefore, the TPOBM is a potential responsive business model for adopting Solar PV technology in the residential market's sectional-title and townhouse community scheme segments.

2.2.3.1.3 Community-Shared Business Model (CSBM)

In the literature, various terms have been employed to describe this business model, such as Shared solar (Augustine & McGavisk, 2016), Community solar (Funkhouser et al., 2015), Community-shared (Augustine & McGavisk, 2016; Chan et al., 2017; Zhang, 2016) and Community-owned model (Hanto et al., 2022). This study will use the 'community-shared' term to maintain consistency. A community-shared business model (CSBM) refers to an energy project established by a collective of community members connected by their geographical location and shared interests (Reis et al., 2021). These projects distribute the costs and benefits associated with the initiative among the participating community members (Ptak et al., 2018). CSBMs require the creation of solid conceptual frameworks to facilitate progress in empowerment and equity, thereby increasing transparency and promoting community involvement in such initiatives.

In 2006, the United States witnessed the completion of its inaugural community-shared initiatives designed to provide individuals with access to energy generated by solar parks and gardens without necessitating the installation of personal photovoltaic panels (Horváth & Szabó, 2018). Organisations such as utility companies, non-profit entities, and solar project development companies can manage and oversee this business model (Augustine & McGavisk, 2016; Horváth & Szabó, 2018; Klein et al., 2021; Zhang, 2016). The ownership structure of a CSBM project directly influences its financing and operational management (Devine-Wright, 2019). CSBMs usually involve professional organisations and feature public-private partnerships. Public authorities are coordinating to bolster private sector engagement and investment in energy projects (Devine-Wright, 2019). Prosumers within CSBM initiatives aim to maximise personal utility by establishing power networks in local and non-local areas.

The primary objective of CSBM initiatives is to stimulate economic growth and well-being by creating job opportunities and developing skills through investment in renewable energy technologies (RET) (Devine-Wright, 2019). The literature reveals numerous positive outcomes of CSBM projects, particularly in the context of solar photovoltaic (PV) technology. These benefits include financial rewards through annual energy cost savings and reduced payback periods, achieving sustainability objectives and enhanced energy security and independence (Devine-Wright, 2019).

CSBM projects can be found in various sizes across the globe, ranging from small-scale rooftop solar installations to mini-grid systems (Hicks & Ison, 2018). The fundamental principles of CSBMs involve promoting sustainable community development and energy democracy, thus ensuring community energy security (Hicks & Ison, 2018). Community cohesion plays a vital role in CSBM initiatives, with collaboration and unity essential for mobilising community members towards a shared goal (Hicks & Ison, 2018). This shared goal is often achieved through interactions and engagement within the community. Generally, CSBM projects contribute to a reduction in greenhouse gas emissions and foster overall community solidarity. The success of CSBM initiatives in achieving sustainable development goals, such as environmental, economic, and social community benefits, depends on government support, widespread community engagement, and the implementation of effective business model designs, among other factors (Devine-Wright, 2019).

Literature indicates that CSBM projects have been studied and implemented in developed countries, including Australia, Scotland, Germany, Italy, the Netherlands, New Zealand, the UK, Denmark, and the USA (Hicks & Ison, 2018; Klein et al., 2021). Community-shared energy business models are still in their infancy in developing countries, with only a few dedicated projects and studies available (Ambole et al., 2021; Bloem et al., 2021). In Sub-Saharan Africa, for example, energy communities have received limited attention from both the government and private sector, partly due to the emerging energy systems in many Sub-Saharan African countries (Ambole et al., 2021; Bloem et al., 2021). However, developing countries have primarily adopted the stand-alone microgrid systems of the CSBM programme for rural electrification (Monyei et al., 2018). Therefore, the CSBM is a potential responsive business model for a grid-connected microgrid to adopt solar PV technology in the residential market's sectional and townhouse community schemes segment.

2.2.4 Solar PV Business Models Applications

A review of the literature reveals that solar PV business models can be categorised into three main types: product-based, service-based, and hybrid models (Cabrera et al., 2020). Product-based models focus on the sale of solar PV systems. In contrast, service-based models offer energy as a service through power purchase agreements (PPAs) or leasing arrangements. Hybrid models combine elements of both product and service-based models to provide a more comprehensive solution (Penna & Geels, 2018). A comparative study by Mukoro et al. (2022) indicated that solar PV systems could be provided as products based on a user-side business model described as a Product Service System (PSS) with three main sub-systems, namely:

a) Product-oriented PSS: pay-as-you-go (rent-to-own) business model, selling renewable energy and providing maintenance services, is for frugal innovations that sell Pico PV and solar home systems to low-income African households while offering maintenance services. The value proposition for these business models is providing simple and affordable plug-and-play systems and end-user financing on a rent-to-own basis to reduce barriers to adoption (Mukoro et al., 2022; Van Opstal & Smeets, 2022a).

b) Use-orientated PSS: lease and rent business model, rent, and leasing renewable energy systems eliminate barriers to the diffusion of renewable energy systems by excluding down payments and charging users for access rather than ownership. For PV applications, the leasing model creates value by installing solar home systems on a user's property in exchange for regular payments for the energy consumed or the system uptime over a lease term. The reviewed studies have two approaches to renting (i.e. fee-for-service). In the first approach, users get access to portable battery kits charged on a need basis at a central energy kiosk powered by a solar photovoltaic mini-grid. In the second approach, users rent solar panels, lighting appliances, and batteries from energy companies (Mukoro et al., 2022; Van Opstal & Smeets, 2022a). The Rationale of leasing and renting business models in underserved markets is to address the affordability-access gap in low-income markets and reduce business risks. Some studies point out that providing end-user finance to users without income details or credit history makes the pay-as-you-go business model a high financial risk. Conversely, the financial risk of the leasing and leasing business model is moderate and associated with paying service providers. In contrast, the risk to users is weak owing to routine maintenance services (Mukoro et al., 2022).

c) Result-oriented PPS: a pay-per-service-unit business model that focuses on generating and selling electricity. Value propositions that meet the criteria for generating and selling electricity include solar home systems installed on users' property that are interconnected to form low-voltage micro-grids, prosumers selling surplus electricity to neighbouring households and businesses and the grid, prosumers storing electricity on a central battery to optimise self-consumption before selling the surplus to the grid (Mukoro et al., 2022; Van Opstal & Smeets, 2022a). These PSS can be provided as a service to applications comprising of pico-PV systems (typically 1–10 W), solar home systems (typically 10–1000W), micro-grids (typically 1–50 kW), and mini-grids (typically 50 kW-1MW) (Mukoro et al., 2022).

2.3 Factors Influencing the Adoption of Solar Photovoltaic Technology

2.3.1 Barriers to the adoption of Solar Photovoltaic (PV) Technology in Small-Scale Embedded Generation (SSEG)

The literature highlights several barriers and factors identified as having a significant impact on implementing Small-Scale Embedded Generation, as summarised in Table 1. The barriers were identified into six groups, and the following sub-sections detail each barrier group.

Table 1: The Main Barriers, Factors, and Related Literature Overview. Adopted from Horváth and Szabó (2018) and Cai et al. (2019).

Main barriers	Main factors, elements	Related literature
Financial and profitability barriers	• High initial installation costs and long payback period of investment costs • Lack of financing options • Difficulty in financing • Low electricity tariffs • Unclear return on investment • Long payback period • Lack of attraction concerning feed-in tariffs • Revenue uncertainty • Low profits	(Cai et al., 2019; Horváth & Szabó, 2018; Kihlström & Elbe, 2021; Mah et al., 2018; Raina & Sinha, 2019; J. P. Walters et al., 2018)
Institutional, policy and legislative barriers	• Poor policy development and ineffective implementation • Challenges in the approval process • Institutional constraints	(Cai et al., 2019; Horváth & Szabó, 2018; Raina & Sinha, 2019; Swartz, 2019; J. P. Walters et al., 2018)

Main barriers	Main factors, elements	Related literature
	• Ineffective regulation • Lack of incentives and subsidies • Unsound and explorative policy for solar PV • Ambiguous responsibility and relationships among relevant departments struggling with coordination. • Lack of non-discriminatory open access to critical energy infrastructure, such as the • National electricity grid • The market power of utilities	
Technological and technical barriers	• The low conversion efficiency of solar photovoltaic technology • Lack of immediate response to load demand • System Performance risks • New and slow implementation of net-billing schemes • Immature skills related to grid connections. • Insufficient independent intellectual property rights and innovation capabilities	(Cai et al., 2019; Horváth & Szabó, 2018; Raina & Sinha, 2019; Thopil et al., 2018; J. P. Walters et al., 2018)
Social (awareness and behavioural) barriers	• Low awareness of energy conservation	(Swartz, 2019)

Main barriers	Main factors, elements	Related literature
	• Lack of knowledge about solar PV technology • Lack of trust and confidence • Behavioural barriers and concerns • Misinformation about the benefits	
Roof Resources barriers	• Changeable housing ownership • Inadequate available rooftops • Unclear property rights • Shared rooftops in multi-unit buildings	(Cai et al., 2019)
Company resource barriers	• Lack of competence • Gaps in product portfolio • Shortcomings in management and business skills	(Horváth & Szabó, 2018)

2.3.1.1 Financial and Profitability Barriers

Solar photovoltaic (PV) technology has gained significant attention recently as a promising solution to reduce greenhouse gas emissions and promote sustainable energy generation. However, the adoption of this renewable technology faces numerous financial and profitable barriers, which hinder its widespread implementation, particularly in the residential sector.

One of the primary financial barriers to adopting solar PV technology is the high initial investment required for installation (Cai et al., 2019; Kuang et al., 2022; Xue et al., 2021). This high upfront cost makes it difficult for homeowners and small businesses to invest in solar PV systems, particularly when considering the long payback period associated with these investments (Kuang et al., 2022; Sewchurran & Davidson, 2021). According to utility managers in Germany, economies of scale cannot be realised in the residential customer segment due to the size of PV projects and high upfront investment costs, which discourages investment in the Distributed Energy market (Horváth & Szabó, 2018; Wirth & Schneider, 2015).

Another significant barrier to solar PV adoption is the lack of financing options for residential customers. In many countries, large portions of society are excluded from government support as solar loan options are not readily available. This issue is particularly evident in China, where financing difficulties have consistently hindered the development of small-scale solar PV projects. Investors are often reluctant to invest in these projects due to a lack of confidence in related policies, small project scale, low revenue expectations, and high investment risk (Cai et al., 2019). Furthermore, banks are more willing to invest in large-scale PV projects that receive government subsidies, leaving small and medium-sized solar PV projects struggling to secure funding. However, banks usually offer short-term loans with high interest rates (Cai et al., 2019).

In contrast, the payback period of small-scale PV projects is up to ten years (Cai et al., 2019). According to McKay and Hendricks (2022), South African banks have no unique credit mechanism for solar power. However, banks offer personal loans, credit cards, mortgage finance or overdrafts, which are challenging to obtain due to strict affordability rules by the National Credit Act 34 of 2005 and carry higher interest rates (McKay & Hendricks, 2022).

Low electricity tariffs pose another financial barrier to solar PV adoption. As household electricity consumption is relatively small and domestic electricity fees are inexpensive, the profitability of solar PV installations is often questioned. Additionally, the lack of a clear return on investment and long payback periods make it difficult for potential investors to justify the expense of solar PV technology (Cai et al., 2019).

Finally, revenue uncertainty and low profits are significant barriers to implementing solar PV technology. The percentage of self-consumed electricity introduces uncertainty under the 'self-generation, self-consumption with surplus sold to the grid' mode of operation for the solar PV system, leading to reduced profits. Furthermore, the lack of an adequate credit system in countries like China increases the risk of default (Cai et al., 2019). This financial risk and the instability in rooftop ownership further discourage investment in solar PV technology.

2.3.1.2 Institutional, Policy and Legislative Barriers

Literature indicates that most institutional, policy and legislative barriers are related to shortcomings in the legal framework or government actions and energy and environmental policy (Horváth & Szabó, 2018). Cai et al. (2019) argue that a lack of strategic planning and coordination among different government agencies often hinders the development and implementation of policies for solar PV technology. This results in fragmented policies that fail to provide a comprehensive framework for promoting and deploying solar PV systems. Moreover, Horváth and Szabó (2018) highlight that poor policy development and implementation can lead to market distortions, undermining the competitiveness of solar PV technology in the energy market.

Despite several policies and strategies supporting renewable energy in South Africa, such as the IRP, REIPPPP and NDP, there is a lack of coherence, consistency, and alignment among them (Swartz, 2019). Moreover, there is a lack of political will and commitment to implement these policies and create a conducive environment for solar PV investment. For instance, the IRP 2019 has been criticised for being outdated, unrealistic, and biased towards coal and nuclear power (Swartz, 2019). The REIPPPP, which has successfully attracted private sector participation and reduced the cost of solar PV, has also faced delays, uncertainties, and opposition from the state-owned utility Eskom, which has a monopoly over electricity generation and transmission (Swartz, 2019).

Another factor that poses challenges to the adoption of solar PV technology in South Africa is the complexity and inefficiency of the approval process. The other barrier to adopting solar PV technology is the complexity and lengthiness of the approval process, which can discourage potential investors and developers (Raina & Sinha, 2019). J. Walters et al. (2018) assert that the approval process for solar PV projects often involves multiple levels of government and numerous regulatory agencies, resulting in delays and increased costs. Streamlining the approval process and reducing bureaucratic red tape can significantly improve the prospects for solar PV deployment. The installation of solar PV systems requires various permits, licenses, and authorisations from national, provincial, and municipal authorities (Swartz, 2019). These include environmental impact assessments (EIAs), grid connection agreements, generation licenses, building plan approvals, and municipal by-laws (Swartz, 2019). However, these processes are often lengthy, costly, cumbersome, and inconsistent across jurisdictions (National Treasury, 2019; SE4ALL & BloombergNEF, 2020). Furthermore, there is a lack of clarity and transparency on the roles and responsibilities of various stakeholders involved in the approval process, such as the Department of Energy (DoE), the National Energy Regulator of South Africa (NERSA), Eskom, municipalities, and independent power producers (IPPs) (Baker et al., 2014; Swartz, 2019).

Institutional constraints, such as limited human and financial resources and inadequate technical capacity, can severely hamper the development and deployment of solar PV technology (Cai et al., 2019). These constraints often result in ineffective coordination and collaboration among relevant stakeholders, leading to suboptimal outcomes for solar PV projects (Cai et al., 2019; Mah et al., 2018). Institutional constraints are another factor hindering the adoption of solar PV technology in South Africa. These include the lack of capacity, coordination, and collaboration among various institutions responsible for planning, regulating, implementing, and monitoring renewable energy policies and projects. For example, there is a scarcity of proficient and certified workforce in the public sector who can design, evaluate, and manage solar PV projects (Mah et al., 2018). Departments and agencies dealing with renewable energy issues suffer from a lack of communication and information sharing. Moreover, there is a lack of stakeholder engagement and public participation in the decision-making process regarding renewable energy development. These institutional constraints result in low awareness, trust, and acceptance of solar PV technology among potential users and beneficiaries (Mah et al., 2018).

Ineffective regulation of solar PV technology can create barriers to deployment by creating uncertainty and increasing risks for investors and developers (Horváth & Szabó, 2018). For instance, inconsistent or poorly designed grid connection regulations can deter investment in solar PV projects, as they may result in higher costs and reduced returns on investment. Ineffective regulation is another factor affecting the adoption of solar PV technology in South Africa. There is a need for clear and consistent regulatory frameworks that can facilitate the integration of solar PV into the electricity grid and market. For instance, there is a lack of regulation on net metering or feed-in tariffs for small-scale embedded generation (SSEG) systems that can enable households and businesses to sell excess electricity generated by solar PV to the grid or other consumers. There is also a lack of regulation on wheeling or third-party access allowing IPPs to transport electricity generated by solar PV across different networks or regions (Kluger, 2019). Furthermore, there is a lack of regulation on quality standards and certification for solar PV equipment and installation that can ensure safety, reliability, and performance.

The absence of adequate financial incentives and subsidies for solar PV technology can significantly hinder its deployment, as it may not be economically viable for investors and developers without such support (Raina & Sinha, 2019). J. Walters et al. (2018) and J. P. Walters et al. (2018) argue that targeted incentives and subsidies can play a crucial role in accelerating the adoption of solar PV technology, particularly in regions with high potential for solar energy generation.

The lack of incentives and subsidies is another factor that limits the adoption of solar PV technology in South Africa. Although the cost of solar PV has decreased significantly over the years due to technological innovation and economies of scale, the upfront capital cost remains high compared to conventional energy sources. Therefore, there is a need for financial incentives and subsidies that can reduce the initial investment and operational costs for solar PV users and producers. However, the current incentives and subsidies are inadequate, inconsistent, and inaccessible for many potential adopters of solar PV (Mah et al., 2018). For example, the DoE offers a rebate scheme for residential solar water heaters (SWHs) (Baker et al., 2014; Thobejane et al., 2019) but not for solar PV systems. However, in 2023, the South African government launched a tax rebate scheme which permits individuals to claim tax deductions of up to 25%, capped at R15,000, on the expenditure incurred for solar PV panels installed on rooftops available for a limited period until the end of February 2024 (Omarjee, 2023). The Department of Trade and Industry (DTI) provides tax incentives for renewable energy projects, which are often limited and difficult for small-scale solar PV adopters to access (Baker et al., 2014).

Unsound and explorative policy for solar PV technology can create market distortions and hinder its deployment (Cai et al., 2019). For instance, policies favouring certain types of solar PV systems over others without considering their relative merits can result in inefficient allocation of resources and suboptimal outcomes for the solar PV market.

Ambiguous responsibility and relationships among relevant departments can result in a lack of coordination and hinder the deployment of solar PV technology (Horváth & Szabó, 2018). Clear delineation of roles and responsibilities and effective mechanisms for inter-agency collaboration is essential for overcoming these barriers and ensuring the successful deployment of solar PV technology.

2.3.1.3 Technological and Technical Barriers

Renewable energy markets depend on technology development and technical capabilities to overcome various obstacles. In developed countries, locally specialised solutions can address supply problems by adapting them to specific contexts (Horváth & Szabó, 2018). However, the situation is more challenging in developing countries such as South Africa, China, and some regions in Asia and South America. These countries lack intellectual property rights and innovation capabilities and rely primarily on foreign technologies and equipment for distributed power projects. This deficiency weakens their technical foundation and hinders the sustainable development of solar photovoltaic (PV) power projects (Cai et al., 2019).

Solar PV technology has made significant progress but still faces some limitations compared to conventional systems. One of the main challenges is the low conversion efficiency of solar PV technology, which affects its cost-effectiveness and competitiveness (Raina & Sinha, 2019). Another challenge is the inability of PV plants to respond quickly to load demand, which reduces their reliability and flexibility (Raina & Sinha, 2019). Although storage mechanisms such as battery banks can help mitigate this problem, they also increase the cost and size of the plant (Raina & Sinha, 2019).

Other technological barriers include the intermittent nature of solar radiation, which affects the consistency and quality of electricity generation; the difference between standard and real-time conditions, which impacts the performance and output of PV systems; and the component failure and hotspot formation, which reduce the efficiency and lifespan of PV modules (Raina & Sinha, 2019;

Sharma et al., 2018). To overcome these barriers, quality control, standardisation, and maintenance are essential for PV module manufacturers and developers (Raina & Sinha, 2019).

Connecting to the grid also poses some technical challenges for solar PV power projects. For instance, the fluctuation and instability of solar energy resources can cause voltage variations and power quality issues on the grid (Cai et al., 2019). Moreover, the non-dispatchable nature of solar energy requires backup sources or battery storage devices to meet the load demand during cloudy and rainy days and at night, resulting in low solar radiation (Bloem et al., 2021; Thopil et al., 2018). Therefore, solar PV power projects must be designed with appropriate grid integration and management strategies (Thopil et al., 2018).

2.3.1.4 Social (Awareness and Behavioural) Barriers

Behavioural barriers, personal values, and norms are significant social factors that affect attitudes towards distributed energy investments (Cai et al., 2019; Horváth & Szabó, 2018). People are risk-averse and do not fully comprehend the benefits of renewable energy technologies (Horváth & Szabó, 2018). This lack of social awareness about solar PV technology is a significant hurdle in developing solar PV systems, particularly in developing countries. Furthermore, a shortage of information about renewables, a poor knowledge base and misinformation about the benefits of renewable technologies are issues in developing countries and affect the deployment of distributed energy technologies more generally (Horváth & Szabó, 2018).

Customer awareness and acceptance are essential in the renewable energy market and can strongly affect demand (Raina & Sinha, 2019). In developing countries, potential customer segments are unskilled due to a lack of information about renewables (Cai et al., 2019; Horváth & Szabó, 2018). For example, in China, residents have limited knowledge about distributed energy products, which has proven to be an obstacle to local consumers' acceptance of solar PV (Cai et al., 2019). The inadequacy of land is also a problem, as large land areas are required to construct large-capacity solar PV power plants (Raina & Sinha, 2019). Therefore, it is essential to increase awareness and knowledge about renewable energy technologies to encourage the adoption of sustainable energy systems.

Customer social factors such as attitudes, beliefs, and behaviours towards renewable energy can play a significant role in determining the success or failure of such projects (Cai et al., 2019; Horváth & Szabó, 2018). Carlisle et al. (2015) and Cai et al. (2019) suggest that properly managing customer social factors can either enable or impede the development of these projects. Therefore, renewable energy project developers must understand and address customer social factors effectively (Cai et al., 2019). Effectively managing customers could involve engaging with local communities, providing education and awareness programmes, and addressing concerns or misconceptions about renewable energy. By doing so, developers can increase the likelihood of successful project implementation and contribute to the broader adoption of renewable energy sources (Carlisle et al., 2015).

2.3.1.5 Roof Resource Barriers

Urban cities are characterised by multi-unit buildings, sectional titles, and townhouse community schemes where rooftops are collectively owned. Installing a photovoltaic (PV) system on rooftops requires coordination and communication with residents and property departments in residential areas (Cai et al., 2019). However, this negotiation is often challenging due to the time needed and the difficulty of reaching a consensus among residents. For example, land and housing ownership in China are separate, making rooftop ownership changeable and property rights unclear when an owner is relocated or a house is demolished (Cai et al., 2019).

Finding available rooftops for customers with detached houses or villas in rural areas is relatively more straightforward. Rooftops on industrial and commercial enterprise plants, such as colour steel and concrete rooftops, are mainly used to generate solar PV power. The lifespan of a solar PV power system is longer than the lifespan of colour steel rooftops, affecting the system's profits (Cai et al., 2019). Therefore, it is essential to consider the rooftops' ownership structure and lifespan when installing PV systems in urban cities.

2.3.1.6 Company Resource Barriers

A lack of company competencies has been observed in developed and developing countries. Utilities have faced significant changes in their business models in recent years, and managers have identified a shortage of competence as a critical barrier in the residential customer segment (Horváth & Szabó, 2018). Decades of experience contracting with corporate customers (B2B) does not necessarily transfer to private customer segments (Horváth & Szabó, 2018). To be competitive in the B2C market, Utilities and energy companies must also develop their product and service portfolio to create value for the residential segment (Horváth & Szabó, 2018). Shortcomings in management and business skills exacerbate the situation in developing countries, where managers lack technical support despite these factors being the keys to value creation and daily corporate operations (Horváth & Szabó, 2018).

2.3.2 Drivers for Adopting Solar Photovoltaic (PV) Technology in Small-Scale Embedded Generation (SSEG)

2.3.2.1 Scale of Projects

The global shift to renewable energy has prompted various approaches to implementing grid-connected solar programs. Governments and stakeholders have adopted strategies to encourage the uptake of solar photovoltaic systems in response to the increasing demand for clean and sustainable energy. Among these strategies, three main approaches have emerged to developing grid-connected solar programmes: utility or third-party-driven programmes, customer-driven programmes, and community-shared energy programmes (Bankel & Mignon, 2022; Horváth & Szabó, 2018; Mukisa et al., 2021).

Utility or third-party-driven programmes involve projects that utilities or third-party developers undertake to fulfil regulatory and policy requirements, such as renewable purchase obligations (Mukisa et al., 2021). These projects typically involve large-scale, megawatt solar power plants that focus on cost optimisation. When third-party developers undertake these projects, they enter into long-term power purchase agreements with utilities, and customers ultimately bear the cost of procurement (Mukisa et al., 2021). One advantage of utility-driven programmes is that they contribute significantly to a region's overall renewable energy capacity, promoting the transition to cleaner energy sources. However, a potential disadvantage is that customers may face higher electricity prices to cover the cost of procurement (Mukisa et al., 2021).

Customer-driven programmes involve consumer projects on their premises, facilitated by government policies and regulations (Mukisa et al., 2021). These programs typically refer to Small-Scale Embedded Generation (SSEG) systems. The growing popularity of customer-driven programmes can be attributed to the decreasing costs of solar PV, fiscal incentives, and the rising costs of grid-based conventional electricity (Mukisa et al., 2021). One advantage of customer-driven programmes is that they empower consumers to produce electricity, reducing reliance on traditional grid-based power. Additionally, these programmes contribute to decentralising energy production, enhancing grid resilience. However, a potential drawback is the initial investment required to install solar PV systems, which may deter some consumers (Mukisa et al., 2021).

Community-shared energy programmes involve collaborative projects owned by various stakeholders, such as utility operators, third-party developers, groups of customers, or charitable non-profit corporations (Bankel & Mignon, 2022; Mukisa et al., 2021). The ownership structure of Community-shared energy programme projects directly affects their financing and operation. These programmes often involve partnerships between the public and private sectors, with public authorities assuming a coordinating role to strengthen private sector engagement and investment in energy projects (Mukisa et al., 2021). The role of prosumers in community-shared energy programmes is to maximise personal utility through the power network established in local and non-local areas (Mukisa et al., 2021). The primary purpose of these programmes is to foster economic growth and well-being by creating jobs, upskilling people, and investing in renewable energy technologies (RET). Additionally, voluntary, non-profit third-party actors can constitute community-shared energy initiatives, further diversifying the ownership and operation of such projects (Mukisa et al., 2021).

To encourage the adoption of SSEG, governments worldwide have implemented a range of incentive policies as tabulated by literature in section 2.3.2.2. These incentives aim to make installing solar PV systems more financially attractive for consumers and promote the growth of the solar PV market.

2.3.2.2 Incentives, Policy, and Legislative Instruments

Energy policy is the decisions and actions that determine how a society produces, distributes, and consumes energy resources. Various factors, such as technological innovation, political interests, social values, and global events, can influence energy policy. Therefore, the government can use demand and supply side instruments to harmonise the market, as summarised in Table 2.

Table 2: Supply-Side and Demand-Side Policies (Kharaji Manouchehrabadi & Yaghoubi, 2023)

Policy	Policy Instrument	USA	Germany	Japan	China
Demand-side	Self-consumption	√	√	√	√
	Feed-in-tariffs (FITs)	-	√	√	√
	Net metering	√	-	-	-
	Subsidies	-	-	-	√
	Green tags	-	-	-	√
	Financing support	√	√	-	-
	Public investment	-	-	√	√
	Consumer subsidy (tax credits)	√	√	√	-
	Performance-based incentives	√	-	-	√
	Government mandates	-	-	√	-
	Interconnection standards	√	-	-	-
	Renewable energy portfolios	√	√	√	√
Supply-side	Demonstration projects	-	-	-	√
	Material and equipment duty-free	-	-	-	√
	Financial support for manufacturing	√	-	√	√

Policy	Policy Instrument	USA	Germany	Japan	China
	Research and development (R&D) grants	√	-	√	√
	Tax concessions or exemptions	√	√	√	√
	Investor subsidy	-	-	-	√
	Subsidized support infrastructure	-	-	-	√

2.3.2.2.1 Demand-side policy instruments

Solar PV systems installations have grown significantly due to the increasing global demand for clean and sustainable energy. Governments worldwide have introduced various policies to incentivise the adoption of solar PV systems. Kharaji Manouchehrabadi and Yaghoubi (2023) highlight that the demand side instruments include Feed-in-tariffs (FITs), subsidies, net metering, green tags, Renewable Energy (RE) portfolios, financial support, public investment, tax credits (consumer subsidies), government mandates and regulatory provision. The policy instruments can be used to foster the solar energy-use market. The FIT instrument is adopted in more than 75 jurisdictions around the world, including China, the USA, Italy, Japan, Sweden, Brazil, India, Sweden, Germany, and Australia, among others (García-Álvarez et al., 2018; Kihlström & Elbe, 2021; Kuang et al., 2022; Rigo et al., 2022). The FITs facilitate long-term financial stability for investors, which improves the financial viability assessment. The policies and incentives can be broadly categorised into two groups: (1) policies that help investors reduce the investment threshold and (2) policies that improve the solar PV investment return.

2.3.2.2.1.1 Investment Threshold Reduction

One of the primary barriers to solar PV adoption is the high initial capital investment required for installation. Governments have implemented several measures to reduce this investment threshold, making solar PV systems more accessible to investors. Such policies include laws that facilitate the application of small-scale embedded generation (SSEG) installations, subsidies for PV installations, low-interest loans, public guarantees, and tax abatement policies (IRENA, 2020). Subsidising PV installations reduces the initial capital outlay, making it more affordable for investors to adopt solar PV systems (J. P. Walters et al., 2018; Yamamoto, 2017).

The implementation of tax abatement policies, including investment tax credits and accelerated depreciation, as well as various tax incentives, such as value-added tax (VAT) exemptions, customs tax exemptions, withholding tax support, and corporate tax exemption, play a crucial role in promoting the financial viability of solar photovoltaic (PV) projects. By reducing the overall capital cost over the system's lifetime, these measures significantly enhance the economic feasibility and attractiveness of investing in solar energy infrastructure (Holmes, 2022; Van Opstal & Smeets, 2022b; Winkler et al., 2020).

Subsidies represent another policy tool that is commonly used (Kharaji Manouchehrabadi & Yaghoubi, 2023). These subsidies, aimed at the demand side, encompass direct and indirect financial support for installing solar energy equipment. This financial support can take various forms, including investment grants, capacity payments, payments based on output or production, and low-interest loans.

Studies have demonstrated that tax incentives, reductions, and credit programmes play a crucial role in promoting the adoption of solar energy in residential settings in the USA (Horváth & Szabó, 2018; Kılıç & Kekezoğlu, 2022). In a similar vein, research conducted in China has shown that tax incentives and favourable policies positively influence the growth of the country's renewable energy industry (Kılıç & Kekezoğlu, 2022). These findings suggest that government policies can significantly influence the adoption and development of renewable energy technologies.

2.3.2.2.1.2 Improving PV Investment Return

The second category of policies aims to improve the return on investment (ROI) for solar PV systems. Net metering and feed-in tariff (FiT) policies are two key examples of such policies (Song et al., 2016). Globally, various initiatives exist under various names to promote the adoption of SSEG among electricity users. The common goal of these initiatives is to incentivise investments in solar PV or other renewable energy technologies by offering compensation to electricity customers, including households and businesses, that install SSEG and supply power to the grid. While some programmes are fundamentally similar yet labelled differently in distinct regions, others share the same title but exhibit subtle or significant operating differences. It is crucial to note that electricity drawn from the grid is referred to as imports. In contrast, electricity fed onto the grid is considered an export. Furthermore, net-metering, or FiT customers, are still categorised as electricity consumers rather than producers, such as IPPs.

2.3.2.2.1.2.1 Self-consumption

The self-consumption approach in the context of rooftop solar PV systems refers to installing these systems to fulfil the energy demands of the premises where they are situated. In this arrangement, a single utility meter is employed, and the sizing of the solar PV system is determined by the prosumer's electricity consumption patterns, as shown in Figure 10. Notably, in cases where the energy generated by the solar PV system surpasses the prosumer's requirements, no financial remuneration is provided for the surplus electricity fed back into the grid. Solar PV electricity grants encourage the self-consumption of PV-generated electricity by promoting self-consumption to improve PV investment return. These grants aim to reduce the dependence on grid-supplied electricity, leading to lower energy costs and increased financial returns for solar PV system owners (IRENA, 2019; REN21, 2022).

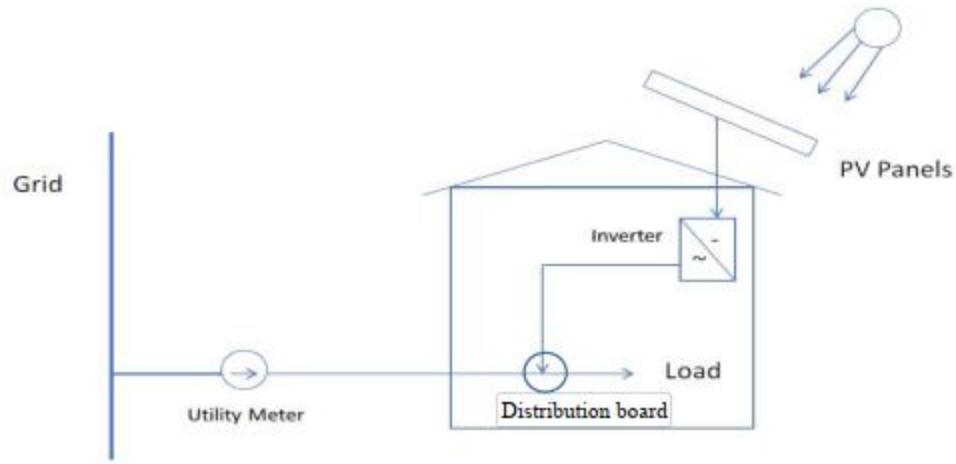


Figure 10: Self-consumption Configuration (Tuson & MacDonald, 2014)

2.3.2.2.1.2.2 Net-metering and net-billing

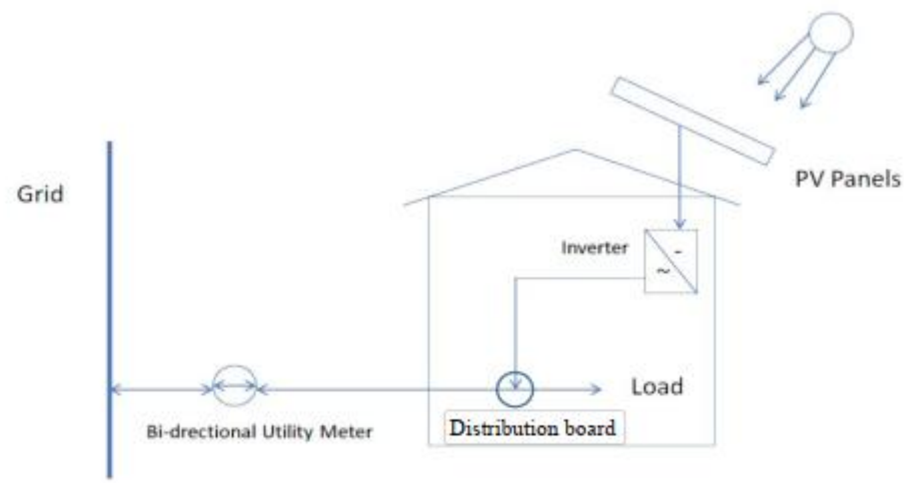


Figure 11: Net-metering Configuration (Tuson & MacDonald, 2014)

In contrast to self-consumption, net metering allows solar PV system owners to sell excess electricity generated by their systems back to the grid, effectively offsetting their electricity consumption costs (IRENA, 2019; REN21, 2022). Under schemes like net metering, customers with SSEG systems can receive credits for exporting surplus electricity to the grid when the electricity generated surpasses the amount consumed. These credits can then be utilised to counterbalance consumption during other billing periods.

In the case of net metering, both import and export rates are equal, meaning that customers generally receive credit at the same value as the retail electricity price (IRENA, 2019; REN21, 2022). Conversely, under the net-billing system, the export rate is lower than the import rate (REN21, 2022). As a result, customers typically receive credit for their surplus electricity at a rate lower than the retail electricity price, with variations in the application of these terms across different jurisdictions. A single bi-directional meter is required to accurately measure energy usage and subsequent exports, as shown in Figure 11 (Boamah, 2020).

2.3.2.2.1.2.3 Feed-in policies (feed-in tariffs (FITs) and feed-in premiums (FIPs))

Feed-in tariffs (FITs) have been specifically designed to promote the implementation and widespread use of renewable energy technologies by providing clear guidance to electricity distributors regarding purchasing power generated from qualifying sources at pre-established rates. This system is distinct from net metering, where the meter reverses to measure the excess electricity exported to the grid. Instead, FITs employ a dual meter system (M1 and M2) that separately records the electricity generated and consumed by the prosumer, as shown in Figure 12, enabling independent pricing (IRENA, 2019; REN21, 2022). A key aspect that sets FITs apart from other mechanisms is the tariff paid to the prosumer, or the FIT level, for the electricity exported to the grid. The determination of FIT levels can be achieved through various methods, depending on the intended effect of the policy in promoting the uptake of solar photovoltaic (PV) technology (Kılıç & Kekezoğlu, 2022; Zander et al., 2019).

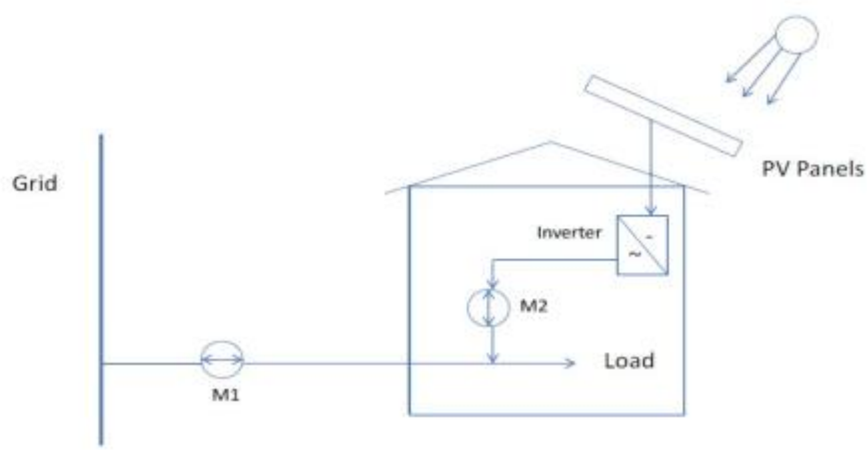


Figure 12: Feed-in-Tariff (Tuson & MacDonald, 2014)

Feed-in policies have emerged as a powerful instrument for promoting the adoption of renewable energy technologies and fostering the growth of small-scale embedded generation (SSEG) systems (REN21, 2022). This policy has been implemented in various countries worldwide, offering a range of incentives to SSEG customers. The FiT policy is characterised by its guarantee of specified payments to SSEG customers for each unit of energy generated over a predetermined period, typically around 20 years (Kılıç & Kekezoğlu, 2022; Zander et al., 2019). This policy framework ensures a stable and secure financial return for investors in renewable energy systems, making it an attractive option for potential SSEG customers (IRENA, 2019; REN21, 2022).

Various options exist to determine the level of incentives offered under the FiT policy. One such option is to structure the payment as a guaranteed minimum price, which ensures that the SSEG customer receives a fixed price for the energy generated, regardless of fluctuations in the wholesale electricity market (Couture et al., 2010). Alternatively, the payment can be designed as a feed-in premium, which allows the payment to float above the prevailing wholesale electricity price (REN21, 2022; Zander et al., 2019). This approach provides an additional financial incentive for SSEG customers by offering the potential for higher returns when market prices are favourable (REN21, 2022).

The FiT policy often sets the export rate for renewable energy technologies at a higher price than the utility's standard energy procurement rate to encourage their uptake. This pricing strategy stimulates investment in SSEG systems by making them more financially viable for customers (REN21, 2022). Additionally, implementing a single bi-directional meter to measure energy consumption and exports simplifies the process for SSEG customers (Boamah, 2020), further enhancing the attractiveness of the FiT policy.

2.3.2.2.1.2.4 Green Tags

Green tags (also known as RE credits) and net metering are two trading-based policy instruments that use the energy market to promote the application of solar energy (Kharaji Manouchehrabadi & Yaghoubi, 2023). Green tags are trading mechanisms adopted by nine European Union (EU) countries, including Germany, Malta, Sweden, and the Netherlands (Kharaji Manouchehrabadi & Yaghoubi, 2023). Depending on the policy changes, this study observes that green tags are privately managed instead of FITs managed mainly by the government. For instance, property rights to environmental benefits from generating rooftop solar electricity can be sold and traded (between private RE producers at their own negotiated cost), and the owners can legally demonstrate they have purchased renewable energy. Net metering allows households and commercial establishments to sell excess electricity generated from the distributed PV system to the grid (Kharaji Manouchehrabadi & Yaghoubi, 2023; Kihlström & Elbe, 2021; Kuang et al., 2022; Rigo et al., 2022).

According to Kharaji Manouchehrabadi and Yaghoubi (2023), electricity customers can offset their electricity consumed with small-scale power over the entire billing period using the power at a different time than it is produced without considering when it is consumed or generated and storing it in the utility's grid. In light of this, a comparison of FITs, green tags, and net metering policies depends on the implementation methods and processes that can influence the economic efficiencies of the policies. Kharaji Manouchehrabadi and Yaghoubi (2023) suggest that combining FIT and net-metering policies improves the profitability of PV projects.

2.3.2.2.1.2.5 Renewable Energy Portfolio

A renewable energy portfolio is another trading regime that sets standards for small-scale solar energy producers without (or with low) renewable electricity content in their overall supply portfolio to buy from large-scale producers with high renewable electricity content and vice-versa, depending on the consumers' location. This policy has been adopted by more than 14 countries, including the USA (Funkhouser et al., 2015; Kharaji Manouchehrabadi & Yaghoubi, 2023). The policy can be merged with the FiT to promote the diffusion of PV systems. For instance, if RE plant 'A' generation levels drop down to the required capacity to supply its consumers, and RE plant 'B' is at excess generation levels (generating more capacity than what is consumed by its consumers), plant 'A' can buy top-up power for its consumers from plant 'B.'

2.3.2.2.2 Supply-side policy instruments

Kharaji Manouchehrabadi and Yaghoubi (2023) appraised several supply-side policy instruments, which include research and development grants, financing support for manufacturing (low-cost loans), investor subsidy, subsidised support infrastructure and tax concession/ exemptions. Such instruments are regarded as 'push-side' by the government. They are further argued to have less attention in the literature than demand-pull policies (Kharaji Manouchehrabadi & Yaghoubi, 2023).

2.3.2.3 Funding Mechanisms

Various funding mechanisms and innovative business models can enable property owners, Body Corporates, and homeowners' associations to access solar PV technology that can be employed to address the affordability gap without bearing the upfront capital costs. It is uncommon for projects to be financed independently based solely on their own merits, without any credit support from sponsors. In the long run, these sponsors may reap benefits in the form of interest rates or through the exchange of services. SE4ALL and BloombergNEF (2020) identify various financing sources for project investments, including:

a. International agencies (e.g., the World Bank, International Finance Corporation, regional development banks, and others)

b. Government subsidies and grants

c. Commercial banks

d. Institutional lenders

e. Money market funds

f. Commercial finance companies

g. Individual investors (such as crown funding)

h. Loans and advances from sponsors

2.3.2.4 Social Influences

Many studies have shown that peers, such as colleagues, neighbours, or friends, can influence people to adopt new technologies (Kastner & Wittenberg, 2019; Palm, 2018; Rai et al., 2016). People can also be motivated by positive feedback or expectations from their acquaintances and by social pressure or the wish to show their social responsibility (Curtius et al., 2018; Palm, 2017; Qureshi et al., 2017; Rode & Weber, 2016; Wong & Cronin, 2019). In contrast to how peer effect encourages adoption, some people adopt PV because they want to be role models for others (Schelly & Letzelter, 2020). Being a role model to others may be related to their desire to keep a good image/reputation (Mundaca & Samahita, 2020) or to express their environmental concern to others (Balcombe et al., 2014).

2.3.2.5 Direct and Indirect Benefits

Economic benefits are a significant motivation for Solar PV adopters. For example, people can save money on electricity bills or earn money by selling electricity to the grid (Ahmad et al., 2017; Kurata et al., 2018; Lee & Shepley, 2020). Another economic incentive is the possibility of avoiding future increases in electricity prices (Balcombe et al., 2014; Karakaya et al., 2015; Korcaj et al., 2015). However, PV systems are expensive, and affordable deposit requirements or no upfront cost can encourage adoption (Lee & Shepley, 2020; Schelly & Letzelter, 2020). Alternative options, such as leasing or power purchase agreements, can help overcome this barrier (Rai et al., 2016).

Another reason why people adopt PV is to reduce their environmental impact, as the built environment contributes significantly to pollution (Balcombe et al., 2014; Kiprop et al., 2019; Lee & Shepley, 2020; Palm, 2018; Wong & Cronin, 2019). Frequent power cuts can also drive people to use PV as a backup source of electricity (Qureshi et al., 2017; Ugulu & Aigbayboa, 2019; J. P. Walters et al., 2018). Some early adapters may also value the independence and self-sufficiency of electricity production (Gava Gastaldo et al., 2019; Korcaj et al., 2015; Schelly & Letzelter, 2020). This benefit may be related to their lifestyle choices or personal satisfaction (King et al., 2014; Palm, 2018).

In rural areas where grid power is not available, PV adoption is motivated by different factors. Kurata et al. (2018) found that households and micro-enterprises in these areas use solar home systems to access electricity for basic needs such as phone charging and lighting and reducing indoor air pollution.

2.4 Theoretical Framework

Various models have been developed to explain the multiple factors in adopting an innovation. This study focuses on adopting solar PV technology in the residential sectional-title and townhouse community schemes market within a business model. In order to establish a conceptual framework for this study, five prominent models were employed: the Technology-Organisation-Environment (TOE) Framework, Diffusion of Innovation (DOI) Theory, Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), and Business Model Theory.

The first model is the Diffusion of Innovation Theory, which explains how innovations spread through a social system. The Technology Acceptance Model, as a second model, considers the attitudes and beliefs of individuals towards adopting technology. The third model is the Innovation-Decision Process Model, which outlines the stages of decision-making that individuals and organisations go through when considering the adoption of an innovation. Finally, the Institutional Theory considers the influence of external factors, such as regulations and norms, on adopting an innovation.

2.4.1 Technology-Organisation-Environment (TOE) Framework

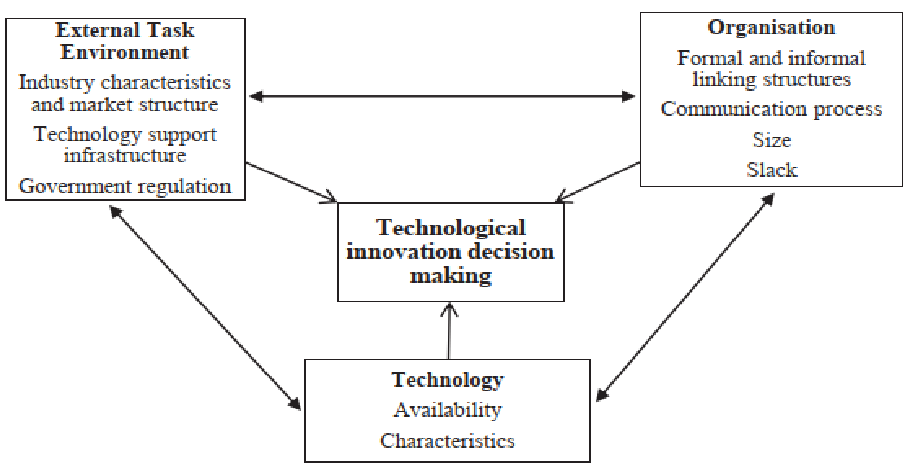


Figure 13: Technology, Organisation and Environment (TOE) Framework. Adopted from Tornatzky et al. (1990)

The Technology, Organisation and Environment (TOE) framework, as shown in Figure 13, proposed by Tornatzky et al. (1990), is a foundational model for understanding how organisations adopt innovations. It suggests that diffusion depends on technology, organisation, and the environment. Technology refers to the availability and characteristics of innovation; the organisation relates to various aspects of the organisation, such as size, structure, resources, and human capital. Environment refers to industry characteristics, technology service providers, and economic and regulatory conditions. Baker (2012) showed that the TOE framework could be applied to different industries and contexts but noted that the measurement items for each factor might vary depending on the specific innovation, culture, and industry. This study also uses different constructs and measurement items from the original TOE framework to identify the barriers to adopting PV in residential sectional-title and townhouse community schemes in South Africa.

This study follows the approach of grouping factors into categories based on their common characteristics, as done by previous researchers who investigated the barriers to the diffusion of innovations in various fields. For example, Seetharaman et al. (2019) categorised the barriers to renewable energy adoption into social, economic, technological, and regulatory barriers; Durdyev et al. (2018) examined the barriers to sustainable construction under five clusters: government, cost, knowledge and information, workforce, and client and market; and Chan et al. (2018) studied barriers to green building adoption using these categories: government-related barriers, human-related barriers, knowledge and information-related barriers, market-related barriers, and cost and risk-related barriers.

2.4.2 Diffusion of Innovation (DOI) Theory

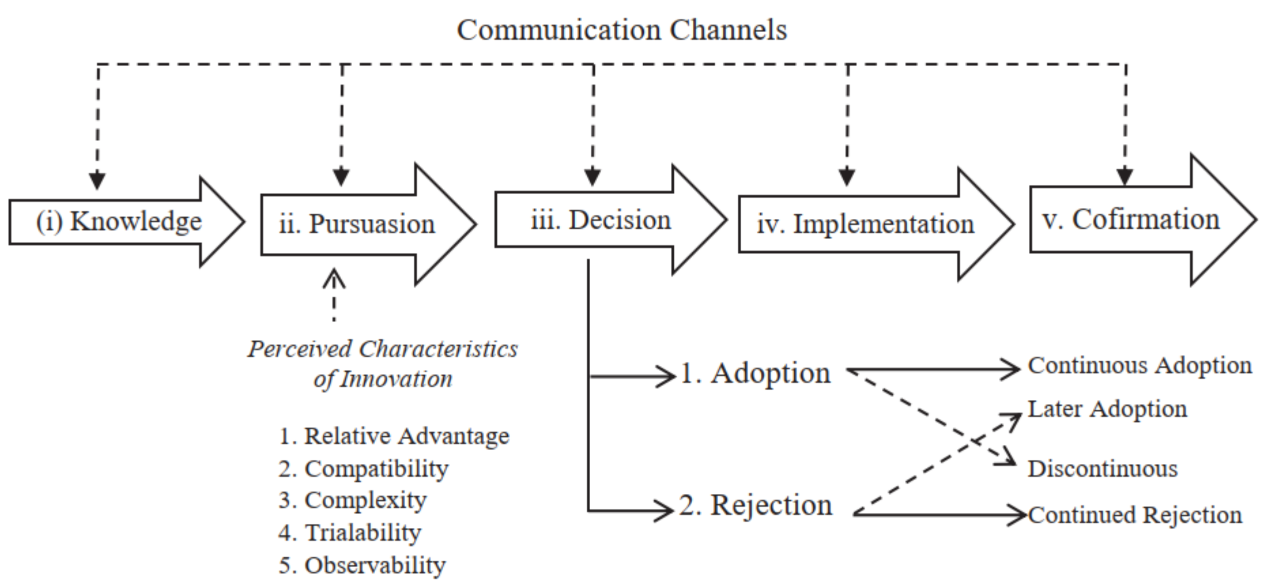


Figure 14: Roger Model for Innovation Decision Process. Adopted from Qureshi et al. (2017)

The diffusion of innovation (DOI) theory, developed by Rogers (2003), is used to study how the adoption of innovations occurs. According to Rogers, innovation can be an object, technology, behaviour, practice, or idea perceived as new to potential adopters. The adoption process involves several stages, including awareness, persuasion, decision-making, implementation, and confirmation, as shown in Figure 14. The adoption decision is influenced by five key characteristics of the innovation, including relative advantage, compatibility, complexity, trialability, and observability. While initially developed to study innovation diffusion in the information technology sector, the DOI theory and its five attributes have been widely adapted for researching renewable energy technologies.

The DOI theory has proven to be a valuable tool for understanding the adoption of Renewable Energy technologies, such as Solar PV. It can help policymakers and practitioners develop effective strategies for promoting their uptake. Numerous researchers have incorporated the DOI theory into their research framework, including Franceschinis et al. (2017), Kapoor and Dwivedi (2020), Qureshi et al. (2017), Wolske et al. (2020), Wolske et al. (2017) and Zhang et al. (2011). For example, Qureshi et al. (2017) used the five attributes to identify factors influencing households' decisions to adopt photovoltaic (PV) technology in Pakistan.

2.4.3 Technology Acceptance Model (TAM)

The technology acceptance model (TAM), as shown in Figure 15, is a theoretical framework that Davis (1989) developed to understand the factors that influence an individual's intention to adopt a new technology. According to TAM, an individual's adoption intention is based on their perception of the technology's usefulness and ease of use. The model suggests that the perceived usefulness of technology is a more significant factor in driving adoption than the perceived ease of use. TAM is grounded on the theory of reasoned action, which assumes that individuals act rationally and consider the consequences of their actions.

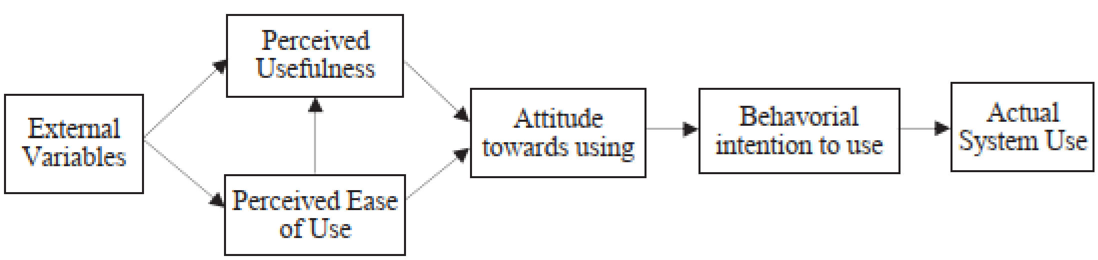


Figure 15: Technology Acceptance Model (TAM). Adopted from Geh et al. (2023)

TAM has been widely used and validated in various contexts and domains, including renewable energy technologies (RETs). Empirical studies have demonstrated the relevance of the TAM in investigating the diffusion of RETs. For example, Akroush et al. (2019) used the TAM to investigate the determinants of solar energy system adoption in Jordan. They found that perceived usefulness, perceived ease of use, subjective norms, and perceived behavioural control positively affected adoption intention. Similarly, Kim et al. (2014) applied the TAM to examine the factors affecting the adoption of smart grid technologies in Korea. Their findings revealed that perceived usefulness, ease of use, and trust positively influenced adoption intention, while perceived risk negatively affected it. These studies demonstrate the usefulness of the TAM in understanding the factors that drive the adoption of new and innovative technologies.

2.4.4 Unified Theory of Acceptance and Use of Technology (UTAUT)

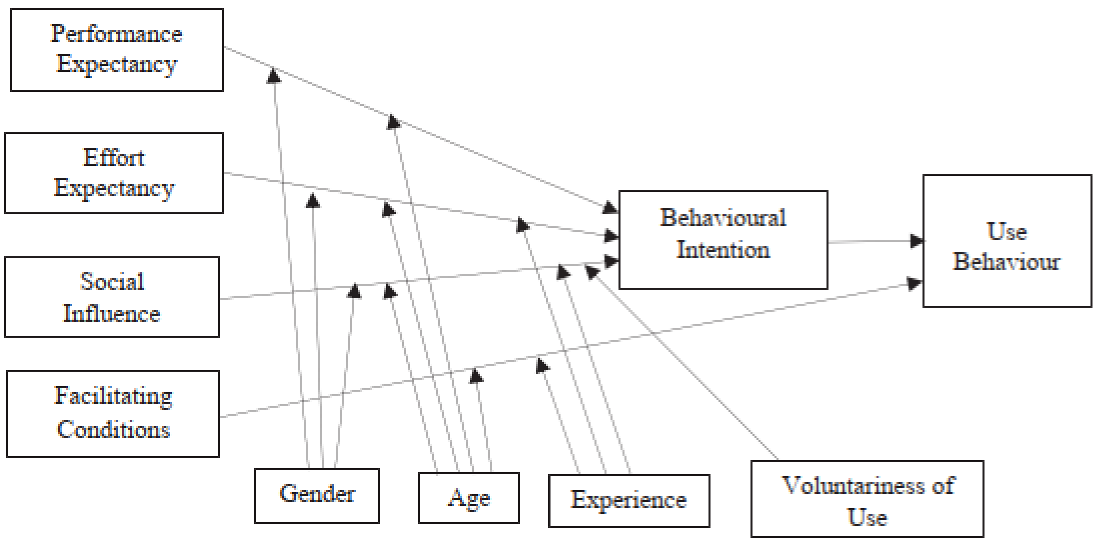


Figure 16: Unified Theory of Acceptance and Use of Technology (UTAUT) Model. Adopted from Venkatesh et al. (2003) and Geh et al. (2023).

The Unified Theory of Acceptance and Use of Technology (UTAUT) was developed by Venkatesh et al. (2003) based on a review and synthesis of eight existing models used to explain information systems usage behaviour. It is a comprehensive model integrating eight previous models to explain how users form their intentions and behaviour towards using a new technology. The model identifies four main factors influencing users' intention and behaviour: performance expectancy, effort expectancy, social influence, and facilitating conditions, as shown in Figure 16. Performance expectancy is the extent to which users believe technology will improve their performance or outcomes. Effort expectancy is the extent to which users believe using technology will be effortless. Social influence is how users perceive those critical to others, such as peers, managers, or family members, to encourage or expect them to use technology. Facilitating conditions are the extent to which users perceive that the technical and organisational infrastructure supports their use of technology. The model also considers how these factors are moderated by users' characteristics, such as gender, age, experience, and voluntariness of use. The model suggests that these moderators affect the strength of the relationship between the factors and users' intentions and behaviour.

Researchers have widely applied UTAUT to examine various aspects of technology adoption in different domains and settings. For example, UTAUT has been used to study the adoption of smart grid technologies by industrial customers in Korea (Kim et al., 2014). The study found that performance expectancy, effort expectancy, social influence, and trust positively affected adoption intention. At the same time, perceived risk had a negative effect. UTAUT has also been used to study information communication technology adoption for collaborative research among university lecturers in Kenya (Muriithi et al., 2016). The study identified significant predictors of adoption intention, including performance expectancy, effort expectancy, social influence, and facilitating conditions.

In addition, UTAUT has been adapted to develop the integrated acceptance and sustainability assessment model (Aizstrauta et al., 2015), which was used to evaluate the acceptance and sustainability of e-government services in Latvia. The study found that performance expectancy, effort expectancy, social influence, trust, and perceived risk were significant for e-government acceptance. Furthermore, UTAUT has been used to study the factors behind the adoption and non-adoption of photovoltaic systems among homeowners in the Netherlands (Vasseur & Kemp, 2015). The study found that performance expectancy, effort expectancy, social influence, facilitating conditions, environmental concern, and personal innovativeness were relevant factors for photovoltaic adoption.

The UTAUT model provides a valuable framework for understanding technology adoption and can be applied in various contexts to identify the critical determinants of behavioural intention and usage. The model can also help integrate business models for solar PV technologies by identifying and addressing the factors influencing the behavioural intention and usage of solar PV solutions among different customer segments and contexts.

2.4.5 Business Model (BM) Theory

2.4.5.1 Business Model

Numerous scholars have uniquely defined the term "business model" to embody the rationale behind a business's operations or profit generation. For instance, Chatterjee (2013) contended that the business model signifies the distribution (active systems) of enterprises (activities) and their investments (resources), founded on the logic that propels the profits of the specified enterprises. Teece (2010) posited that the crux of a business model is a notion, a manner for enterprises to convey value to customers and steer them to make purchases, subsequently generating profits. This contribution mirrors managerial suppositions regarding customers' needs, satisfying these requirements, and ways of attaining profits. In line with Osterwalder and Pigneur, "A business model delineates the rationale of how an organisation creates, delivers, and captures value" (Johnson, 2010), which captures the business model of renewable energy very well.

A business model should comprise three components: suppositions about the business environment, conjectures about the business's objectives, and a company's core competence. Christensen and Johnson (2009) identified four crucial elements:

a) Essential resources encompass labour, technology, products, tools, and brands,
b) Key processes encompassing design, manufacturing, and research and development (R&D),
c) The value proposition for customers encompasses price and payment methods, and
d) The form of profit encompasses cost structure and the revenue model.

Osterwalder and Pigneur (2010) observed that the following four factors should be incorporated into a business model. The first is "How", referring to the resources and capabilities enterprises depend on to generate value (Johnson, 2010). The second is "What", referring to products and services that reflect the business's value propositions (Johnson, 2010). The third is "Who", referring to the end-customers to whom enterprises provide products and services through marketing channels, and the inverse process of gathering customer requirements and relaying this information to the value creation department (Johnson, 2010). Ultimately, the ability to derive value is by identifying and implementing an effective profit model. Businesses can maximise their revenue generation “how much” and enhance the value creation process, ultimately leading to a sustainable and competitive business model (Teece, 2010).

When developing a business model, it needs to align with the company's objectives and create a core that directs the business towards identifying and fulfilling customer needs, achieving customer satisfaction, continuously enhancing customer value, and improving partner value. Maintaining internal consistency is also essential. The business model's components must be intrinsically connected. To be effective, a business model should possess a unique value orientation that is not easily replicated or surpassed by competitors quickly (Strupeit & Palm, 2016). Therefore, it is necessary to design a forward-looking business model that can withstand the test of time. Business models should be concise, simplified, and straightforward (Strupeit & Palm, 2016).

2.4.5.2 The Business Model Canvas

In the realm of organisational business model design, the focus lies primarily on the creation, delivery, and capture of value. Osterwalder and Pigneur (2010) introduced a shared language, the Business Model Canvas (BMC), to facilitate the development, visualisation, assessment, and transformation of existing business models. The BMC comprises nine components: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure, as shown in Figure 17 (Gabriel & Kirkwood, 2016; Osterwalder & Pigneur, 2010; Osterwalder et al., 2011).

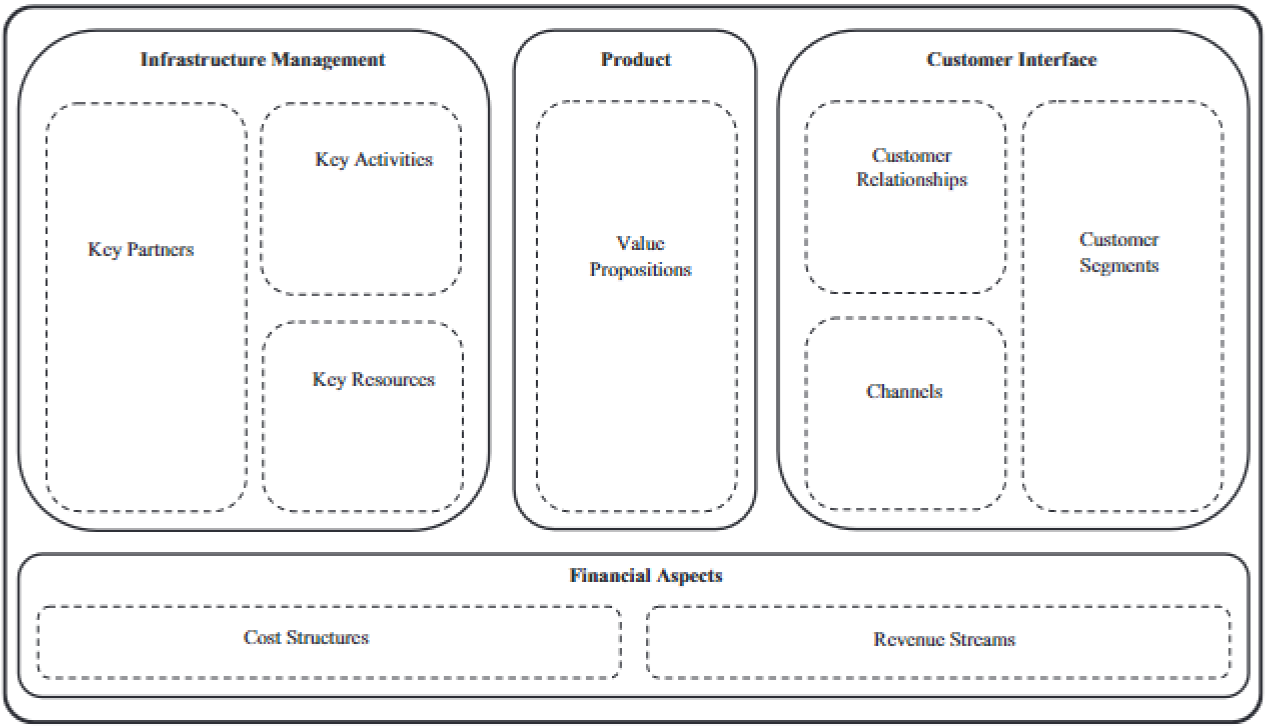


Figure 17: The Business Model Canvas (Gabriel & Kirkwood, 2016; Osterwalder & Pigneur, 2010)

The BMC has gained widespread recognition within the business community and has emerged as a universally adopted framework for examining business models. As a result, the BMC has become a valuable strategic tool that offers several strengths, including its ability to simplify and visually represent the components of a business model and its adaptability to various industries and business types (Yu et al., 2019). However, it also has limitations, such as its oversimplification of complex business models and its lack of consideration for the external environment in which a business operates, such as the competitive landscape or regulatory context (Gassmann et al., 2014). Despite its limitations, the Business Model Canvas (BMC) continues to be an invaluable resource for comparing and comprehending the fundamental logic of businesses across various organisations. Its value stems from its standardised framework and visual format, which facilitate flexible planning, swift adaptation to customer needs, and the preservation of a logical structure. Furthermore, it ensures clear visual representation and robust operability (Osterwalder & Pigneur, 2010; Xiaoxun et al., 2015; Yu et al., 2019).

In the realm of renewable energy, several researchers have examined the business model of distributed energy utilising the Business Model Canvas (BMC). Huijben and Verbong (2013) revealed three business models (i.e., COBM, TPOBM, CSBM) within the Dutch PV industry through literature reviews and interviews, analysing these models using the BMC. Similarly, Gabriel and Kirkwood (2016) applied the BMC to identify factors influencing renewable energy enterprises' selection of business models, delving into regional disparities and their impact on adopting various business models. Furthermore, Strupeit and Palm (2016) employed the business model concept as an analytical instrument to explore how diverse business models can facilitate the adoption of customer-owned PV systems in the USA, Japan, and Germany. Horváth and Szabó (2018) employed the BMC to scrutinise three distinct business models (i.e., COBM, TPOBM, CSBM) of global photovoltaic (PV) systems, showcasing the ways these models can surmount obstacles during distributed energy implementation, thus offering valuable insights. Concurrently, Cai et al. (2019) and Heirani et al. (2022) employed the BMC to scrutinise further three distinct business models of PV systems used in China and Iran, respectively, on the extent to overcome identified barriers and identify a business model that has the highest potential in the distributed generation market.

2.4.5.2.1 Customer-Owned BMC

Table 3: Customer-Owned Business Model Canvas (BMC). Adopted from Cai et al. (2019); Horváth and Szabó (2018)

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• Producers of PV system components • Wholesalers of PV system components • Utilities or grid-companies • Banks	• Turn-key solutions. • Sales of PV panels • After-sales services • Customer support services • PV insurance service • Price bargaining • Supplier selection • Marketing activities	• Pre-fixed packages • Non-pre-fixed packages • Possibility of installing the system individually • Independence from utilities • Reduced energy bills • Benefit from feed-in tariffs • Reduced investment risk and competitive investment opportunity • Tax benefits • Initial investment support possibilities • Benefit from special financial support programmes	• Direct interactions, personal relationships • Word of mouth • Online contact form	• High-incomer Homeowners • Farmers • Small and medium-sized enterprises
	Key Resources		**Channels**	
	• Technical knowledge • Human capital (e.g., expert staff) • Close knowledge of consumers • Close knowledge of local markets • Visibility of the company • Brand image		• Sales representatives • Different personal channels, e.g., solar walks, housing fairs and home exhibitions • Company website • Ground promotions	
Cost Structure			**Revenue Streams**	
• Sales costs • Wages • Stock costs • Inventory holding and warehousing costs			• Sales of PV system • PV system installation, repairs and maintenance • After-sales services • Energy consulting	

Table 3 summarises the Customer-Owned Business Model Canvas, and its components are discussed in the following sub-sections.

Value Proposition

Energy service companies offer clients pre-assembled photovoltaic (PV) systems, which consist of intricate packages containing specific components such as inverters, PV panels, and cables. These companies are responsible for installing, repairing, and maintaining these systems. Alternatively, non-pre-assembled packages are available, allowing for a customised solar PV system catering to the customer's requirements. In this scenario, customers can install the PV system themselves (Huijben & Verbong, 2013; Karakaya et al., 2016; Zhang, 2016).

Upon installing the PV system on their rooftops, customers can generate electricity for personal use anytime. They can choose different operating modes, "self-consumption" or "self-generation, self-consumption with excess sold to the grid", or "all sold to the grid". Customers can capitalise on feed-in tariffs (FiTs), which considerably influence investment decisions. FiT rates offer a competitive return on investment (ROI) compared to alternative investment opportunities (Couture et al., 2010; Hashim & Ho, 2011; Solangi et al., 2011). As a result, these tariffs can substantially mitigate investment risks and encourage the proliferation of RETs (Horváth & Szabó, 2018). Consequently, policymakers should meticulously develop and execute these tariffs (Couture et al., 2010; Strupeit & Palm, 2016). Depending on the specific national regulations, residential customers may also be eligible for tax benefits, initial investment support, or other exclusive financial assistance programmes (Horváth & Szabó, 2018; Zhang, 2016).

Customer Segment

Energy service companies that use the customer-owned model primarily target specific customer demographics. One primary group comprises households possessing suitable roofs and adequate financial resources to invest in Solar PV technologies despite the considerable initial costs and extended payback periods (Horváth & Szabó, 2018; Zhang, 2016). The capacity of installed systems in the residential sector typically reaches up to 10 kWp (Reis et al., 2021). Individuals within this group can be categorised as early adopters, driven by aspirations for energy autonomy and environmental advantages. However, information regarding their lifestyles, social and familial statuses, attitudes, and additional characteristics is scarce. Other customer segments for this model include farmers and small to medium-sized enterprises (Gao, 2018; Horváth & Szabó, 2018; Zhang, 2016).

Customer Relationships

Undeniably, customer relationships play a pivotal role in tackling issues related to awareness, customer acceptance, and behavioural barriers concerning renewable energy technologies within the customer-owned business model. For instance, before preparing a sales quotation, a sales representative visits the customer's residence to assess the available roof space, sunlight potential, and the customer's preferences (Horváth & Szabó, 2018).

Energy service companies strive to preserve and enhance customer relationships by providing exceptional after-sales service. Moreover, they create and maintain online customer connections through various means, such as enterprise websites or other e-commerce platforms (Zhang, 2016). As a result, they can maintain customer relationships, minimising transaction costs as much as possible and establishing a foundation of trust and long-term rapport with all customers (Zhang, 2016).

Channels

The channels identified hold a solid connection to customer relationships, with personal channels being a crucial aspect in building trust and fostering consumer engagement. Company sales representatives are the most critical channel components, as they are responsible for initiating contact with customers. This first interaction can significantly influence the entire relationship with the energy business and the selection of quotations (Liu, 2015).

Word-of-mouth communication also plays a vital role in consumers' investment decisions (Liu, 2015). The monthly HET solar walks are a prime example of personal channels in action. During these events, potential customers can visit several reference houses equipped with PV systems installed by HET. Another valuable practice that energy businesses in the DE market can adopt, which also serves as an excellent model for multilevel marketing, is SolarCity's Ambassador Programme. In this scheme, existing consumers can refer SolarCity to others. The referrer can earn a monetary reward if the recommended individual purchases a PV system.

Numerous energy service companies engage directly with customers through traditional channels, including sales representatives, advertisements, housing fairs, home exhibitions, ground promotions, and conference marketing (Horváth & Szabó, 2018; Liu, 2015; Strupeit & Palm, 2016; Zhang, 2016). Regular housing fairs, home exhibitions, ground promotions, and conference marketing within communities or private establishments significantly enhance customers' understanding of renewable energy technologies (Liu, 2015). Energy business websites and specialised PV magazines are essential channels, allowing companies to inform potential customers about their product and service offerings.

Moreover, energy service companies establish and maintain online customer communication through corporate websites or alternative e-commerce platforms (Liu, 2015). Using these channels, energy service companies can build and maintain strong customer relationships, increasing consumer engagement and trust in the renewable energy sector (Horváth & Szabó, 2018; Liu, 2015; Zhang, 2016).

Revenue Streams

The primary revenue source for energy service companies can be attributed to the sales of Solar PV systems. These companies also generate income from installing, restoring, and maintaining such PV systems. Furthermore, they offer energy consultancy and training services, educating clients on the operation and management of PV systems. This multifaceted approach allows energy service companies to maintain a steady income while promoting sustainable and environmentally friendly energy solutions.

Key partners

The key partners for solar photovoltaic (PV) companies are producers and wholesalers of essential system components, such as inverters and solar panels. Additionally, these partners provide vital support in the form of technical, marketing, and project-specific knowledge. Establishing a stable relationship with these partners is crucial to ensure a consistent product supply and fortify solar PV companies' bargaining position (Horváth & Szabó, 2018; Zhang, 2016).

Another significant partner is the utilities or grid company. Customers may adopt either the "all sold to the grid" model or the "self-generation, self-consumption with excess sold to the grid" model. Both approaches necessitate a connection to the public power grid. Therefore, nurturing a solid cooperative relationship with the grid company is vital to guarantee successful grid connections (Horváth & Szabó, 2018; Zhang, 2016).

Furthermore, many energy service companies collaborate with banks to offer financing services, such as loans, to their customers. This financial support enables customers to invest in solar PV systems more efficiently. Additionally, governments play a crucial role by providing subsidies for PV power generation through the grid company (Horváth & Szabó, 2018; Zhang, 2016). This incentive encourages more customers to adopt solar PV systems, thereby promoting the growth of the solar PV industry.

Key activities

In the customer-owned model, the primary focus is offering comprehensive services encompassing pre-purchase consultation, scheme design, engineering installation, grid connection support, monitoring and maintenance, system upgrades, and additional services (Horváth & Szabó, 2018; Zhang, 2016). Customer support services have been recognised as a crucial aspect of this model. Certain energy service companies also sell photovoltaic (PV) panels or provide special after-sales services, such as system performance monitoring and repairs (Zhang, 2016). These energy service companies typically offer guidance on financing, support and incentive systems, taxation, and renewable energy solutions (Horváth & Szabó, 2018). Some market players extend PV insurance services, which mitigate investment risks and bolster the customers' sense of security (Horváth & Szabó, 2018; Huijben & Verbong, 2013).

By offering a well-rounded service package, these companies ensure clients receive a seamless experience when adopting renewable energy solutions (Horváth & Szabó, 2018). Price negotiation and supplier selection are key activities, as energy service companies source solar system components from various producers and wholesalers (Horváth & Szabó, 2018; Huijben & Verbong, 2013). Furthermore, companies frequently employ diverse marketing strategies to enhance their reputation and fortify customer relationships.

Key resources

The fundamental assets for energy service companies comprise local market resources, encompassing relationships with local government, customers, communities, and financial institutions. The local government assumes a significant role in the distribution of energy development by granting substantial subsidies, offering technological support, and initiating promotions for energy distribution. Technical expertise, skilled personnel, and unique know-how are essential for the success of energy service companies. The human capital of these companies serves as a critical factor in determining their competitive advantage and prospects (Horváth & Szabó, 2018; Zhang, 2016).

Furthermore, acquiring a comprehensive understanding of consumers and local markets, often from geographical closeness, is indispensable. The understanding is particularly pertinent for local businesses that consistently interact with their clientele, enabling them to delve deeper into their customers' lifestyles and preferences. In conjunction with these factors, a company's prominence, attainable through well-planned marketing and social endeavours, can considerably sway consumer interest. Sales professionals possess expertise in various channels and customer resources, encompassing tactics for captivating customers and pinpointing their prospective requirements, lifestyles, and individual preferences. Local communities, existing patrons, and regional celebrities can play a significant role in establishing and continuously promoting a company's brand image and reputation. (Horváth & Szabó, 2018; Zhang, 2016).

Cost structure

The primary focus of energy service companies in the photovoltaic (PV) industry is to market and sell PV equipment through various channels, including sales representatives. To achieve this, these companies invest substantially in market expansion and promotion, incurring marketing, channel expenses, customer data acquisition fees, and sales personnel salaries (Horváth & Szabó, 2018; Zhang, 2016).

In addition to the abovementioned expenses, supplementary costs are associated with installing, repairing, and maintaining PV systems. These costs include upgrading system components and brackets, solar inverters, and grid-connection distribution boxes. Furthermore, the wages of technical staff responsible for these tasks also contribute to the overall expenditure. Moreover, stocking and warehousing expenses for PV system components constitute a significant portion of the PV sector's financial outlay for energy service companies (Horváth & Szabó, 2018; Zhang, 2016).

2.4.5.2.2 Third-Party Owned BMC

Table 4: Third-party Owned Business Model Canvas (BMC). Adopted from Cai et al. (2019); Horváth and Szabó (2018)

<table>
<tr>
<td rowspan="2">Key Partners
• Banks, large corporations
• Utilities or grid companies
• Producers and wholesalers of PV components
• Consultants
• Law company's
• Insurance companies
• Installation and maintenance companies</td>
<td>Key Activities
• Provide lease or PPA.
• Fund management
• Providing turn-key solutions
• Taking permits, arranging interconnections with utilities and completing documentation for incentives and tax breaks
• Sale of Renewable Energy Certificates
• System operation, maintenance
• Active marketing activities</td>
<td rowspan="2">Value Propositions
• No up-front costs
• Immediate energy savings (reduced energy bills)
• Green energy at a very competitive price
• Predictable cost of electricity
• The high transaction cost of handling is linked to complex regulatory and policy systems.
• Removal of operation and maintenance tasks
• Reduced technology risks
• Environmental protection</td>
<td>Customer Relationships
• Long-term relationships
• Personal contacts
• Online contact forms</td>
<td rowspan="2">Customer Segments
• Urban residents
• Township residents
• Neighbourhoods and communities
• Farmers
• Companies
• industrial and commercial enterprises
• Public organizations
• Institutional and private investors</td>
</tr>
<tr>
<td>Key Resources
• Existing customer base
• Project management software
• Well-trained employees</td>
<td>Channels
• Sales representatives
• Conferences and events
• Online and printed marketing tools
• Active media relations
• Company website</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Construction of PV system
• PPA and lease management costs (labour and IT)
• Acquiring investors
• Sales costs
• Marketing costs
• Stock and warehousing costs</td>
<td colspan="3">Revenue Streams
• Power Purchase Agreements
• Solar lease
• Central government subsidies
• Local government subsidies
• Incentives offered by municipalities and local utilities.
• Government tax benefits incl., including renewable energy investment.
• A tax credit, and accelerated depreciation
• Revenue from the sale of Renewable Energy Certificates
• Development, monitoring and other service fees</td>
</tr>
</table>

Table 4 summarises the Third-Party Business Model Canvas, and its components are discussed in the following sub-sections.

Value Proposition

The TPO model overcomes the two significant barriers to developing distributed energy: high upfront costs and an extended payback period (Zhang, 2016). In the TPO model, host customers receive solar power at a price lower than the retail price under the power purchase agreement mode (Cai et al., 2019; Zhang, 2016). In the leasing mode, customers receive clean and low-cost power generated by the PV system (Cai et al., 2019; Zhang, 2016). The cost of electricity becomes predictable for the duration of the contract, which can last up to 25 years and avoid unforeseen price fluctuations from utility rates (Strupeit & Palm, 2016).

The subsidy income from selling excess power to the grid is separated into two components following the developer and customer's agreed-upon proportion. Under the TPO model, customers can access clean and preferential PV power with minimal input through power purchase agreements and lease modes. Developers complete the repairs and maintenance of the PV system during the usage period. As a result, customers do not need to invest in operation and maintenance, making the investment akin to purchasing an insurance policy (Cai et al., 2019).

This approach appeals to most customers, as it minimises holding and technological risks and operation and maintenance costs (Wang, 2018). Strupeit and Palm (2016) also emphasised that developers could provide additional consumer benefits by managing the high transaction costs associated with the complex regulatory and policy systems. PPA contracts place the responsibility of operation and maintenance on the solar service company rather than the customer (Horváth & Szabó, 2018; Zhang, 2016). For lease agreements, while the host is responsible for the upkeep, solar lease companies typically offer maintenance packages and performance guarantees, reducing the tasks and risks for the customer. Furthermore, with PV power generation, sunlight is converted into electrical energy that is pollution- and noise-free. This process contributes to reduced gas pollution and carbon emissions, ultimately protecting the environment.

Customer Segments

In the TPO model, the primary customer segment encompasses households, particularly those situated in urban and township areas (Cai et al., 2019; Horváth & Szabó, 2018). These residents often face financial constraints, making it difficult to afford the high upfront costs of solar energy systems. However, they expressed keen interest in reducing their electricity expenses and contributing to environmental sustainability. Urban dwellers typically reside in multi-unit sectional title buildings or high-rise structures where the roofs are communally owned, which makes it difficult for the residents to negotiate with the property owners to install their own solar PV systems (Cai et al., 2019; Zhang, 2017). As Horváth and Szabó (2018) suggest, third-party-owned buildings hold significant appeal for a younger, unqualified demographic who may not be as financially stable. This TPO model offers an accessible solution for those seeking to utilise solar energy without bearing the initial costs.

In addition to households, other customer segments targeted by soar PV developers include farmers and public, industrial, and commercial companies (Cai et al., 2019; Strupeit & Palm, 2016). These entities can become the technical owners of photovoltaic (PV) systems and reap the benefits of Power Purchase Agreement (PPA) payments and government subsidies. By catering to both public and private organisations, solar PV developers can effectively expand their market reach and promote the adoption of sustainable energy solutions in various sectors, including industrial and commercial enterprises (Cai et al., 2019; Horváth & Szabó, 2018).

Customer Relationships

The TPO model functions through two primary methods: power purchase agreements and leasing arrangements (Cai et al., 2019; Horváth & Szabó, 2018). These contracts are essential for the long-term success of Solar PV developers, as they require sustained commitment from clients. Power purchase agreements usually span 10 to 25 years, while leasing arrangements typically last between 15 and 25 years (Zhang, 2016). Due to the extended nature of these contracts, Solar PV developers need to build and maintain robust relationships with their customers. One practical approach to achieve this is offering long-term consulting services at in-person specialised consulting spots to address problems customers' problems and maintain and further enhance the relationship with them (Cai et al., 2019; Horváth & Szabó, 2018). Solar PV developers have also embraced digital platforms such as corporate websites and other online contact forms as valuable tools for capturing potential clients and sustaining existing relationships (Cai et al., 2019; Horváth & Szabó, 2018). By utilising these online resources, Solar PV developers can ensure they remain accessible and responsive to their customers' needs, thus fostering trust and loyalty, which are crucial for long-term success in the industry.

Channels

Sales representatives are crucial in educating prospective clients about the advantages of Solar PV developer solutions, fostering more robust connections. Solar PV developers frequently participate in various conferences and events, such as energy industry gatherings and consumer exhibitions, which enable them to expand their professional network. Many marketing tools, including print and digital materials and proactive media engagement, are used across multiple channels.

Third-party organisations might contemplate establishing physical consultation service centres within various markets to broaden their market presence and solidify client relationships. These venues would function as a hub for customers to gain insight into power purchase agreements, leasing alternatives, and other pertinent information (Cai et al., 2019; Horváth & Szabó, 2018). Moreover, promotional endeavours, corporate websites, and other e-commerce platforms aid in drawing a more extensive array of potential customers.

Revenue Streams

Solar service companies' primary revenue stream is from PPAs and lease contracts. With PPAs and lease contracts, the host customer initially provides a minimal deposit payment to the Solar PV developer, followed by ongoing periodic payments per the agreed terms. After the initial down payment, the host customer is obligated to pay a predetermined sum monthly (R/month) for lease contracts or on a per-unit basis (R/kWh) for PPA contracts, with the amount being contingent on the energy generated per kWh within a given month. PPA contracts typically last between 10 and 25 years. Upon expiration, customers can purchase the PV system, renew the contract, or have the PPA provider remove the system.

Conversely, solar leases constitute an alternative approach where customers rent the necessary equipment and harness the energy generated by the photovoltaic (PV) system. This arrangement leads to monthly rental payments, such as a specified monthly rate. Solar leases are predominantly found in the United States, where power purchase agreements (PPAs) are prohibited (Cai et al., 2019; Horváth & Szabó, 2018).

Other sources of income for Solar PV developers may include government subsidies, state and federal incentives, and incentives offered by local municipalities and utilities. System owners can benefit from federal tax incentives—unavailable to tax-exempt units—such as investment tax credit (ITC) and accelerated depreciation. The ITC allows for 30% of the total investment amount of PV systems to appear as a tax credit. Accelerated depreciation permits a total depreciation during the first five years of operation by offsetting income tax (Cai et al., 2019; Horváth & Szabó, 2018).

In the USA and other countries where the Renewable Portfolio Standard (RPS) is enforced, which mandates increased energy production from renewable sources, Solar PV developers can generate additional revenue from the sale of Renewable Energy Certificates. Furthermore, depending on the scope of activities, development, monitoring, and other service fees may also contribute to revenue streams (Cai et al., 2019; Horváth & Szabó, 2018).

Key partners

Banks and various sizeable corporations, such as green finance funders, have the potential to significantly support the funding of projects by providing subsidies to the Solar PV developer's PPA and lease business models. In this context, they serve as crucial intermediaries amongst the primary stakeholders. Like the customer-owned model, the TPO models also show the importance of establishing relationships with utilities, producers, and wholesalers of photovoltaic components. Moreover, additional partners that may be involved in these models encompass consultants, legal companies, insurance companies, installation teams, and maintenance organisations (Cai et al., 2019; Horváth & Szabó, 2018).

Key activities

Key activities exhibit significant diversity in the TPO model, although several aspects are commonly found among Solar PV developers. Among the most critical activities are the provision of leases and Power Purchase Agreements (PPAs). Solar leasing companies typically organise financing by pooling multiple PV projects into a fund and marketing it to investors. Consequently, this necessitates fund management functions within the service company to oversee these processes. Furthermore, numerous companies provide comprehensive solutions in TPO and customer-owned models, which suggests that under the all-inclusive service concept, Solar PV developers are responsible for installing PV systems, obtaining the required permits, coordinating with utilities for interconnections, and completing applications for tax incentives and rebates. For instance, these Solar PV developers in the USA often sell Renewable Energy Certificates across multiple states. Additionally, companies frequently offer supplementary services such as performance monitoring, maintenance, and repairs. Active marketing strategies are also evident, as many companies utilise various media and complementary channels to promote their services (Cai et al., 2019; Horváth & Szabó, 2018).

Key resources

In the TPO model, key resources primarily encompass the relationships resources forged with local authorities, clients, communities, and financial institutions. Local governments significantly offer subsidies, technical assistance, and support in promoting services to Solar PV developers. It is particularly vital to efficiently manage the relationship with the Residential Owners' Administrative Committee (for example, in the Southern Africa context, Homeowners Associations (HOA), as it facilitates marketing endeavours within residential zones (Cai et al., 2019; Horváth & Szabó, 2018).

Under the PPA mode, Solar PV developers are responsible for ensuring the smooth functioning of PV systems, providing a consistent power supply to customers, and managing the risks associated with system operations. Consequently, compared to the customer-owned model, it is of greater importance for Solar PV developers to possess ample technical resources and employ a highly skilled professional workforce (Cai et al., 2019; Horváth & Szabó, 2018). Financial institutions, such as banks, serve as essential funding sources for third-party companies, making establishing relationship resources with these institutions a critical component of the model.

Cost structure

Although there are notable distinctions between the TPO and host-owned models, certain costs are expected to be similar, such as sales, marketing, inventory (components of PV systems, for example, panels and inverters), and warehousing expenses (Cai et al., 2019; Horváth & Szabó, 2018). In the TPO model, most expenditures are constructing the PV system and associated with PPA and lease agreement management, which includes securing public and private investors through labour and IT expenses. Solar PV developers are vital in constructing the PV system, which necessitates adopting various marketing approaches to promote the TPO model. Solar PV developers must consistently maintain and repair the PV system, leading to supplementary costs concerning employee wages and maintenance and material fees (Cai et al., 2019; Horváth & Szabó, 2018). As a result, marketing expenditures also play a crucial role.

2.4.5.2.3 Community-Based BMC

Table 5 summarises the Community-Based Business Model Canvas, and its components are discussed in the following sub-sections.

Value Proposition

Due to three primary constraints, numerous individuals face significant challenges installing a photovoltaic (PV) system on their rooftops. Firstly, they may not possess the property, as is the case with tenants. Secondly, they could reside in a condominium where installation is not feasible. Lastly, the available rooftop space may be inadequate or unsuitable for a PV system, such as a shaded or ageing roof. Additionally, concerns regarding system performance, efficiency, or a general unwillingness to install a PV system on their property may deter potential users (Horváth & Szabó, 2018). For instance, in the USA, other obstacles may include a lack of creditworthiness or residing in a state without a net energy metering policy. The community-shared (CS) model offers a viable alternative, allowing customers to access green energy without hosting a PV system, which can be achieved through virtual net metering, which lowers their electricity bills. Subscribers to the CS model receive credits on their energy bills proportionate to their share in the PV system's power generation.

Contract subscriptions typically range from 5 to 20 years, presenting an attractive long-term saving option with minimal risk. Furthermore, the CS model reduces financial barriers and decreases PV system costs for customers due to group purchasing. Flexibility is a crucial aspect of the CS model. If subscribers sell their property, they have two options. They can sell the subscription, either with the property or separately. Alternatively, suppose they choose not to sell their shares and relocate within the service territory. The solar credits can be transferred to their new location if a CS installation exists (Horváth & Szabó, 2018; Reis et al., 2021). This business model also fosters customer commitment to renewable energy sources, further promoting the adoption of sustainable power generation.

Table 5: Community-Based Business Model Canvas (BMC). Adopted from Cai et al. (2019); Horváth and Szabó (2018)

<table>
<tr>
<td rowspan="2">Key Partners
• Community members
• Municipalities and public entities
• Distribution System Operators (DSO) and other network operators
• Subcontractors (e.g., construction companies)
• Producers and wholesalers</td>
<td>Key Activities
• Subscriber management
• Program management incl., including customer protection, data reporting, regulatory compliance.
• Installation
• System purchase
• System operation and maintenance</td>
<td rowspan="2">Value Propositions
• Use of green energy without hosting the PV system
• Energy self-sufficiency
• Economic value due to a reduced electricity bill
• Decreased financial barriers and costs.
• Distribution of costs and responsibilities
• Social Value
• Environmental value</td>
<td>Customer Relationships
• Personal relationships
• Online contact forms</td>
<td rowspan="2">Customer Segments
• Residential customers
• Businesses
• Commercial companies who lease their buildings
• Non-profit organizations
• Institutional consumers (e.g., universities, military)</td>
</tr>
<tr>
<td>Key Resources
• Existing customer base
• IT infrastructure
• Workforce (incl. sales representatives)</td>
<td>Channels
• Conferences, meetings
• Educational programmes
• House parties, community events
• Websites
• Sales representatives</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Technical and economic feasibility studies,
• Planning and licensing costs
• Capital costs for building and installing PV systems.
• Operation and maintenance
• Labour and IT costs</td>
<td colspan="3">Revenue Streams
• Sale of solar bonds
• Sale of community member's shares
• Sale of energy to other customers
• Sales of generation surplus
• Upfront payments
• Government incentives
• Tax incentives incl. renewable energy investment tax credits and accelerated depreciation
• Subsidies or long-term contracts between the government and renewable energy producers</td>
</tr>
</table>

Customer Segments

The customer segment encompasses residential clients who encounter the challenges outlined in the value propositions section, such as renters. Solar PV developers also pursue businesses; commercial enterprises and non-profit organisations like religious institutions lease their premises. Additional subscriber categories include institutional consumers, local governments, universities, and the military (Horváth & Szabó, 2018; Reis et al., 2021).

The CS model requires the 'customer segment' to possess the financial capacity and suitable spatial conditions to become prosumers. Alternatively, some models advocate for the involvement of public institutions, such as energy cooperatives, or the inclusion of low-income consumers. Multi-tenancy buildings, where space is limited, serve as the focal point for collective generation business models. In contrast, end-users residing in smart homes or possessing appliances designed for demand management and willing to accept Demand-Side Management (DSM) actions, which allow for consumption deduction, are targeted by the community system operator (Horváth & Szabó, 2018; Reis et al., 2021).

Customer Relationships

In the CS model, as with Customer-owned and TPO models, establishing and sustaining personal connections play a crucial role in the effective functioning of these business models. Solar PV developers enter into extended agreements with clients, lasting up to two decades. Consequently, they must utilise various means of communication to initiate contact, such as direct (in-person) and indirect (e.g., digital, written) methods. These channels encompass meetings, customer support platforms, and websites, all enhancing trust and dedication (Horváth & Szabó, 2018; Reis et al., 2021). Also, these relationships are commonly established over a long period consistent with the project's lifetime to ensure its stability and financial continuity as well as the interest of the stakeholders. The relationship with customers is primarily indirect and supported by automated devices. For this purpose, physical infrastructures (Solar PV system and storage assets, distribution networks, smart meters), automated devices (for DSM) and key partnerships with energy suppliers and local utilities are required (Reis et al., 2021).

Channels

Community-shared business models are currently in a nascent growth stage, making the continuous acquisition and dissemination of information crucial in shaping their implementation. Solar PV developers can organise conferences, workshops, educational programmes, house gatherings, and community activities to facilitate this knowledge exchange. Additionally, utilising websites to share information can effectively reach consumers and prospective investors. Furthermore, the foundation for corporate success can be significantly supported by sales representatives of solar service providers, who also contribute to the knowledge pool (Horváth & Szabó, 2018; Reis et al., 2021).

Revenue Streams

The CS model offers two primary methods for generating revenue from consumers. The first approach involves customers purchasing a share of the energy produced by solar parks or gardens, resulting in most owners' income from selling solar bonds. The share prices are typically adjusted according to government-imposed tax rates. The second approach allows customers to pay an upfront fee covering all project costs. Some projects employ selling ownership shares, surplus energy to other community members, external retailers or last resort traders, and balancing reserve and ancillary services (Horváth & Szabó, 2018; Reis et al., 2021).

The regulatory framework in the United States enables solar project operators to benefit from federal and state-level tax incentives. Federal tax incentives are accessible for individually owned residential system installations or commercially owned projects. However, community-owned systems do not fall into either category, creating project design challenges. Augustine and McGavisk (2016) also highlighted this issue when exploring the potential of CS projects for public utilities, noting that municipalities and regulated utilities typically do not have a tax liability. Consequently, when a utility seeks to utilise tax incentives, including the renewable energy investment tax credit and accelerated depreciation, it often needs to collaborate with a third party eligible to receive the tax benefits, such as a non-profit organisation or Special Purpose Vehicle (Reis et al., 2021; Winkler et al., 2020). For an entity to fully utilise federal tax reliefs, it must own and operate the infrastructure and have sufficient community subscribers, which ensures that the benefits of the CS model can be maximised for all parties involved, contributing to the growth and development of renewable energy projects across the nation (Horváth & Szabó, 2018; Reis et al., 2021).

Key partners

Key partnerships are formed between energy communities and a variety of stakeholders, including network operators, as distribution networks are utilised; retailers and last resort traders, who guarantee the sale of power deficits and purchase of surplus generation; technology providers, offering relevant technical assistance; social entrepreneurs, local entities, utilities or other partners financing projects; and system operators, if demand flexibility is exploited for commercial purposes (Horváth & Szabó, 2018; Reis et al., 2021). Firstly, subscribers to a community solar farm must be customers of the local utility company where the solar farm is situated. Moreover, implementing net-metering in solar community projects necessitates synchronising generated electricity with the utility companies' billing systems, ensuring appropriate customer account adjustments (Reis et al., 2021). As a result, solar project operators need to foster strong relationships with utility companies. In cases where service providers are responsible for constructing the infrastructure, collaboration with additional partners, such as subcontractors, producers, and wholesalers, becomes essential.

Key activities

In the CS business model, Solar farms or solar garden owners, such as Solar PV developers, present a variety of subscription alternatives to subscribers, such as acquiring or leasing panels, investing in systems, and purchasing energy or capacity. Their primary focus is managing subscribers, which entails enrolling customers and maintaining communication with them. Additional responsibilities encompass safeguarding consumers, submitting data reports, and ensuring adherence to regulations. While these owners typically oversee the infrastructure installation, there are instances where they merely assume control of the completed PV systems. In such cases, the service provider operates and maintains the systems (Horváth & Szabó, 2018; Reis et al., 2021).

Key resources

As in the TPO model, the existing customer base is a crucial resource in the CS model. This customer base allows companies to attract more clients, potentially leading to increased investments. Service providers must have a robust IT infrastructure to effectively manage community projects and synchronise data with utility systems, which includes appropriate software solutions for real-time energy generation monitoring and subscriber contract management (Horváth & Szabó, 2018; Reis et al., 2021). A vital component of these models is the workforce, consisting of sales representatives who play a significant role in expanding networks and managing complexity. The success of solar community models relies on a combination of factors, including a strong customer base, efficient IT infrastructure, a dedicated workforce, and the availability of key resources. By addressing these elements, CS models can contribute to a more sustainable and decentralised energy future (Horváth & Szabó, 2018; Reis et al., 2021).

Cost structure

Cost structures encompass fixed and variable costs throughout the lifespan of a project. Fixed costs include energy procurement costs when a project cannot guarantee a complete energy supply to its members and must purchase from third parties, as well as expenses related to technology, land acquisition, rent, interest, and asset depreciation. On the other hand, variable costs consist of wages and other monthly operating expenses (Horváth & Szabó, 2018; Reis et al., 2021).

Firstly, high costs may arise during infrastructure development if the community does not finance the initial installation investments. There are instances where future subscribers bear the upfront costs, as demonstrated by Briston Energy Solar (BES) and funds for their project. BES sold shares ranging from £250 to £20,000 (approximately R6000 to R480,000) to individuals (Horváth & Szabó, 2018). This initiative proved to be highly successful, as the necessary amount was raised within three weeks, thanks to the contributions of 103 non-corporate investors. Another example is in the South African context. Eskom funded the project for R4 million rand as an experiment of the community-based model (Bloem et al., 2021). Secondly, a substantial portion of the costs is likely associated with the operation and maintenance of the photovoltaic (PV) system. Subscriber management expenses, such as labour and IT costs, are also expected to be significant, as these are crucial aspects of service providers' operations. The IT costs play a vital role due to management tasks and the sophisticated software required to synchronise the utilities' billing system with the amount of energy produced. Therefore, understanding and managing the various cost structures is crucial for successfully implementing and operating energy projects (Horváth & Szabó, 2018).

2.5 Conceptual Framework

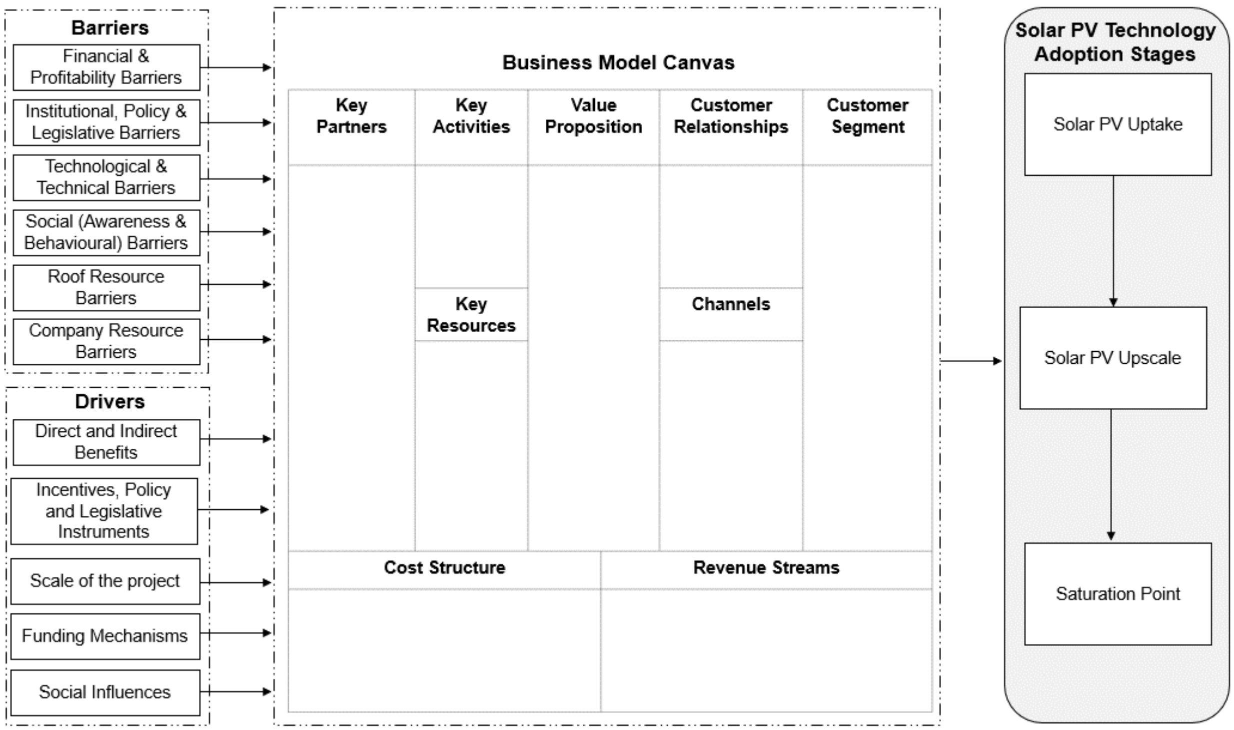


Figure 18: Conceptual Framework. Adopted from Cai et al. (2019), Geh et al. (2022, 2023), Horváth and Szabó (2018) and Reis et al. (2021).

While solar business models are effective ways to overcome barriers and leverage the drivers to solve electricity reliability challenges, there is very little theoretical guidance on how they can assist in adopting solar PV technology, especially in residential sectional-title and townhouse community schemes segments in South Africa. Therefore, the conceptual framework is developed based on several scholarly contributions in the fields of solar business models by examining the literature review and how the concepts of the literature review relate to each other, assisting in data gathering and eventual analysis. Evidence from the literature suggests that drivers and barriers significantly influence the adoption of solar PV technology (Cai et al., 2019; Horváth & Szabó, 2018). The proposed conceptual framework, as depicted in Figure 18, is adapted from several studies (Cai et al., 2019; Geh et al., 2022, 2023; Horváth & Szabó, 2018; Van Opstal & Smeets, 2022a), consisting of "Barriers", "Drivers", "Business Model Canvas", and "Solar PV Technology Adoption Stages" constructs.

The study of Geh et al. (2022) explores the identified barriers (i.e., cost and funding-related, institution-related, and government-related barriers) on how they hamper solar PV deployment in South Africa's public universities. In addition, the study of Geh et al. (2023) explores the identified drivers (i.e. direct benefits, indirect benefits, social influences, and relative advantage factors) that influence the deployment of Solar PV technology in public universities in South Africa. Though the studies by Geh et al. (2022, 2023) were undertaken in a different context, such as a public university, the conceptual framework is adapted for this study.

Lastly, the studies of Horváth and Szabó (2018) and Cai et al. (2019) investigated different solar PV business models using the Business Model Canvas. They explored how the different business models can overcome the main barriers to adopting distributed energy. These insights could be instrumental in understanding and promoting the adoption of Solar PV technology in residential sectional-title and townhouse community schemes in South Africa.

2.5.1 Barriers

Based on the evidence of the literature review and as shown in Figure 18, six constructs are proposed to explore the factors that inhibit the solar PV technology adoption in the residential sectional-title and townhouse community scheme as adapted from the study by Geh et al. (2022). These constructs include i) Financial and profitability barriers, ii) Institutional, policy and legislative barriers, iii) Technological and technical barriers, iv) Social (awareness and behavioural) barriers, v) Roof resource barriers, and vi) Company resources barriers. According to the TOE framework, an organisation's characteristics and prevailing conditions influence the adoption of innovations. Hence, the study included “Institutional, policy and legislative barriers” as the Body Corporate or HOA are institutions susceptible to government influences such as policy and regulations—for instance, the Sectional Title Act.

2.5.2 Drivers

Based on the evidence of the literature review and as shown in Figure 18, five proposed constructs were deemed relevant to the study. These constructs include i) direct and indirect benefits, ii) incentives, policy, and legislative instruments, iii) the scale of the project, iv) funding mechanisms, and v) social influences. The direct and indirect benefits and social influence have been identified as relevant factors in the adoption process, as adapted in the study conducted by Geh et al. (2023). These factors have been validated empirically and applied to the diffusion of renewable energy technologies (Geh et al., 2023). Other scholars have adopted similar approaches in investigating the diffusion of PV and other green technologies (Aggarwal et al., 2019; Kim et al., 2014; Korcaj et al., 2015). In addition, the constructs incentives, policy and legislative instruments, and funding mechanisms are major diffusers for solar PV adoption in studies conducted by Cai et al. (2019), Horváth and Szabó (2018) and Reis et al. (2021). Cai et al. (2019) reported that the scale of the projects needs to be big enough to lure investors to provide funding for solar PV projects.

2.5.3 Solar PV Technology Adoption Stages

The study suggests that adopting PV systems in residential sectional-title and townhouse community schemes is gradual, as shown in Figure 18, as adapted in the studies by Geh et al. (2022, 2023). The first phase, "Solar PV Uptake," involves installing the first PV system to partially meet energy demand, such as the sectional-title and townhouse community schemes shared property loads. This phase is a trial period, and the success of the first installation is necessary for further adoption. The next phase, "Solar PV Upscale," involves adding additional PV systems to increase generation capacity. This phase may include installing several systems over time, such as PV modules and inverters that will feed electricity to different apartments using the embedded network within the sectional-title and townhouse community scheme development, as in the case of Lynedoch EcoVillage (Bloem et al., 2021). The final phase, "Saturation Point," is reached when all available spaces, such as the rooftop and carports, and options for solar electricity generation have been utilised, including installing backup sources or battery storage devices in the residential sectional-title and townhouse community scheme. These backup sources can dispatch power during power outages, at night, cloudy and rainy days (Bloem et al., 2021; Thopil et al., 2018).

2.5.4 Business Model Canvas

Horváth and Szabó (2018) and Cai et al. (2019) used Lean Canvas (LC) as a tool to test a responsive business model, which is then adapted for this study for exploring a responsive business model in the context of residential sectional title and townhouse community scheme and also overcoming the identified barriers. The LC is an effective method for testing and validation and is considered a development of the BMC. The LC follows a specific order of addressing firm or product problems. However, in this study, the discussion will be limited to the use of business model canvas to arrive at achieving the objectives set out in this study, as shown in Figure 18 (Cai et al., 2019; Horváth & Szabó, 2018).

2.6 Proposition to Research Questions Based on Literature

What are the factors that hinder or facilitate solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa? (Research question one)

a) Considering the literature analysis on the factors influencing the adoption of solar PV technology, it can be expected that the findings of this study reveal that these sectional-title and townhouse community schemes face financial-related barriers, institutional, policy and legislative-related barriers, technological and technical-related barriers, social-related barriers, roof resources-related barriers, and company resources-related barriers when deploying solar PV technology.

b) Considering the literature analysis on the factors influencing the adoption of solar PV technology, it can be expected that the findings of this study reveal that these sectional-title and townhouse community schemes leverage the scale of projects, incentives, policy and legislative-related instruments, funding-related mechanisms, social-influences, and perceived benefits facilitating drivers when deciding on deploying solar PV technology.

What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa? (Research question two)

- Based on the solar business models from the literature, it can be expected that the findings of this study indicate that solar energy companies offering solar PV technology in the sectional-title and townhouse community schemes market will provide offerings using customer-owned business model, third-party-owned business model, and community-shared business model.
- Based on the solar business models from the literature, it can be expected that the findings of this study indicate that solar energy companies offering solar PV technology in the sectional-title and townhouse community schemes market will highlight the customer-facing and organisation-facing activities (encompassing value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure) that are being implemented to overcome the identified barriers and leverage the facilitating drivers.

2.7 Conclusion

The literature review offers a comprehensive understanding of the background discussion, factors influencing the adoption of solar PV technology, and different theoretical frameworks. It also proposes a conceptual framework based on various solar PV business models. This approach will aid in comprehending the complex interplay of factors that influence the diffusion of barriers and identifying the components of responsive business models for adopting solar PV technology in the residential sectional-title and townhouse community scheme market.

3 RESEARCH METHODOLOGY

3.1 Introduction

The current chapter outlines the research methodology employed to address the overarching research question systematically. Basias and Pollalis (2018) emphasise the importance of selecting an appropriate research methodology as a crucial prerequisite for conducting a successful investigation that effectively achieves the research objectives. In line with this, the chosen research method aims to gain a deeper understanding of the factors, including barriers and drivers, that impact the adoption of solar PV technology in residential sectional-title and townhouse community schemes in South Africa. Additionally, the study explores how the responsive Solar Business Model can facilitate increased adoption of solar PV technology residential sectional-title and townhouse community schemes.

This section of the research report presents the methodological approach to gathering data for this study. It encompasses the research approach, research design, participant profiles, data collection and interpretation methods, research instrument, and ethical considerations of this research study.

3.2 Research Overall Approach and Design

3.2.1 Research Approach

Given the nuances of challenges related to the adoption of Solar PV technology and business models, this study's chosen research approach was qualitative. According to Basias and Pollalis (2018), qualitative research can be defined as a broad category of research methodologies that focus on analysing experiences and behaviours without relying on statistical or numerical data. Qualitative research involves investigative methods that prioritise non-numerical data and emphasise in-depth analysis. Consequently, it requires researchers to have a more involved and subjective role, unlike the supposedly impartial and objective approach of quantitative studies (Basias & Pollalis, 2018).

A qualitative research approach was deemed appropriate for this study, as it allowed for collecting data that included firsthand personal experiences from various stakeholders regarding the adoption of solar PV technology in sectional-title and townhouse community schemes in South Africa. This approach focuses on the occurrence of specific phenomena or events and the subsequent results of those occurrences (Basias & Pollalis, 2018). In the context of this research study, the focus was on examining the factors that influence the adoption of solar PV technology in the residential market segment of sectional-title and townhouse community schemes, as well as exploring the experiences of solar energy companies about the activities of the solar PV business. A qualitative approach offers various benefits, one of which is the researcher's ability to gain a comprehensive understanding of the field and topic under investigation. This approach is particularly advantageous when dealing with complex subjects that require integrating knowledge from multiple disciplines and stakeholders (Basias & Pollalis, 2018).

3.2.2 Research Design

The research design examined the analysis methodology (Saunders et al., 2019). The structure of a research design can be classified into two categories: inductive and deductive studies (Mouton, 2011). Inductive studies involve gathering information from data, while deductive studies utilise literature review, modelling, methodological, and conceptual reviews to generate new findings (Basias & Pollalis, 2018). This particular study focused on a deductive approach, drawing from various sources that explore the factors influencing the adoption of solar PV (Cai et al., 2019; Geh et al., 2022, 2023; Horváth & Szabó, 2018; Van Opstal & Smeets, 2022a, 2022b) as well as the responsive solar PV business model identified in the literature review (Burger, 2022; Horváth & Szabó, 2018; Huijben & Verbong, 2013; Klein et al., 2021; Zhang, 2016), in order to formulate the research questions.

Additionally, an inductive approach was employed to gain insights from the data collected in this study. Qualitative data was collected through in-depth interviews using open-ended questions (Basias & Pollalis, 2018). According to Palinkas et al. (2015), adopting a qualitative research method provides a deeper understanding of a specific phenomenon. It allows for selecting groups or individuals well-versed in a particular research phenomenon. This research method is commonly used to explain human behaviour, opinions, experiences, and knowledge that are difficult to capture through quantitative data collection approaches (Basias & Pollalis, 2018). This study used qualitative research to comprehend the factors (i.e., drivers and barriers) influencing the adoption of solar PV technology and its connection to a responsive solar business model.

3.2.3 Participants and Sampling

The primary method of choosing interviewees is a homogenous purposeful sampling approach called judgment sampling. Thus, the selection is not statistically representative. The initial research and literature findings identified relevant stakeholders, summarised in Table 6, that could help meet the research objective. For this reason, non-probability sampling was used for the sampled participants (Yin, 2015). Maximum variation was attempted in sampling. The interviewees were chosen through convenience sampling for a sampling size of 10 respondents, with a minimum of 2 respondents from each group (Sekaran & Bougie, 2016; Yin, 2015), as summarised in Table 6.

Table 6: Profile of Identified Participants

Description of Participants/ Organisation Identified	**Sample**
Property Developers, Body Corporates and HOAs representatives, Managing Agents, and Law Firms	2
National and Local government department representatives	2
Energy Industry Bodies and Experts	2
Owners or managers of solar energy companies	2
Financial service providers funding solar energy projects	2

The convenience sampling technique is suitable when the researcher aims to recruit participants who possess expertise in the subject matter and are willing to offer their perspectives on the topic under investigation (Sekaran & Bougie, 2016). For each purposeful sampled interviewee group, several potential participants were approached through referrals and social media platforms like LinkedIn and WhatsApp. After the participants agreed to participate, follow-up e-mails containing the participation sheet, ethics clearance certificate, and consent form were sent to participants. After that, meetings were scheduled with participants to conduct the interviews.

The researcher faced difficulties conducting interviews with the initially identified participants due to their lack of responsiveness. As a result, the researcher had to depend on referrals from their connections and other participants. The sample size and the profiles of the 14 participants who were interviewed are summarised in Table 7.

Table 7: Profile of Interviewed Participants

Description of Participants/ Organisation Interviewed	**Sample**
Trustees of Body Corporates and HOA representatives	2
Managing Agent	1
Local government department representatives	1
Energy Industry Bodies and Experts	3
Managers of solar energy companies	6
Financial service providers funding solar energy projects	1

3.2.4 Data Collection

The researcher maintains the utmost ethical standards by safeguarding the confidentiality of respondents' personal information in compliance with relevant legislation such as the Protection of Personal Information Act (POPIA). Respondents were thoroughly informed about the aim of the study, which is to encourage participation.

Data collection assisted in achieving the aim of the study. The primary method for collecting data adopted for this study is in-depth (open-ended) interviews (Sreejesh et al., 2014; Yin, 2015).

The study used in-depth and open-ended questions to interview respondents with personal and professional experience in the renewable energy sector and those representing the community and associations. Interviews were conducted in person at the participant's chosen venue or through video calling platforms such as Microsoft Teams, with each session scheduled for 45-60 minutes to allow ample time for respondents to express their views. The interview guide's reliability was tested through a pilot study to evaluate the study's feasibility and practicality. Appendix A contains the compilation of questions for the interview.

3.2.5 Data Analysis and Interpretation

As discussed in the preceding sections, the data collection method allowed the researcher to collect relevant data from the research population and enable data analysis. The data was gathered through in-depth interviews, using a prepared interview guide to prompt respondents as needed. The audio recordings of these interviews were transcribed into written text, which took between two to four hours to listen to the audio recordings and transcribe for each interview. The data was coded and categorised into themes. The software ATLAS.ti 24 was adopted to make the coding process manageable. To analyse the qualitative data, the researcher identified recurring themes based on critical points raised or quotes provided by the participants.

Data from interviews with respondents who agreed to participate was analysed. The interviews' qualitative data underwent thematic analysis, which entailed pinpointing, examining, and presenting recurring patterns or themes in the data (Braun & Clarke, 2006). The process involved reducing and processing data, which focused on inductive and thematic analysis of data from the results. The reduction aspect of the data entailed identifying and formulating specific concepts and themes relevant to the study's objectives and summarising data into more meaningful themes.

3.2.5.1 The Process of Thematic Analysis

The process of thematic analysis involves several steps, which can be broadly categorised into data familiarisation, coding, theme development, and reporting (Braun & Clarke, 2006). The first step, data familiarisation, requires researchers to immerse themselves in the data by reading and re-reading the transcripts of interviews or other qualitative data sources. This step allows researchers to gain an initial understanding of the content and identify potential patterns or themes.

The next step is coding, assigning labels or codes to data segments that capture their meaning or significance (Braun & Clarke, 2006). Coding is an iterative process, as researchers may need to revise and refine the codes as they progress through the data. Once the data have been coded, researchers can categorise the codes into broader themes, representing patterns or recurring ideas within the data.

After identifying the themes, researchers can analyse and interpret them to provide a detailed and nuanced understanding (Braun & Clarke, 2006), which may involve comparing different themes, exploring their relationships, and considering the broader implications of the findings. The final step involves the researcher encapsulating the findings in a report coherently and engagingly, presenting the themes and their interpretations.

3.2.5.2 Significance of Thematic Analysis

The thematic analysis offers several benefits in the context of qualitative research. Firstly, it provides a systematic and transparent approach to data analysis, enhancing the findings' credibility and trustworthiness (Braun & Clarke, 2006). Secondly, it allows researchers to capture the complexity and diversity of participants' experiences and perspectives, providing a rich and in-depth understanding of the phenomena under investigation. Finally, thematic analysis facilitates the identification of commonalities and differences within the data, enabling researchers to make meaningful comparisons and draw insightful conclusions.

3.3 Trustworthiness

Great care was taken to ensure the transferability of the findings, thereby enhancing the reliability of this research (Connelly, 2016). This measure was implemented to verify that the data, analysis, and conclusions are relevant to various individuals and organisations. The list includes managers of solar energy companies, policymakers, regulators, financial services, managing agents, homeowners, trustees of Body Corporates, and homeowners' associations (HOAs). To further bolster the credibility of this study, Chapter 4 will provide an in-depth presentation of the data findings, thereby ensuring the data's transferability, authenticity, and consistency (Kirkman, 2008).

3.3.1 Credibility

Credibility, defined as the level of confidence and trustworthiness of data findings, is a crucial element in research regarding the consensus between the participants and the researcher (Creswell &

Creswell, 2017; Polit & Beck, 2022). It is closely related to the concept of internal validity of the research study (Connelly, 2016). Furthermore, credibility will be ensured through standardised data collection procedures and an interview guide to maintain consistency.

3.3.2 Dependability

Dependability refers to the stability and consistency of the data across time and conditions in the research study (Denzin & Lincoln, 2011; Polit & Beck, 2022). This study assumes that the data collected from the participants is accurate and will not change during the study period. The study will ensure dependability by following a rigorous process of thematic analysis. These steps could be replicated by other researchers who want to conduct a similar study (Braun & Clarke, 2006). However, it is essential to note that this study's circumstances and context may change over time, affecting the possibility of reproducing this study.

3.3.3 Confirmability

According to Polit and Beck (2014), the replication of this study is possible for other researchers. The research methodology employed in this study is robust and well-supported by existing literature on qualitative research, making it a valuable resource for scholars and researchers to emulate.

3.3.4 Transferability

The research study's findings are applicable and valuable to other individuals or groups in similar conditions and settings (Polit & Beck, 2014), which differs from generalisation, as qualitative research aims to gain in-depth insights and experiences from participants (Connelly, 2016). The study provides detailed accounts of the interviews conducted with participants, ensuring their perspectives are captured without the researcher's biases. All interactions between participants and the researcher are recorded, stored, and presented to facilitate an audit, including the original data, transcriptions, analysis, outcomes, and conclusions. The data is securely stored in the Wits SharePoint cloud and accessible only to the researcher through login credentials. The study ensures transferability through a transparent and comprehensive process (Creswell, 2003).

3.4 Limitations of the Study

The research objective and sub-objectives influence the sampling technique, and the choice selected for this study is homogeneous sampling, a purposive technique. It is important to note that this sample may not reflect the population statistically. The sample may have some biases due to time constraints and accessibility issues of the participants, and these factors were considered carefully.

Another possible drawback of the research method is the interviewee or responsive bias due to the skills and experience of the interviewer and when respondents have a particular view of the interviewer or the topic and feel uncomfortable with the in-depth exploration of an interview (Sreejesh et al., 2014). The researcher was careful not to influence or interfere too much with the interview process. The interviewees were made aware of the potential for intrusive questioning.

3.5 Ethical Considerations

Researchers prioritised ethical considerations, such as disclosing any conflicts of interest, ensuring the safety and privacy of interview participants, and obtaining their consent, as emphasised by various scholars (Bell et al., 2022; Cooper & Schindler, 2011).

This study was conducted according to the ethical principles of the University of the Witwatersrand regarding human subjects and participants. Before beginning the research, ethics review and clearance were obtained (protocol number: WBS/BA0504038T/847) to ensure that all procedures were ethical and complied with the university's guidelines.

Participants were invited to participate in the study through an introductory letter from the university, and their consent was obtained before the interview began. The researcher explained the relevance and purpose of the research to the participants and informed them that their participation was voluntary and confidential and that no rewards would be given for their participation.

To ensure transparency and build trust between the researcher and participants, a Participation Information Sheet was provided to participants outlining the purpose of the study and what their involvement would entail. Participants provided their signatures on a consent form to indicate their willingness to participate. However, there were instances when the consent form was signed after the interview.

In order to ensure the anonymity and confidentiality of participants, pseudonyms (such as Participant 1 and Participant 2 until Participant 14) were used in the report. Audio recordings of interviews will be made with the consent of the participants.

4 PRESENTATION OF RESEARCH FINDINGS

4.1 Introduction

This chapter unveils the findings from the data gathered during the interview process, providing comprehensive answers to the research questions. The structure of this chapter is meticulously organised around various themes, ensuring a coherent and thematic presentation of the results. Integrating the results and discussion into a single section provides a holistic narrative of the findings, further substantiated by direct quotes from the participants, serving as compelling evidence.

4.2 Findings On Research Question One

What are the factors that hinder or facilitate solar PV technology adoption in sectional-title and townhouse community schemes segment of the residential market in South Africa?

The findings of this question are divided into sub-sections 4.2.1 and 4.2.2.

4.2.1 Factors that hinder the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

The interview guide questions for defining factors that hinder adopting Solar PV technology were Questions g) and i). The following findings were the most common responses to factors hindering the adoption of Solar PV Technology in Sectional-Title and Townhouse Community Schemes in South Africa. The findings on factors that hinder adoption are summarised in section 4.2.3, Table 8.

4.2.1.1 Theme 1: Social and Stakeholders Collaboration Barriers

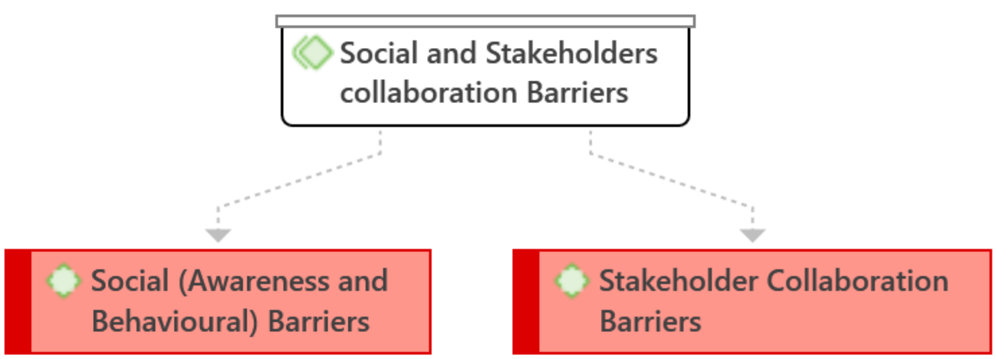


Figure 19: Social and Stakeholders Collaboration Barriers Ad hoc Network

Figure 19 highlights the central theme, social and stakeholder collaboration barriers, with two sub-themes: i) social (awareness and behavioural) barriers and ii) stakeholder collaboration barriers, which are discussed in the following subsections.

4.2.1.1.1 Social (Awareness and Behavioural) Barriers

The findings indicate a prevalent resistance to renewable energy and solar technology among specific community individuals. Participants highlighted a lack of education as a critical factor contributing to this resistance, with misconceptions about solar energy being common. The perception that solar technology is a foreign concept and myths such as solar panels preventing rain were identified as barriers to acceptance.

“The Body Corporates and trustees, for instance, trust their managing agent. So, a lot of them do not actually have the know-how or education within community schemes. Because as I said again, it is a completely different ball game, and people underestimate it. So, a lot of the time, people do not know; they are intimidated, and then they just go to the know-all and see-all, which is their managing agent, whom they trust. But like I said, this thing is a little bit dangerous because these managing agents are overworked a lot of the time. They are, you know, really not well educated or trained” - **Participant 4**

“The main major one is lack of information, obviously, because that is where it starts. You need to be familiar with this thing before you even consider whether you need to do it or not” - **Participant 10**

“The only reason people are not adopting it right now in community schemes we find is due to a lack of education. They do not understand it” - **Participant 4**

“There are people who are really anti-renewable or anti-solar. It’s embedded in them; it’s like it’s in their core to say no to these things. They just don’t believe in renewables or solar because they lack education on the subject. They don’t understand solar energy; they just see it as a Chinese or European thing that they just want to dump here” - **Participant 3**

“One of the myths, particularly in South Africa, is that when you install solar, it prevents rain from coming.” **- Participant 3**

Furthermore, the participant alluded to the challenges associated with community scepticism and hesitance towards adopting solar technology, attributing this reluctance to a collective subconscious mistrust and reluctance to incur additional costs.

“I just find that a lot of people are hyper-vigilant. It’s within our subconscious as a collective. We don’t trust anything, we don’t want to pay extra, but we want all the benefits. Yet, we suffer from analysis paralysis.” - **Participant 4**

4.2.1.1.2 Stakeholder Collaboration Challenges

The findings revealed several key insights from the participant's responses. The participants highlighted that the Trustees, Body Corporates, and Managing agents are the main stakeholders and emphasised the role of managing agents as gatekeepers in influencing decisions related to the adoption of solar technology.

"*For me, it's sometimes the managing agents. We often find that they act very much like gatekeepers. So, they're very much like journalists in a way where the nicer the relationship you have with them, the more they tend to pass through your recommendations. We often find that if we do not have an open and really good relationship with certain managing agents, they don't even propose this."* – **Participant 4**

Furthermore, the participants underscored the issue of siloed work within the industry, with various organisations and stakeholders working independently without cohesive collaboration. This fragmented approach was a significant barrier to advancing solar PV adoption efforts.

"So, normally, what happens in the industry is that people work in silos. For example, you're doing this work at Wits. Wits probably have a lot more information about this space, especially as part of the research outputs. SAPOA, SANEDI, SALGA, and SAPVIA are all doing their own things. But there is no interlink happening. It's like everyone is working in silos. This becomes a continuous cycle of repetitive work and initiatives being done. I think the efforts are happening, but not at the pace that they're supposed to be happening, considering what's happening. Right, because there are a lot of energy services companies out there." - **Participant 5**

"There's a lot of silo work that happens. What ends up happening is that people tend to forget that SAPOA is integral if you want to buy in from a lot of the property space. People also forget that you need SALGA because SALGA has access to municipalities, and municipalities are not easy to work with." - **Participant 5**

"People tend to forget that yes, you can complain about capacitation with these companies, energy service companies, but SANEDI, ETC, SETA, etc., all of those people, they have training courses for companies. And information, yes, it exists. It's there, they'll tell you it's there, but everyone is doing their own thing and that, for me, is a big issue" - **Participant 5**

"*More importantly, I think we need to also bring these insurance companies on board. That's been one of the key challenges we have because, on the one hand, the issue here has never been about not being able to deploy that because funding is made available by the banks. We've got technical guys who can deploy that, and we've got Body Corporates that are willing to do that. But now the issue becomes how do we insure this asset? How do we define a house now? So, you need those* *guys to come on board, and we need them to help make this situation much easier for deployment"* - **Participant 14**

"We also need municipalities, right? Municipalities are currently heavily reliant on sales revenue. I think 26%, if you look at the Stats SA report that was published last year or so, it indicated that in terms of the amount of revenue that the municipality receives, the two top high revenues are government transferring subsidies, which is around 31%, and electricity, which is 26%. Now, you can understand that they need to be brought to this table so they can understand how can they (the municipalities) continue to be sustainable in a situation where they are losing revenues from sales of electricity and how they can continue to support this large-scale deployment of rooftop solar for residential customers, particularly the ones that you mentioned. So, we need a number of stakeholders to ultimately help with this situation because you don't want to just solve one problem, load shedding, while also completely creating job loss because the municipalities cannot now be sustainable from that point of view." - **Participant 14**

4.2.1.2 Theme 2: Institutional, Policy and Legislative Barriers

Figure 20 highlights the central theme of Institutional, Policy and Legislative Barriers with two sub-themes: i) Electricity Regulatory Framework and Government Policy Challenges and Restrictions Towards Grid Integration, and ii) Sectional-Title Legislation and Body Corporates Rules Restrictions discussed in the following sub-sections.

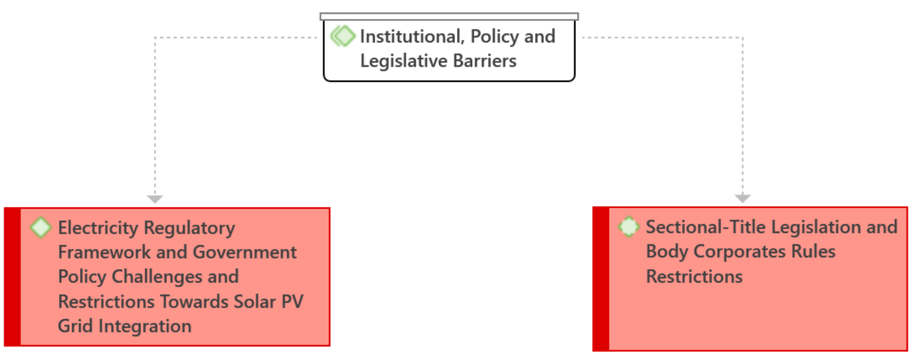


Figure 20: Institutional, Policy and Legislative Barriers Ad hoc Network

4.2.1.2.1 Electricity Regulatory Framework and Government Policy Challenges and Restrictions Towards Grid Integration

The participant critiques municipalities' lack of foresight and proactive planning, highlighting the disconnect between future energy trends and current infrastructure capabilities. The failure to predict disruptions, such as customers' increasing adoption of solar PV systems, underscores the inadequacy of existing distribution grids to accommodate bi-directional power flows, posing technical challenges and operational inefficiencies.

"Municipalities in themselves have no foresight. Obviously, municipalities plan for the future, but in our planning, we sometimes are unable to capacitate ourselves for what is coming in the future, a disruption of some sort. We are unable to plan for those disruptions, and then businesses and they (customers) have to do what they have to do to make sure that they have electricity. So, you have failed as a municipality. So, then they move forward, and you find yourself that actually these customers now have solar power, and they're connected to our distribution grid, but now they're starting to feed back a lot of their electricity. But wait, our distribution grids are not designed for that" - **Participant 12**

The participants articulate the complexities surrounding power integration into the grid without the requisite licensing, particularly in individual installations and community-based connections. The challenges in navigating these regulatory ambiguities underscore the need for clear and coherent policies to facilitate the seamless integration of solar PV systems into the existing grid infrastructure.

"There have been a number of these challenges. For instance, how much power can be allowed to connect to the grid without being licensed? From the point of individual installations, which could be a single household or a group of communities with a single point of connection, navigating these challenges was difficult." - **Participant 11**

The participants underscored a notable gap in the policy framework related to the application process. They also pointed out the absence of formal communication channels via media platforms and direct customer interaction. Furthermore, they highlighted the billing system's inability to integrate solar PV systems effectively. These observations suggest a systemic issue in modifying the existing infrastructure to accommodate renewable energy technologies. This shortfall is mainly due to the lack of established policies governing the system, resulting in delays and obstacles in the implementation process.

"In some municipalities within South Africa, what you will find is that there is no policy that creates an environment for such to occur" - **Participant 12**

"*So, it's those things that sometimes the policies are not there. Sometimes, the policies that do not promote despite their national power flow. Sometimes they do promote it, but there's no incentive to improve the business case from the customer's side, and sometimes the bureaucracy within the municipality becomes a stumbling block."* - **Participant 12**

"They have an electricity bylaw, but that electricity bylaw does not reference an SSEG policy, so because the SSEG policy does not exist, there is no policy giving direction on how to move forward within this jurisdiction. So, the absence of policies can be a barrier." - **Participant 12**

"From our side, there is no formal communication via media or any other communication platform, perhaps even direct communication to the customers regarding the solar PV system application process. There is no communication between us and the customers due to policies regarding this system that have not yet been signed. There's a delay from our side. Even the billing system is not yet ready to cater for the solar PV system" - **Participant 10**

Moreover, the participants discussed the lack of clarity and communication between customers, installers, and utility providers regarding the application process for solar PV systems. Adherence to municipal bylaws, electricity regulations, and SSEG policies was underscored as crucial for ensuring compliance with grid-code requirements and facilitating grid integration.

"*If the whole estate wants to install solar panels, it will obviously have to adhere to municipal or Eskom requirements. For instance, if you want to have an alternative generation connected to a distribution grid, there are certain municipal bylaws, electricity bylaws, and various policies, including an SSEG policy. Within that policy, it will stipulate the requirements from a municipal side for the various customers within this particular distribution grid to connect. Most of the time, if I speak to this particular type of customer, they will be receiving a three-phase connection at some point, and their systems would be less than 1MW.*" - **Participant 12**

"For customers like that, they have to adhere to what we call the NRS 097 specifications. The main purpose of this specification is to ensure that the grid-code is adhered to. It further simplifies or clarifies the grid-code for smaller customers. In a municipal setting, these types of customers, or a solar PV for that particular customer, would be called a small-scale embedded generation (SSEG)." - **Participant 12**

"*So, there is something called an SSEG. It is a form that you need to fill out in order for the government or Eskom, whoever is supplying electricity in that area that you want to help out. This thing is called an SSEG, which stands for Small Scale Embedded Generation. You have to fill out this application form. It gives them a breakdown of where exactly you're going to be setting up your small-scale generation and how much you're going to be bringing into that area. Are you going to be feeding back to the grid or just supplying to that residential area? You have to fill that out in the form. Then the municipality or Eskom, depending on who's supplying that, has to approve it. And then you'd find the municipality taking forever actually to sign that. So that is where the issue is, yeah.*" - **Participant 6**

"Perhaps I could also add the application process from the municipality. There is a lot of technical paperwork, and customers often do not want to follow this process due to the technical questions involved. Sometimes, there is a lack of effective communication between the customer and the installer. As a utility, we allow customers to install the system. The application process works like this: the customer needs to apply with us before the installation to check if the installation will comply with the regulations in place at the utility. If we find the application is complete, we advise the customer or issue pre-approval, indicating that they can now install their system. After installation, we check if the system is connected according to the application. We have experienced cases where customers are not aware of this application process. They install without following our processes. Later on, it may happen that we, the utility, tell the customer that their system does not comply. Given the investment the customer has made, it's difficult for them to decommission the whole system and redo it, just to follow the process." - **Participant 10**

The participant highlighted the cumbersome process of obtaining permits for solar grid integration, citing the need for approximately 28 permits from various regulatory bodies and authorities. These permits range from telecommunication companies to Environmental Authorizations and approvals from multiple government departments. The participant emphasised the arduous nature of this permit acquisition process, underscoring the significant time and effort required to navigate through the myriad of regulatory requirements.

"So, my understanding is that, and I know this from the typical ground-mounted solar panels, right? Besides, you need to get about 28 permits. Because if you think about it, it is just a permit to say that your system will not interfere with the telecom systems. It's not going to interfere with the aviation traffic routes and whatnot" - **Participant 5**

The participants also touched upon the challenges property developers and Body Corporates faced in installing solar PV systems, emphasising the need for streamlined processes and faster approvals from regulatory authorities. The delays in obtaining approvals for SSEG applications were highlighted as a significant barrier to the widespread adoption of solar technology.

"*So, I think if the government, especially Eskom, could respond quicker to these SSEG applications, it would be beneficial. I've heard stories where the SSEG was actually submitted about five months ago, but the solar energy company hasn't really received any feedback from Eskom. Then, after those five months, you'd find a response saying that they actually need a single line diagram (SLD), and then there's another process that's going to take another three months or so. So, I think if they could just try to sign these things when they have to, it might make things much easier for newcomers to adopt the whole thing.*" - **Participant 6**

"*From a technical perspective, making life easier for community schemes to adopt solar involves standardizing small-scale embedded generation (SSEG) applications and providing faster turnaround for approvals of those applications. For example, in Tshwane, applications can take up to two years to be approved, whereas in Cape Town, you've got a three-month approval process. So, that's one area: the SSEG applications. Making it easier for the adoption of these solutions would require government policies to align to assist with that.*" - **Participant 7**

Furthermore, the participants discussed the unused energy generated by solar systems during peak production hours, which cannot be fed back into the municipality due to the absence of net metering guidelines or frameworks. This limitation results in the loss of excess energy generated by solar systems, highlighting the inefficiencies in the current grid integration policies.

"*You get solar power from around 7:00 AM till 4:00 pm. Your house generates solar power, and then you store it in a battery. You can use it for a maximum of 4 hours, or if you're on the high end, you can use it for a bit more. However, what ends up happening is that if your house is generating solar power during the day when no one is home, and the demand for power is very low, it means that you're using less power from your system. So where is the rest of that power going? It becomes unused energy, so unused energy means it's power that's just going to be lost. Right now, you can't push that extra power back into the municipality because there's no municipality that has successfully implemented the net metering guidelines or framework."* - **Participant 5**

The participant's responses cited bureaucratic processes and lack of expertise within municipal personnel as factors impeding the smooth implementation of solar projects.

"*But now, the municipal personnel themselves are not well-versed in issues around these types of technologies. So now, you want to apply for your system to be connected, but no one is picking up the call. You want to apply; you want to find out what the requirements are. The policy exists, but the policy itself states that before you connect, you have to be granted permission by certain individuals within the municipality. Then, that person is unavailable. Sometimes, they are not well-equipped, and sometimes, they are too busy and understaffed, so this does not become a priority for them. And sometimes there's high municipal staff turnover; someone who knew something yesterday is no longer there."* - **Participant 12**

4.2.1.2.2 Sectional-Title Legislation and Body Corporates Rules Restrictions

The findings from the participants' responses under the sub-theme Sectional-Title Legislation and Body Corporates Rules Restrictions shed light on the challenges faced in the adoption of solar PV technology within sectional-title and townhouse community schemes. The participants highlighted several key barriers that hinder the widespread installation of rooftop solar panels in such communal setups.

One of the primary obstacles identified was the restrictive nature of Sectional Title Act regulations governing the management of sectional title properties. The Act mandates that any changes require unanimous consent from all individuals within the complex. This requirement poses a significant challenge as not all residents may align with or consent to such installations, leading to delays in decision-making processes.

Moreover, the participant emphasised the complex dynamics within Body Corporates, where decision-making and budgeting for alternative energy solutions become intricate matters. The need for collective agreement among owners, many absentee landlords with renters occupying the properties, further complicates the process. The participant highlighted instances where disagreements and delays in reaching a consensus hindered the implementation of solar projects.

"*There have been a lot of alternatives, especially with lights, such as rechargeable lights, but these are mainly just for lighting. I think there has been less installation of rooftop solar, mainly because of the rules. In a complex, you only own the inside, not the outside. So, you definitely do not own the roof, and you will hardly find solar panels on top of the roof.*" - Participant 3

"*I think that has been one of the key challenges faced by most of the sectional title owners or townhouse owners. Beyond just installing a solar rooftop on your house, you still need to get the necessary approvals. These approvals need to go through your Body Corporate "* - **Participant 14**

"So, I think what's important is the Sectional Title Act, which governs how the sectional title needs to be managed. Obviously, within the sectional title, there are different people, and there's also the issue of beliefs. The Sectional Title Act covers these aspects and requires that everyone's beliefs be accommodated. Depending on the size of the complex, consent is needed from each individual for any changes. For example, if you want to install solar panels, every single person within the complex needs to consent. You often find that not everyone aligns with or consents to having solar panels installed. The second thing to note is that most of the time, the owners of the sectional title properties do not live there; it's usually people who are renting. Obviously, renters are not the decision-makers. So, if there's anything that needs to be done, the Body Corporate needs to speak to the owners. Yes, there are AGMs, proxies, and all that, but most of the time, it takes a while for people to reach a common ground and agree on what needs to be done. The decision-making process, along with budgeting, is a complex matter within the Sectional Title" - **Participant 3**

"Some chairpersons just like their voices and the power that comes with it. Sometimes, we submit proposals, and honestly, everyone would vote. Just so you know, the voting process, along with the

legislation, means that if it's not done correctly, unfortunately, we can't proceed. So, then this whole process needs to start over again. I'm talking about special AGMs and so on, as you know, and then you have to get a quorum and stuff like that. A lot of people just feel like it's done; they get frustrated, even though it's not a fault on our part, but we try to help people through the process. So that's also a problem" - **Participant 4**

Participate 8 posits that 75% of the members present at the special general meeting need to vote in favour instead of every person as suggested by Participant 3 - "every single person within the complex needs to consent".

"*Again, it's about the resolutions that need to be taken. If an owner wishes to install solar, it's always a longer process for the first owner. Once the resolution is in place, you need to call a special general meeting. This is a special resolution, which means that 75% of the owners present need to agree that the specific owner wants to install solar. The roof of the sectional title complex is deemed to be common property. Essentially, the resolution gives that specific owner the exclusive use of that piece of roof. That's the first step. The second step is for the trustees to create the specification, so that when another owner wants to install solar, the specification is already in place. This ensures that we still conform to some form of uniformity and the aesthetic appeal of the complex is maintained.*" - **Participant 8**

"The Sectional Title Act was updated in 2016, a time when load-shedding wasn't such a significant issue. It probably needs to be revised to acknowledge the increasing number of people interested in installing solar PV technology. With the correct resolutions in place, it's not that it can't be done. The use of Body Corporate funds, monitored by CSOS and through the Act, allows the complex to manage the funds. The Act also permits the managing agent, Body Corporate , and owner to pass resolutions to include the solar project in the 10-year maintenance plan" - **Participant 8**

4.2.1.3 Theme 3: Financial Barriers

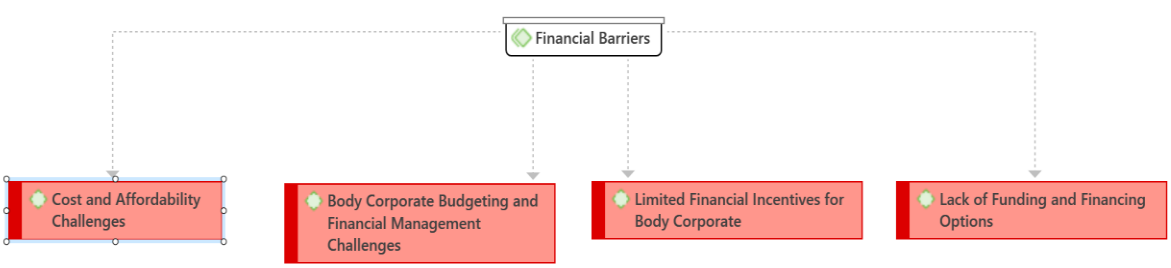


Figure 21: Financial Barriers Ad hoc Network

Figure 21 highlights the central theme, Financial Barriers, with four sub-themes: i) Cost and Affordability Challenges, ii) Body Corporate Budgeting and Financial Management Challenges, iii)

Limited Financial Incentives for Body Corporates and iv) Lack of Funding and Financing Options, discussed in the following sub-sections.

4.2.1.3.1 Cost and Affordability Challenges for Adopting Alternative Energy

The participants highlighted various aspects of the cost implications of implementing alternative energy solutions, particularly solar PV technology in Sectional-title and townhouse community schemes.

One participant emphasised the substantial initial investment required to adopt solar PV systems, noting that the cost could exceed 250 thousand rands for basic house installations. The participant underscored the financial burden of purchasing solar panels, inverters, and other necessary components, which could pose challenges for many residents within sectional-title and townhouse communities.

"What's happening now is that people are adding solar plus storage to try to convert solar energy into some sort of a base load, not really a base load, but some sort of a base load with storage. But the challenge is the cost. Solar alone could be affordable, but when you add storage, it becomes very expensive." - **Participant 3**

"They're not as cheap as one might think. The upfront or initial investment is very high. You must really do your homework. For a basic house, it has been estimated that you must spend at least 250 thousand rands. This is because you need to buy stoves and there are certain things that you need to ensure so that you're not spending at least 200 thousand rands. So, if you put 250 thousand rands on top of your budget, it's actually more than that, which is the amount that has already increased due to interest." - **Participant 2**

"Looking at the South Africans, the community there, the price of good solar system panels is high. I think it ranges above R100,000. People are unable to afford that." **- Participant 9**

However, the participants also highlighted cheaper solutions such as portable inverters and backup solutions that can be used to carry loads for lights, televisions, routers, and other small loads but are not suitable for heavy loads such as geysers and electricity stoves and may not be compliant with the Grid-code .

"*So, I mean, cooking is not really an option when it comes to backup systems. Unless it's a full solar system and maybe for an off-grid application, or it's big enough to allow cooking and the like. So, cooking really is not the main focus. It's more to do with things like lights, plugs, TVs, Wi-Fi, routers, and all of the other loads. But for cooking and things like geysers, it's not very economical to put* *these on a solar system. You can, especially with the geyser, depending on how big it is and how big your system is."* - **Participant 1**

"Let's start by saying that the cost of the system is largely due to the type of inverter that has been approved by the utilities. We are guided by the National Distribution and Renewable Energy Grid-code . Therefore, even the inverters need to comply with the grid-code , and those inverters tend to be more expensive. There are alternative inverters that are cheaper, but they do not comply with the grid-code ." **- Participant 10**

Moreover, participants highlighted that the cost of alternative energy resources put financial strain on residents, coupled with the reluctance of community schemes to impose special levies for solar projects.

"Everything you do affects your levies, and people are under a significant amount of financial strain at the moment." - **Participant 8**

"*If these solutions come at a cost, meaning unit owners have to incur an additional cost over and above their levies, the likelihood of any solution, solar or otherwise, being approved is very low*." - **Participant 7**

"As you know, batteries are quite expensive. I'm reminding you of the point about special levies; not many community schemes are keen on extra levies, especially when owners are already struggling to pay." - **Participant 4**

The participants emphasized the need for cost-effective solutions. They suggested that solar companies revise their pricing models to make solar technology more accessible to a broader range of stakeholders.

"I genuinely think that some of these solar companies can revise some of their costings to make it a bit more affordable. And I guess within this affordability part, we're talking about the people living in townhouses. In a townhouse, you will find people who have their own roof. You might call it five standalone houses, but it's all within a sectional title." - **Participant 5**

4.2.1.3.2 Body Corporates Budgeting and Financial Management Challenges

The participants highlighted various obstacles and considerations for implementing alternative energy solutions within community schemes, particularly solar PV technology.

One of the prominent challenges identified was the financial constraints faced by Body Corporates in funding solar PV energy projects. Participants noted that limited funds and the reluctance of residents to incur additional costs through special levies hindered the adoption of solar energy solutions. The participants emphasised the importance of affordability and the need for a holistic approach to benefit all residents, including those renting properties within the schemes. The concept of special levies was discussed as a potential funding mechanism. However, the resistance to imposing additional financial burdens on residents was a recurring theme.

"*Each year, the Body Corporate creates a budget. This includes all items and projected projects. For instance, the installation of solar would be a planned project. All these factors come into play and are added up with the levy. The levy income and your expenses, such as fees, repairs and maintenance, insurance, and so on, are all added up. That's how the levies are calculated"* - **Participant 8**

"In my understanding, not many complexes have adopted this because they are managed by Body Corporate s. If anything needs to be done, the money has to come from the people, perhaps as part of a special levy. Most of them don't really want to impose a special levy because if you have a system that will supply the entire complex, it will cost millions" - **Participant 3**

"There's also a culture that of not paying for levies by homeowners, so that is a very big hindrance for us as well, because obviously that delays growth." - **Participant 4**

"So, if you (Trustees) approach the people (homeowners) again and tell them that they will have to pay a special levy, especially for those projects, because you (Body Corporate) cannot fund it just from the coffers. Yes, because there's a certain amount (reserve funds) that you (Body Corporate) must always have. So, you (Body Corporate) need to have a special levy to be able to undertake those types of projects" - **Participant 2**

"Some complexes struggle financially, while others have enough savings to afford it. However, we also need to take legislation into account. Each Body Corporate needs to have an investment account (reserve finds) according to the Sectional Title Management Act. This account should be interest-bearing and have a certain amount saved as per the Act. These funds are exclusively used in conjunction with a 10-year maintenance plan. Therefore, you (the Body Corporate) cannot just use the funds. The Body Corporate needs to incorporate this project into its 10-year maintenance plan. This way, we (the Body Corporate) can abide by what the Sectional Title Act and CSOS Act allow for the funds to be used for." - **Participant 8**

"There are three tiers.

i) If the Body Corporate has less than 25% of their yearly income saved, they need to make a provision with the next budget, a reserve fund levy which is equivalent to 15% of the yearly income

ii) If the Body Corporate has more than 25% but less than 100% of their yearly income saved, they need to make provisions for a reserve fund levy equal to the Body Corporate 's repairs and maintenance items for the year. In my experience, 90% of the complexes are in this second tier.

iii) Then you've got the third tier. If the Body Corporate has more than 100% of the annual income saved, they do not have to make a provision into the 10-year maintenance plan on getting more. This is the exception for the complexes. So, most of the complexes, as you say, would be in the middle tier, more than 25% but less than 100%. This excludes complexes that are financially in trouble, which are in the first tier, and there are rich complexes that can afford it, which are in the third tier." **- Participant 8**

4.2.1.3.3 Limited Financial Incentives for Body Corporates

The participants highlighted the consideration of tax rebates as a potential financial incentive for individuals adopting solar PV technology. However, complexity arises in communal living arrangements such as sectional titles and townhouse community schemes, where the question of who should be incentivised—individual unit owners or the Body Corporate—remains unanswered. The participant emphasised the need for policymakers to address this issue and develop strategies to incentivise sectional titles and townhouse community schemes.

"I think in the last fiscal year, the Minister of Finance mentioned that there would be tax breaks or incentives when installing solar, but I am not sure about the amount. But I still feel that the mandate was mentioned." - **Participant 9**

"No, they were also considering the policy of some tax rebates that you can get. If you do it individually, then you can get that tax rebate, I'm sure. Well, I think it's on an individual basis out there. So, I think that maybe we'll be able to, but I think they need to do more. There are various things that governments need to be able to do." - **Participant 2**

"I think another option is what the government is already doing, providing incentives where people could be incentivized. But the challenge with sectional titles is how do you tackle them? I think the government needs to go further. With standalone properties, it's easier. It's your solar, and you can then make claims and such. But if it's a sectional title and you install solar, who gets to be incentivized? The complex, the Body Corporate ? Policymakers need to look into this. They need to figure out how to incentivize sectional titles or complexes. I've not seen any studies. I don't know if there's something coming." **- Participant 3**

The participants mentioned the 12B allowance as a tax incentive that, while beneficial for companies, does not apply to community schemes that do not pay taxes. This underscores the need for tailored financial incentives and regulatory frameworks to support alternative energy adoption in sectional titles and townhouse community schemes.

"I think a great incentive that has already been implemented is the 12B allowance. This is a 125% wear and tear allowance that can be applied to companies' taxable income. However, the problem

with this for community schemes is that they don't pay tax, so there's no tax incentive for them to apply. Therefore, there's no benefit to a community scheme. It works well for companies, but not so much for community schemes, as it isn't really applicable in their environment." - **Participant 7**

4.2.1.3.4 Lack of Funding and Financing Options

The findings from the participant's response under the sub-theme of Lack of Funding and Financing Options for Body Corporates for Adopting Alternative Energy in the study on the Adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes shed light on several critical issues hindering the widespread adoption of alternative energy solutions in communal living spaces.

One of the primary concerns highlighted by the participant is the exorbitant interest rates prevalent in the current financial landscape. The participant pointed out that the escalating interest rates, coupled with the rising costs of bonds, have created a significant financial burden for residents in communal living arrangements. This financial strain has made it challenging for homeowners to secure funding to adopt alternative energy technologies such as solar PV systems. The participants also noted the reluctance of banks to finance rooftop solar installations for residential properties, citing low-risk appetite and credit scoring as limiting factors.

"If you look at the interest rates, they are very expensive. People are paying for bonds, which have increased. I mean, I think some of the bonds have gone up by close to two to three thousand rands." - **Participant 2**

"With the freestanding homes or smaller Body Corporates that go via our project loans, this is via a different business, as I said. So there, it's prime +2%, I think prime +3%, and you only get interest on the drawdown amounts." **- Participant 4**

"Sometimes they need funding from the bank. Sometimes banks reject them based on their credit record and scoring." **- Participant 9**

The participants emphasised that the lack of financing options for sectional titles and the reluctance of financial institutions to provide capital funding for community schemes were highlighted as significant barriers to the widespread adoption of solar PV technology. Participants suggested the need for transparent risk assessment and financing models catering to community schemes' unique financial challenges.

"From the financial institutions, I think it's crucial that they reanalyse the risk. If they categorise it as medium or high risk, there needs to be transparency in terms of what they can offer. Maybe they will just have a higher interest rate than the normal individual, but those things are not clear. Financial institutions just don't want to provide capital funding for these complexes. So, they need to

reevaluate the risk and then check what they can offer. It needs to be transparent, saying, 'OK, the risk is higher, this is the interest rate,' and leave it to the complex to make a decision." - **Participant 3**

"So, most commercial banks have opted for a five-year type of business model in anticipation of de-risking as much as possible. So, for the scale that you want to deploy at, it might not be feasible if you want to go for 10 MW and long-term PPA." **– Participant 14**

Larger community schemes with a higher number of units were deemed more financially viable compared to smaller complexes. Lack of economies of scale can make a project less viable.

"*Another factor that limits us is just the economies of scale. So, smaller community schemes. You can have a community scheme of, say, 5 units."* - **Participant 7**

The participants also highlighted service providers' challenges in securing upfront payments for equipment and installation costs. While service providers must procure materials, this payment structure can deter complexes from pursuing solar PV installations.

"It all depends on the agreed payment terms. Typically, installers want to get paid the bulk of the payment for the equipment and all related costs. In most cases, there's a deposit, which may range from 70 to 90%, and the rest is paid upon completion. Once the certificate of compliance is issued, the remaining payment is made." - **Participant 1**

4.2.1.4 Theme 4: Land, Building and Roof Resources Barriers

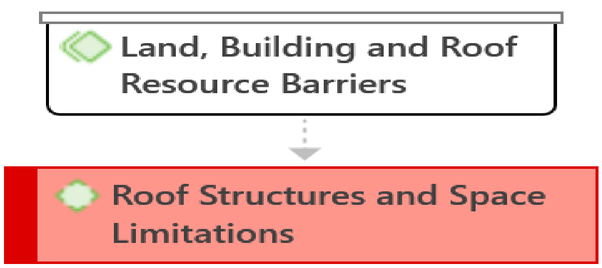


Figure 22: Land, Building and Roof Resources Barriers Ad hoc Network

Figure 22 highlights the central theme of land, building, and roof resource barriers, as discussed below. The theme of Land, Building, and Roof Resources Barriers emerged as a significant factor hindering the adoption of solar PV technology in sectional-title and townhouse community schemes in South Africa. The study delved into participants' perspectives regarding the challenges associated with land, building, and roof resources in implementing solar PV systems within such residential complexes.

The need for adequate space for solar installations was highlighted as a crucial factor. Participants emphasised that most complexes only have access to rooftops for potential solar panel placement. However, it was noted that simply having a roof was insufficient; it needed to be structurally suitable and oriented correctly, preferably facing the north side to maximise solar irradiance harvesting.

"*Most complexes only have the roof available, and it's not just about having a roof. The roof needs to be structurally suitable and oriented correctly, such as facing the north side, to harvest most of the solar irradiance."* - **Participant 3**

"One of the limiting factors is space requirements. We've spoken about these 60,000 community schemes. There's going to be a percentage of community schemes where it's just not technically feasible to actually deploy solar. Either there's no space, or the roof requirements are such that they're all south-facing roofs, or they've got vegetation, such as trees, that is causing a lot of shading. So, from a technical perspective, a requirement is that there's space and there's no shading. That also plays a factor." **- Participant 7**

The structural integrity of the building, particularly the strength of the roof to support the weight of solar panels, was also a key consideration in decision-making processes.

"The roof itself needs to be strong enough to carry the weight of the solar panels. These considerations are measured when making a decision." - **Participant 3**

The retrofitting of solar systems in existing complexes was acknowledged as challenging due to the ownership transition from developers to Body Corporates.

"Retrofitting is the same thing, but retrofitting will be a bit of a challenge because now the complex is no longer in the hands of the developers, it's in the hands of the Body Corporate." - **Participant 1**

Participants expressed concerns about limited space within complexes, primarily due to units occupying the available areas, often maximising rental space.

The lack of space for installing solar panels or related equipment was a significant barrier, with participants noting that larger systems required more space, posing challenges in complex setups.

"The reality is that if you're living in a townhouse or an apartment, you can't install PV because the roof isn't solely yours." - **Participant 5**

"So, complexes are tricky, especially for the residents. Let's say it's a 5-storey block or whatever. For each resident to put up solar panels, for example, will not work for starters. Unless they have an open space where they can mount a solar system that will service the whole complex, which is also not easy." - **Participant 1**

“The bigger the system, the more space you need. So, in a complex setup, it’s not possible. There are always space limitations for you to install your panels or sometimes even the equipment. It’s a problem unless you have utilized one of your bedrooms for that, which is also problematic. So, it’s not possible, and I think many complexes, reasonably so, will not allow it. I wouldn’t allow putting backup equipment in a bedroom or a spare bedroom.” **- Participant 1**

4.2.1.5 Theme 5: Technical and Technological Barriers

Figure 23 highlights the central theme Technical and Technological Barriers with three sub-themes: i) Sectional-title and Townhouse Community Schemes Distribution Network Challenges in Grid Integration; ii) Utility Metering and Billing System Challenges; and iii) Technology Reliability, Performance and Compliance Challenges; discussed in the following sub-sections.

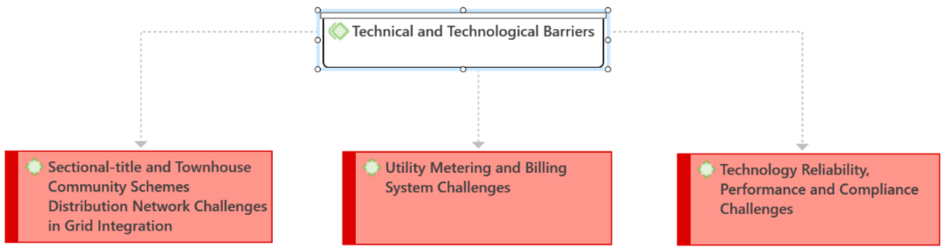


Figure 23: Technical and Technological Barriers Ad hoc Network

4.2.1.5.1 Sectional-title and Townhouse Community Schemes Distribution Network Challenges in Grid Integration

The participants' responses highlighted several critical challenges within the sub-theme of Sectional-title and Townhouse Community Schemes Distribution Network Challenges in Grid Integration.

Firstly, the participants emphasised the limitations of installing solar systems and highlighted feeding back into the grid issues in the system due to safety concerns.

“They are designed for unidirectional power flow. Now, there's also power flow coming from their side. This might have certain implications on our networks, might mess up our (municipality) voltages, and might have safety implications for our staff. The power, for instance, you can have a municipality, a line that is out. You have a line that is out, and then there you can have a line or a feeder cable connecting a certain customer that is off, maybe due to maintenance. But because now you have solar PV customers, that can on the other side during peak generation in the day starts to feed back into your feeder.” - **Participant 12**

The discussion on metering infrastructure revealed a significant regulatory obstacle, particularly in older community schemes where utility metering points are located within individual units. This restriction poses a challenge in providing adequate renewable energy solutions within sectional-title and townhouse community schemes, especially where a centralised solar and backup system is needed.

"Another factor that would impact the ability to implement renewable solutions is the metering infrastructure. Typically, what we find in older community schemes is that the municipalities' bylaws had their points of supply or their points of metering right at the units. So, if you remember, you may know some of the olden-day flats. The Council meter was actually sitting inside the units. Obviously, as time has gone by, municipalities have changed that methodology to provide just a bulk meter at the boundary with their metering points, and then all the metering is done internally. So, many community schemes. Well, one of the questions we ask before providing a technical solution is how they are metered directly because, obviously, then, we are not able to implement it, and that is a fact that limits us from implementing a solution. It's the points of metering and where that sits from the municipalities' perspective." - **Participant 7**

Moreover, the participant highlighted the need for centralised backup systems to supply multiple units and pointed out practical difficulties in separating essential and non-essential loads within a complex with many units. The necessity to partition the main feed into the complex for efficient power distribution raises cost implications that may not be feasible for complex owners and residents to afford, further hindering the implementation of renewable energy solutions.

"Looking at the main feed going into the complex, which is being used for everything from stoves to geysers, you cannot partition it. So, this in itself will demand that we have a very large system. It becomes very expensive and, let's be honest, the complex owners and residents are not well-managed to afford it. So again, it's something that's not easy." - **Participant 1**

4.2.1.5.2 Utility Metering and Billing System Challenges

The participants' responses under the sub-theme of Utility Metering and Billing System Challenges in Grid Integration shed light on the complexities and nuances surrounding the integration of solar power into existing utility grids.

The participant highlights the necessity for utility meters to accurately differentiate between power generated by the customer and power supplied by the grid to the customer. This differentiation is crucial in ensuring fair billing practices and appropriate reimbursement for the surplus power generated by customers and fed back into the grid. The participant emphasizes the need for robust metering systems that can effectively track and account for these dynamics, ultimately leading to a more equitable system for solar power integration.

"When a customer installs a solar PV system, they can generate power. If the customer is not at home during the day, the solar panel continues to generate power. This power needs to go

somewhere, and it ends up going through our grid. Therefore, our meters need to be programmed to read and differentiate between the power that the customer generates (export power) and the power that the grid supplies to the customer (import power). Once we resolve the part where the meter can differentiate between import and export power, we need to take the study to the billing department for their review and implementation." - **Participant 10**

Furthermore, the participants highlighted billing systems and the challenges different municipalities face in adapting to the complexities of solar power integration. It highlights the need for proactive measures to streamline the process and ensure that customers are fairly compensated for their contributions to the grid.

"*Some municipalities have moved to advanced stages in terms of billing. Initially, when there were a few of these customers, this was handled in a spreadsheet format in a very simplistic manner. But now, different billing systems have the functionality to handle such bills. For cities like Johannesburg, they are on the SAP system or the billing system because there are various billing systems. Some are more complex than others to amend, so they have the functionality to do this particular type of credit. Some municipalities are moving slower because of the complexity of their billing systems.*" - **Participant 12**

4.2.1.5.3 Technology Reliability, Performance and Compliance Challenges

The participant's responses shed light on various aspects related to technology reliability, performance, and compliance challenges.

The participant touched on the complexities of the application process for solar PV installations, emphasising compliance with grid-code and regulatory standards, technical requirements and regulatory procedures set by utilities. The participant discussed the higher costs associated with inverters that comply with grid-code, as opposed to cheaper alternatives that may not meet regulatory requirements. Inverter functionality, such as anti-islanding testing, was highlighted as a crucial aspect of compliance, ensuring safe and synchronised grid connections.

"there's NRS097-2-1 standard since most municipalities are primarily guided by Eskom, they conducted a study and concluded that an inverter, which needs to connect to the grid, must wait 60 seconds for synchronization purposes before it can reconnect after a loss of grid power. This is commonly referred to as the anti-islanding test. Some cheaper inverters are not programmed to perform this function. Because of these requirements, every inverter needs to have a certificate. It is just a matter of programming the inverter, which some people are unable to do." - **Participant 10**

"Let's start by saying that the cost of the system is largely due to the type of inverter that has been approved by the utilities. We are guided by the National Distribution and Renewable Energy Grid-

code . Therefore, even the inverters need to comply with the grid-code , and those inverters tend to be more expensive. There are alternative inverters that are cheaper, but they do not comply with the grid-code ." - **Participant 10**

Power supply reliability and quality were identified as critical responsibilities for system operators, especially when selling excess power to industrial consumers who require consistent power quality to avoid penalties.

"So, the maintenance of that infrastructure, the functioning of that infrastructure, and the quality of power that the user needs to get at the end are all their responsibilities. Also, remember, if you're selling some of this power to big industrial people, power quality is a big thing. They actually get penalized for that." - **Participant 5**

"If you are using inverter-based technology and we are connected on the same network, and I have some sensitive equipment on my side like a paper mill or cotton mill, your connection with your inverter-based technology can affect my operations and damage my equipment. So, those things also pose a problem, which means additional equipment like harmonic filters needs to be put in place. It can be high cost so that you don't disturb other customers." - **Participant 11**

4.2.1.6 Theme 6: Company Resources and Operational Barriers

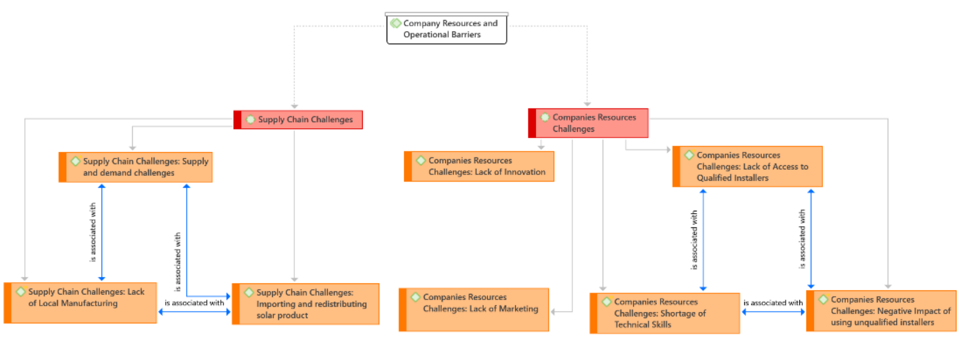


Figure 24: Company Resources and Operational Barriers Ad hoc Network

Figure 24 highlights the central theme, Company Resources and Operational Barriers, with two sub-themes, i) Company Resources Challenges and ii) Supply Chain Challenges, discussed in the following sub-sections.

4.2.1.6.1 Company Resources Challenges

The "Companies Resources Challenges" sub-theme highlights the difficulties solar companies encounter regarding resources and managing regulatory issues.

The participants highlighted several key challenges faced by companies in the sector. The participant highlighted the shortage of skilled resources, particularly in electrical engineering, as a significant impediment to implementing solar solutions. The scarcity of qualified personnel and the high costs associated with skilled engineers pose challenges to companies seeking to deploy solar PV technology effectively.

"It's common knowledge that there's a skills shortage. One of the struggles that we find, for example, is the shortage of electrical engineers. Going to the Technikons and universities to try and access these resources is always a challenge. Any good engineer is either going overseas or costs too much money as a resource to be effectively used within the organization. It really is a struggle to get skilled resources to implement these solutions." - **Participant 7**

"And I mean, the other one that I think I mentioned in passing is access to qualified installers. You will always have a lot of people who say they can do this installation for you (the customer), just to make a quick buck. Those are also some of the challenges that affect the adoption of solar PV technologies." **- Participant 11**

"Once you've ascertained the size, the electrical connection of that solar PV system, or the electrical connectivity, needs to be done by a registered electrician with what we call a wireman's license. Then they do that. So, already, there is a cost associated with a registered electrician with the wireman's license doing that for you. Also, there are already limitations to the size that you can install for your purposes so that grid-code requirements are not violated." **- Participant 12**

"Also, someone has to take ownership of the system configuration. For a system of the size we are talking about, some municipalities would require a registered engineer to sign off on the whole system and confirm that it complies with the necessary requirements. To get engineering or PrEng or PrTech sign off before the municipality allows you to generate can also have a cost implication." **- Participant 12**

Another critical issue raised is using unqualified installers, known as "bakkie brigades," for solar installations, leading to safety risks such as fire hazards. The lack of accountability in such instances further complicates the situation, emphasising the need for qualified and reputable installers in the industry.

"We get people who use bakkie brigades, which is not ideal because there's also the risk of fires breaking out. It's really a problem because who do you hold accountable, especially because your communal property is the responsibility of the Body Corporate ." - **Participation 4**

Moreover, the participant emphasised the lack of innovation and the need for companies to conduct more research, tailor their approach to the target audience, and increase visibility to enhance market acceptance of solar PV technology.

"Look, they must conduct more research. They must engage with people. They must make themselves visible to the people they are marketing to and gain an understanding of their audience. How can they do this? They can tailor their approach to whatever the people want. That's what they must do. They need to gather information from the people." - **Participant 9**

4.2.1.6.2 Supply Chain Challenges

The sub-theme of Supply Chain Challenges revealed crucial insights into the country's current state of solar technology adoption.

The participant highlighted that essential components of solar systems, such as batteries, inverters, and solar panels, are predominantly imported from Europe or China due to the lack of local manufacturing plants capable of producing these items at scale. While the participant acknowledged the existence of a few companies engaged in local manufacturing, the scale of production remains limited, particularly for larger solar panels.

"But in terms of the products, most of them, the major ones like your batteries, your inverters, your solar panels, none of these things are manufactured locally. They either come from Europe or China, most of them. We do not have, say, for example, panels. We do not have a manufacturing plant, a big enough manufacturing plant. I am aware of two other companies that do manufacturing, but they are still on a very small scale. Another company I know does manufacturing, but only for those smaller solar panels, not the big ones, because mostly we import." - **Participant 3**

The participant emphasized the challenges posed by the reliance on imported solar products, citing shortages during times of high demand and periods of higher stages of load shedding in South Africa and being affected by macro-environmental factors of other countries. The participant noted that such shortages often lead to price escalations, highlighting the supply chain's vulnerability and the potential impact on end-users.

"The biggest factor is the price of the solar system, as it is very expensive. I can provide a few examples, even though I'm not sure if they're relevant to the question. One factor is the availability of inverters. There was a time, I'm not sure, when, possibly during the Russia-Ukraine war, when there was a shortage of inverters in the country due to a worldwide shortage of electronics. This had a significant impact on customers. The inverters were not available throughout the country, and prices increased. However, after some time, the stock availability increased, and inverters became available again, causing the prices to decrease." - **Participant 10**

Furthermore, the participants raised concerns about price fluctuations driven by suppliers of inverters, who justify higher prices based on the need for compliance with grid-code and investment in research and development. The participant cautioned against stakeholders capitalising on supply chain challenges to inflate prices, emphasising the importance of solutions that benefit residents and communities over profit-making motives.

"The suppliers of the inverters are the ones driving the prices. They argue that in order to comply with the grid-code, they need to invest significantly in research and development to ensure compliance. The inverters that are certified end up being more expensive, while the others, which do not comply, are cheaper." - **Participant 10**

The participants also highlighted the need for stringent testing and reliability measures for solar panels to minimize risks associated with these assets and promote industry growth.

"We need to put technical measures in place and make it an instruction that all solar panels need to be reliability tested to ensure that the risk associated with fire is minimal." - **Participant 14**

4.2.2 Factors that facilitate the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

The following findings were the most common responses to factors facilitating the adoption of Solar PV Technology in Sectional-Title and Townhouse Community Schemes in South Africa. The interview guide questions for defining factors that are obstacles to adopting Solar PV technology were Questions h) and j). The findings on factors facilitating adoption are summarised in section 4.2.3, Table 8.

4.2.2.1 Theme 7: Frequency and Higher Stages of Load-Shedding

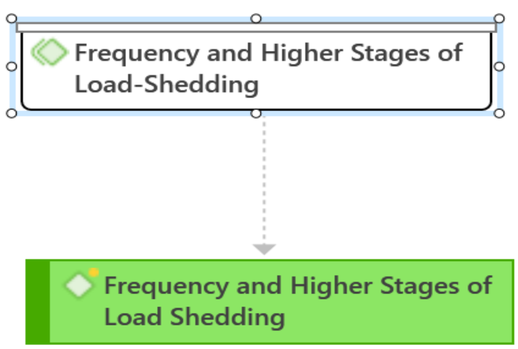


Figure 25: Frequency and Higher Stages of Load-Shedding Ad hoc Network

Figure 25 highlights the central theme of frequency and higher stages of load-shedding as a facilitating factor in the adoption of Solar PV Technology, as discussed below. The participant emphasized the significant role of the government's strategy in shaping the community's response to load shedding, particularly in South Africa, where load shedding has become a norm. The familiarity and acceptance of load shedding among residents have led to a certain level of adaptation, with residents adjusting their daily routines to accommodate the scheduled power outages.

"It's dependent on the government's strategy going forward. Remember, I think we're in South Africa. We're used to it now. We're used to load-shedding. We have embraced it. That's why we even understand the times when the power is going to go out. We have adjusted to it" - **Participant 2**

The participant highlighted that the decision to invest in backup solutions, particularly solar PV technology, is influenced by the severity and frequency of load shedding. Notably, when load shedding escalates to higher stages, there is an increased demand for backup solutions among community schemes and individuals, especially those working from home who require an uninterrupted power supply. This observation underscores the correlation between the intensity of load shedding and the willingness of residents to explore alternative energy sources.

"When they choose to go for the backup solutions, what we're seeing, and from our experience, is that when load shedding gets to stage 6, for example, there's a greater requirement for it. It might sound obvious, but it's quite apparent that as load shedding comes and goes, some clients are reevaluating their decision whether they need the backup or not, and whether to just go for solar. This is because the load shedding at this stage is obviously at stage one and two, for example. Whereas last year, we saw an influx of inquiries for stage 6, which obviously affected the decision for some of the schemes, as well as those who worked from home." - **Participant 7**

Furthermore, the participant drew attention to the role of frequency in load shedding in incentivising community schemes to consider renewable energy solutions. Areas that experience minimal or no load shedding may lack the motivation to invest in backup solutions, as the continuous power supply diminishes the urgency for alternative energy sources. This dynamic illustrates the direct impact of load shedding on the decision-making process of community schemes regarding the adoption of solar PV technology.

"*Another factor would be the frequency of the load shedding. In many instances, if load shedding is not a problem, as you know, some areas don't get load shed for whatever reason. Those community schemes have no incentive to actually put a renewable solution in place or a battery solution because they've got power all the time. So, if load shedding continues to be a problem, that's going to be a factor as to whether or not community schemes actually implement the solutions."* - **Participant 7**

4.2.2.2 Theme 8: The Interplay of Industrial, Stakeholder and Societal Influences

Figure 26 highlights the central theme, the Interplay of Industrial, Stakeholder and Societal Influences as a facilitator for the adoption of Solar PV technology with three sub-themes, i) Social Influence, ii) Stakeholder Influence and iii) Industry Influence, discussed in the following sub-sections.

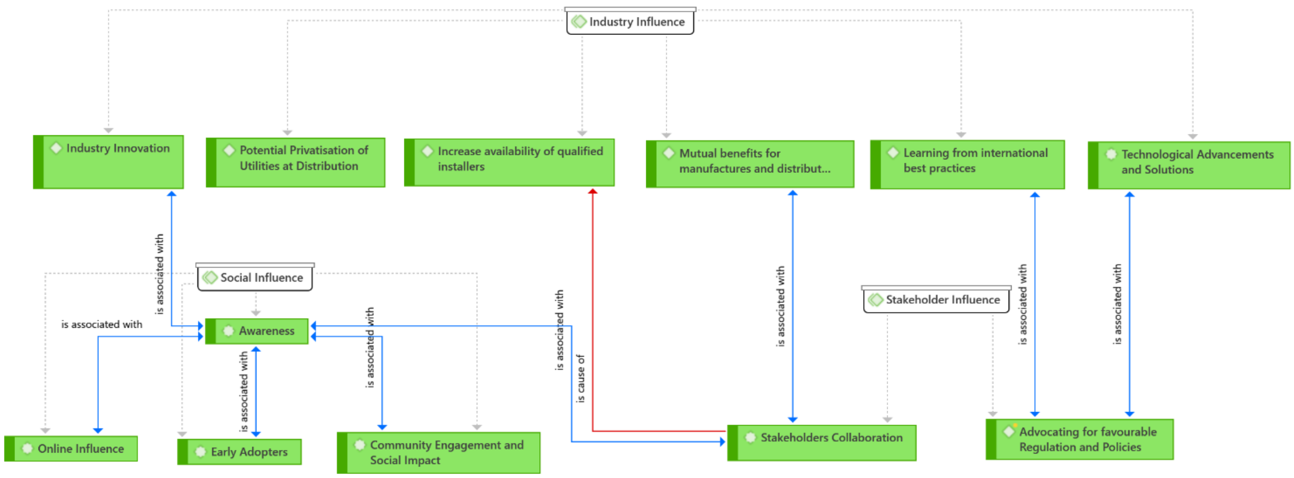


Figure 26: Interplay of Industry, Stakeholders and Social Influences Ad hoc Network

4.2.2.2.1 Social Influence

The participants highlighted that individuals with the necessary knowledge and connections often took the initiative to install solar panels themselves.

"Individuals who had the know-how and connections ended up deciding to do it themselves." - **Participant 2**

Education emerged as a crucial factor influencing the decision-making process, with the participant emphasising the importance of demystifying myths surrounding solar energy. The need for education to address complexities, instil knowledge and clarify pricing structures was highlighted as essential for facilitating adoption. The participant suggested that influencing and persuading individuals through case studies, project videos, and snippets could enhance understanding and foster openness to adopting solar technology.

"Education is a significant factor. I believe many people don't understand the benefits of solar energy." - **Participant 4**

"The complexities involved in installing it and what to consider can be intimidating a lot of the time. So, I'm saying it really comes down to education, knowledge, and pricing." - **Participant 4**

"So, showing people through case studies, project videos, and other types of snippets really assists in people's understanding. Once they understand something, they tend to be more open to adopting it" - **Participant 4**

"I think there's still a bit of education that needs to happen within the South African context around alternative power supplies. What worked for me, as embarrassing as it sounds as an engineer, was seeing a post on social media where someone asked for recommendations for batteries they could buy. In that post, there were a lot of testimonials from people saying, 'Oh, I've bought this brand, it actually works. Please don't buy this brand. I had to return this brand.' That helped quite a bit." - **Participant 5**

"I would say fostering community buy-in is essential, whether it's through organising campaigns or awareness programs, but essentially educating the residents and communities in sectional title and townhouse schemes. You can educate them about the benefits of solar PV, go through frequently asked questions to address any common concerns, and showcase success stories or case studies from other communities or business owners." - **Participant 11**

Given their roles as trusted advisors, managing agents were identified as key individuals who could influence decisions. Efforts to foster relationships with managing agents and provide education to empower decision-makers within community schemes were emphasised as essential strategies for promoting solar technology adoption.

"It's literally that significant because a lot of the Body Corporates and trustees, for instance, trust their managing agent." - **Participant 4**

"You can create order by allowing the solar energy companies to go through the Trustees of the Body Corporate. This is a structure that exists between residents and Trustees. It is easier to have a meeting when you start with the trustees and then go to the owners." - **Participant 9**

4.2.2.2.2 Stakeholders Influence

The participants highlighted the need for stakeholder engagement, the significance of cohesive industry collaboration, and awareness-building initiatives to encourage adoption, build credibility, and facilitate partnerships within the sector. Collaboration and engagement with stakeholders through national roadshows were identified as crucial steps in influencing perceptions and promoting the benefits of solar technology adoption.

"So, you understand the different stakeholders that are in place. Yes, you need the funders and technical support. That technical support would normally come from groups such as your lobbying groups like SAPVIA. SAPVIA plays a critical role in terms of creating awareness and providing the

necessary skill set and training, along with the likes of the CSIR. They play a significant role in advising, guiding, and showcasing the positive impact that these types of solutions may have in terms of mitigating load shedding, achieving our environmental goals, and potentially reducing costs." - **Participant 14**

"People tend to forget that yes, you can complain about capacitation with these companies, energy service companies, but SANEDI, ETC, SETA, etc., all of those people, they have training courses for companies" - **Participation 5**

4.2.2.2.3 Industry Influence

The participants' responses highlighted various key insights under the sub-theme of industry influence on the adoption of solar PV technology in sectional-title and townhouse community schemes. The participant emphasised the importance of manufacturers catering to this niche market through innovative solutions, such as more efficient solar panels that produce higher power outputs within limited space constraints.

> *"Manufacturers need to consider how they can service this particular market through innovations. For example, we just talked about solar panels that can produce more power with less size to deal with these situations. So, those are some of the things that can be considered."* - **Participant 1**

A critical factor identified was the impact of metering infrastructure on implementing renewable energy solutions, particularly in older community schemes where metering systems were initially located within individual units. The shift towards bulk metering points at the community scheme boundaries was highlighted as a facilitator for implementing solar PV solutions, with the participant emphasising the need to assess metering arrangements before proposing technical solutions.

The role of Body Corporates in settling electricity accounts and managing metering services within community schemes was underscored, showcasing the evolution towards smart metering solutions and the potential for simplifying billing processes.

> *"It would make it a lot easier for the municipalities to provide a bulk supplier with a bulk metering point at the boundary of the community scheme. Then, the Body Corporate just settles that account and is responsible for the collection of those electricity costs from each of the unit owners. Typically, how they would do that varies. I know some Body Corporates do it themselves. They, for example, take the caretaker, and if it's a rotary meter or something, they go and read the opening and closing balances on all the meters every month. In some schemes, they've got a metering service provider that provides a solution where they provide a metering report at the end of the month of consumption and the charges. Then, in other cases, we've got a full smart metering solution in the scheme where there's a wallet provided to the unit owner. So, that's the difference between the*

municipality or Eskom billing the unit owners directly versus having just that one bulk metering supply." - **Participant 7**

Accredited installers and awareness campaigns are crucial to driving solar PV adoption. Policy reforms can also foster competition among installers and reduce installation costs.

"You (the electrician) have to be accredited or have also gone through training and passed the green card solar installations courses to be credited as a qualified installer that can issue a certificate of compliance for the installation" - **Participant 11**

"We can also reverse the issue of qualified installers. If there's a wide access to qualified installers, their price can come down, because there's competition." - **Participant 11**

Moreover, the participant emphasised the value of partnerships in the solar PV industry, pointing out how collaborative relationships between manufacturers, distributors, and installers can lead to more competitive pricing and enhanced service offerings.

4.2.2.3 Theme 9: Improving Solar PV Investment Returns through the Use of Incentives, Policy and Legislative Instruments

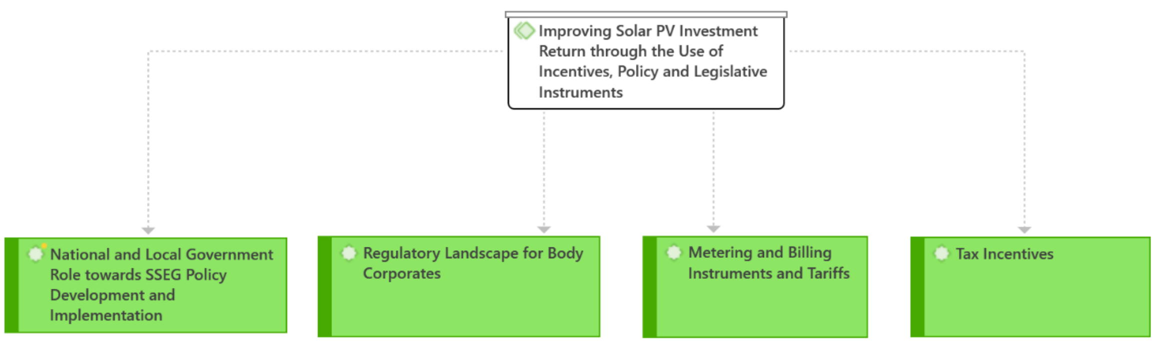


Figure 27: Policy and Legislative Instruments Ad hoc Network

Figure 27 highlights the central theme of Improving Solar PV Investment through the Use of Incentives, Policy and Legislative Instruments with four sub-themes: i) National and Local Government Role towards SSEG Policy Development and Implementation; ii) Regulatory Landscape for Body Corporates, iii) Tax Incentives, and iv) Metering and Billing Instruments, discussed in the following sub-sections.

4.2.2.3.1 National and Local Government Role towards SSEG

The participants' responses regarding the national and local government's role in SSEG adopting solar PV technology in sectional-title and townhouse community schemes provide valuable insights into the various mechanisms and interventions at play in promoting the uptake of renewable energy technologies.

At a local and national government level, the participant discussed the role of government bodies like the SALGA and the NERSA in tracking progress and intervening when necessary. Furthermore, the participant emphasised the importance of creating an enabling environment through policy formulation, technical grid-code development, and financial incentives to encourage the adoption of solar PV technology. The participant also highlighted the role of the National Executive Committee in promoting solar uptake and the need for clear regulations and incentives to facilitate customer adoption.

"a National Executive Committee was developed, presumably to stop load shedding. Within that, there are work streams, and one of them looks specifically at small-scale embedded generation where this particular customer falls under" - **Participant 12**

"That committee has a mandate to promote the uptake of solar PV technology. So how do they do that? They assist in creating an environment within distributors, an environment that enables customers to uptake this type of technology. By 'environment,' I mean the right policies are in place, the type of legislation that is in place is not too stringent, but also still covers the bases, so you could say there's a bit of loosening of regulation." **- Participant 12**

"At a national level, they would track the progress and intervene if progress is not moving at the right pace. Then, there are organizations like SALGA and the regulator, NERSA, playing an important part. On our side, it's a matter of creating that environment from a practical perspective. We write the policies, assist in the formulation of the policies, assist in the formulation of the understanding of these types of technology from a policy perspective to the technical grid-code perspective, and also the financial implications." **- Participant 12**

Moreover, the participant underscored the significance of capacity-building efforts to ensure that municipalities thoroughly understand renewable energy technologies, thereby increasing acceptance and uptake.

"So, we capacitate municipalities so that institutionally, this technology is understood. Once you understand something, you are more likely to accept it because you know how to deal with it."- **Participant 12**

The participant also shed light on the financial flows from international sources, such as bilateral agreements with countries like Germany and financial support from entities like the USA and the UK. These financial resources are channelled through not-for-profit organisations (NPOs) to fund capacity-building initiatives to train municipalities on renewable energy technologies.

"South Africa, which has a bilateral agreement with Germany, for instance. South Africa just got a loan from the USA for some billions, for instance, or maybe something in kind, like a grant. Then,

there are some other relationships with the UK government. Loosely speaking, we say Western donors, so we can call them donors. This donor money comes through not-for-profit (NPO) organizations. It funds NPOs to be able to open up the market. You open up the market through capacity building, training municipalities about these types of technologies." - **Participant 12**

The participant's examination of the policy landscape surrounding small-scale embedded generation highlighted the progressive removal of constraints and the inclusive approach adopted in recent years. The participant's reference to the policy evolution towards embedded generation and behind-the-meter installations reflects a positive trajectory towards enhancing renewable energy uptake within diverse market segments.

"The electricity market in the country, but we understand where we are and how far we've come. At a high level, we know that over the last few years, a number of policies have been adopted to accept the deployment of embedded generation. Initially, we started with a threshold of 100 MW, which was not for sectional titles but for private consumers like the mines. Recently, that has been completely removed. This indicates that policy-wise, there's been a clear direction and incentive to proceed with embedded generation and behind-the-meter installations." - **Participant 14**

"The policy related to small-scale embedded generation has opened up to the entire market in the last couple of years" **- Participant 14**

"There are no advanced studies required, you (the applicant) just follow a specification that is available. That makes the process very easy because the specification is clear. You just follow that, then you connect to the distribution grid. For some customers, maybe larger ones, it may be a bit more complex because you need a study, you need to prove certain things to the municipality, but the idea is that those customers would have that kind of money to do that and also their impact on the grid is much bigger than these smaller ones. So, the types of regulations in place assist in the uptake of Solar PV within this particular customer category." **- Participant 12**

4.2.2.3.2 Easing of Regulatory Landscape for Body Corporate s

The participants' responses shed light on the regulatory landscape for Body Corporates in the context of adopting solar PV technology within sectional-title and townhouse community schemes. The participant discusses the evolution of rules within their community schemes, highlighting the process of allowing individuals to install solar panels on their roofs. The need for a shift in regulations was prompted by the increasing interest in solar energy among residents, leading to a proactive approach that involved legal consultations, resolutions, and rule amendments.

"Over the years, during our negotiations and other discussions, we found a few people who started applying to have solar as an alternative energy source. We then conducted our investigation and

hired some lawyers to understand the amendments that needed to be made to the rules. We realised that no matter how much you deny it, it will happen eventually due to the current circumstances. So, we ended up changing the rules to allow people to install their solar panels." - **Participant 2**

"Get your resolutions and specifications in place." - **Participant 8**

The participant emphasises the practical benefits of solar energy adoption, such as reducing reliance on the grid during load-shedding periods. In addition to solar panels, the participant mentioned using gas stoves and geysers, solar geysers, rechargeable lights, and generators as alternative energy solutions within community schemes. However, the participant acknowledges the challenges associated with noise levels and sustainability when using generators in close-quarter living arrangements.

"Yes, for instance, in my house, I've moved away from using an electric stove and now use gas stove. So now, we're not affected that much when there's load shedding; we can still cook. And then, I've got those rechargeable lights and such." - **Participant 2**

"In some places, depending on the rules of the complex, they are allowed to use generators. So, you find some have smaller generators just for use during that period." - **Participant 3**

"What is also helping now is that a lot of places where we stay have gas stoves. So, it is much easier to continue with a bit of normalcy, even when there are power interruptions because cooking can still happen. The normal TV and internet are still there. The laptops and phones are charged." **- Participant 5**

"Yes, gas installations are used for cooking with gas stoves and ovens. You also get gas geysers, which I think are a better option than a solar geyser. I know of a few individuals who have installed gas systems along with a full solar system. They are 90% off the grid." - **Participant 8**

Furthermore, the participant calls for revisions to existing legislation to overcome the barriers to a resolution that require a special general meeting, suggesting that the Sectional Title Act needs to be updated to accommodate the growing demand for solar PV technology. The participant advocates for streamlining decision-making processes within Body Corporates to facilitate quicker resolutions on solar installations. They propose granting more voting power to the Body Corporates to represent the collective interests of residents effectively.

"Maybe starting from the Sectional Title Act, there needs to be a revision to relax and remove some of the red tape. Perhaps there could be a proxy if you want every owner within the complex to vote. Obviously, that is going to be almost impossible, so if the Body Corporate could be given more

voting power to represent the larger masses, decisions would be made much quicker." - **Participant 3**

4.2.2.3.3 Tax Incentives

The participants' responses regarding tax incentives in the context of the adoption of solar PV technology within sectional-title and townhouse community schemes reveal crucial insights into the perceived impact of governmental policies on incentivising renewable energy adoption. The participant highlighted the significance of tax rebates offered to individuals who install solar panels, suggesting that such incentives play a pivotal role in promoting the uptake of solar technology at the individual level. Moreover, the participant emphasised the need for policymakers to consider expanding these rebates to cover not only solar panels but also inverters and storage systems, which are considered critical components of solar PV installations.

"Rooftop solar incentives for individuals: A tax rebate to the value of 25% of the PV panels up to a maximum of R15,000." - **Participant 12**

"It's really about the rebates from the government. If you install solar, you can claim it as part of your tax returns. You can just claim the solar part. But with a sectional title, how do you claim? Maybe the Body Corporate can. But I think policymakers need to look at that and see how they can improve and include that." - **Participant 3**

In addition to individual tax incentives and subsidies, the participants discussed the 12B allowance. This tax benefit allows companies to claim a 125% wear and tear allowance on renewable assets. While acknowledging the benefits of the 12B allowance for companies, the participant noted its limited applicability to community schemes that do not pay taxes, thus highlighting a potential gap in incentivising renewable energy adoption within such communal settings.

"Renewable energy tax credit for businesses: A 125% tax deduction in the first year for qualifying capital expansion with respect to all renewable energy projects with no threshold on generation capacity." - **Participant 12**

"The South Africa Revenue Service (SARS) or the Minister of Finance announced that we've always had the 12B allowance, but last year in March, they increased the 12B allowance from 100% to 125%. This means that any renewable asset you purchase, let's say a company purchases 1,000,000 Rand worth of renewable assets, they are able to write off 125% of that asset against taxable income. This would reduce their tax payable at the end of the financial year and for their submissions to SARS. They could then claim that which is obviously an incentive." - **Participant 7**

"However, the problem with this for community schemes is that they don't pay tax, so there's no tax incentive for them to apply. Therefore, there's no benefit to a community scheme. It works well for companies, but not so much for community schemes" - **Participant 7**

4.2.2.3.4 Metering and Billing Instruments

The findings from the participants' responses within the sub-theme of Commercial Viability of a Project in the study on the Adoption of solar PV Technology in Sectional-title and townhouse community schemes reveal several vital insights.

The participant addressed the impact of high electricity prices and load shedding on community schemes, emphasising the need for affordable and reliable energy solutions.

"The other thing is that electricity costs will keep on going up. Soon, NERSA has already approved the increase for next year. But we will see another request for an increase. So, electricity bills will keep on going up" - **Participant 3**

"I mentioned the current high price of electricity, which is also a motivating factor because these systems assist in the reduction of electricity bills." **- Participant 12**

The participants' responses shed light on the Metering and Billing Instruments sub-theme concerning the adoption of solar PV technology in Sectional-title and townhouse community schemes.

Advanced metering technologies, particularly bidirectional smart meters, were highlighted as essential for accurately tracking energy generation and consumption within community schemes.

"When a customer installs a solar PV system, they can generate power. If the customer is not at home during the day, the solar panel continues to generate power. This power needs to go somewhere, and it ends up going through our grid. Therefore, our meters need to be programmed to read and differentiate between the power that the customer generates (export power) and the power that the grid supplies to the customer (import power)." - **Participant 10**

Municipal billing systems were noted to have evolved to accommodate bidirectional power flow, enabling customers to receive credits for excess energy generation.

"Certainly, municipalities, for example, within the Western Cape, such as Cape Town or George municipality, and I'm sure many others, have this meter with bidirectional power flow. It records kilowatt-hours consumed, and kilowatt-hours generated by a particular customer." - **Participant 12**

The participant delved into the concept of SSEG Feed-in tariffs, which incentivise solar energy generation by compensating customers for surplus power fed back into the grid. Municipalities implement these incentivisation mechanisms to encourage compliance with grid-code requirements.

"Municipalities are encouraged to have SSEG tariffs, so a customer like this would have an SSEG tariff in most municipalities. The tariff essentially states that as a municipality, they will compensate you for the feedback electricity that you send onto their grid." - **Participant 12**

The participant elucidated the intricacies of net billing scenarios, emphasising that excess solar credits may not carry over into subsequent billing cycles due to regulatory constraints.

"The SSEG tariff, sometimes referred to as a net billing tariff, or the municipal policy, strictly states that if you, as a customer, generate more than you consume, for instance, during a month you consume let's say 100 kWh, then you credit 120 kWh. The net billing scenario says that I'm going to take your tariff and multiply it by that 100 kWh, the consumption tariff. I get maybe 100 rands on the bill. And then I take maybe R0.80 per kWh or the credit, I multiply it by the electricity you generated. So, what I can have on my bill is zero rands." - **Participant 12**

"At the scale that you want to do it for these communal or townhouse communities and sectional titles, and obviously depending on the scale, you can actually go with a much lower tariff than that. You can even achieve R0.80 per kWh for a 10MW deployment, which I think is most likely something that you might want for your townhouse communities" - **Participant 14**

The mention of credit accumulation and potential banking of kilowatt-hours for future use provided insights into the operational dynamics between consumers and municipalities in the context of solar energy generation.

"But I've heard of discussions where they call it banking. Then you (the customer) bank your kilowatt hours for the next month. It's not a great business model, but those municipalities bank maybe an extra 10-kilowatt hours to take to the next month. And then they take to the next month and then you may be credited in the next month that 10 kWh plus anything else that you generate excess on, but if we get to the end of the year and you have excess solar credit, then the municipality can't take the excess solar credit to the next year. So those are sometimes the two scenarios that play out. Either you bank and take it to the next month, or everything is forfeited at the end of the month, but most municipalities are at the end of the month. If you have generated more than consumed energy, then those extra solar credits will not be compensated." - **Participant 12**

4.2.2.4 Theme 10: Economies of Scale of Community Schemes Sub-Metering and Recovery

Figure 28 highlights the central theme, economies of scale of community schemes sub-metering and recovery, with two sub-themes: i) economies of scale and ii) Effective management of Body Corporate sub-metering and utility metering accounts, discussed in the following sub-sections.

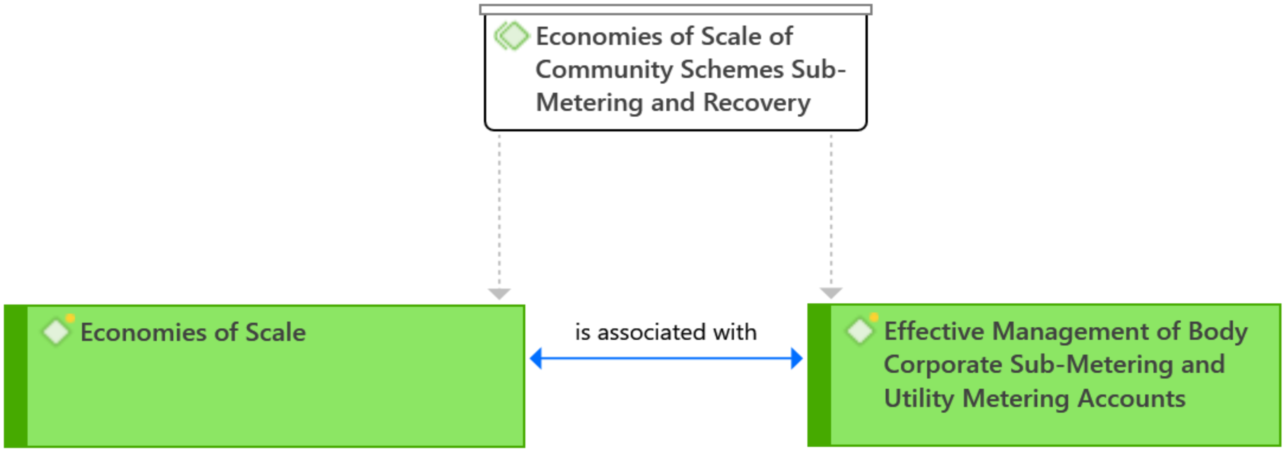


Figure 28: Economies of Scale of Community Schemes Sub-Metering and Recovery ad hoc network

4.2.2.4.1 Economies of Scale

Moreover, the participant underscored the economies of scale in determining the feasibility of solar PV installations in communal living spaces.

> *"Just on economies of scale, 500 units would be more feasible than, say, 5 units as an example. So, the number of units in a community would make a difference."* - **Participant 7**

The participant noted that individuals who had installed solar PV systems experienced cost savings and reached a break-even point, indicating the long-term financial viability of such installations.

> "*The people who have installed them do see the value for money, not just in combating load shedding, but also in their electricity bill. After some time, you (the Body Corporate) reach a break-even point where you (the Body Corporate) see that you are (they are) gaining."* - **Participant 3**

4.2.2.4.2 Effective Management of Body Corporate Sub-Metering and Utility Metering Accounts

The participants highlighted the effective management of the Body Corporate account in collecting revenue from sub-metering within the community scheme and settling the utility bulk metering account.

> *"The municipalities to provide a bulk supplier with a bulk metering point at the boundary of the community scheme. Then, the Body Corporate settles that account and is responsible for the collection of those electricity costs from each of the unit owners. Typically, how they would do that varies. I know some Body Corporates do it themselves. They, for example, take the caretaker and if it's a rotary meter or something, they go and read the opening and closing balances on all the meters every month. In some schemes, they've got a metering service provider that provides a*

solution where they provide a metering report at the end of the month of consumption and the charges." – **Participant 7**

The intricacies of negotiating Power Purchase Agreements (PPAs) with utilities were detailed, underscoring the need for better tariffs to make solar investments more viable.

"For instance, if a community scheme is located in Ekurhuleni versus the City of Johannesburg (CoJ), we are probably going to find it easier to make it commercially feasible in Ekurhuleni because the tariff structures are higher than in CoJ. So, what we do internally is identify the areas that would make more commercial sense to deploy these solutions. We're able to not only avoid charging more than what they're paying but also provide the return to the investor on the money that we've managed to raise." - **Participant 7**

The participants highlighted the concept of renting solar infrastructure with a rent-to-own option, highlighting reduced costs once the system has been paid.

"There is an alternative where you know more or less the cost if it is a rental option. Some are fixed for a period where at the end of that period you own it, so you are renting to own. So, you are paying a little bit more during the period, but after that, you are not really paying because you own the infrastructure" - **Participant 3**

4.2.2.5 Theme 11: Funding Instruments

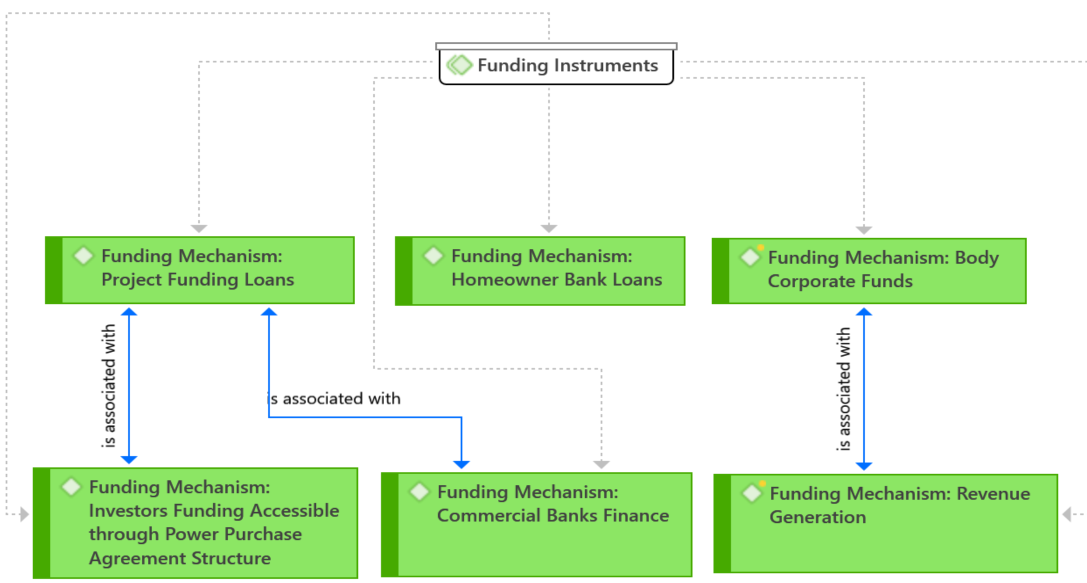


Figure 29: Funding instruments Ad hoc network

Figure 29 highlights the theme for funding instruments ad-hoc network. The theme of funding mechanisms offers valuable insights into the financial considerations crucial for implementing renewable energy solutions in sectional-title and townhouse community schemes. The participants made several key findings, shedding light on the significance of financial resources and structures in facilitating the adoption of solar technology within community schemes.

The participants discussed the concept of offsetting power consumption within residential complexes, suggesting that incentives for solar energy adoption could involve offsetting energy bills through renting out roof space for solar panel installation, a practice seen in countries like Australia.

"What I'll do is that I will just offset some of that power within my residence of the entire complex where they get some of the incentives. For them, the incentives will not necessarily be them getting money but them getting some of that power. I think what they are doing in Australia is that they actually offset your energy bill for renting part of your roof as a sectional title owner." – **Participant 5**

One prominent finding highlighted the essential requirement of sufficient savings, using reserve funds as per the Sectional Title Act, for initiating projects such as solar projects. Participants emphasised the importance of financial stability within sectional-title and townhouse community schemes, noting that proposing investments without the necessary funds could hinder adoption efforts.

"You (the Body Corporate) must have sufficient savings. You cannot afford to go back to people and say, 'Let's try and invest in this thing, but you will pay 1000 rands." - **Participant 2**

"If the complex has the finances, and it would not affect the levies or the owners are in a position to pay the levies, then adopting solar would be beneficial." - **Participant 8**

"So again, if you have savings as a Body Corporate, you can use those to buy the solar system and finance it through the Body Corporate but do it through a special levy." - **Participant 8**

Moreover, the participants underscored the role of financial institutions in supporting solar initiatives through facilitating loans and project funding. Participants acknowledged the pivotal role of banks and other financial entities in providing financial assistance for solar installations, thereby enabling individual homeowners or the Body Corporate of the community schemes to pursue renewable energy projects.

"I think it can be broken down into two parts. The first one is if it's an individual. The easiest option is only when you're going for storage. So obviously, then you can do it as an individual with the bank. That's quick and easy. The other option is a bit complex because it needs to involve the Body Corporate and the owners. You need to reach a quorum because it's like a vote. The majority who vote for the alternative power supply, and then the financial institution can have a deal with the Body Corporate to give them a loan for the Body Corporate, not for the individual." - **Participant 3**

"In our Home Loans Department, clients who want to install solar have several options. If there's equity in the property, they can either take out a second bond or look at readvance or further

advance on the property. I know that in the retail individual space, they look at funding through their current home loans or mortgage" **- Participant 13**

"With the freestanding homes or smaller Body Corporates that go via our project loans, this is via a different business, as I said. So there, it's prime +2%, I think prime +3%, and you only get interest on the drawdown amounts" **- Participant 4**

"They would approach the bank, tell them what they want to do, and then the bank will finance the whole thing. They will have an agreement with the bank about repayment. I think that's another reason why we are actually able to see PV technology being installed almost every day these days. The financial institutions have already started addressing this issue." **- Participant 6**

"We've seen banks encouraging people to take out a second mortgage or an additional bond to finance these rooftop solar installations. They've taken a conservative approach in terms of risk, stating that they will deal with large companies that can support deployment at scale. So, as an individual, you may want to do it, but they'll still direct you to go through this channel, which is essentially a large company that can work with them." **- Participant 14**

The study also revealed the diverse financing options available for solar PV adoption, ranging from individual financing for storage solutions to project loans for community schemes. Participants discussed the intricacies of financing structures within Body Corporates, emphasising the viability of centralised systems and the potential benefits of Power Purchase Agreements (PPAs) in managing financial aspects of solar installations, with participants citing various sources of funding, including banks, pension funds, private equity, and institutional investors. Notably, the analysis highlighted the role of tax incentives in driving solar adoption, with participants noting the impact of tax considerations on the feasibility of direct purchase by community schemes.

"We, on the other hand, prefer centralised systems. As you know, you get centralised and decentralised systems. We prefer a centralised system because, as we said, the model has worked out in such a way that we get funds from investors. We are then able to partner with solar installers, etc., to then go and install these systems to then sell electricity back to the people at a cheaper rate." - **Participant 4**

"The structure within a Body Corporate setup suggests that a Power Purchase Agreement (PPA) would work. Essentially, the structure is set up such that the bank is the financier, and the Body Corporate, who are the developers in this case, become the custodians of the system. With that, they need to sell the power to their homeowners, and then sell excess power back to the grid." - **Participant 5**

"Certainly, capital is one of our significant requirements for our organisation. We need to have the capital resources to deploy these solutions. We acquire these capital resources through institutions such as banks, pension funds, private equity, and high-net-worth individuals. There are various sources of funding that we can approach. I know that DBSA and a couple of other institutions are now providing these funds, which can be accessed more easily. If there was easier access to capital for community scheme renewable assets, that would obviously be one of the resources that would help improve the situation." - **Participant 7**

"Our organisation makes use of that tax incentive for all the purchases that we do." - **Participant 7**

4.2.2.6 Theme 12: Perceived Benefits

Figure 30 highlights the central theme, Perceived Benefits as a facilitating factor for the adoption of solar PV technology, with four sub-themes: i) Economic Benefits, ii) Environmental Benefits, iii) Social Benefits, and iv) Energy Security Benefits, as discussed in the following sub-sections.

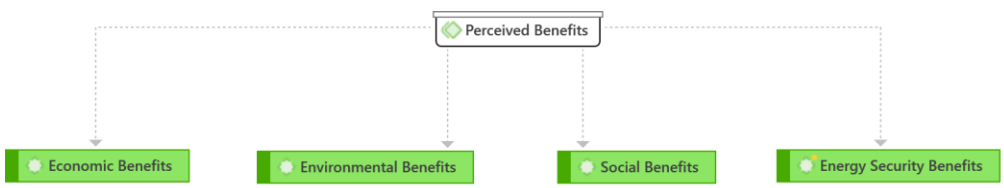
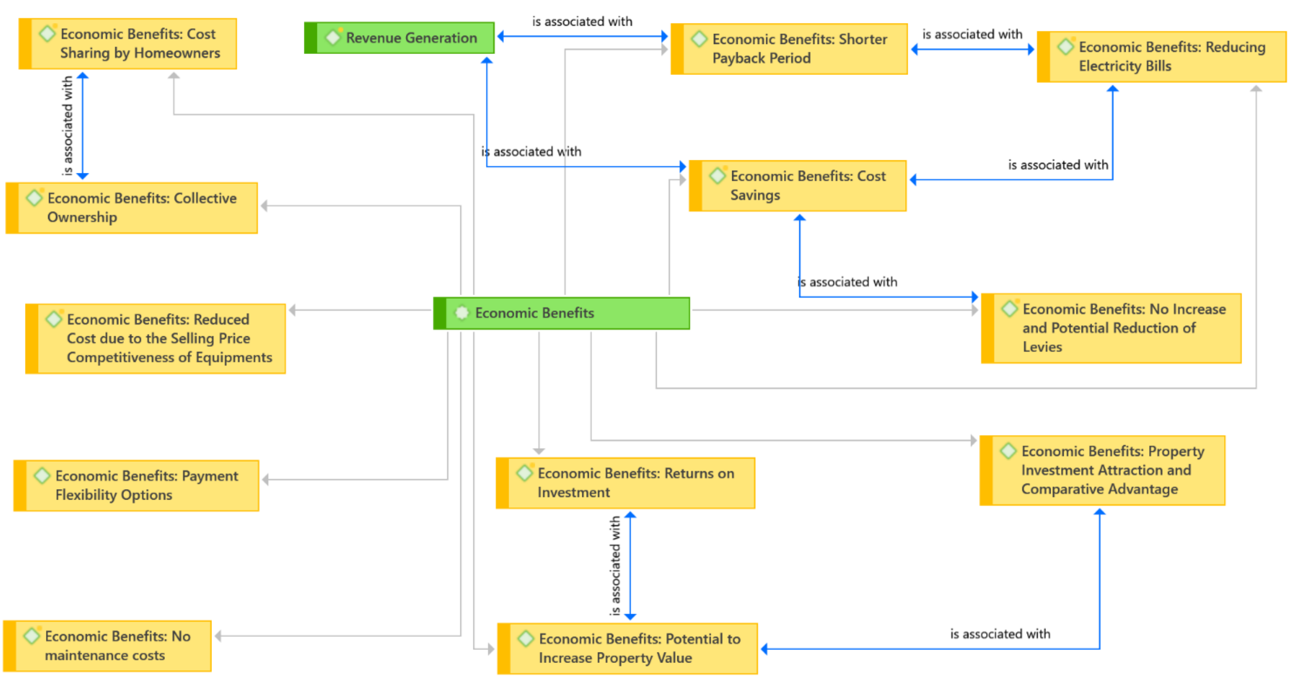


Figure 30: Perceived Benefits Ad hoc Network

4.2.2.6.1 Economic Benefits



The participant's responses within the sub-theme of economic benefits revealed several key findings. The participant highlighted the potential for solar power to reduce electricity bills, and the concept of returns on investment in solar technology was explored, highlighting how savings on monthly bills can lead to a gradual payback of the initial investment, ultimately making solar systems a sustainable and cost-effective solution.

"The main advantages are that you're obviously going to cut your monthly electricity bill, which is very important" - **Participant 6**

"For instance, a customer might buy electricity for around R2000, mostly before installing the PV system. Once they have installed PV, they might be able to reduce their monthly bill to R100 to R600-800, sometimes even to R0.00. It all depends on the system installed" **- Participant 10**

"Let's say you invest R20,000 to install solar technology. Maybe in the next three to five years, you would actually see that R20,000 returned. Let's start from the beginning. Immediately when you install solar in your residence, you see a difference in your electricity bill. For example, let's say you're paying R1,500.00 monthly for your bill. Once you have solar, you're going to be paying around R1,000. Of course, it depends on how you employ this technology in your house. Some people would use Eskom or the municipality as the main source and have solar as a backup. Some people will have solar as the main source and Eskom as the backup. It depends on which one you prefer. But if you go with solar as the main source and Eskom as the backup, then that's when you start to see your returns. Returns would mean that after so many years, you would have made back the money that you invested into this technology." **- Participant 6**

Furthermore, the participant emphasized the importance of financial flexibility in adopting solar technology, suggesting that offering payment options over time can facilitate increased deployment of solar systems within community schemes.

"So, if they could have options to say, maybe the Body Corporate will be responsible, or the complex will be responsible, but give them flexibility. They can pay over a period of time, so we will see more solar being deployed within the complexes." - **Participant 3**

The presence of warranties for the solar and storage systems further adds to the value proposition, ensuring longevity and reliability for the residents within the community schemes. The notion of installing the systems without increasing levies or maintenance costs was deemed attractive to community scheme members, who may lack the technical expertise to manage such technology independently.

"These systems come with a warranty of 10 years or more, and the same thing with solar where you've got 15 years or more in terms of warranty. Obviously, the people who've installed them do

see the value for money, not just in combating load shedding, but also in their electricity bill. After some time, you reach a break-even point where you see that you're gaining" - **Participant 3**

"So, it's often this solution where we come and install it for people without the need to increase levies or anything like that. That is very attractive to the community scheme members. Because now there's no maintenance, there's no cost. Not a lot of people have the technical skills to run these types of things. And then we also find that a lot of people can't afford the maintenance, the levies. So, then we pay that. They're very keen on saving electricity as well." - **Participant 4**

Moreover, the participant pointed out the value-added proposition of solar technology for community schemes, particularly in attracting tenants and investors. The ability to structure financial solutions without imposing additional costs on residents was identified as a crucial factor influencing the uptake of renewable energy solutions within these schemes.

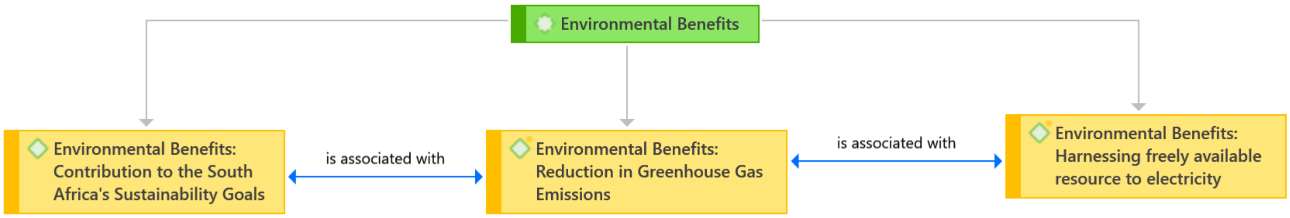
"Many schemes are seeing this as a value-add to their schemes. Certainly, in community schemes where there are a lot of investors that rent out their properties, they're seeing this as an attractive investment vehicle. If you're looking for a tenant who is renting, they are naturally going to be drawn towards a scheme that has some kind of backup solution, compared to a scheme, maybe next door, that has nothing. So, those are the most significant reasons that we are seeing in the community scheme environment." - **Participant 7**

"What we've been able to achieve in our organisation, and I think that's one of the advantages we have, is that we've been able to structure these solutions financially, from a commercial perspective, to make them commercially feasible both for the investor and for the unit owners who live there, to the extent that they're not paying an additional fee for the service. That's really what we try to do and that's the number one factor that influences the choice of these solutions." - **Participant 7**

Moreover, the participant highlighted the concept of renting out the roof and generating new revenues as a way to mitigate electricity expenses over time, highlighting the importance of exploring new business models and international best practices to enhance the commercial viability of solar projects in townhouse estates.

"What I'll do is that I (as a Body Corporate) will just offset some of that power within my (Body Corporate) residence of the entire complex where they (residence) get some of the incentives. For them (residents), the incentives will not necessarily be for them getting money but for them getting some of that power. I think what they are doing in Australia is that they actually offset your (the residence) energy bill for renting part of your (Body Corporate) roof as a sectional title owner." - **Participant 5**

4.2.2.6.2 Environmental Benefits



The participants highlighted several critical findings under the sub-theme of environmental benefits. The participant emphasised the ease of access to solar energy as a motivating factor for the Body Corporates and homeowners to consider this technology. The abundance of the sun's energy makes it a readily available resource for harnessing power, thus presenting a compelling case for its adoption.

> *"So, I think what really motivated the owners of these houses and commercial buildings to consider this technology is the fact that it's easy to access. It's the sun, right? The sun is always there, so you can easily harness its power. That was one reason."* - **Participant 6**

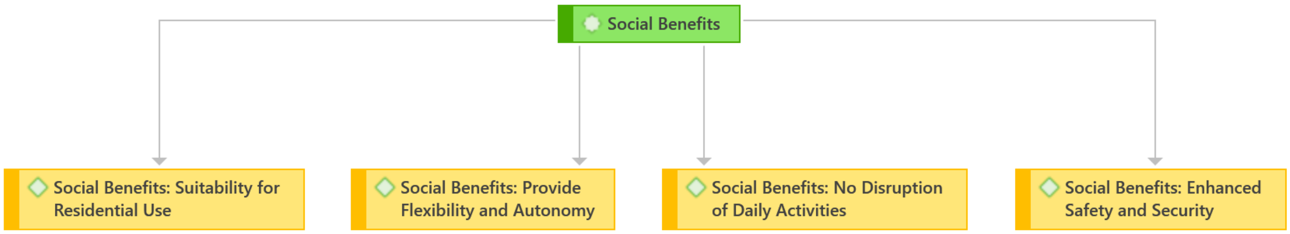
The participant also alluded to the potential marketing appeal of clean energy and the reduction of greenhouse gas emissions, particularly in the context of global environmental concerns such as climate change and the commitments outlined in the Paris Agreement.

> *"The issue around clean energy and the reduction of greenhouse emissions could be a selling point in some parts of the world. We are talking about global warming and the Paris Agreement. Companies nowadays want to be portrayed as contributing to the reduction of greenhouse emissions, so that is sometimes a motivational factor"* - **Participant 12**

From an environmental standpoint, the participant highlighted the environmental benefits of reducing one's carbon footprint and potential tax incentives, and the participant stressed the positive impact of reducing greenhouse gas emissions on both current and future generations.

> *"Besides the tax incentives, reducing your carbon footprint from an environmental point of view is positive for both you and future generations. So, environmentally, it's a no-brainer, and I think everyone should accept it"* - **Participant 14**

4.2.2.6.3 Social Benefits



The findings from the participants' responses within the sub-theme of social benefits emphasised the heightened demand for solar systems driven by security concerns within these residential settings. Many complexes have recognized the importance of installing backup systems, ranging from simple backups to complete solar PV systems, to enhance security measures.

The participant highlighted modern batteries' portability and storage capacity, underscoring their utility during power outages. The ability to sustain essential activities such as watching TV, using the internet, and maintaining power levels above 40% for extended periods exemplifies the value proposition of these higher-end battery solutions, albeit at a substantial cost. The convenience of portable batteries offers residents the flexibility to relocate with their power source, aligning with the transient nature of sectional and townhouse living.

"What's also been nice is that some of the batteries now available, like the portable ones I have, are quite large. I forget the exact size, but we can go for almost 10 hours with no power, watching TV, using the internet, and everything else, and it still won't go below 40%. Obviously, this is a higher-end type of expense because I think it was going for almost R30,000. The advantage, especially in a sectional or townhouse setting, is that if we decide to leave, we can just take our battery and go. What's also helping now is that a lot of places where we stay have gas stoves. So, it's much easier to continue with a bit of normalcy, even when there are power interruptions, because cooking can still happen. The normal TV and internet are still there. The laptops and phones are charged. "- **Participant 5**

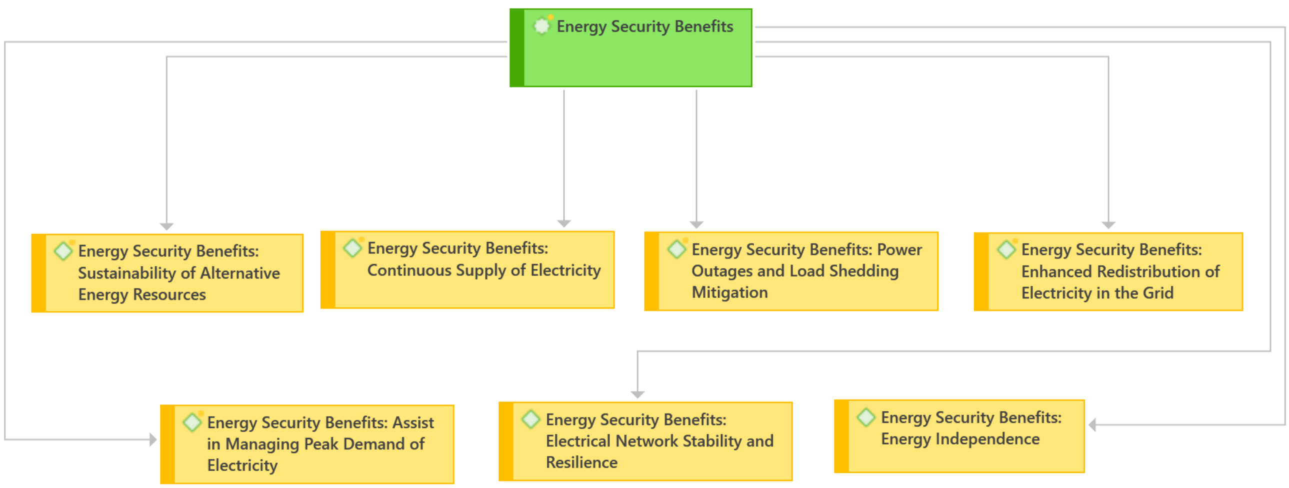
The participant's observation of uninterrupted power supply at the guardhouse during load-shedding events, where some of the adoption of solar PV technology was implemented, underscores the reliability and sustainability of solar systems in supporting essential security functions. The ability to maintain visibility and operational capabilities at the guardhouse despite power outages highlights the strategic advantage of solar technology in enhancing security measures within residential estates.

"What I noticed is that when there's load-shedding, at those six complexes inside the estate, there will be no electricity and light. However, at the guardhouse, power will be available, and the security will be able to assist people who are coming in and out. The security guards have visibility on who is

coming in and out, especially at night. This indicates that the solar system installed is sustainable for the security system installed there, because it is always working." - **Participant 9**

Overall, the participant's insights underscore the multifaceted benefits of solar PV technology adoption in sectional-title and townhouse community schemes, ranging from addressing security concerns and enhancing communal living to offering resilience during power disruptions. These findings contribute valuable perspectives to the discourse on sustainable energy solutions in residential developments, emphasising solar energy's social benefits and practical applications in diverse community settings.

4.2.2.6.4 Energy Security Benefits



The participant's responses within the sub-theme of Energy Security Benefits highlighted numerous benefits derived from adopting solar PV technology, emphasising the enhancement of energy security within these schemes.

The participant emphasised the practical benefits of having a small inverter, highlighting the uninterrupted access to essential services such as Wi-Fi, ensuring continuous productivity during work or study sessions. The participant expressed confidence in always having internet connectivity and lights, even during extended power outages, thus underscoring the reliability and resilience of solar PV technology in maintaining essential services.

"I have a small inverter, so I think the benefit is that if you're doing anything, like in my house, the Wi-Fi will always be on. So, if I'm working, doing homework, or anything else, I won't have any issues. I benefit from this" – **Participant 2**

"I think it's twofold. From a general perspective, I believe these alternatives are sustainable. For example, I work from home about 50% of the time, and I also study on the side. I have a three-year-old toddler, so it serves its purpose" **– Participant 5**

"And it's another benefit that we get now from energy security because you can at least still continue to do your day-to-day activities when you are under load shedding because you'll be able to use your solar power during the day and at night, compensated with a battery. So, the benefits are enormous. So there, yeah." **– Participant 14**

The participants emphasised the role of solar energy in promoting energy independence and reducing dependence on traditional grid infrastructure, thereby enhancing overall energy security within communities. By mitigating the impacts of load shedding on businesses and providing a reliable energy source, solar PV technology was seen as a crucial solution to address the challenges posed by unreliable grid power supply. Additionally, the participant recognised the broader societal benefits of solar technology adoption beyond individual households, particularly in commercial buildings and industries.

"I think when the property developers are saying that they've installed solar PV for their customers. After installation, we can see a reduction in power consumption from the municipal substation. This indicates that these customers have installed this solar system, and we can distribute that power to other customers." – **Participant 10**

"I think property developers can play a significant role in helping the country or municipality reduce energy consumption. Let's say they installed solar PV for their customers. After installation, we can see a noticeable difference from our substation, indicating that these customers have installed this solar system. We can then redirect the power they were using to other customers." – **Participant 10**

Moreover, the participants highlighted the potential for solar PV technology to facilitate load-shedding protection and grid independence over time. Gradually transitioning towards renewable energy sources and incorporating battery storage solutions will establish a more sustainable energy system. It also highlighted that the electrical grid and storage solutions can provide electrical network stability and resilience. The participant emphasised the importance of government support and policy frameworks to incentivise the adoption of battery storage solutions and accelerate the transition towards a more sustainable and secure energy infrastructure.

"What's happening now is that people are adding solar plus storage to try to convert solar energy into some sort of a base load, not really a base load, but some sort of a base load with storage." – **Participant 3**

"What we anticipate specifically with battery storage is that the government should probably enhance it, given that load shedding is an issue. So, probably from a commercial perspective, incentivise customers, including community schemes, to implement battery storage solutions. If there's battery storage implemented and distributed across the network, you're providing resilience and a more robust infrastructure throughout the network because you've got all these battery storage resources that can be called upon." – **Participant 7**

"What we're seeing, like in Europe, America, and Australia, is that battery storage is not only for backup but can be utilised for voltage regulations, frequency regulations, and reduction of maximum demand. So, there's a whole range of services that these batteries can provide. The government should provide a policy and a framework to encourage specifically battery storage to be implemented to address these things." – **Participant 7**

4.2.3 Summary of Findings On Research Question One

Based on the research findings, the factors considered barriers to the adoption of solar PV technology are summarised in Table 8, which provides six main themes and fourteen sub-themes. Based on the research findings, the factors considered facilitators of the adoption of solar PV technology are summarised in Table 8, which provides six central themes and eleven sub-themes.

Table 8 Summary of Factors that Hinder and Facilitate the Adoption of Solar PV Technology in Sectional-Title and Townhouse Community Schemes.

Theme	Sub-theme	Findings
Factors that hinder the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes		
Theme 1: Social and Stakeholders Collaboration Barriers	Social (awareness and behavioural) barriers	• Lack of education and understanding • misconception about solar panels • Misinformation about solar energy • Lack of trust • reluctance to incur additional costs.

Theme	Sub-theme	Findings
		• delays in decision-making and implementation • Concerns about unscrupulous installers
	Stakeholders Collaboration Barriers	• Lack of information and knowledge • Managing agent gatekeeping • lack of cohesiveness by industry stakeholders • Lack of engagement and support by industry stakeholders
Theme 2: Institutional, Policy and Legislative Barriers	Electricity Regulatory Framework and Government Policy Challenges and Restrictions Towards Grid Integration	• Lack of foresight and proactive planning from municipalities • Absence and Restrictive SSEG Policy • Challenges to policy implementation (political and policy misalignment, bureaucratic inefficiencies, lack of expertise within the municipalities, restriction of MFMA to make payment to customers)
	Sectional-Title Legislation and Body Corporates Rules Restrictions	• Sectional Title Management Governance Restrictions in decision making

Theme	Sub-theme	Findings
Theme 3: Financial Barriers	Cost and Affordability Challenges	• The high installation cost of solar PV panels and battery storage • Financial strain due to energy costs and alternative energy solutions • Cost of additional equipment such as solar geyser or gas geyser and stove • An additional cost of installing a smart meter for SSEG metering
	Body Corporate Budgeting and Financial Management Challenges	• Body Corporate budget challenges • Levies collection challenges • Lack of reserve funds/savings • Reluctance to impose a special levy. • Need for funding and payment flexibility.
	Limited Financial Incentives for Body Corporates	• Lack of tax incentives for Body Corporate • Low feed-in tariff structures • Limitation in existing incentives for Body Corporate
	Lack of Funding and Financing Options	• High interest rates are offered for bank loans.

Theme	Sub-theme	Findings
		• Low-risk appetite by banks to offer financing. • Downpayment requirement by Solar PV • Weak business case for funding due to lack of economies of scale • Short-term capital restrictions
Theme 4: Land, Building and Roof Resources Barriers	Roof Structure and Space Limitations	• Lack and unsuitable roof space • Shared roof resource restrictions • Building and roof structure strength limitation • Shading issues on available spaces
Theme 5: Technical and Technological Barriers	Sectional-title and Townhouse Community Schemes Distribution Network Challenges in Grid Integration;	• Safety concerns raised by the utilities due to exporting power into the grid. • Sub-metering restrictions in older community schemes whereby the households are metered individually by utilities. • Difficulty in separating essential and non-essentially within the distribution network of the community scheme.

Theme	Sub-theme	Findings
	Utility Metering and Billing System Challenges	• Limited net-metering capability on the existing installed meters • Manual billing using spreadsheets. • Lack of net-metering and net-billing capability on the existing billing system
	Technology Reliability, Performance and Compliance Challenges	• Non-compliant with installed equipment to the grid-code and NRS097 standard • Poor quality of excess power exported to the grid.
Theme 6: Company Resources and Operational Barriers	Company Resources Challenges	• Shortages of skilled resources • Lack of access to qualified installers • Negative impact on the use of unqualified solar PV installers • Lack of marketing • Lack of innovation
	Supply Chain Challenges	• Reliance on imported solar PV technology. • Lack of local manufacturing • Lack of reliability testing facility • Supply and demand challenges

Theme	Sub-theme	Findings
Factors that facilitate the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes		
Theme 7: Frequency and Higher Stages of Load-Shedding		• The severity and frequency of load shedding positively influence the need for alternative energy resources.
Theme 8: The Interplay of Industrial, Stakeholder and Societal Influences	Social Influence	• Awareness (public education, community awareness and buy-in, individual knowledge, access to information) • Community engagement and social impact (collective effort, trustees influence, solar PV installer's visibility and support for community needs) • Early adopters (affluent areas, environmental consciousness, industries, and commercial estates) • Online influence (social media and customer reviews)
	Stakeholders Influence	• Advocacy for favourable regulations and policies. • Stakeholder awareness initiatives, facilitating partnership and collaboration.

Theme	Sub-theme	Findings
	Industry Influence	• Technological advancement and solutions (introduction of smart meters, the evolution of metering services, improved efficiency of equipment. • Increase access to qualified installers through training and certification. • Partnership and collaboration of manufacturers, distributors, and installers
Theme 9: Improving Solar PV Investment Return through the Use of Incentives, Policy and Legislative Instruments	National and Local Government Role towards SSEG Policy Development and Implementation	• Creating an enabling environment. • SSEG policy formulation and improvement • Municipality personnel awareness, training, and capacity building
	Easing of Regulatory Landscape for Body Corporate s	• Resolution supporting solar installations in community schemes. • Rules amendments in favour of solar adoption. • Permissible use of other energy resources (gas stoves and geysers and solar geysers)

Theme	Sub-theme	Findings
	Tax Incentives	• Solar energy tax credit for individual taxpayers. • Section 12B enhanced renewable energy tax incentives for companies.
	Metering and Billing Instruments	• High cost of electricity due to approved tariffs by NERSA • Modern Billing System with SSEG capabilities • SSEG Feed-in Tariff. • SSEG Fee-in Credits are applied to monthly bills. • Wheeling framework.
Theme 10: Economies of Scale of Community Schemes Sub-Metering and Recovery	Economies of scale	• Economies of scale with regard to the number of units in a community scheme
	Effective management of Body Corporate sub-metering and utility metering accounts	• Body Corporate's role is to pay the utility electricity account. • Management and administration of sub-metered electricity within a community scheme.
Theme 11: Funding Instruments		• Potential revenue from roof rental • Body Corporate Funds • Homeowner bank loans • Project funding loads

Theme	Sub-theme	Findings
		• Commercial banks finance • Investor and investment institution funding is accessible through power purchase agreement structures.
Theme 12: Perceived Benefits	Economic Benefits	• Reduced electricity bills • Reduced cost of buying solar equipment due to competition in the market. • Cost sharing by homeowners • Collective ownership • Payment flexibility options • Return on investment. • Shorter payback period • No increase and potential reduction in levies • Potential to increase property values. • Property value attraction and comparative advantage
	Environmental Benefits	• Harnessing freely available resources for electricity • Reduction in Greenhouse Gas Emissions • Contribution to South Africa's Sustainability Goals

Theme	Sub-theme	Findings
	Social Benefits	• Enhanced safety and security • Suitability for residential use • No disruption of daily activities • Provide flexibility and autonomy
	Energy Security Benefits	• Power outages and load-shedding mitigation • Support to provide a continuous supply of electricity. • Sustainability of alternative energy resources • Enhanced redistribution of electricity in the rid • Assist in managing the peak demand for electricity. • Provide electrical network stability and resilience. • Support energy independence goals.

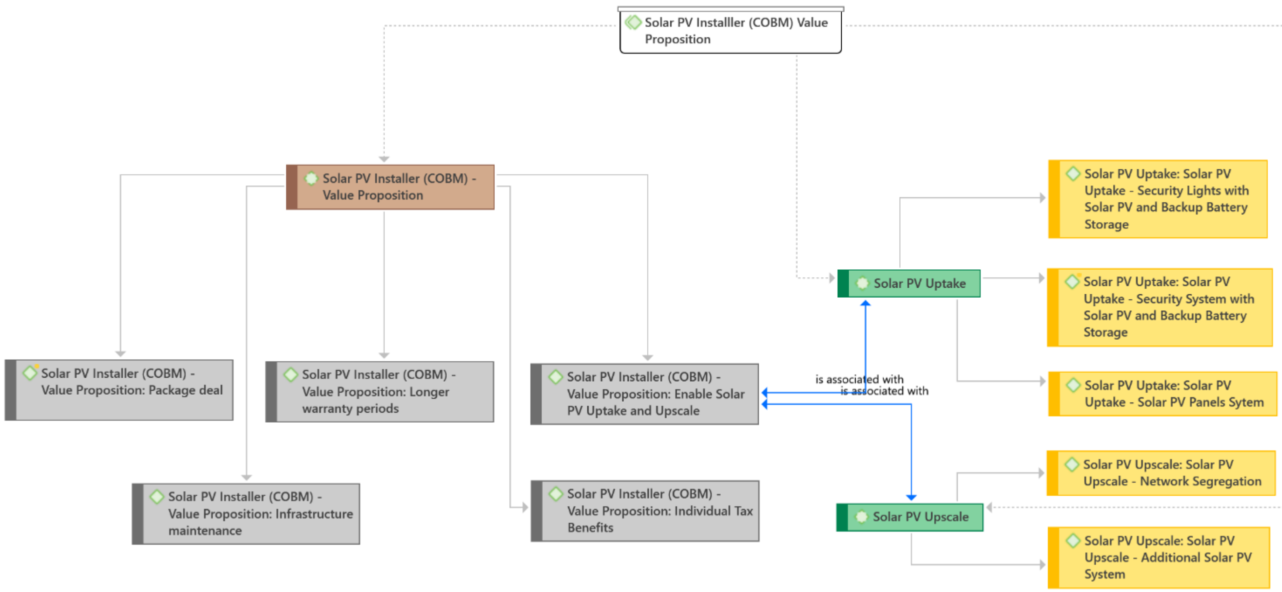
4.3 Findings On Research Question Two

What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional title and townhouse community schemes in South Africa?

The findings to this question are divided into two themes: solar PV installers focused on the customer-owned business model, and solar energy companies focused on the third-party-owned business model, presented in the form of the business model canvas.

4.3.1 Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)

4.3.1.1 Value Proposition of Solar PV Installers



The participants highlighted the need for reliable solar panels and batteries, mainly for security purposes such as powering gates, alarms, and electric fences during power outages.

The participant suggested that Solar PV installers offering competitive package deals for solar and storage solutions could enhance the value proposition for community schemes. They highlighted the increasing demand for battery backup solutions to address security concerns during load shedding, especially for CCTV, electric fencing, and area lighting. The participant also mentioned the uptake of solar PV of solar panels and inverters for charging batteries at guardhouses and entrance points in some complexes. They noted a growing trend among property developers to incorporate alternative power supplies like solar panels and battery storage into new complexes, enhancing their attractiveness to buyers or renters. Security emerged as a primary driver for adopting solar and battery backup systems in community schemes.

"Complexes are looking into alternative solutions, at least for the guard house and the entrance. By 'guard house,' I mean the systems that run the electric fence, cameras, and the lights at the gate. Some complexes are using solar panels and inverters to charge the batteries" - **Participant 8**

"*One of the primary aspects affected in community schemes due to load shedding is security. In most instances, we are receiving inquiries to provide battery backup solutions to address load shedding, but more specifically, to address security. This includes CCTV, electric fencing, and area* *lighting for security purposes. At the moment, that's the number one reason community schemes are requesting it."* **- Participant 7**

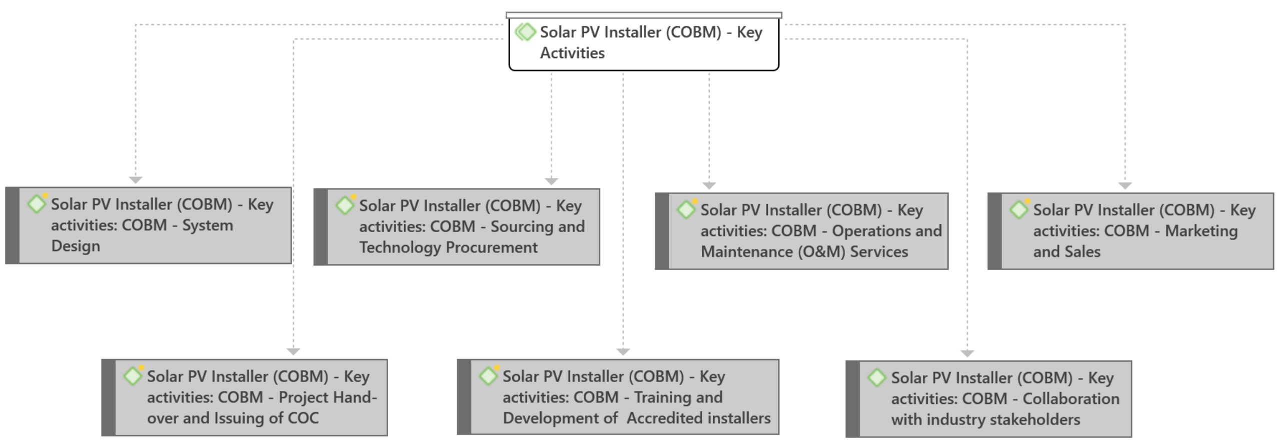
The participant highlighted offering more extended warranty periods and maintenance services as added value that forms part of the offering.

"These systems come with a warranty of 10 years or more, and the same thing with solar where you've got 15 years or more in terms of warranty."- **Participant 2**

The participant emphasised the importance of ensuring that garages and facilities in common areas are functioning by installing solar panels and inverters connected to multiple distribution boards, which enable Solar PV upscaling by adding more solar panels and segregating the distribution network within the sectional-tile and townhouse community scheme.

"I think another thing we need to do for the common area is to ensure that garages and all other facilities are functioning. We can probably divide it because we have four DB boards. For each DB board, we can install some panels and then put an inverter. This way, we'll always have lights, and the entire complex will be supported." - **Participant 2**

4.3.1.2 Key Activities of Solar PV Installer



The participant's response highlighted Solar PV Installers key activities that include system marketing and sales, system design, technology selection and sourcing, project hand-over, and issuing of Certificates of Compliance (CoC), and may involve additional tasks based on client preferences, such as operation and maintenance (O&M) services. Solar PV Installers are responsible for designing compliant systems, procuring equipment, and ensuring proper installation. The process involves various teams, including engineers, contractors, and O&M personnel. Engineers conduct site assessments and design systems, while contractors handle installations. O&M teams maintain systems post-installation.

"I believe the first thing these individuals consider is your profile, specifically the number of jobs or solar projects you have completed. Therefore, it's crucial to present a comprehensive and accurate record of your work. Once they see this, they are typically convinced. Of course, another important factor is ensuring that your pricing is reasonable." - **Participant 6**

"The role of installers is rather self-explanatory. They install, so they buy the equipment, come to your house, install the equipment, and commission it. That's what they do. So obviously, it's a value chain from the manufacturer until everything is installed." - **Participant 1**

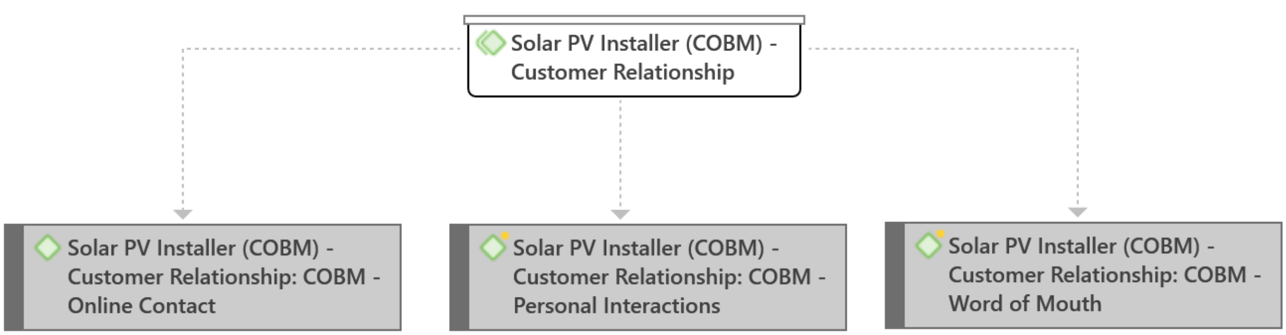
Accredited installers are crucial for ensuring compliance and issuing CoCs. Training and certification, including the green card solar installations course, are prerequisites for becoming an accredited installer. Solar suppliers can collaborate with industry bodies to promote awareness, offer technical expertise, and provide ongoing support to residents.

"They can also collaborate with a number of organizations, industry professionals, and government agencies for widespread communication, technical expertise, financial support, and best practices" - **Participant 11**

"So, you understand the different stakeholders that are in place. Yes, you need the funders and technical support. That technical support would normally come from groups such as your lobbying groups like SAPVIA. SAPVIA plays a critical role in terms of creating awareness and providing the necessary skill set and training" - **Participant 14**

"You have to be accredited or have also gone through training and passed the green card solar installations courses to be credited as a qualified installer that can issue a certificate of compliance for the installation that you've made" **- Participant 11**

4.3.1.3 Customer Relationship of Solar PV Installers



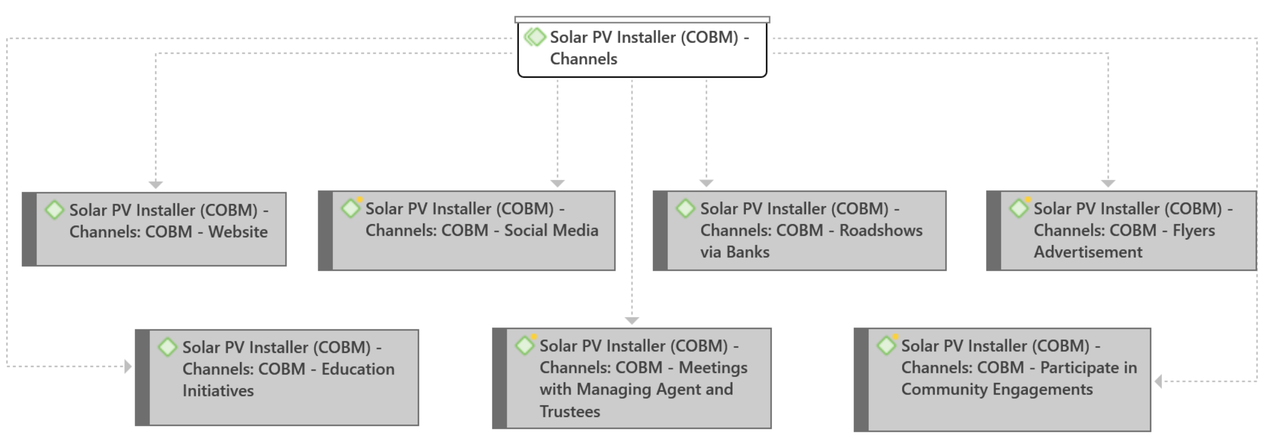
The participant emphasised the significance of building trust and maintaining reliable service to establish strong customer relationships. They suggested that security companies could serve as potential partners for solar PV installers in contacting community schemes. The participant also stressed the importance of effective communication through word of mouth, personal engagement, cold calls, and emails for managing agents and trustees in decision-making processes related to solar energy adoption. Furthermore, the participant discussed the value of establishing partnerships rather than transactional relationships between solar energy companies, installers, and distributors to enhance mutual benefits and promote the adoption of solar technology.

"I think the relationship they can have is with security companies. Those security companies are everywhere. If, let's say, my complex doesn't have any system, they should be able to make sure that the gate staff is powered. Then you come in and say, 'Yes, this system will save you so much money, maybe 1000 rands more. We'll also put the system in place so that our staff doesn't go without.' But then, with you that are there, they also upsell to the individuals. There are various ways because I think you could trust word of mouth more than anything else." - **Participant 2**

"The first point of contact would be the solar energy company giving us, the managing agent, a call and asking for a follow-up email based on our phone conversation. I would then forward the email to the trustees. If they are interested, the trustees will call a meeting with the solar company, who will present their proposal. This presentation can either be virtually on screen or through printed physical documents. After presenting to the trustees, we take that same communication and send it through to the owners. At the end of the day, the trustees represent the owners, so the owners need to agree" - **Participant 8**

"So, I think it's very important when these communities of the sectional title need a particular service provider, and there's a relationship that is built with them. But how do you build this relationship? It's through service. If you've got a promise, you keep the promise, then you build the relationship. Then there could be a trust, a common trust between the service provider and the occupants or the residents." **- Participant 3**

4.3.1.4 Channels of Solar PV Installer



The participant highlighted various channels through which solar PV installers can engage with potential customers.

The participants suggested that installers could leverage trusted relationships with Body Corporates and use solar PV installer websites and social media platforms for marketing to reach a wider audience within sectional-title communities. Traditional methods like distributing flyers and cold calling were also mentioned as effective communication strategies. The participant highlighted the significance of engaging managing agents to facilitate interactions with Body Corporates and stressed the need for collaboration with associations of managing agents for broader outreach.

"I think marketing on social media is also important. The younger ones, they love TikTok, Facebook and such. So, you know, people love and can relate to adverts like Nando's because there's a pun, there's fun. Through these TikTok or Facebook posts where you have this fun kind of content, whether it's videos or whatever, that's just been shared. I mean, these people have phones, almost everyone is using smartphones nowadays and they do have Instagram, TikTok, Facebook accounts. So, you can also reach a bigger community within the sectional titles through these digital platforms or through social media." - **Participant 3**

"So, the usual way involves methods like distributing flyers. Let's say there are places with many of these complexes. You can have someone handing out flyers, you can do cold calls to the Body Corporates, or you can use the managing agents to get through to the Body Corporate and things like that. These would be the typical ways to communicate with the Body Corporates." **- Participant 1**

The participant emphasised the role of banks in hosting roadshows and business days to educate individuals on solar technology, suggesting that partnerships with such financial institutions could facilitate adoption. From a Body Corporate perspective, the participant stressed the importance of clear communication regarding solar PV systems' benefits and payback period to ensure cost-effectiveness and long-term planning.

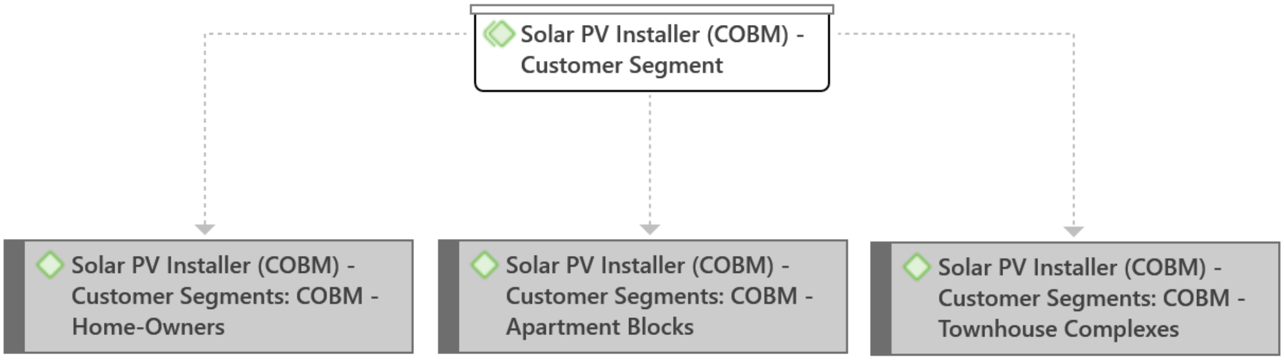
"They're hosting a lot of roadshows, but those roadshows are actually limited. Especially the banks, they're the ones conducting them." - **Participant 2**

"Now, you're creating an opportunity for people to work together. You're also probably able to get some kind of business day." **- Participant 2**

"As a solar company we will go them and present our work, submit our profile" **- Participant 6**

Clear communication channels, transparency, and incentives were identified as crucial elements in engaging residents and promoting the adoption of solar PV technology within sectional-title and townhouse communities.

4.3.1.5 Customer Segments of Solar PV Installers



The participants' responses regarding customer segments of solar PV installers highlighted the individual homeowners, from the young population to the elderly population, in sectional-title and townhouse community schemes. They noted a demographic divide, with lower to middle-class residents, including young families, being more receptive to solar solutions, especially post-COVID, due to remote work implications during load shedding.

"I think in my own experience, you'll find that there are a lot of elderly people in the complex. Currently, there are many elderly people, but new young people are coming in. However, the majority are still elderly." - **Participant 2**

"I think the first thing to consider is the demographics of the people living in these complexes. Most of them are likely to be lower class, with some middle class, especially in townhouses that fit within that demographic area." - **Participant 3**

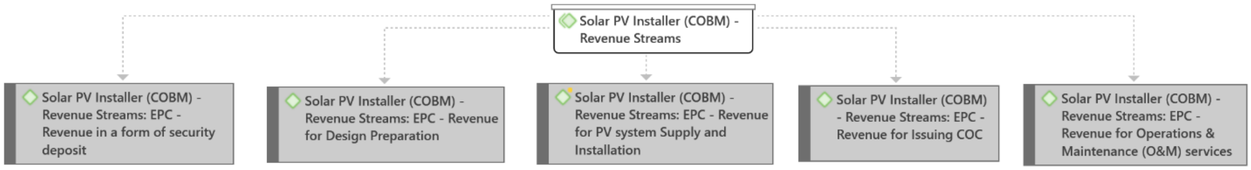
"These are usually young people or young families, perhaps a family with one or two children at most. Especially post-COVID, we have people working from home. For the working class, this is the first major impact, where their work is affected during periods of load shedding if there's no alternative power supply." **- Participant 3**

The participants also mentioned different types and sizes of community living spaces, which include apartment blocks and townhouse complexes.

"In a townhouse, you will find people who have their own roof. You might call it five standalone houses, but it's all within a sectional title." - **Participant 5**

"I noticed it because it's an estate that has six different sectional-title complexes, and the solar panel was installed at the main guardhouse" **- Participant 9**

4.3.1.6 Revenue Streams of Solar PV Installer



The participant highlighted that a screening process is recommended at the initial stage, whereby a solar PV installer assesses the site's power requirements. Following the screening process, a preliminary design is presented to the client for approval, and payment is required for this phase. Subsequent stages include detailed design, construction, and handover, marked complete by issuing a Certificate of Compliance (CoC). The payment structure is tailored to the project's progression, with clients having the option to extend the scope to cover O&M services, subject to corresponding payment obligations.

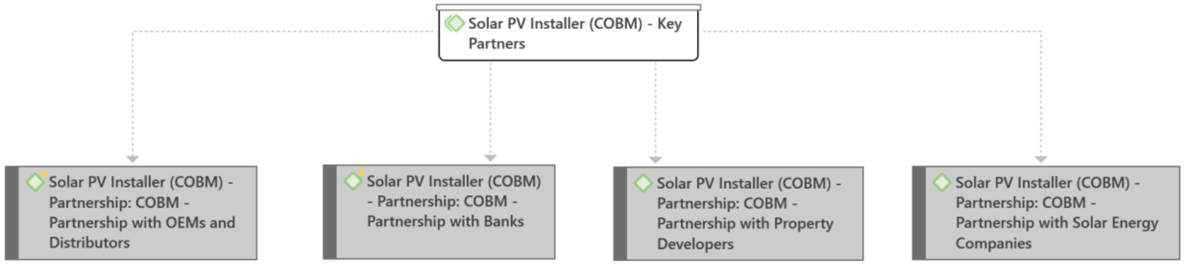
"In our company, at the initial stage, we do screening is where an engineer goes on site to check your incoming power, like what type of transformer is bringing in the feed, how many volts, and all that type of stuff. Once we have that information, we go back to the office and do a preliminary design. This is where we show the client what we think the package should look like for them. If the client approves that, then we move on to the next stage. On that initial thing, we recommend that the client pays for that part. If I do the screening and give you the preliminary design, you're going to pay for that. Once you approve that, we can move on to the next stage, which will be your detailed design and all that type of stuff. Of course, in that stage, once I have my package, then I can do the presentation to you, and you pay for that as well. Once you have paid and approved that" - **Participant 6**

"It all depends on the agreed payment terms. Typically, installers want to get paid the bulk of the payment for the equipment and all related costs. In most cases, there's a deposit which may range from 70 to 90%, and the rest is paid upon completion. Once the certificate of compliance is issued, the remaining payment is made." - **Participant 1**

"The service providers or installers, in this case, only require a deposit. In most cases, they don't have the capacity to finance on behalf of the customer, which is why a deposit is required. This deposit is used to procure the material. Then, of course, the balance is paid upon completion. This system works well." **- Participant 1**

Installers cannot finance on behalf of customers, hence the necessity for a deposit to procure materials. This deposit is crucial for initiating the project, with the final payment made post-completion. The remaining balance is settled upon completion and issuance of the certificate of compliance.

4.3.1.7 Key Partners of Solar PV Installer



The findings from the participants' responses regarding key partnerships of Solar PV Installers reveal the importance of collaborating with various stakeholders. Partnerships with banks, property developers, OEMs, and distributors emerged as crucial elements in the solar energy industry. The participant underscored the significance of partnerships with solar equipment manufacturers to obtain discounted rates and ensure the quality and reliability of the products. The need for long-term, mutually beneficial relationships with OEMs and distributors was emphasized to enhance the affordability and efficiency of solar energy systems.

"It becomes very important that distributors and installers use high-quality manufactured equipment. They should use reliable OEMs that have a track record. They shouldn't just go to an OEM/supplier and buy the equipment because the supplier is selling it cheaper, versus going to another where their equipment has been proven, it's reliable, but it's a little bit more expensive than the other OEM. In these situations, it's better to go for reliability more than just buying something cheap that's going to break tomorrow." - **Participant 11**

The participant highlighted the role of banks in hosting roadshows to educate the public about solar energy financing, signalling a willingness for alternative power supply solutions. Participants suggested that solar PV installers could work with banks to provide financing options for customers, especially in residential complexes.

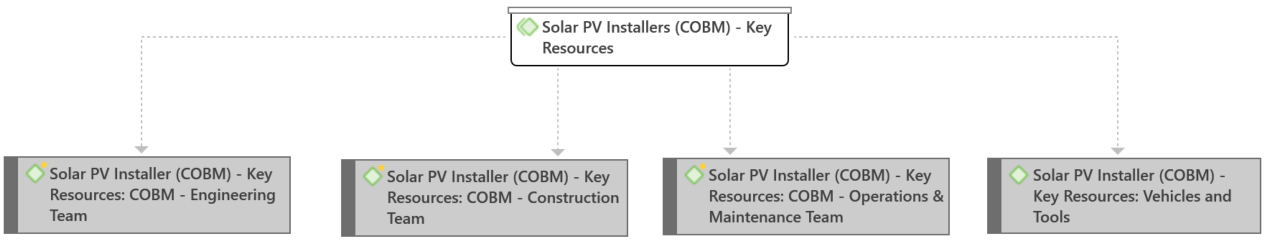
"*a partnership with financial institutions or the service provider and maybe a bank where they go together. And then they offer this alternative power supply, and then the bank becomes the debt collector. You know, the service provider will get paid. And then it's betwee*n the complex and the bank" - **Participant 3**

Additionally, partnering with property developers was emphasized as a strategic approach to integrating solar power systems into new complexes and estates, thereby addressing the challenges associated with buy-in from residents and financing.

"Complexes are developed by property developers. Yes, where a service provider for any alternative power supply can partner with developers. And then in the beginning, when the

developer is still planning to have a complex, you incorporate the alternative power supply. That will be the easiest thing. Whether you're going to rent or you're going to sell, when someone is coming to buy, the alternative power is already part of the package. Yes. So, you can even go with solar PV panels or even battery energy storage. Yes, but you walk into your complex, you buy a unit, and it already has the alternative power supply." - **Participant 3**

4.3.1.8 Key Resources of Solar PV Installer



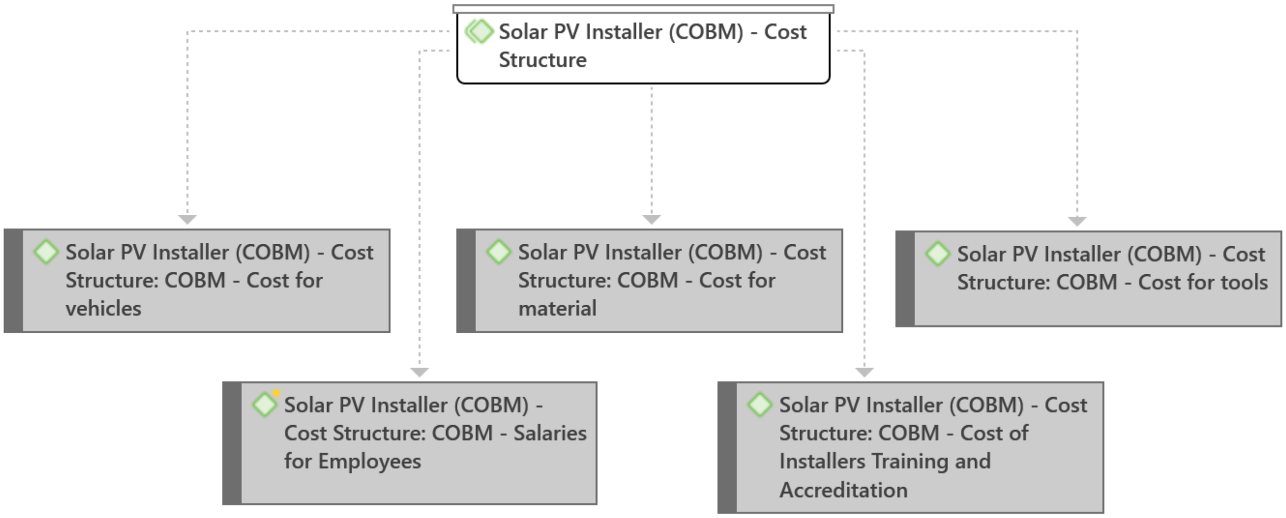
The key resources for a Solar PV installer include an engineering team, a construction team, an operations and maintenance team, and vehicles and tools. The engineering team, responsible for system design, consists of full-time employees. Although the construction team is in-house, it is part-time and only engaged in construction tasks. The operations and maintenance team, crucial for system upkeep, is full-time. The primary resource is skilled personnel, including designers, installers, and O&M technicians. Solar companies typically employ a mix of engineers, technicians, and artisans to ensure competitive and efficient operations. Vehicles, essential for transporting personnel and equipment to installation sites, are also a key resource. Overall, the success of a solar PV installation company hinges on having a skilled and diverse team.

"You need skills to design the system and to do the installation, including all the wiring and other necessary tasks." - **Participant 1**

"You also need vehicles to transport you and your equipment to the site. So, those are the basic requirements." - **Participant 1**

"The engineering team is in-house, like full-time employees, right? And then the construction team is in-house, but it's not full-time. They only come in when there's construction that needs to be done. Then there's O&M, which is full-time. So, it's engineering and O&M full-time, then construction part-time" - **Participant 6**

4.3.1.9 Cost Structure of Solar PV Installer



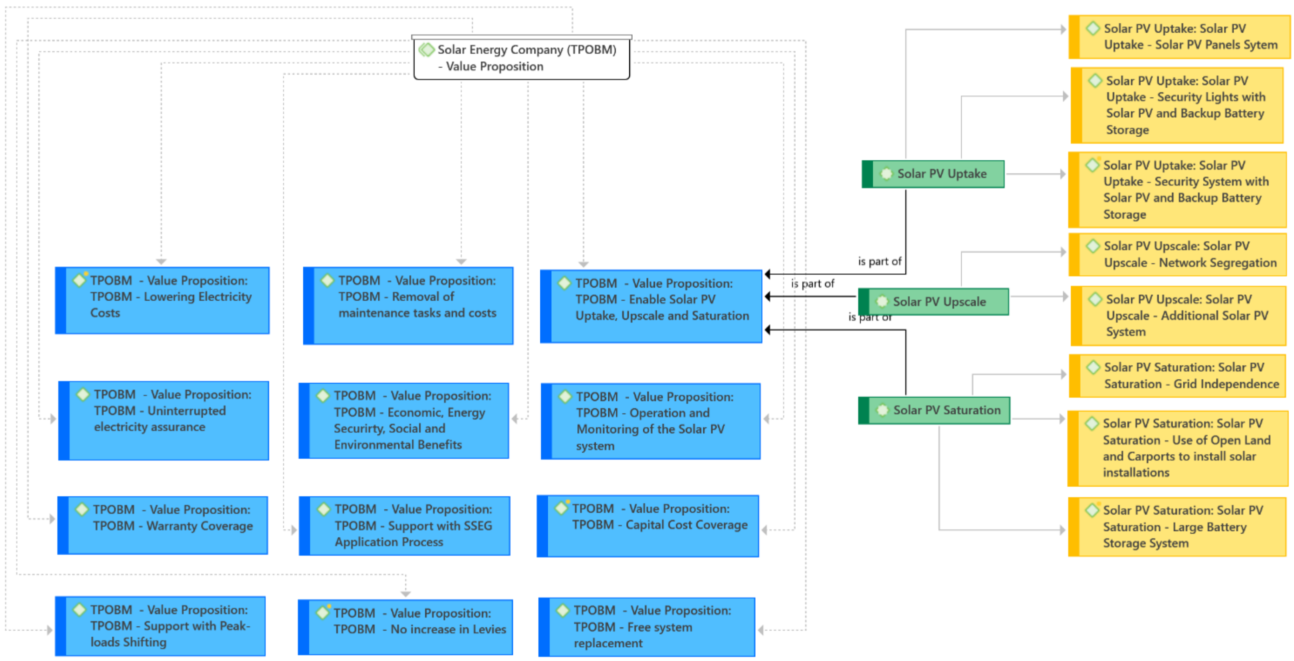
The participants highlighted various costs involved in the operation of Solar PV installers, including salaries for employees, installers training cost and accreditation, material costs, tools, and vehicles. The breakdown of the cost structure revealed that skilled personnel are crucial for the successful execution of the project, with the engineering team being full-time employees. In contrast, the construction team is part-time and called in as needed. The participant underscored the significance of having competent and skilled individuals across all project stages, from design and installation to operation and maintenance.

"You (solar PV Installers) need skills to design the system and to do the installation, including all the wiring and other necessary tasks. You (solar PV installers) also need vehicles to transport you (their teams) and your (their) equipment to the site" - **Participant 1**

"You (the installer) need to be a trained electrician. One needs to take an electrical installer's exam and pass it to get the certificate to be an accredited electrical installer for normal electrical installations. Then there is an additional one, I think it is called a green card installation certificate, which is specific to solar installations." – **Participant 11**

4.3.2 Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)

4.3.2.1 Value Proposition of Solar Energy Company



The participant highlighted several critical findings under the Value Proposition of Solar Energy Companies sub-theme. The focus areas include Solar PV uptake for security systems and lights, Solar Upscale with additional panels and network segregation, and Solar PV saturation for achieving grid independence. The participant highlighted installing solar panels and batteries at the gate to address power outages and enhance security. The discussion also emphasized the importance of adequate storage sizes for larger complexes and the gradual transition towards grid independence.

The participant noted that the primary driver for adopting solar solutions in community schemes is security, particularly for CCTV, electric fencing, and area lighting. The journey towards grid independence was highlighted as a gradual process, starting with limited backup solutions and potentially evolving into renewable energy sources in the future. The challenges of cost and individual implementation within complexes were also acknowledged. Overall, the findings suggest a growing interest in solar technology adoption within community schemes, primarily driven by security needs and a long-term goal of achieving grid independence.

"Bigger storage sizes are indeed an option when you're treating the complex as a commercial and industrial (C&I). I've seen this in wealthier complexes, like Midstream Estate and others, where they have the land needed for this. They have the land, they come in and put in large containers for

storage. Yes, and if you have open land or carports and such where you can put the solar panel, that is fine." - **Participant 3**

"That's why we talk about this journey towards grid independence. The commercial feasibility might say that we can only afford it, or we can only implement a backup at this stage, without incurring additional costs for the scheme. But as time goes on, that may change, and then, as the tariffs increase, for example, we may be able to get to a three-hour backup and then a four-hour backup. Part of that journey will take you to the point in the next 10 years where the majority of your supply comes from renewable sources within a community." - **Participant 7**

These findings emphasized the benefits of solar energy in terms of lowering electricity costs, removing maintenance tasks and costs, enabling solar PV uptake, ensuring uninterrupted electricity assurance, and providing energy security and social and environmental benefits. The participant also mentioned the importance of operation and monitoring of the solar PV system, warranty coverage, support with SSEG application processes, capital cost coverage, support with peaking load shifting, and no increase in levies.

"All our solutions with community schemes are under a PPA-styled structure. Generally, the tariff that's signed in the PPA is lower than what they're paying to the council. So, they are going to be paying for electricity that is cheaper than what they're currently paying." - **Participant 7**

"So, it's often this solution where we come and install it for people without the need to increase levies or anything like that. That is very attractive to the community scheme members. Because now there's no maintenance, there's no cost. Not a lot of people have the technical skills to run these types of things. And then we also find that a lot of people can't afford the maintenance, the levies. So, then we pay that. They're very keen on saving electricity as well." - **Participant 4**

"So, we find that because technology changes so quickly and the maintenance of the panels, you know, they really have a warranty and so forth. We free you from all of that. We come and install this system, monitor it, operate it, and make sure it's insured. It's all hassle-free solar," **- Participant 4**

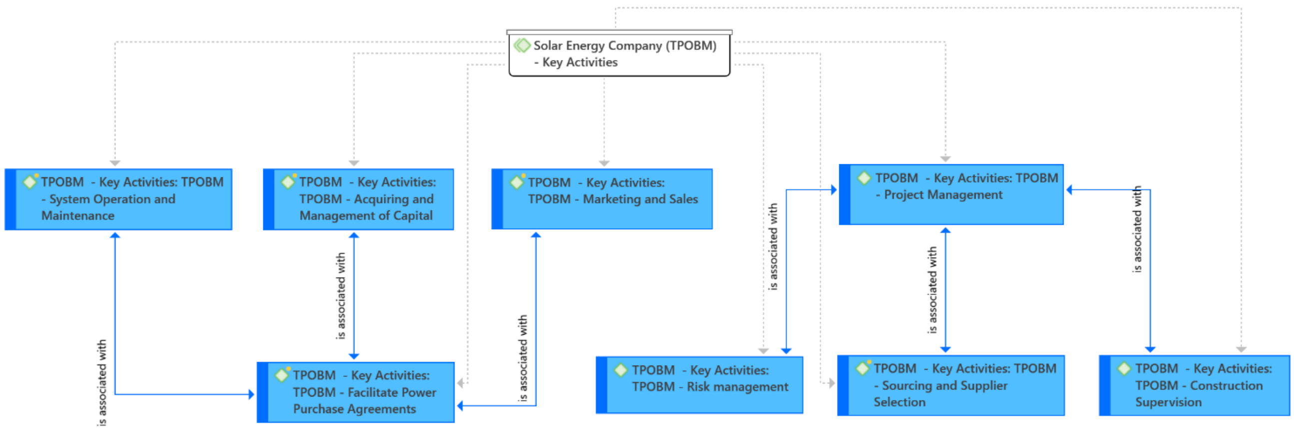
Furthermore, the participant highlighted the attractiveness of hassle-free solar solutions, including free system replacement after 25 years, flexible payment structures, and the option to push excess solar power back into the grid to reduce levies potentially. The participant also highlighted the preference for centralized systems and the challenges faced in implementing solar solutions, particularly in community schemes.

"So, for us, that's a big benefit for people is the fact that they don't have to worry about the system; we maintain and operate it. I suppose that's the biggest advantage. Like I said, the biggest go-to is

if you need to replace it, then after 25 years or something, we replace the whole system for free." - **Participants 4**

Overall, the participant emphasized the importance of structuring solar energy solutions to be financially feasible for investors and unit owners, ensuring that the tariff is lower than what is currently paid to the council.

4.3.2.2 Key Activities of Solar Energy Company



The participant's responses highlighted key activities for a solar energy company, focusing on marketing and sales, power purchase agreements, project management, risk management, sourcing and supplier selection, construction supervision, system operation and maintenance, and acquiring and managing capital. The preference for centralized systems was emphasized due to investor considerations and the benefits of hassle-free maintenance for customers. The participant highlighted the process of facilitating power purchase agreements (PPAs) with entities like developers and Body Corporates, involving negotiations, tariff agreements, and financial modelling for securing funding. Construction supervision and risk management were highlighted as crucial for ensuring project success and maintaining investor trust. The participant stressed the need for reliable equipment sourcing to ensure system longevity and return on investment.

"Then we say to the bank, on top of that agreement, we have run our financial model based on these Power Purchase Agreements (PPAs) that we have signed. This is our financial model, and this is our business model. Can you give us R20 million?' The bank does the due diligence, checks everything, and gives us the money. We go out and install the system.' **- Participant 5**

"Certainly, what organisation does is it goes out to financial institutions to raise capital for the purpose of deploying renewable assets into community schemes. When we go on these capital raise initiatives and campaigns with the institution, we obviously set a target of returns for that investor. So, if we are raising, say, 50 million Rand from a particular institution, that institution has

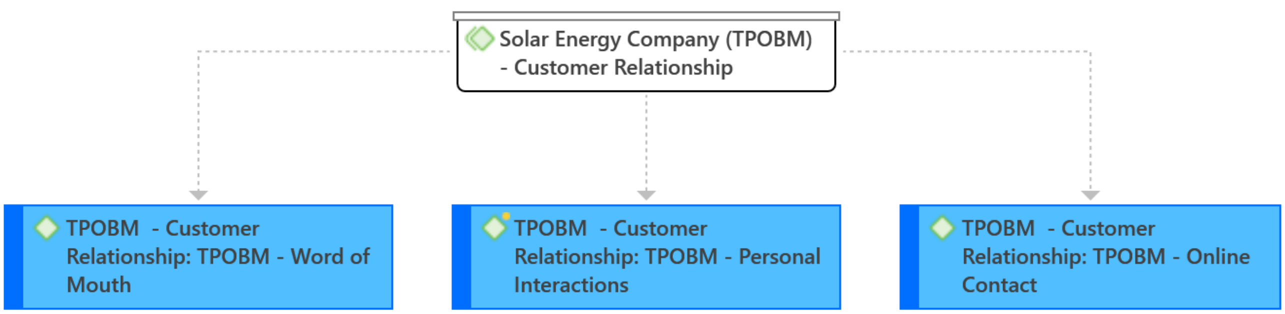
minimum return requirements for their capital. They want certain interest rates. They want a certain return on that money, and we need to then achieve that return in order to secure the funding." - **Participant 7**

"Once we've secured the funding, we would then look for opportunities in various community schemes where we could potentially allocate capital for these renewable assets." **- Participant 7**

"Now, from a PPA point of view, it means that we need to look at the business slightly differently. You go to a number of sectional titles and townhouses, and you say that we can provide you with a 10 MW plant that would be able to provide you with power for the next 20 years, and all you need to do is agree on a fixed tariff. This alone helps you to reduce the Capex because now you've got a firm supply in terms of the capacity that you need to deploy" - **Participant 14**

"In most cases, I know for rooftop systems, they even supervise the construction. So, during construction, they oversee the solar energy company that is doing the EPC (engineering, procurement, and construction)." - **Participant 5**

4.3.2.3 Customer Relationship of Solar Energy Company



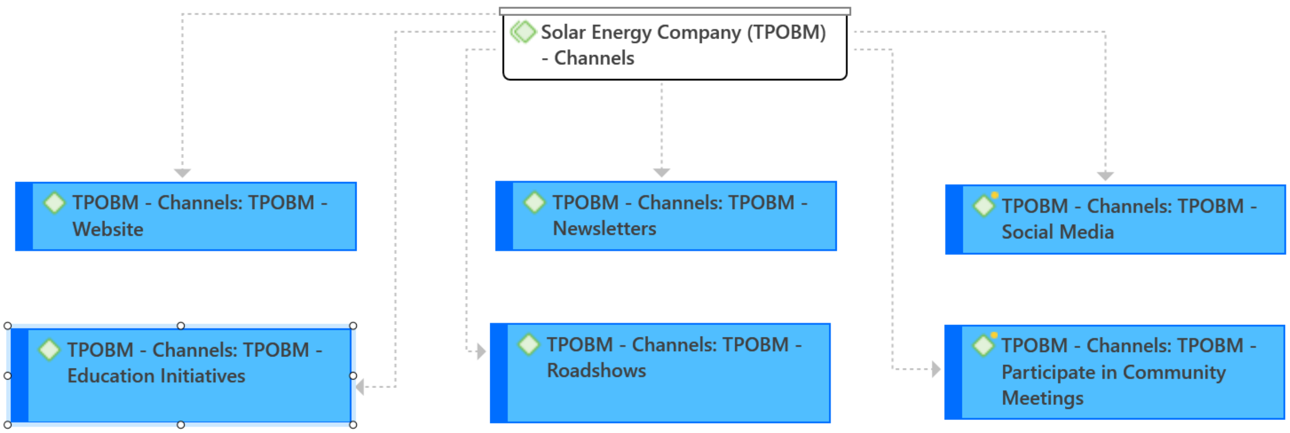
The participants highlighted the significance of developing strong relationships with managing agents within community schemes to adopt solar energy solutions successfully. Managing agents were described as key decision-makers whose support could influence the acceptance of recommendations. The participant emphasized the need for open and positive relationships with managing agents to facilitate the proposal of solar solutions to Body Corporates and trustees.

"For me, it's sometimes the managing agents. We often find that they act very much like gatekeepers." "The nicer the relationship you have with them, the more they tend to pass through your recommendations. We often find that if we do not have an open and really good relationship with certain managing agents, they don't even propose this." - **Participant 4**

"We have good relationships with managing agents. But like I said, there's a lot of competition and a lot of these managing agents have their own internal businesses as well. Therefore, we put a lot of effort into our managing agents, fostering those relationships." **- Participant 4**

The participant also stressed the importance of effective communication through word of mouth, personal engagement, cold calls, and emails for managing agents and trustees in decision-making processes related to solar energy adoption.

4.3.2.4 Channels of Solar Energy Company



The participants highlighted various channels a solar energy company uses to engage with the community schemes. These channels include websites, newsletters, social media, education initiatives, road shows, and participation in community meetings. Marketing strategies that included pull mechanisms through social media channels like Facebook and LinkedIn, targeting specific age groups and decision-makers. The importance of communication channels like newsletters, websites, sales representatives, and customer service was emphasized.

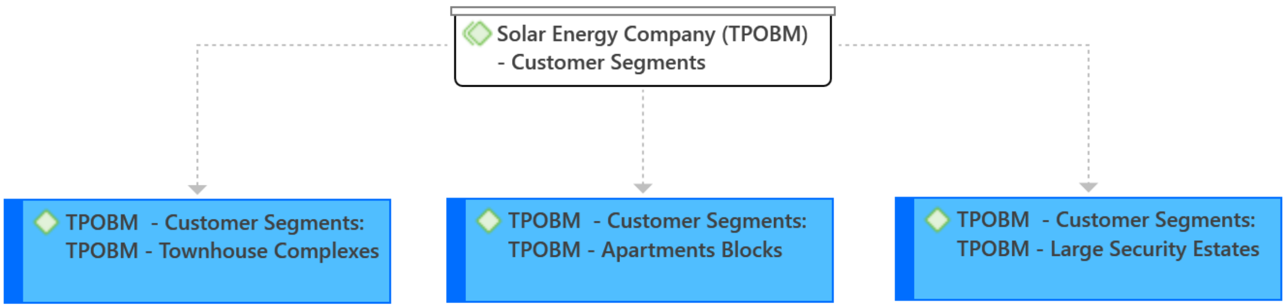
> *"We tend to use pull marketing mechanisms and entertainment. People will go online to do research themselves. So, we make sure that we are on social media channels because a lot of our target audience, for instance on Facebook, is between the ages of 37 to 55 or 60. They tend to be on Facebook or LinkedIn, the same with our managing agents and so forth. That is business to business. Obviously, in our LinkedIn space, we also tend to find that a lot of the decision-makers are usually engineers, etc. So, they also do their research via LinkedIn."* - **Participant 4**

> *"We definitely make sure that we always have an open loop when it comes to communication. You can sign up for our newsletters where we provide education through various angles every month, from tackling solar installations, within Community schemes specifically. So, we have newsletters, we have the website itself, we have our sales guys for face-to-face. Yeah, we have customer service where people can actually come and talk to us or have that line emails, direct communication, those are the other channels"* - **Participant 4**

The participants highlighted that case study videos and training help educate stakeholders and address psychological factors influencing decision-making.

"The way to influence and persuade people is always through proof in the pudding. So, showing people through case studies, project videos, and other types of snippets really assists in people's understanding. Once they understand something, they tend to be more open to adopting it" - **Participant 4**

4.3.2.5 Customer Segments of Solar Energy Company

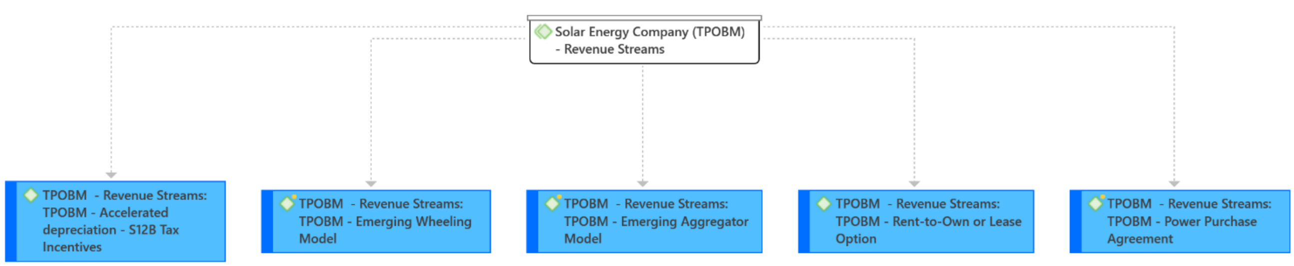


The findings from the participants' responses regarding customer segments for a Solar Energy Company highlight the potential for solar energy adoption in various residential complexes, specifically townhouse complexes, apartment blocks, and large security estates. The participant noted that large security estates with ample land space and carports are more likely to invest in solar energy infrastructure, such as ample storage containers and solar panels, which makes the power purchase agreements viable due to the economic scale.

"They have the land needed for this. They have the land, they come in and put batteries in large containers for storage. Yes, and if you have open land or carports and such where you can put the solar panel" - **Participant 3**

"Again, our main focus is centralized systems, so we always go for a viability study, etc., beforehand. We prefer for it to be viable for us. It's usually that a complex has to have about 30 units minimum to get the maximum return on investment." **- Participant 4**

4.3.2.6 Revenue Streams of Solar Energy Company



The participants highlighted various revenue streams for a solar energy company, focusing on power purchase agreements (PPAs), Section 12B tax incentives, rent-to-own or lease options, emerging wheeling and aggregator models, and partnerships with Body Corporates. The participant highlighted the preference for PPA structures over ownership models due to long-term viability concerns and highlighted the benefits of section 12B tax incentives on project feasibility for an organisation registered as a company and its application in reducing tariffs for community schemes. The participants highlighted that on the PPA structure, the electricity that the community schemes pay for is 30% less than utility and municipality tariffs.

"Our solution is that you either pay for the electricity you use, which is usually up to 30% less than your Council tariff because we use the sun to generate most of the electricity." - **Participant 4**

"Our organisation, we take advantage of the 12B allowance in the funding structure. That's how we are able to pass on the 12B benefit to the community schemes, which essentially results in a lower tariff and makes these projects commercially feasible." - **Participant 7**

"Last year (2023) in March, they increased the 12B allowance from 100% to 125%. This means that any renewable asset you purchase, let's say a company purchases 1,000,000 Rand worth of renewable assets, they are able to write off 125% of that asset against taxable income. This would reduce their tax payable at the end of the financial year' **- Participant 7**

The participants highlighted the rent-to-own options and emphasised the affordability and benefits of rental options.

"Some partnership with Body Corporates where there could be options. You know, mostly those will just be rental options where a service provider will go and then offer alternative power supply at no cost to the complex, and then they can just do a rental payment of 36, 48, and 60 months. Yeah, depending on the affordability" - **Participant 3**

The participants highlighted the wheeling model as a potential model for revenue stream. They described the process of selling excess power to off-takers and municipal involvement in wheeling agreements in supporting Solar PV technology in community schemes.

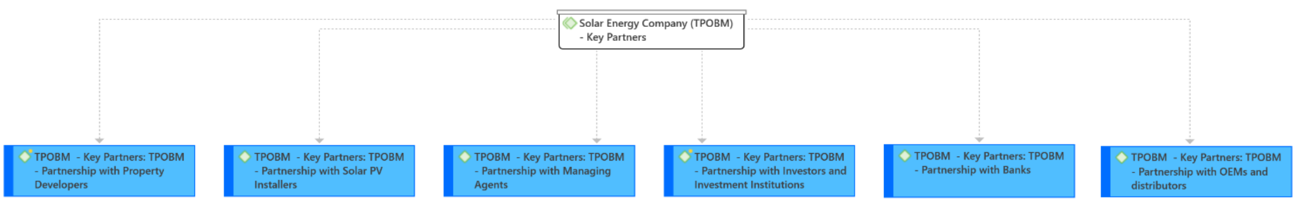
"As the Body Corporate , along with the rest of the Body Corporate , get into an agreement that we have sold power to, let's say, Blue Light Steel Manufacturers for 20 years. They have said that they want to buy X amount of power. Then we're left with this other Z amount of power. We go back to the municipality and say, 'Hey, listen, because we're going to be wheeling our power to our customer, don't you want to then buy the remaining power? From the part that will be wheeling, you take X amount of power for your network and then you wheel the rest to our customer.' The municipality will agree." - **Participant 5**

In addition, the participants highlighted the evolving aggregator model and its role in balancing supply and demand in the electricity market by guaranteeing 100% availability of electricity on dynamic pricing.

"But now, the difference is that you've got the suppliers of these renewable energy companies agreeing on saying that they're going to be generating 10 MW for argument's sake. On the other hand, you also have the demand centre, your aggregators who are purely there to understand if they can get 10 megawatts demand that they will be able to supply from this supply that they have. Now the deal here is that you've got the middlemen, who are purely there to ensure that they balance the supply and demand throughout, and the contract now is no longer long term. It's day-to-day." - **Participant 14**

The participant also noted the advantages of their organisation's deep understanding of community schemes, which allows for the provision of credit enhancements and compelling collection of funds from community schemes.

4.3.2.7 Key Partners of Solar Energy Company

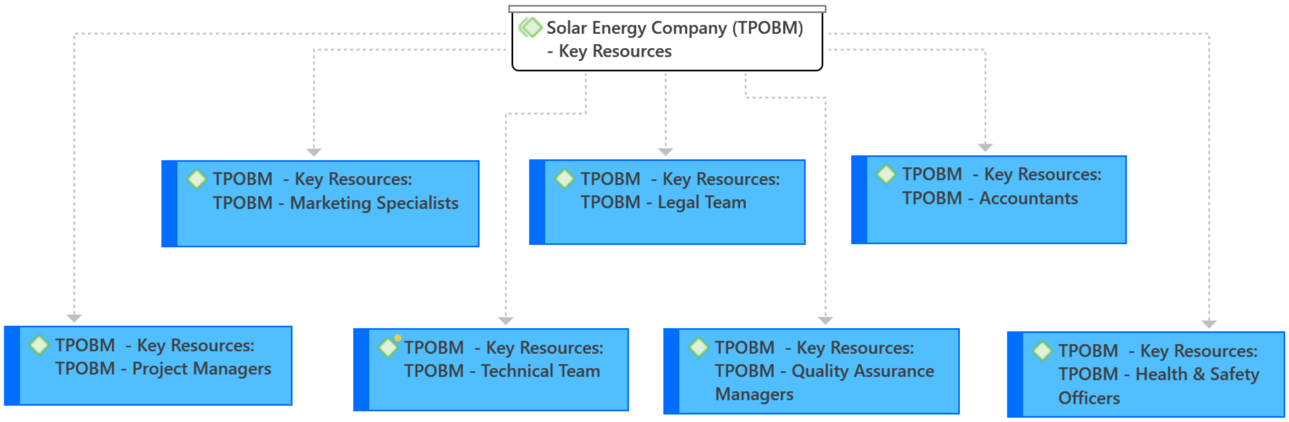


The findings from the participants' responses regarding key partnerships for a solar energy company revealed several important insights. Participants highlighted the importance of partnerships with property developers, solar PV installers, managing agents, OEMs and distributors, investors, investment institutions, and banks, as discussed in section 4.3.1.7.

They highlighted the importance of collaboration with investors and investment institutions to secure funding for solar projects and ensure financial viability.

Partnerships with banks were seen as key to addressing the financial challenges associated with solar energy projects.

4.3.2.8 Key Resources of Solar Energy Company



The participants highlighted key resources necessary for a solar energy company, focusing on roles such as marketing specialists, legal teams, accountants, project managers, technical teams, quality assurance managers, and health and safety officers. Marketing was emphasized as essential for raising awareness within the community and engaging with sectional-title properties through Body Corporate s.

"Marketing is one of them. Marketing will come with education. Because if you are not marketing, the larger community within the sectional title will not know that there are these offerings. But if you're marketing to them, it's even easier to market through the Body Corporates of the sectional-title properties because you can reach the mass right instead of just marketing to the individuals." - **Participant 3**

"We need resources like marketing specialists, and social media resources so that we can market these solutions." **- Participant 7**

The legal team was noted for its expertise in navigating legal agreements related to electrical services and supplies, ensuring smoother implementation of solutions. Participants stressed the importance of having a knowledgeable legal team to handle legislative matters and resolutions effectively.

"We definitely need to get a substantial legal team who knows the legislation, the adoption of resolutions" - **Participant 4**

As part of the technical team, an owner's engineer was described as crucial in project development, conducting preliminary studies, determining power capacity, overseeing construction, and facilitating necessary permits and clearances. This role was considered integral in preparing procurement documentation and financial models for solar projects.

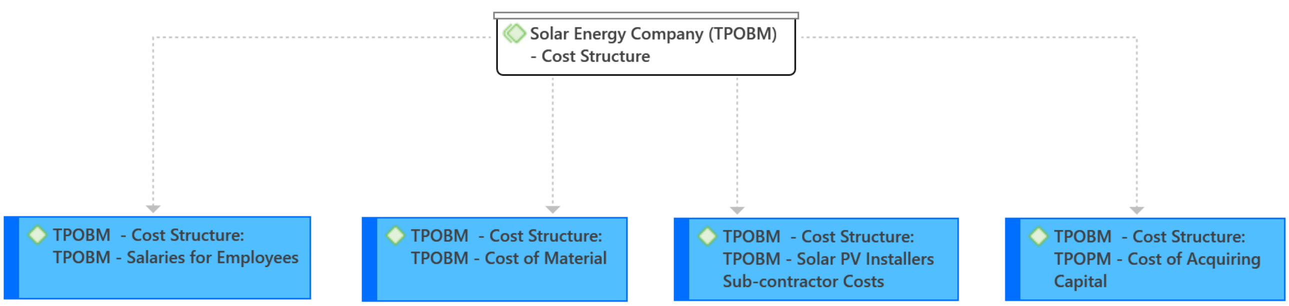
"The owner's engineer is also responsible for helping with fundraising in most cases. You cannot develop a financial model without that conceptual design because that conceptual design says that I

want X amount of money to be able to build approximately X number of megawatts of power on my roof. This is the tariff that I'm projecting, this is how my system is going to be operating within a month, a daily profile, or an annual profile. This is how much power I expect to generate during the day. All of those designs are plugged into the financial model before they get started. So, an owner's engineer does that." - **Participant 5**

The need for a diverse range of internal and external resources was emphasised, including engineers, accountants, technicians, electricians, project managers, health and safety officers, quality assurance managers, and marketing specialists. These resources were deemed essential for ensuring the longevity and success of solar energy solutions.

"Some of the resources are internal, and some of them are external. We need everything from engineers to accountants, technicians, and electricians. We also need project managers, health and safety officers, and quality assurance managers. Obviously, these are solutions that we want to ensure last for 20 years, and that is part of what we need." - **Participant 7**

4.3.2.9 Cost Structure of Solar Energy Company



The participants highlighted key cost structures for a solar energy company, including employee salaries, sub-contractor costs, cost of materials, and cost of acquiring capital. They emphasized the need for a substantial legal team, partnership with EPCs, administrative management, securing funding, and deploying assets. The adoption of batteries was mentioned as part of the business model, with savings from tariffs used to pay off batteries. The organisation raises capital from financial institutions for renewable asset deployment in community schemes. Various resources are required, both internal and external, such as engineers, accountants, technicians, electricians, project managers, health and safety officers, quality assurance managers, marketing specialists, and social media resources to ensure long-lasting solutions.

4.3.3 Summary of Findings On Research Question Two

Business Model Canvas Activities	Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)	Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)
Value Proposition	• Enable solar PV uptake and upscale. • Offering package deals • Longer warranty periods as a value-add. • Offering maintenance services as a value-add • Enable access to individual tax benefits	• Enable solar PV uptake, upscale and saturation. • Support with the SSEG application process • Capital cost coverage. • Lowering electricity costs • Removal of maintenance tasks and costs • Uninterrupted electricity assurance • Maintenance and operation of the solar PV system • Support with peak-loads shifting. • No increase in levies due to solar adoption • Warranty coverage • Free system replacement • Enable access to economic, energy security, social and environmental benefits.
Key activities	• Marketing and sales • System design • Sourcing and technology procurement	• Acquiring and managing capital • Marketing and sales • Facilitate power purchase agreements.

Business Model Canvas Activities	Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)	Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)
	• O&M services • Project hand-over and issuing of Certificate of Compliance • Training and development of accredited installers • Collaboration with industry stakeholders	• Project management • Sourcing and supplier selection • Construction supervision • Risk management • System operation and maintenance services
Customer Relationship	• Online contact • Personal interactions • Word of mouth	• Online contact • Personal interactions • Word of mouth
Channels	• Website • Social media • Roadshows (led by banks) • Flyer's advertisement • Education initiatives • Meetings with managing agents and trustees • Participate in community engagements.	• Website • Social media • Roadshows • Newsletters • Education initiatives • Meetings with managing agents and trustees • Participate in community engagements.
Customer Segments	• homeowners • apartment blocks • townhouse complexes	• apartment blocks • townhouse complexes • large security estates

Business Model Canvas Activities	**Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)**	**Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)**
Revenue Streams	• security deposits • design preparation • PV system supply and installation • Issuing of COC • O&M services	• Power purchase agreement • Rent-to-own option • Accelerated depreciation – S12B tax incentives. • Emerging wheeling model • Emerging aggregator model
Key Partners	• Partnerships with OEMs and distributors • Partnership with banks • Partnership with property developers • Partnership with solar energy companies	• Partnerships with OEMs and distributors • Partnership with banks • Partnerships with investors and investment institutions • Partnership with property developers • Partnership with solar PV installers companies
Key Resources	• Engineering team • Construction team • Operations and maintenance team • Vehicle and tools	• Marketing Specialist • Legal team • Accountants • Project Managers • Technical team • Quality Assurance Managers • Health and Safety Officers
Cost Structure	• Salaries for employees • Training and accreditation	• Salaries for employees • Cost of material

Business Model Canvas Activities	Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)	Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)
	• Cost of vehicles • Cost of material • Cost of tools	• Sub-contractors (Solar PV installers) cost • Cost of acquiring Capital

4.4 Conclusion

The research findings were derived solely from the data gathered within this study. External data was excluded, confining the results to the insights from the 14 interviewees.

To summarise the key finding per proposition based on the research questions:

Research question one: What are the factors that hinder or facilitate solar PV technology adoption in sectional-title and townhouse community schemes segment of the residential market in South Africa?

a) Factors that hinder the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

The participants affirmed that social barriers, institutional, policy and legislative barriers, financial barriers, land, building and roof resources barriers, and company resources barriers pose challenges to adopting solar PV technology in sectional-title and townhouse community schemes in South Africa. Notably, stakeholder collaboration emerged as a new finding and was grouped with social barriers in theme 1. In addition, supply chain challenges emerged as new findings and were grouped with company resource barriers in theme 6.

- Firstly, the Social and Stakeholders Collaboration Barriers highlight the critical role of education, awareness, and trust in influencing the adoption of solar technology. Misconceptions, lack of information, and concerns about unscrupulous installers contribute to a reluctance to invest in solar PV systems. Additionally, the lack of engagement and support from industry stakeholders further exacerbates the challenges faced by community schemes.
- Secondly, the Institutional, Policy, and Legislative Barriers underscore the importance of a conducive regulatory environment for the successful integration of solar PV technology. Issues such as restrictive policies, bureaucratic inefficiencies, and governance restrictions within Sectional-title legislation hinder the implementation of solar projects.

- Financial Barriers emerge as a significant impediment to the adoption of solar technology, with high installation costs, budget constraints, and limited incentives posing challenges for Body Corporates. The lack of funding options, high interest rates, and financial management issues compound community schemes' financial difficulties.
- Land, Building, and Roof Resources Barriers highlight the physical limitations and structural constraints that impede the installation of solar PV systems. Issues such as inadequate roof space, shared resources, and shading problems present obstacles to the widespread adoption of solar technology. Technical and Technological Barriers emphasise grid integration, metering systems, and equipment compliance complexities. Safety concerns, metering limitations, and technology reliability issues present substantial obstacles to the successful execution of solar projects in community schemes.
- Lastly, Company Resources and Operational Barriers point to the shortage of skilled resources, reliance on imported technology, and supply chain challenges as key obstacles to the successful adoption of solar PV technology. The lack of qualified installers, innovation, and local manufacturing capabilities hinder the scalability and sustainability of solar projects.

b) Factors that facilitate the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

The participants affirmed that factors such as social influence, incentives, policy and legislative instruments, perceived benefits and funding instruments are facilitators for adopting solar PV technology in the sectional title and community schemes. In addition, several factors have emerged from the research findings, which include severity and frequency of load-shedding, stakeholders and industry influence, national and local government role towards SSEG applications, easing of the regulatory landscape for Body Corporates, and commercial viability of projects.

- The results indicate that the severity and frequency of load-shedding play a significant role in driving the need for alternative energy resources, particularly solar power. This finding underscores the importance of reliable and sustainable energy solutions in the face of ongoing challenges with the national grid.
- Furthermore, the interplay of industrial, stakeholder, and societal influences has been identified as crucial in promoting the uptake of solar PV technology. Social influences, such as public education, community engagement, and early adopters in affluent areas, raise awareness and foster a culture of environmental consciousness. Stakeholder advocacy for favourable regulations and policies, industry advancements in technology, and collaboration also play a pivotal role in facilitating the transition to solar energy.

- Incentives, policies, and legislative instruments have been highlighted as key drivers in supporting the adoption of solar PV technology and improving solar PV investment returns. The role of national and local governments in creating an enabling environment through policy formulation and implementation and providing incentives such as tax credits and feed-in tariffs are crucial in incentivising investment in solar energy projects. Additionally, easing the regulatory landscape for Body Corporates by supporting solar installations and amending rules further promotes the integration of solar power within community schemes.
- The economies of scale and effective management of community schemes, as well as sub-metering and recovery of electricity costs used by residents in a community scheme, support the commercial viability of solar projects. The perceived benefits of solar PV technology, including economic, environmental, social, and energy security benefits, highlight the multifaceted advantages of transitioning to solar power within community schemes. These benefits range from reduced electricity bills and greenhouse gas emissions to enhanced safety, security, and energy independence.
- Moreover, funding instruments such as Body Corporate funds, homeowner bank loans, and commercial bank finance play a crucial role in facilitating the financial viability of solar projects. Access to investor funding through power purchase agreement structures further supports the scalability and sustainability of solar energy initiatives within community schemes.

In conclusion, the findings suggest that regulatory support, stakeholder engagement, financial incentives, and awareness-building efforts are essential in promoting the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes. By addressing the various factors influencing decision-making processes and highlighting the benefits of solar energy, stakeholders can strive for a future of community living environment that is both more sustainable and resilient in terms of energy.

Research question two: What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional title and townhouse community schemes in South Africa?

The business model canvas activities for solar PV installers focusing on the Customer-Owned Business Model (COBM) and solar energy companies concentrating on the Third-Party Owned Business Model (TPOBM) reveal distinct value propositions, key activities, customer relationships, channels, customer segments, revenue streams, key partners, key resources, and cost structures.

- The COBM **value proposition** emphasizes enabling solar PV uptake and upscale, offering package deals, more extended warranty periods, maintenance services, and access to individual tax benefits. On the other hand, the TPOBM value proposition highlights enabling solar PV uptake, upscale, and saturation, supporting the SSEG application process, covering capital costs, lowering electricity expenses, providing uninterrupted electricity assurance, and offering numerous benefits.

- **Key activities** for COBM include marketing, system design, sourcing, O&M services, project hand-over, training of installers, and collaboration with stakeholders. In contrast, TPOBM's key activities involve acquiring and managing capital, marketing and sales, facilitating power purchase agreements, project management, supplier selection, construction supervision, risk management, and system operation and maintenance services. **Customer relationships** for both models focus on online contact, personal interactions, and word of mouth. At the same time, channels encompass websites, social media, roadshows, advertisements, education initiatives, and community engagements.
- **Customer segments** for COBM and TPOBM target homeowners, apartment blocks, townhouse complexes, and large security estates. Revenue streams for COBM include security deposits, design preparation, PV system supply and installation, COC issuance, and O&M services. In contrast, TPOBM revenue streams consist of power purchase agreements, rent-to-own options, tax incentives, and emerging models. **Key partners** for both models involve OEMs, distributors, banks, property developers, investors, and solar energy companies. In contrast, **key resources** vary from engineering, construction, and operations teams to marketing specialists, legal experts, accountants, project managers, and technical staff.
- **Cost structures** for COBM encompass salaries, training, vehicle, material, and tool costs. At the same time, TPOBM involves salaries, materials, subcontractor expenses, and capital acquisition costs.

These findings underscore the diverse strategies and operational aspects of solar PV installers and energy companies catering to different customer needs and market dynamics.

5 DISCUSSION OF THE RESEARCH FINDINGS

5.1 Introduction

This chapter delves into the findings presented in Chapter 4, drawing connections to the literature review in Chapter 2 and the propositions posed by the research questions. The data summarised in Chapter 4 has been instrumental in identifying 14 key themes that overlap among the responses from various study participants. This chapter demonstrates how these key themes contribute to answering the research questions posed in this study.

5.2 Discussion On Research Question One

What are the factors that hinder or facilitate solar PV technology adoption in sectional-title and townhouse community schemes segment of the residential market in South Africa?

The discussion of the findings of this question is divided into sub-sections 5.2.1 and 5.2.2.

5.2.1 Discussion on factors that hinder the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

5.2.1.1 Theme 1: Social and Stakeholders Collaboration Barriers

Common misconceptions about solar energy, exemplified by the erroneous belief that solar panels obstruct rainfall, have been underscored as significant impediments to its acceptance (Participant 3), as behavioural barriers, personal values, and norms were identified as substantial social factors affecting attitudes towards distributed energy investments (Cai et al., 2019; Horváth & Szabó, 2018). A prevailing resistance to these technologies was observed, with a lack of education and a shortage of information about renewables, a poor knowledge base, and misinformation about the benefits of renewable technologies identified as critical factors contributing to this resistance (Horváth & Szabó, 2018).

The lack of social awareness about solar PV technology was highlighted as a hurdle in developing solar PV systems, particularly in developing countries such as South Africa (Horváth & Szabó, 2018). Customer awareness and acceptance were underscored as essential in the renewable energy market, with a shortage of information and misinformation about renewable technologies posing challenges to their deployment (Raina & Sinha, 2019).

Furthermore, stakeholders such as trustees, body corporates, and managing agents were identified as key decision-makers influencing the adoption of solar technology. Managing Agents were described as gatekeepers whose relationships with stakeholders could impact the consideration of solar technology recommendations (Participant 4). The study also revealed challenges related to stakeholder collaboration, lack of communication and sharing information with participants due to ambiguous responsibilities and relationships among relevant departments (Horváth & Szabó, 2018), noting that siloed work within the industry is a significant barrier to advancing solar PV adoption efforts, resulting in low awareness, trust, and acceptance of solar PV technology among potential users and beneficiaries (Mah et al., 2018).

Effectively managing customer social factors, engaging with local communities, providing education and awareness programs, and dispelling misconceptions about renewable energy are essential steps towards successful project implementation and broader adoption of sustainable energy sources (Cai et al., 2019; Carlisle et al., 2015). By increasing awareness and knowledge about renewable energy technologies, stakeholders can work towards overcoming social barriers and fostering a more sustainable energy future.

5.2.1.2 Theme 2: Institutional, Policy and Legislative Barriers

The installation of solar PV systems into existing electricity grids poses significant challenges due to the lack of foresight and proactive planning by municipalities, which is exacerbated by fragmented policies, lack of strategic planning, and poor policy development and implementation, hindering the deployment of solar PV technology (Cai et al., 2019; Horváth & Szabó, 2018). Participant responses underscore the disconnect between current infrastructure capabilities and future energy trends, particularly customers' increasing adoption of solar PV systems. This inadequacy in predicting disruptions leads to technical challenges and operational inefficiencies within utility distribution grids (Participant 12).

The process of obtaining permits for solar PV installation necessitates obtaining permits from diverse levels of government and several regulatory agencies, resulting in delays and increased costs (Swartz, 2019; J. Walters et al., 2018). Streamlining approval processes, enhancing institutional capacity, implementing clear regulatory frameworks, and providing targeted incentives can accelerate the deployment of solar PV systems (Raina & Sinha, 2019; J. Walters et al., 2018).

Property developers and body corporates also face challenges in installing solar PV systems within communal setups due to restrictive Sectional Title Act regulations and complex dynamics within body corporates, hindering the widespread adoption of rooftop solar panels in such environments (Participant 3). There is a need for clear and consistent regulatory frameworks that can facilitate the installation of solar PV into the electricity grid. The absence of formal communication channels, inadequate policy frameworks within the municipalities, A lack of a clear and consistent SSEG policy among the municipalities results in confusion, uncertainty, and increasing risks for communities that want to adopt the technology (Horváth & Szabó, 2018). For instance, there is a lack of clarity on how the SSEG supports net metering or feed-in tariffs for SSEG systems that can enable selling excess power generated by solar PV to the grid and the deficiencies in the billing system, further exacerbating the challenges faced in adapting existing infrastructure to accommodate renewable energy technologies (Participant 10). The results affirm that local government departments are experiencing a shortage of skilled engineers capable of designing, assessing, and overseeing solar PV projects (Mah et al., 2018) as a result of a lack of capacity, coordination, and cooperation among the various institutions tasked with planning, regulating, executing, and monitoring renewable energy policies and initiatives (Participants 5, 12)

Addressing these challenges through coordinated efforts, streamlined processes, and supportive policies is crucial for overcoming barriers and promoting the successful integration of solar PV technology into existing electricity grids.

5.2.1.3 Theme 3: Financial Barriers

One of the primary financial barriers identified in the study is the significant initial investment required to install solar PV systems, as highlighted by participants (Cai et al., 2019; Kuang et al., 2022; Xue et al., 2021). The high upfront costs pose challenges for homeowners and small businesses, particularly considering the extended payback period associated with such investments (Kuang et al., 2022; Sewchurran & Davidson, 2021). The lack of economies of scale in the residential segment further complicates matters, discouraging investments in Distributed Energy markets (Horváth & Szabó, 2018; Wirth & Schneider, 2015).

Moreover, the study underscores the limited availability of financing options for residential customers, a common barrier to solar PV adoption in other countries. In various countries, including China, financing difficulties have hindered the development of small-scale solar PV projects, with investors wary due to policy uncertainties, small project scales, and high investment risks (Cai et al., 2019). Banks' preference for large-scale projects receiving government subsidies leaves smaller projects struggling to secure funding (Cai et al., 2019). They often resort to short-term loans such as personal loans, credit cards, mortgage financing, or overdrafts with high interest rates due to the stringent affordability regulations of the National Credit Act 34 of 2005 (Cai et al., 2019; McKay & Hendricks, 2022).

The study also highlights the impact of low electricity tariffs on solar PV adoption. With household electricity consumption relatively low and domestic electricity fees inexpensive, the profitability of solar PV installations is questioned (Cai et al., 2019). Additionally, the lack of a clear return on investment and extended payback periods make it challenging for potential investors to justify the costs associated with solar PV technology.

The findings underscore that revenue unpredictability and minimal profits pose substantial barriers to the adoption of solar PV technology. This situation mirrors that in China, where the absence of a definitive policy on compensation for excess power exported to the grid hinders progress. Additionally, the lack of a robust credit system in South Africa and the hesitation of the body corporates of community schemes to levy special charges for solar PV projects further deter investment in this technology (Cai et al., 2019).

The study's findings shed light on the multifaceted financial challenges hindering the widespread adoption of solar PV technology in communal living spaces. Addressing these barriers will require tailored financial incentives, transparent risk assessment, and financing models catering to community schemes' unique needs. Policymakers and stakeholders must collaborate to develop strategies that promote affordability, accessibility, and sustainability in adopting alternative energy solutions within sectional-title and townhouse community schemes.

5.2.1.4 Theme 4: Land, Building and Roof Resources Barriers

One of the primary obstacles identified was the need for adequate space for solar installations. Participants emphasised that most complexes only have access to rooftops for potential solar panel placement. However, it was highlighted that having a suitable roof was crucial, with the ideal orientation facing the north side to maximise solar irradiance harvesting (Participant 3).

The structural integrity of the building, particularly the ability of the roof to support the weight of solar panels, was also a key consideration in decision-making processes (Participant 3). Retrofitting solar systems in existing complexes was recognised as challenging due to the transition of ownership from developers to Body Corporates (Participant 1). Concerns were raised about limited space within complexes, as units often occupied available areas, thereby complicating the task of identifying appropriate sites for installing solar panels. Larger systems requiring more space posed challenges in complex setups (Participant 5).

The literature supports these findings by highlighting the complexities of installing PV systems in urban areas with multi-unit buildings. Negotiating with residents and property departments in such areas can be challenging due to the time required and difficulties in reaching a consensus among residents (Cai et al., 2019). The ownership structure of rooftops in urban cities, where rooftops are collectively owned, such as sectional titles and townhouse community schemes, adds another layer of complexity to the installation process. In contrast, finding available rooftops for customers with detached standalone houses in large security estates is relatively more straightforward (Cai et al., 2019).

The barriers related to land, building, and roof resources present significant challenges to adopting solar PV technology in sectional-title and townhouse community schemes in South Africa. Addressing these barriers will require careful consideration of space requirements, building structural integrity, and consensus on using the rooftop for sectional title and townhouse community schemes. Collaboration among residents, property departments, and stakeholders will be essential in overcoming these challenges and encouraging the extensive implementation of solar PV systems in residential sectional-title and townhouse community schemes.

5.2.1.5 Theme 5: Technical and Technological Barriers

Several significant insights were derived from the research on the technical and technological challenges faced with integrating solar PV systems into the grid. The participants highlighted safety concerns raised by utilities regarding exporting power into the grid, cautioning that with solar PV integration into the gird, the energy flow will alternate between the consumer and the grid and reciprocally from the grid back to the consumer, so in case of troubleshooting during faulty conditions and maintenance, utility staff are at risk of being electrocuted (Participant 12). As a result, the utilities have developed a regulatory framework, the grid-code and the NRS097 standard that will guide the installation of solar PV equipment, such as the inverter, to ensure that no power flows to the grid when the grid is off. However, cheaper inverters may not comply with that requirement. The municipalities have developed an SSEG application process for customers to apply for the solar PV system to be checked and tested for compliance (Participant 12).

Technological challenges related to compliance with grid-code and standards were identified, with participants noting the higher costs associated with inverters that meet regulatory requirements (Participant 10). Participant 5 argued that the reliability and quality of power supply were emphasised as critical responsibilities for utility, mainly when selling excess power to industrial consumers, requiring compliance with the grid-code requirements (Participant 5).

The literature supports these findings by highlighting the technological barriers faced in renewable energy markets, particularly in developing countries. Challenges such as low conversion efficiency, the inability to respond quickly to load demand, and the intermittent nature of solar radiation impact the cost-effectiveness and reliability of solar PV technology. However, battery banks can help mitigate this problem. They also increase the cost and size of the plant (Raina & Sinha, 2019). Quality control and standardisation are crucial for overcoming these barriers (Raina & Sinha, 2019).

The difficulty in separating essential and non-essential loads within complex community schemes further complicates power distribution, raising cost implications that may be prohibitive for complex owners and residents (Participant 1). Additionally, sub-metering restrictions in older community schemes hinder the commercial viability of installing solar systems due to the location of utility metering points within individual units (Participant 7).

Furthermore, limitations in net-metering capability on some of the existing meters and manual billing processes using spreadsheets add to the challenges faced in integrating solar power into the grid (Participant 10). The study also highlighted the need for utility meters to accurately differentiate between power generated by customers and power supplied by the grid for fair billing practices (Participant 10). Challenges in adapting billing systems to accommodate solar power integration were noted, emphasising the importance of proactive measures to ensure equitable compensation for customers (Participant 12).

5.2.1.6 Theme 6: Company Resources and Operational Barriers

The findings from the study shed light on the challenges solar companies face in the industry, particularly in the context of South Africa. The research revealed several key issues hindering the effective implementation and adoption of solar photovoltaic (PV) technology. One of the primary challenges identified was the shortage of skilled resources, specifically in electrical engineering. Participants highlighted the difficulties in accessing qualified personnel, citing high costs and a lack of availability of qualified electricians and engineers as significant obstacles to deploying solar solutions. This shortage of skilled resources was noted to impede the effective utilisation of solar PV technology within organisations (Participant 7).

Moreover, the study highlighted concerns regarding using unqualified installers, commonly called "bakkie brigades," for solar installations (Participant 4). The reputation of solar energy has suffered due to unscrupulous installers who sell inferior products, overcharge customers, and neglect post-sales service and maintenance (McKay & Hendricks, 2022). Participants emphasised the safety risks associated with employing unqualified installers, such as fire hazards and the lack of accountability in such instances (McKay & Hendricks, 2022). The need for qualified and reputable installers was underscored as essential for ensuring the safety and efficacy of solar PV installations (Participant 4).

Beyond the constraints of resources, the study pinpointed concerns associated with managing the supply chain within the solar sector. Participants noted that essential components of solar systems, including batteries, inverters, and solar panels, are predominantly imported from Europe and China due to the limited local manufacturing capacity in South Africa. This reliance on imported solar products was highlighted as a significant challenge, leading to shortages during periods of high demand and price escalations. Participants emphasised the supply chain's vulnerability and the potential impact on end-users due to these challenges (Participant 3).

The study also emphasised the importance of innovation and market visibility for companies operating in the solar sector. Participants highlighted the need for companies to conduct more research, tailor their approach to target audiences, and increase visibility to enhance market acceptance of solar PV technology (Horváth & Szabó, 2018). The lack of innovation and market engagement were identified as barriers to the broader adoption of solar solutions (Participant 9).

Furthermore, concerns were raised regarding price fluctuations driven by inverter suppliers, who justified higher prices based on compliance requirements and research and development costs. Participants cautioned against stakeholders capitalising on supply chain challenges to inflate prices, emphasising the importance of solutions that prioritise the interests of residents and communities over profit motives (Participant 10).

The outcomes of the results corroborate the assertions made in prior scholarly work, highlighting the significance of organisational abilities and managerial expertise in surmounting obstacles to the adoption of solar technology. Research has shown that a lack of technical competence and business skills can impede energy companies' value creation and operational efficiency, particularly in developing countries such as South Africa. To be competitive in the residential customer segment, utilities and energy companies must build their product and service portfolios to cater to customers' needs in the residential sectional-title and townhouse community schemes (Horváth & Szabó, 2018).

5.2.2 Discussion on factors that facilitate the adoption of Solar PV Technology in Sectional-title and Townhouse Community Schemes

5.2.2.1 Theme 7: Frequency and Higher Stages of Load-Shedding

The research findings presented shed light on the significant impact of load-shedding severity and frequency on the necessity for alternative energy resources, particularly in the context of South Africa. The study highlighted the pivotal role of the government's strategy in influencing community responses to load shedding, with participants expressing a sense of familiarity and acceptance towards scheduled power outages. This acceptance has led to a level of adaptation among residents, who have adjusted their daily routines to accommodate the occurrence of load shedding (Participant 2). This finding affirms the work done by McKay and Hendricks (2022) that the intermittent nature of load shedding makes customers forget the inconvenience caused by load-shedding.

Moreover, the study emphasised the correlation between the severity and frequency of load shedding and the decision-making process regarding investment in backup solutions, such as solar PV technology. Participants noted that as load shedding escalates to higher stages, there is a surge in demand for backup solutions, especially among individuals working from home who require an uninterrupted power supply. This observation underscores the direct relationship between the intensity of load shedding and residents' willingness to explore alternative energy sources (Participant 7), which aligns with findings in the study by McKay and Hendricks (2022).

Furthermore, the research highlighted the role of load-shedding frequency in driving community schemes to consider renewable energy solutions. Areas experiencing minimal or no load shedding may lack the motivation to invest in backup solutions, as the continuous power supply diminishes the urgency for alternative energy sources (McKay & Hendricks, 2022). This dynamic underscores the influence of load shedding on the decision-making process of community schemes regarding the adoption of solar PV technology (Participant 7).

5.2.2.2 Theme 8: The Interplay of Industrial, Stakeholder and Societal Influences

The findings from the research on factors influencing the adoption of solar PV technology in community settings shed light on various sub-themes, including Social Influence, Stakeholders Influence, and Industry Influence. Within the sub-theme of Social Influence, awareness, community engagement, and early adopters were identified as key factors driving the adoption of solar technology. Individuals with knowledge and connections were found to take the initiative to install solar panels, emphasising the importance of education in demystifying myths and complexities surrounding solar energy (Participants 2, 4, 5). Community engagement and education were highlighted as essential for fostering openness to adopting solar technology, as Carlisle et al. (2015) alluded to, with efforts to highlight success stories and provide case studies being emphasised (Participants 4, 11). Horváth and Szabó (2018) proposed that solar PV installers could foster knowledge sharing by arranging conferences, workshops, educational initiatives, home meetings, and community engagements.

The literature supports the findings of this research, indicating that social influence factors such as social pressure and the desire to be role models can significantly impact individuals' decisions to adopt new technologies like solar PV (Kastner & Wittenberg, 2019; Palm, 2018; Rai et al., 2016). Peers, colleagues, and friends can influence adoption through positive feedback and social pressure. At the same time, some individuals may adopt solar technology to highlight their environmental concerns or desire to be role models (Schelly & Letzelter, 2020).

Moreover, stakeholders' influence was deemed crucial in advocating for favourable regulations and policies and facilitating partnerships and collaboration within the industry (Participant 14, 5). National roadshows and awareness-building initiatives were identified as effective strategies for engaging stakeholders and promoting the benefits of solar technology adoption.

In the realm of Industry Influence, technological advancements such as smart meters and improved efficiency of equipment were noted to play a significant role in driving the adoption of solar PV technology (Participant 1), as this type of meter facilitates net-metering and feed-in tariff policies by accurately measuring consumed power from the grid and exported power from the customer solar PV system (Song et al., 2016). Access to qualified installers through training and certification was highlighted as essential for reducing installation costs and fostering competition among installers (Participant 11). Additionally, partnerships and collaborations among manufacturers, distributors, and installers were emphasised as critical drivers for competitive pricing and enhanced service offerings within the solar PV industry (Participant 11).

In essence, the study highlights the crucial role of social influence, active stakeholder participation, and industry progress in promoting solar PV technology use in communal environments. The solar sector can expedite the shift towards eco-friendly energy alternatives by capitalising on these elements and encouraging cooperation among essential stakeholders.

5.2.2.3 Theme 9: Improving Solar PV Investment through the Use of Incentives, Policy and Legislative Instruments

The study delves into the role of national and local governments in promoting small-scale solar energy generation (SSEG) through the adoption of solar PV technology in sectional-title and townhouse community schemes. The participants' responses shed light on various mechanisms and interventions to facilitate the uptake of renewable energy technologies. Government bodies such as the SALGA and the NERSA were highlighted for their roles in monitoring progress and creating an enabling environment through policy formulation, grid-code development, and financial incentives to support solar PV adoption (Participant 12). Additionally, capacity-building initiatives were deemed crucial to enhance municipal understanding of renewable energy technologies and promote acceptance (Participant 12). These findings confirm that previous studies have suggested that these entities are instrumental in promoting the use of solar PV technology in residential areas by establishing suitable regulations, pricing structures, and incentives (Eberhard et al., 2014; Eberhard & Naude, 2017; Filipova et al., 2019).

Financial resources from international sources, including bilateral agreements with countries like Germany and financial support from entities like the USA and the UK, were noted to fund capacity-building initiatives through not-for-profit organisations aiming to train municipalities on renewable energy technologies (Participant 12). The participants' analysis of the policy landscape surrounding small-scale embedded generation revealed a positive trend towards removing constraints and adopting an inclusive approach in recent years (Participant 14).

Regarding the regulatory landscape for Body Corporates in adopting solar PV technology, participants highlighted the evolution of rules within community schemes to accommodate the installation of solar panels. Residents' growing interest in solar energy prompted legal consultations and rule amendments, leading to proactive changes in conduct rules within Body Corporates (Participant 2). Similar to the findings of McKay and Hendricks (2022), practical benefits of solar energy adoption were emphasised, such as reducing grid reliance during load shedding and mitigated by utilising alternative energy solutions like gas stoves for cooking and gas geysers and solar geysers for heating water within community schemes (Participant 2). Calls for revisions to existing legislation to facilitate quicker resolutions on solar installations within Body Corporates were made, suggesting the need to streamline decision-making processes and grant more voting power to the Body Corporate to represent residents effectively (Participant 3).

Tax incentives were also discussed as pivotal in incentivising solar technology adoption at the individual level. The findings suggest that they are limited to solar PV panels, with suggestions to expand tax incentives to cover additional components like inverters and storage systems (Baker et al., 2014) and cater to Body Corporates in sectional title and townhouse community schemes. Furthermore, the discussion on metering and billing instruments emphasised the importance of advanced metering technologies, bidirectional smart meters, and SSEG Feed-in tariffs in accurately tracking energy generation and consumption within community schemes to aid in improving the returns in investment for solar PV projects (Kharaji Manouchehrabadi & Yaghoubi, 2023).

The findings suggest that balanced policies like Feed-in tariffs (FITs), subsidies, net metering, and tax incentives are crucial in incentivising solar PV adoption (Kharaji Manouchehrabadi & Yaghoubi, 2023). Feed-in tariffs, in particular, have been effective in other countries (such as China, the USA, Italy, Japan, Sweden, Brazil, India, Sweden, Germany, and Australia) in promoting renewable energy adoption by providing financial stability for investors and ensuring a stable financial return over a specified period (IRENA, 2019).

The findings underscore the significant influence of national and local government policies, financial incentives, and regulatory frameworks in promoting the adoption of solar PV technology in sectional-title and townhouse community schemes. The affirmation of participant responses with existing literature highlights the importance of policy support, tax incentives, and metering mechanisms in driving the transition towards sustainable energy practices in residential settings.

5.2.2.4 Theme 10: Economies of Scale of Community Schemes Sub-Metering and Recovery

The principle of economies of scale is underscored when considering solar PV installations in communal living spaces. Participants emphasised that the feasibility of these installations is directly influenced by the number of units in a community scheme. Larger communities tend to be more financially viable due to their economies of scale, which are likely to have a shorter payback period on their solar PV investment than smaller community schemes. Economies of scale make sectional title and community schemes more suitable for service-based business models. These include large-scale solar PV systems facilitated through power purchase agreements or rent-to-own options rather than product-based business models. This finding underscores the significance of scale in determining the financial sustainability of solar PV systems within community schemes.

Furthermore, effectively managing Body Corporate sub-metering and utility metering accounts is crucial for revenue collection and utility account settlement within community schemes. Participants emphasised the role of the Body Corporate in settling utility electricity accounts and collecting revenue from residents of community schemes using sub-metering. Collecting funds from the homeowners through levies and recovery costs for utilities allows community schemes to be sustainable. It enables them to assess their ability to enter long-term power purchase agreements or rent-to-own options.

The findings resonate with previous research by Bloem et al. (2021), suggesting that townhouse developments can offer a conducive environment for solar PV systems due to shared infrastructure and collective decision-making. By leveraging economies of scale and shared resources, residents in townhouse complexes can reduce energy costs, enhance energy security, and contribute to overall sustainability (Bloem et al., 2021).

5.2.2.5 Theme 11: Funding Instruments

The research findings shed light on the critical role of funding mechanisms in facilitating the implementation of solar PV technology within sectional-title and townhouse community schemes. The data in Chapter 4 highlighted the diverse financing options available for solar PV adoption, ranging from individual financing for storage solutions to project loans for community schemes.

One of the sources of funding that can be used by sectional title and townhouse community reserve fund or savings acquired through the collection of levies from the homeowners of the Body Corporate Furthermore, the study revealed the essential requirement of sufficient savings, in alignment with the Sectional Titles Act and the Sectional Title Management Schemes (STMS) Act (Paddocks, n.d), for initiating projects such as solar installations. Participants emphasised the necessity of financial stability within sectional-title and townhouse community schemes to support such initiatives, highlighting that proposing investments without adequate funds could impede adoption efforts (Participant 2, Participant 8).

The concept of offsetting power consumption as a potential incentive for solar energy adoption, which involves renting out roof space for solar panel installation, a practice observed in countries like Australia (Participant 5), will contribute to the reserve fund of the Body Corporate.

The data in Chapter 4 highlighted the pivotal role of banks and other financial institutions in providing the necessary financial assistance in supporting solar initiatives through loans and project funding, enabling individual homeowners or the Body Corporate of community schemes to pursue renewable energy projects (Participant 3, 4,6 13,14). Various sources of funding, including banks, pension funds, private equity, and institutional investors, were cited as potential avenues for financing solar projects within community schemes, which affirms SE4ALL and BloombergNEF (2020) identifying various funding sources for project investments, including international agencies, government subsidies, commercial banks, and individual investors, the study's findings align with the notion that credit support from sponsors is crucial for financing projects.

The literature also highlights the challenges small and medium-sized solar PV projects face in securing funding compared to large-scale projects that receive government subsidies. Additionally, the payback period for small-scale PV projects is up to ten years, indicating the long-term financial commitment required for such initiatives (Cai et al., 2019; McKay & Hendricks, 2022). According to the data in Chapter 4, "*most commercial banks have opted for a five-year type of business model in anticipation of de-risking*" (Participant 14) for customer-side solar PV projects. This finding highlights that commercial banks adjust their business model to support a payback period of over five years.

5.2.2.6 Theme 12: Perceived Benefits

The data in Chapter 4 has revealed many benefits across economic, environmental, social, and energy security domains. The economic advantages of adopting solar power include reduced electricity bills, potential returns on investment, shorter payback periods, and the potential to increase property values (Ahmad et al., 2017; Kurata et al., 2018; Lee & Shepley, 2020). The competitive market for solar equipment has led to cost reductions by distributors of solar PV equipment. At the same time, cost-sharing models and payment flexibility options have the potential to facilitate increased deployment of solar systems within community schemes (Balcombe et al., 2014; Karakaya et al., 2015; King et al., 2014). Furthermore, the participants affirm that the collective ownership and maintenance of solar technology without increasing levies have been identified as attractive features for community scheme members (Schelly & Letzelter, 2020).

From an environmental perspective, harnessing solar energy represents a sustainable and readily available resource for electricity generation, contributing to reducing greenhouse gas emissions and aligning with South Africa's sustainability goals (Palm, 2018; Wong & Laschinger, 2012). The social benefits of solar technology adoption within residential settings include enhanced safety and security, flexibility in maintaining daily activities, and the autonomy provided by backup systems during power outages (Qureshi et al., 2017; Ugulu & Aigbayboa, 2019). Modern batteries' portability and storage capacity have further enhanced the security measures at guardhouses for security purposes within these schemes and within residents' units, ensuring uninterrupted power supply for essential activities (Gastaldo et al., 2019; Pickerill, 2018).

In terms of energy security, solar PV technology has been instrumental in mitigating power outages and load-shedding events, providing a continuous supply of electricity and enhancing the redistribution of energy within the grid (Walters et al., 2018). The transition towards renewable energy sources and battery storage solutions can enhance energy independence and grid stability, thereby contributing to a more resilient energy infrastructure (Pacudan, 2018; Rai et al., 2016). Government support and policy frameworks are crucial in incentivising the adoption of battery storage solutions and accelerating the transition towards a sustainable energy system (Lee & Shepley, 2020; Schelly & Letzelter, 2020).

The findings underscore the multifaceted benefits of adopting solar PV technology in residential community schemes, emphasising the economic savings, environmental sustainability, social enhancements, and energy security improvements associated with integrating solar PV system systems. These insights contribute valuable perspectives to the discourse on sustainable energy solutions in residential developments, highlighting the potential of solar energy to address various challenges and enhance the overall quality of life within community settings.

5.2.3 Conclusion on discussion for findings on research question one

The findings in Chapter 4 on Research Question One on the factors hindering or facilitating solar PV technology adoption in sectional-title and townhouse community schemes in the South African residential market highlight several key themes.

The barriers identified are consistent with the results obtained from the literature review. The findings encompass social and stakeholder collaboration, institutional, policy, and legislative challenges, financial constraints, land, building, roof resource limitations, technical and technological obstacles, company resources, and operational hindrances. The findings identified include:

- Social and stakeholder collaboration barriers identified include misconceptions about solar energy, lack of customer awareness, challenges with critical decision-makers such as

Trustees and Managing Agents, and governance challenges in community schemes related to solar panels and battery storage placement in communal living spaces.

- Institutional, Policy and Legislative Barriers identified include inconsistencies in policies and regulatory frameworks, bureaucratic approval processes, clear regulatory frameworks, and lack of institutional capacity to facilitate the integration of solar PV systems into existing electricity grids.
- The identified financial barriers are the challenges posed by significant initial investments, limited financing options, low electricity tariffs, and revenue uncertainties that deter investors from investing in solar PV systems.
- Land, Building, and Roof Resources Barriers identified include limited space regarding available land, carports and rooftops, building structural integrity, and consensus among residents and stakeholders to overcome challenges related to solar panel placement in communal living spaces. Collaboration and carefully considering these factors are essential for promoting the widespread adoption of solar PV systems.
- Technical and Technological Barriers identified safety concerns, compliance with grid-code, limitations in net-metering capabilities, and challenges in adapting billing systems to accommodate solar power integration.
- Company Resources and Operational Barriers identified the shortage of skilled resources, unscrupulous installers damaging the solar industry's reputation, and supply chain management issues.

The facilitators identified are consistent with the results obtained from the literature review. The findings encompass the severity and frequency of load-shedding, social influence, stakeholder and industry influences, improving solar PV investment through the use of incentives, policy and legislative instruments, economies of scale and effective management of sub-metering and recovery processes, funding instruments and perceived benefits. The findings identified include:

- The severity and frequency of load-shedding facilitate a surge in demand for backup solutions like solar PV technology, especially among individuals working from home and requiring uninterrupted power supply.
- Social, stakeholder and industry influence were identified as key factors driving adoption, as they facilitate awareness and community engagement. Early adopters also played a significant role. Stakeholders’ influence was particularly crucial in advocating for favourable

regulations and policies. Furthermore, technological advancements and collaborations among industry players were noted to drive adoption significantly.

- Using incentives, policy and legislative instruments was identified as a driver for Improving solar PV investment. Streamlining of the SSEG policy and relaxed regulatory landscape for Body Corporates was identified as a driver to facilitate decision-making processes to facilitate solar installations. Financial resources from international sources and capacity-building initiatives were highlighted as crucial in supporting solar PV adoption.
- The concept of economies of scale emerged as a critical driver for adopting solar PV installations, particularly in larger communities where it proves to be more cost-effective. Furthermore, the efficient handling of sub-metering and utility metering accounts by the Body Corporate was deemed to be essential for the successful collection of revenue and settlement of utility accounts within community schemes.
- Various funding instruments, including individual financing, project loans, and financial assistance from banks and other financial institutions, were discussed. Body Corporate reserve funds or savings were identified as another instrument to fund solar projects.
- The perceived benefits of solar PV adoption across economic, environmental, social, and energy security domains were identified as facilitating factors emphasising reduced electricity bills, ecological sustainability, enhanced safety and security, and energy independence.

5.3 Discussion On Research Question Two

What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional title and townhouse community schemes in South Africa?

The discussion of the findings of this question is divided into sub-sections

5.3.1 Theme 13: Solar PV Installers Focused on Customer-Owned Business Model (COBM)

The findings regarding the **value proposition** of the Customer-Owned Business Model (COBM) highlight that Solar PV installers are seen to offer package deals for solar PV technology and storage solutions to enhance value for homeowners and community schemes focusing on security systems and lights. The focus areas identified include enabling solar PV uptake and upscale, as the high installation cost and limited financing options are enormous barriers for COBM. The emphasis on more extended warranty periods and maintenance services as added value aligns with the literature suggesting that reliability and added services are crucial for customer satisfaction and trust (Cai et al., 2019; Horváth & Szabó, 2018). PV installers support property developers to incorporate solar panels and battery storage into new complexes, enhancing their attractiveness to buyers or renters resonates with (Gao, 2018; Zhang, 2016). Homeowners who have installed solar PV panels may be eligible to receive a tax credit benefit (Horváth & Szabó, 2018; Zhang, 2016).

The **key customer segments** have been identified as homeowners who have obtained approval to install solar PV on community scheme roofs and community schemes in apartment blocks and townhouse communities. These target demographics, which have either the initial investment or access to financing for solar PV technologies, highlight the need to understand customer lifestyles and preferences (Gao, 2018; Reis et al., 2021).

Regarding **key activities**, Solar PV installers are responsible for system marketing and sales, system design, technology selection, and sourcing, which are consistent with the literature emphasising the importance of comprehensive services from pre-purchase consultation to system upgrades (Horváth & Szabó, 2018; Zhang, 2016). Accredited installers and collaboration with industry bodies for training and support align with the necessity for technical expertise and ongoing customer education (Cai et al., 2019; Huijben & Verbong, 2013).

In terms of **customer relationships**, establishing trust and maintaining reliable service is crucial for Solar PV installers, as highlighted in the literature emphasising the significance of customer relationships in promoting renewable energy technologies (Horváth & Szabó, 2018). Effective communication through word of mouth, personal engagement, and online channels aligns with studies suggesting that customer engagement and trust are essential for long-term relationships (Liu, 2015; Zhang, 2016).

Regarding **channels**, Solar PV installers can leverage personal interactions, social media, and traditional methods like flyers and roadshows to engage with potential customers, which resonates with the literature emphasising the role of various channels in building customer relationships and promoting renewable energy solutions (Liu, 2015; Strupeit & Palm, 2016). Collaboration with banks for education and financing options mirrors the importance of partnerships with financial institutions in promoting renewable energy adoption (Horváth & Szabó, 2018; Zhang, 2016).

The **revenue streams** are based on pre-agreed milestone payments, which include security deposit, design preparation, supply and installation, and CoC issuing. Additional services may consist of O&M services.

The **key partners** are partnerships with OEMs and distributors, which are essential for supplying system components such as inverters and solar PV panels (Horváth & Szabó, 2018; Zhang, 2016).

Banks are critical to offering capital to solar PV installers and financing services, such as loans, to customers (Horváth & Szabó, 2018; Zhang, 2016). Property developers and solar energy companies are strategic partners, as service will be rendered on their behalf.

Key resources include key personnel, tools and vehicles, which affirm the literature, and the personnel are critical in determining competitive advantage and prospects for growth (Horváth & Szabó, 2018; Zhang, 2016).

The **cost structure** identifies salaries for key personnel, the cost of purchasing tools and vehicles, stock taking and other running costs (Horváth & Szabó, 2018; Zhang, 2016).

5.3.2 Theme 14: Solar Energy Companies Focused Third-Party Owned Business Model (TPOBM)

The findings in terms of the **value proposition** of solar energy companies in the context of the third-party-owned business model (TPOBM) highlight the various benefits and activities associated with adopting solar energy solutions within community schemes. The focus areas identified include enabling solar PV uptake, upscale, and saturation to reach energy independence. Assist in applying for the SSEG integration, covering capital costs, lowering electricity costs, removing maintenance tasks and costs, ensuring uninterrupted electricity assurance, and providing various economic, energy security, social, and environmental benefits. These findings align with existing literature that emphasises the value proposition of TPO models in overcoming barriers related to high upfront costs and extended payback periods in distributed energy development (Cai et al., 2019; Zhang, 2016).

The participant discussions underscored the importance of solar PV systems in enhancing security through installations for security systems and lights, addressing power outages, and gradually transitioning towards grid independence. The findings also highlighted the significance of cost considerations and individual implementation challenges within complexes, indicating a growing interest in solar technology adoption driven by security needs and long-term grid independence goals. These insights resonate with prior research emphasising TPO models' role in providing customers with clean and low-cost power through power purchase agreements and lease modes, making solar energy solutions more accessible and financially feasible (Cai et al., 2019; Zhang, 2016).

In the TPO model, customer segments include community schemes in apartment blocks, townhouse communities, and larger security estates focusing on installing a centralised solar PV system and battery storage, which require available spaces on the rooftop, carports, and open land. This finding resonates with the literature that customers of the TPO, farmers, and industrial/commercial entities have plenty of space to adopt solar energy solutions under TPO models (Cai et al., 2019; Horváth & Szabó, 2018).

Moreover, the participant remarks shed light on the operational aspects of solar energy companies, emphasising **key activities** such as marketing and sales, power purchase agreements facilitation, project management, risk management, sourcing, and supplier selection. These activities align with the literature that underscores the importance of sustained commitment from clients through long-term contracts like PPAs and leasing arrangements, necessitating robust customer relationships and effective communication strategies (Cai et al., 2019; Horváth & Szabó, 2018).

Regarding **customer relationships**, the participants highlighted the influential role of managing agents and the key decision-makers of Trustees and the Body Corporate in community schemes, stressing the need for positive relationships to influence the acceptance of solar solutions.

Furthermore, the participant discussions on **channels** utilised by solar energy companies, such as websites, newsletters, social media, and community engagements, align with literature that underscores the importance of diverse marketing strategies and online platforms in engaging with customers and promoting solar energy solutions (Cai et al., 2019; Horváth & Szabó, 2018).

The **revenue streams** identified by the participants, including power purchase agreements, rent-to-own options, tax incentives, and emerging models like wheeling and aggregation, reflect the financial viability and sustainability of TPO models in generating income through long-term contracts and government incentives such as section 12B allowance, accelerated depreciation scheme of up 125% of the installed solar PV system (Cai et al., 2019; Horváth & Szabó, 2018).

Based on the participants' responses, key partners on the TPOBM are similar to those in COBM. However, the TPOBM has additional partners, such as private investors and investment institutions, to access financial services through long-term relationships.

The **key resources** include a technical team, marketing specialists, a legal team, health and safety, and a quality assurance team to acquire funds, look for opportunities to deploy capital, supervise the site, and monitor and control the system.

Cost structures include the cost of capital acquisition and management, employee salaries, sub-contracting costs and the cost of sourcing PV systems and battery storage.

Solar energy companies align with existing literature that emphasises the role of partnerships with banks, investors, OEMs, and legal teams, as well as the need for diverse resources and efficient cost management in implementing solar energy solutions under TPO models (Cai et al., 2019; Horváth & Szabó, 2018).

5.3.3 Conclusion on discussion for findings on research question two

Chapter 4's findings regarding Research Question Two, which focuses on the activities of a responsive business model facilitating solar PV system installation in residential sectional title and townhouse community schemes in South Africa, are divided into two main themes: Customer-Owned Business Model (COBM) and Third-Party Owned Business Model (TPOBM).

- In the Customer-Owned Business Model (COBM) theme, the study highlights that solar PV installers offer package deals for solar PV technology and storage solutions to enhance value for homeowners and community schemes, focusing on security systems and lights. The findings underscore the importance of enabling solar PV uptake and upscale solar adoption stages, given the high installation costs and limited financing options as significant barriers for COBM. The study also emphasises the benefits of extended warranty periods and maintenance services. These added values are in line with existing literature, which suggests that reliability and additional services are crucial to customer satisfaction and trust. Furthermore, the study suggests that property developers can enhance the appeal of new complexes to potential buyers or renters by incorporating solar panels and battery storage into their designs.

  Key customer segments identified include homeowners who approve installing solar PV on community scheme roofs and community schemes in apartment blocks and townhouse communities. These target demographics, having the initial investment or access to financing for solar PV technologies, emphasise the importance of understanding customer lifestyles and preferences due to this model lacking financing options in its offering. Solar PV installers are responsible for key activities such as system marketing and sales, system design, technology selection, and sourcing, aligning with literature emphasising comprehensive services from pre-purchase consultation to system upgrades.

  The literature highlights the significance of customer relationships in promoting renewable energy technologies. Establishing trust and maintaining reliable service is crucial for solar PV installers in terms of customer relationships. Leveraging personal interactions, social media, and traditional methods like flyers and roadshows to engage with potential customers are essential channels for Solar PV installers. Revenue streams are based on pre-agreed milestone payments, with key partners including OEMs, distributors, banks, and property developers.

- In the Third-Party Owned Business Model (TPOBM) theme, the study highlights the benefits and activities associated with solar energy companies adopting the third-party-owned business model. The focus areas include enabling solar PV uptake and upscale and saturation adoption stages to reach energy independence. Customer segments include community schemes in various settings, focusing on installing centralised solar PV systems and battery storage. Operational aspects of solar energy companies include marketing and sales, power purchase agreements facilitation, project management, risk management, and supplier selection.

Managing agents, Trustees, and the Body Corporate are critical decision-makers in community schemes, emphasising the role of positive relationships in influencing the acceptance of solar solutions. Revenue streams for TPOBM include power purchase agreements, rent-to-own options, tax incentives, and emerging models like wheeling and aggregation. Key partners and resources for TPOBM include private investors, investment institutions, technical teams, marketing specialists, legal teams, and health and safety and quality assurance teams.

In conclusion, COBM and TPOBM offer valuable insights into the activities and strategies that can facilitate solar PV system installation in residential sectional title and townhouse community schemes in South Africa. While COBM focuses on customer-owned solutions and partnerships with property developers, TPOBM emphasises third-party ownership models and diverse revenue streams.

Based on the findings of the customer-owned business model and third-party-owned business model, the researcher concludes that the third-party-owned business model is the responsive business model since it can overcome the initial investment barriers by accessing various options of funding and leverage the tax incentives (S12B tax allowance) on behalf of the community schemes and able to pass the benefit in the form of lower electricity tariffs being applied to a community scheme. However, the third-party-owned business model may not be viable for small-scale solutions, for example, a backup solution for a single household or a community scheme with 5 units. In that scenario, the customer-owned business model may be viable due to the flexibility of how the solution can be packaged to suit the customer's needs. Still, each deliverable requires upfront investment or milestone payment, as the solar PV installer offers no financing options.

5.4 Conclusion

Research Question One: **What are the factors that hinder or facilitate solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa?**
Summary of factory hindering solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa:

- Social and Stakeholders Collaboration Barriers identified include misconceptions about solar energy, lack of customer awareness, challenges with critical decision-makers such as Trustees and Managing Agents, and governance challenges in community schemes related to solar panels and battery storage placement in communal living spaces.
- Institutional, Policy and Legislative Barriers identified include inconsistencies in policies and regulatory frameworks, bureaucratic approval processes, clear regulatory frameworks, and lack of institutional capacity to facilitate the integration of solar PV systems into existing electricity grids.
- The identified financial barriers are the challenges posed by significant initial investments, limited financing options, low electricity tariffs, and revenue uncertainties that deter investors from investing in solar PV systems.
- Land, Building, and Roof Resources Barriers identified include limited space in terms of available land, carports and rooftops, building structural integrity, and consensus among residents and stakeholders to overcome challenges related to solar panel placement in communal living spaces. Collaboration and careful consideration of these factors are essential for promoting the widespread adoption of solar PV systems.
- Technical and Technological Barriers identified include safety concerns, compliance with grid-code, limitations in net-metering capabilities, and challenges in adapting billing systems to accommodate solar power integration.
- Company Resources and Operational Barriers identified include the shortage of skilled resources, unscrupulous installers damaging the solar industry's reputation, and supply chain management issues.

Summary of factors facilitating solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa:

- The severity and frequency of load-shedding facilitate a surge in demand for backup solutions like solar PV technology, especially among individuals working from home and requiring uninterrupted power supply.
- Social influence, stakeholder influence, and industry influence were identified as key factors driving adoption, as they facilitate awareness and community engagement. Early adopters also played a significant role. Stakeholders' influence was particularly crucial in advocating

for favourable regulations and policies. Furthermore, technological advancements and collaborations among industry players were noted to drive adoption significantly.

- The use of incentives, policy and legislative instruments was identified as a driver for Improving solar PV investment. Streamlining of the SSEG policy and relaxed regulatory landscape for Body Corporates was identified as a driver to facilitate decision-making processes to facilitate solar installations. Financial resources from international sources and capacity-building initiatives were highlighted as crucial in supporting solar PV adoption.
- The principle of economies of scale was identified as a factor driving adoption in larger community schemes and making solar PV installations more financially viable. Effective management of Body Corporate sub-metering and utility metering accounts was deemed crucial for revenue collection and utility account settlement within community schemes.
- Various funding instruments were discussed, including individual financing, project loans, and financial assistance from banks and other financial institutions. Body Corporate reserve funds or savings were identified as another instrument to be used to fund solar projects.
- The perceived benefits of solar PV adoption across economic, environmental, social, and energy security domains were identified as facilitating factors emphasising reduced electricity bills, ecological sustainability, enhanced safety and security, and energy independence.

Chapter 2 Propositions to Research Question One:

- Considering the literature analysis on the factors influencing the adoption of solar PV technology, it can be expected that the findings of this study reveal that these sectional-title and townhouse community schemes face financial-related barriers, institutional, policy and legislative-related barriers, technological and technical-related barriers, social-related barriers, roof resources-related barriers, and company resources-related barriers when deploying solar PV technology. **(This was found to be true as the data in findings of the results in Chapter 4 suggest that sectional-title and townhouse schemes may face obstacles in the adoption of solar PV technology. In addition, stakeholder collaboration and Operational barriers (supply chain challenges) barriers are added to the proposition of research question one).**
- Considering the literature analysis on the factors influencing the adoption of solar PV technology, it can be expected that the findings of this study reveal that these sectional-title

and townhouse community schemes leverage the scale of projects, incentives, policy and legislative-related instruments, funding-related mechanisms, social-influences, and perceived benefits facilitating drivers when deciding on deploying solar PV technology. **(This was found to be true as the data in the findings of the results in Chapter 4 suggest that sectional title and townhouse schemes' adoption of solar PV technology will be facilitated by the facilitating factors mentioned above. In addition, the factor scale of the project evolved to be economies of scale of community schemes sub-metering and recovery. Social influences evolved to be the interplay of industrial, stakeholder and social influences. Lastly, a new facilitate factor is the frequency and higher stages of load-shedding added to the proposition of research question one)**
Research question Two **What are the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa?**
Summary of the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa: • In the Customer-Owned Business Model (COBM) theme, the study highlights that solar PV installers offer package deals for solar PV technology and storage solutions to enhance value for homeowners and community schemes, focusing on security systems and lights. The findings underscore the importance of enabling solar PV uptake and upscale solar adoption stages, given the high installation costs and limited financing options as significant barriers for COBM. The study also emphasises the benefits of extended warranty periods and maintenance services. These added values are in line with existing literature, which suggests that reliability and additional services are crucial to customer satisfaction and trust. Furthermore, the study suggests that property developers can enhance the appeal of new complexes to potential buyers or renters by incorporating solar panels and battery storage into their designs. Key customer segments identified include homeowners who approve installing solar PV on community scheme roofs and community schemes in apartment blocks and townhouse communities. These target demographics, having the initial investment or access to financing for solar PV technologies, emphasise the importance of understanding customer lifestyles and preferences due to this model lacking financing options in its offering. Solar

PV installers are responsible for key activities such as system marketing and sales, system design, technology selection, and sourcing, aligning with literature emphasising comprehensive services from pre-purchase consultation to system upgrades.

The literature highlights the significance of customer relationships in promoting renewable energy technologies. Establishing trust and maintaining reliable service is crucial for solar PV installers in terms of customer relationships. Leveraging personal interactions, social media, and traditional methods like flyers and roadshows to engage with potential customers are essential channels for Solar PV installers. Revenue streams are based on pre-agreed milestone payments, with key partners including OEMs, distributors, banks, and property developers.

- In the Third-Party Owned Business Model (TPOBM) theme, the study highlights the benefits and activities associated with solar energy companies adopting the third-party-owned business model. The focus areas include enabling solar PV uptake and upscale and saturation adoption stages to reach energy independence. Customer segments include community schemes in various settings, focusing on installing centralised solar PV systems and battery storage. Operational aspects of solar energy companies include marketing and sales, power purchase agreements facilitation, project management, risk management, and supplier selection.

  Managing agents, Trustees, and the Body Corporate are critical decision-makers in community schemes, emphasising the role of positive relationships in influencing the acceptance of solar solutions. Revenue streams for TPOBM include power purchase agreements, rent-to-own options, tax incentives, and emerging models like wheeling and aggregation. Key partners and resources for TPOBM include private investors, investment institutions, technical teams, marketing specialists, legal teams, and health and safety and quality assurance teams.

Chapter 2 Propositions to Research Question Two:

- Based on the solar business models from the literature, it can be expected that the findings of this study indicate that solar energy companies offering solar PV technology in the sectional-title and townhouse community schemes market will provide offerings using customer-owned business model, third-party-owned business model, and community-shared business model **(This was found to be partially true as the data in the findings of the results in Chapter 4 indicates that customer-owned business model and third-**

party owned are available to be used in South Africa. However, the third-party third-party-owned business may be used as part of the community-shared business model with correct elements in place.)

- Based on the solar business models from the literature, it can be expected that the findings of this study indicate that solar energy companies offering solar PV technology in the sectional-title and townhouse community schemes market will highlight the customer-facing and organisation-facing activities (encompassing value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure) that are being implemented to overcome the identified barriers and leverage the facilitating drivers (**This was found to be true as the data in the findings of the results in Chapter 4, containing all elements as summarised above).**

6 CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

This section finalises the research document, drawing on the insights obtained from chapter 4 and deliberated in chapter 5 of the research task. The conclusions are grounded on the data outcomes pertinent to this study's research inquiries. This section suggests areas for further exploration and puts forth recommendations for different stakeholders, considering the study's aim and its implications for the adoption of solar PV technology in the sectional title and townhouse community schemes in South Africa.

6.2 Conclusion on Research Question One

The research conducted on the factors hindering and facilitating solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa has revealed significant insights. The study identified many barriers that impede the widespread adoption of solar PV systems in these community schemes. These barriers encompass social and stakeholder collaboration challenges, institutional, policy, and legislative hurdles, financial constraints, limitations in land, building, and roof resources, technical and technological obstacles, as well as company resources and operational barriers.

On the contrary, the study also shed light on various factors that facilitate the adoption of solar PV technology in these residential communities. These facilitating factors include the impact of load-shedding on the demand for backup solutions like solar PV, the influence of social, stakeholder, and industry players in driving awareness and engagement, the role of incentives, policy, and legislative instruments in promoting solar PV investment, the principle of economies of scale in driving adoption in larger communities, and the perceived benefits of solar PV adoption across economic, environmental, social, and energy security domains.

The propositions derived from the literature analysis and the subsequent findings of the research study indicate that while sectional-title and townhouse community schemes face numerous barriers to solar PV adoption, they also have access to various facilitating drivers that can support and promote the integration of solar PV technology. These propositions highlight the complex interplay of financial, institutional, social, and technological factors that influence decision-making processes regarding the adoption of solar PV systems within these residential communities.

The research findings underscore the importance of addressing and overcoming the identified barriers while leveraging the facilitating factors to promote the widespread adoption of solar PV technology in sectional-title and townhouse community schemes in South Africa. By understanding and navigating these factors effectively, stakeholders can work towards creating a more sustainable and energy-efficient residential market that embraces renewable energy solutions.

6.3 Conclusion on Research Question Two

The research question focused on exploring the activities of a responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa. The study findings revealed two business models, i.e., the customer-owned business model (COBM) and the third-party-owned business model (TPOBM).

In the COBM, the research highlighted that solar PV installers offer package deals, including solar PV technology and storage solutions, to enhance value for homeowners and community schemes. The emphasis was on security systems and lights, focusing on enabling solar PV uptake and upscale solar adoption stages. The study identified high installation costs and limited financing options as significant barriers for COBM, suggesting the importance of more extended warranty periods and maintenance services to build customer trust and satisfaction. Additionally, supporting property developers in integrating solar panels and battery storage into new complexes was crucial for attracting buyers or renters.

Key customer segments identified included homeowners with approval to install solar PV on community scheme roofs and community schemes in apartment blocks and townhouse communities. The study underscored the importance of understanding customer lifestyles and preferences, given the lack of financing options in the COBM model. Solar PV installers were found to be responsible for various key activities such as system marketing and sales, system design, technology selection, and sourcing, aligning with existing literature emphasising comprehensive services from pre-purchase consultation to system upgrades.

In the TPOBM, the research highlighted the benefits and activities associated with solar energy companies adopting the third-party-owned business model. The focus was on enabling solar PV uptake, upscale, and saturation adoption stages to achieve energy independence. Customer segments included community schemes in various settings, emphasising installing centralised solar PV systems and battery storage. Operational aspects of solar energy companies in TPOBM included marketing and sales, power purchase agreements facilitation, project management, risk management, and supplier selection.

The study emphasised the role of critical decision-makers such as managing agents, Trustees, and the Body Corporate in community schemes, highlighting the significance of positive relationships in influencing the acceptance of solar solutions. Revenue streams for TPOBM included power purchase agreements, rent-to-own options, tax incentives, and emerging models like wheeling and aggregation. Key partners and resources for TPOBM encompassed private investors, investment institutions, technical teams, marketing specialists, legal teams, and health and safety and quality assurance teams.

The research findings indicated that solar energy companies in South Africa offer solar PV technology using both customer-owned and third-party-owned business models. The study highlighted the importance of customer-facing and organisation-facing activities to overcome barriers and leverage facilitating drivers in the solar PV market for sectional-title and townhouse community schemes.

6.4 Implications of the Study

The findings of the study led to the development of recommendations for different stakeholders that this research is likely to impact significantly, which include:

6.4.1 The South African Government

- A national renewable energy platform should be established to actively engage with South Africans, mainly in the residential sectional-title and townhouse community schemes market. It should also provide them with information about the benefits and potential cost savings associated with solar PV technology. The Renewable Energy Platform should focus on addressing the barriers and challenges that hinder the adoption of solar PV technology in the residential sectional-title and townhouse community schemes market. The Renewable Energy Platform should emphasize the environmental benefits of solar PV technology and its role in achieving individual and global net-zero goals.

  By providing residential sectional-title and townhouse community schemes with green energy certifications, the Renewable Energy Platform can create a sense of responsibility and encourage residents in residential sectional-title and townhouse community schemes to adopt solar PV technology. The platform should also highlight the positive impact of solar PV technology on reducing carbon emissions and mitigating climate change, aligning with the broader organisational climate ambitions of businesses. Renewable energy platforms should act as an aggregator model, which collects data on installed SSEGs that are not registered, triggers a new installation of SSEGs, provides a market for financiers with different financing options and a database of certified solar companies that build and provide maintenance of solar PV technology. Renewable Energy Platform should be integrated with the relevant stakeholders and government agencies to streamline the process of installing solar PV systems and provide guidance for financial incentives and access to funding.

- Develop comprehensive and standardised SSEG policies that clarify the support for net metering or feed-in tariffs for SSEG systems. Additionally, addressing deficiencies in the billing system is crucial to ensure fair compensation for excess power generated by solar PV systems.
- Overcoming restrictive sectional-title legislation: The current restrictions imposed by sectional-title legislation and body corporates rules hinder the installation of solar PV systems in communal setups. This necessitates the development of clear and consistent regulatory frameworks that facilitate the integration of solar PV into the electricity grid in these environments. Establishing formal communication channels and engaging stakeholders, including property developers and body corporates, can help address concerns and promote collaboration.
- Initiate public campaigns and workshops to increase awareness and understanding. These efforts should focus on community schemes, equipping them with essential information and resources. Additionally, to promote solar PV technology, engaging and educational campaigns should be launched, utilizing social media to connect with a broader audience. Emphasizing the advantages and potential savings offered by solar PV could encourage more individuals to explore and adopt this technology.
- Streamline the process of acquiring permits to alleviate administrative burdens and reduce delays in project implementation. Streamlining these approval processes can significantly reduce barriers to entry and accelerate the deployment of solar PV systems. This can be achieved through the establishment of a centralised platform or agency responsible for issuing permits and coordinating with relevant stakeholders.
- Extend the Tax Incentives that were introduced in 2023 to provide a rebate of 25% of the cost of new and unused solar PV panels, up to a maximum of R15,000 to a higher percentage, for example, 75% for sectional-title and townhouse community schemes, would further encourage households to invest in solar technologies. This financial incentive would increase affordability and accessibility, ultimately leading to a greater adoption of solar PV technology. It is essential for the government to carefully consider the financial implications of such a tax break and evaluate its potential impact on the overall energy landscape in South Africa.

- Extend the 12B Incentive currently being enjoyed by businesses to sectional-title and townhouse community schemes and provide clear guidelines and education on the 12B incentive for sectional-title and townhouse community schemes to ensure they can fully benefit from the opportunity to claim back investments in renewable energy projects.
- Provide clear and accessible information about the tax incentives for rooftop solar installations, which can include publishing comprehensive guidelines and conducting awareness campaigns to ensure that firms and tax specialists understand the requirements and benefits of the incentives.
- Extend subsidies for battery energy storage systems (BESS) can optimize the use of solar energy and ease the load on the power grid when solar radiation is not available.
- Compile best practices and case studies from municipalities that have successfully implemented regulatory mechanisms and incentives for SSEGS and provide support to municipalities that are struggling.

6.4.2 National Energy Regulator of South Africa (NERSA)

- Provide clear guidelines to address uncertainties regarding customers' obligations to pay utilities access charges when adopting SSEGs and reconsider the proposed increase in the access charge for solar users, as high access charges may discourage individuals from investing in solar PV systems as they seek to reduce their reliance on the national grid. A balanced and reasonable access charge should be established to incentivise solar PV adoption.
- Harmonize the FIT or SSEG tariff rates for all municipalities so that the tariff rates used across provinces enable households, community schemes, and businesses to optimize their solar investments and take advantage of feed-in tariffs.

6.4.3 Utilities (i.e. Municipalities and Eskom)

- Utilities' policies and bylaws need to be in line with the changing electricity generation landscape to accommodate the connection and feed-in of solar power. A focus should be placed on managing excess power and potential disruptions to the grid caused by multiple small-scale installations.
- Policies must be reviewed and updated to create an enabling environment for the adoption of solar PV technology. A well-designed policy framework should ensure that homeowners receive proper compensation for the excess electricity generated by their systems without

imposing excessive fees or bureaucratic burdens. However, it is crucial to address concerns regarding legal issues and additional charges, as these can deter individuals from investing in solar PV.

- The government should prioritise the development and implementation of FiTs. These tariffs facilitate the compensation of private solar PV generators for excess energy fed back into the grid. National implementation of FiTs will create a market for private solar PV generation, encouraging further investment and adoption of renewable energy.
- Develop and implement a billing system that is compatible with and inclusive of solar PV technology to incentivise its adoption and ensure fair billing for all parties involved. It is also essential to improve the billing system to accurately measure and bill for electricity generated by solar PV systems.
- Assess the economic impact of the widespread adoption of solar PV technology on municipalities and the national grid, considering both the potential revenue loss and the savings from reduced demand on Eskom's network.
- Municipalities should revise their bylaws and regulations to accommodate the installation of solar PV, ensuring that metering infrastructure is designed to support renewable energy generation to address the issue of metering infrastructure needs to be addressed. Old community schemes often lack the necessary.
- Distribution grids must be designed to accommodate the two-way flow of electricity from solar PV systems to prevent strain on the infrastructure. Lastly, municipalities should prioritize long-term planning and ensure that their distribution grids are designed to accommodate the influx of solar PV systems.
- Measures such as the installation of harmonic filters and proper synchronization strategies should be implemented to avoid grid instability and power quality issues, disruptions and damage to equipment as a result of the introduction of inverter-based technologies that can impact the overall grid performance.
- Utilities should improve their support for solar PV installations by streamlining administrative processes and providing adequate resources. Municipal personnel should be trained and well-equipped to handle inquiries and applications related to solar PV installations.
- Utilities should invest in training and capacity-building programs to prepare staff with the skills needed to manage renewable energy projects and overcome the lack of skilled engineers for

solar PV projects in local governments. Partnering with universities and industry experts can close the skills gap and guarantee a supply of qualified professionals.

- Utilities should focus on creating clear communication channels and efficient decision-making processes, which are essential to facilitating the adoption of solar PV technology at the community level.

6.4.4 Industry Bodies (i.e. Department of Energy (DoE), South African National Energy Development Institute (SANEDI), South African Photovoltaic Industry Association (SAPVIA))

- Education and awareness campaigns are needed to address residents' lack of awareness and understanding of solar technology's benefits and functioning, as well as concerns about additional costs and the complexities of the installation process.
- Foster collaboration between the government, utilities, energy regulator (NERSA), and industry bodies to address the barriers and challenges faced by rooftop solar SSEG through regular discussions, consultations, and the establishment of working groups to develop solutions and strategies for promoting the adoption of solar PV technology.
- Engage with Eskom, Municipalities and NERSA to advocate for favourable conditions for rooftop solar installations. This could involve lobbying against excessive capacity charges and advocating for transparent and fair fee structures that support the growth of the rooftop solar industry.
- Engage with municipalities to develop and standardise by-laws that facilitate the transition to SSEG solutions while ensuring the financial stability of local governments and enabling mechanisms for customers to sell surplus energy back to the grid.
- Financial Incentives: Encourage municipalities to offer financial incentives, similar to the City of Cape Town’s credits for surplus green energy, to motivate more households to adopt solar PV systems.
- Lobby for policies that support the growth of solar PV technology, such as reducing red tape for solar system installation and operation.
- Policy Influence: Use the study's findings to influence policy, advocating for support mechanisms that align with the goals of private renewable energy platforms and financial institutions.

- Lobby for the inclusion of battery storage in government renewable energy incentives. Highlight the role of battery storage in enhancing grid stability and providing energy security during peak demand or when solar generation is not possible.
- Benchmark the best practices internationally for successful renewable energy platforms to develop a model that can be replicated across residential communities.
- Establish a monitoring and evaluation framework to track the progress and impact of solar PV adoption initiatives, ensuring they deliver the intended benefits.
- Continuously monitor the implementation of these incentives and tariff changes to ensure they are achieving the desired effect of boosting solar PV adoption.
- Launch educational campaigns to inform residents about the benefits of solar PV technology, the process of transitioning to off-grid solutions, and the financial and environmental implications.
- Engaging with universities and training centres to attract and retain qualified engineers and electricians can aid in securing the necessary expertise for implementing solar PV solutions. Additionally, offering incentives and training programs, such as the green card programme, can help bridge the skills gap and provide employment opportunities.
- Engaging stakeholders such as the municipality's electrical department and installers can help promote awareness and understanding of solar PV technology. By collaborating with qualified installers and ensuring proper training and certification, the quality of installations can be improved, and regulatory issues can be minimised.
- Improve the qualification and training of installers to ensure safe and efficient installations and deal with the lack of qualified installers for solar PV installations. Hiring unqualified installers can lead to issues in network operations and maintenance.

6.4.5 Trustees, Body Corporates, homeowners' associations (HOAs), Managing Agents and Community Schemes Ombud Service

- Advocate for an addendum to the Sectional Title Act to relax and remove some of the bureaucratic processes involved in decision-making. Participants suggested that the Trustees should be given more voting power to represent the larger masses, allowing decisions to be made more efficiently and the use of body corporate funds for such projects, as well as the inclusion of solar PV technology in the 10-year maintenance plan.

- Increasing awareness and education about the importance of levies and the costs associated with communal living is necessary. Many residents are not adequately informed about the financial obligations involved in community schemes, which can lead to non-payment of levies. This lack of understanding hampers the implementation of projects that require additional funds.
- Streamlining the approval process for installing solar PV systems in community schemes by exploring alternative decision-making processes, such as allowing a majority vote or considering individual sub-sections within the larger community scheme, could facilitate the adoption of solar PV systems.
- Encourage homeowners to pay their levies in community schemes and make use of more robust enforcement mechanisms to ensure that homeowners fulfil their financial responsibilities. Additionally, raising awareness about the benefits of solar PV systems, such as reducing electricity bills, could incentivize homeowners to pay their levies and contribute to the adoption of renewable energy technologies.
- Highlight the potential for emissions reduction through the adoption of solar PV technology, aligning with global sustainability goals and appealing to environmentally conscious investors.
- Engaging with insurers to develop policies that cover potential risks, such as fires and provide adequate protection for community schemes would give homeowners peace of mind and further incentivise the adoption of solar PV technology.
- Segregates common property electricity loads that are provided to the security systems and common property lights with those that supply electricity to the individual units within the sectional-title and townhouse community schemes during the adoption of solar PV technology.
- Encourage homeowners to use energy-efficient appliances within their units and install solar geysers and gas stoves and geysers, where feasible, to reduce electricity consumption when solar PV technology is adopted.

6.4.6 Solar Energy Companies

- Launch targeted awareness campaigns to inform residents about rising electricity costs and the cost-saving benefits of solar PV while also highlighting its role in mitigating load shedding. Develop educational programs tailored for sectional-title and townhouse communities that underscore the reduced grid dependence and sustainability advantages of solar adoption. Conduct extensive market education to communicate the immediate financial savings, load-shedding resilience, and environmental benefits of solar PV. Lastly, precise information on the investment value of solar PV systems should be disseminated to shift perceptions and foster investment despite initial costs. This integrated strategy aims to enhance knowledge, alter perceptions, and drive the widespread adoption of solar technology.

- Explore revising pricing structures to increase affordability for sectional-title schemes and townhouses. This could involve offering payment plans with lower interest rates or extending the repayment period to make the initial cost more manageable for community schemes.
- Partner with financial institutions to offer financing options such as loans or instalment payment plans, making the upfront costs of the installations more affordable for sectional-title and townhouse community schemes.
- Establish a financial model that is financially viable and offers a more extended payback period, which can be achieved through financing options such as power purchase agreements (PPA) or rental agreements that allow for gradual payment over time. By providing flexibility in payment methods, more residents within the community schemes can afford to install solar panels. There is potential for solar PV technology to not only reduce electricity bills but also generate additional revenue for community schemes. For instance, excess solar power can be pushed back into the grid, potentially offsetting levies and reducing the financial burden on residents.
- Partner with property developers to offer solar PV system turnkey solutions during the development phases of the sectional title and townhouse community schemes, which help to overcome decision-making barriers once the body corporates of the community schemes are operational.
- Leverage Economies of Scale as larger community schemes tend to be more feasible for implementing renewable solutions due to their potential to yield higher returns and make the investment more financially viable.
- Leverage low tariff structures and consider applying the 12B allowance, which can provide additional benefits and improve the commercial feasibility of solar PV projects.
- Explore options to upgrade metering infrastructure in older community schemes to ensure accurate metering and billing systems that align with municipality requirements and facilitate excess energy resell in community schemes.
- Explore options for offsetting excess power generated within the community's residence through incentives like reduced energy bills or renting roof space. Learning from international

best practices and adopting relevant strategies to fit the South African jurisdiction can be beneficial.

- Explore partnerships and collaborations with banks and property developers to help address financial barriers and create opportunities for project development.
- Explore cost-effective solutions and incentivizing system signoffs by registered engineers can help mitigate costs related to electrical connection, wireman's license, inverters, and system configuration, which can impact the accessibility and affordability of these systems.
- Promote community-shared business models, especially in areas with a mix of rental and ownership properties. This model would allow the community members to collectively own and contribute to the costs of solar PV systems. This approach could provide a sense of ownership and shared benefits while reducing the financial burden on individual households.
- Engage with manufacturers and suppliers should focus on designing robust and high-quality systems that operate effectively and require minimal maintenance to ensure the reliability and durability of the solar PV systems, as customers expect a long lifespan of 5 to 10 years to see a return on their investment.

6.4.7 Commercial Banks and Investments Institutions

- Commercial banks should be encouraged to take on more risk and provide financing options specifically tailored to the needs of community schemes to address the challenges faced by community schemes in accessing funds. This would enable sectional-title and townhouse community schemes to access funding for solar PV installations and contribute to the overall growth of renewable energy in South Africa.
- Develop financial models that show the long-term cost savings and potential return on investment for sectional-title and townhouse community schemes when adopting solar PV technology.
- Financial institutions could develop specialised loan options designed explicitly for sectional-title schemes to facilitate the adoption of solar technology. These loans could be tailored to address the financing needs and constraints unique to communal living arrangements.
- Financial institutions should reevaluate the risk associated with these projects and offer transparent and flexible loan options to the sectional-title and townhouse community schemes.
- Leverage partnerships with solar energy companies to provide solar PV solutions to residential communities and to ensure that solar PV projects are financially viable and have reliable

returns. Holding solar energy companies accountable and regularly checking the system's performance is crucial in meeting the expected power generation and avoiding potential losses.

6.5 Suggestions For Further Research

Considering the limitations of this research and the interpretation of its results, the following recommendations are proposed for future studies on this topic:

- It is recommended that a quantitative research study is conducted, considering the added hindering and facilitating factors that can be leveraged in the adoption of solar PV technology in the sectional title and townhouse community schemes.
- It is recommended that a study incorporating the emerging wheeling framework be undertaken in the form of qualitative research to understand how it can help encourage the adoption of solar PV technology to the sectional title and townhouse community schemes.
- Conduct further research and analysis to assess the potential impacts of the tax incentives, tariff restructuring, and fee structures on the residential sectional-title and townhouse community schemes market. This can help identify any additional barriers or opportunities and inform the development of targeted policies and interventions.
- Conduct further research on the various ownership issues involved with renewable investments under the 12B incentive to provide clarity and guidance for solar energy companies and residential sectional-title and townhouse community schemes.

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APPENDICES

APPENDIX A: RESEARCH INSTRUMENT

RESEARCH QUESTION ONE:

What are the factors that hinder or facilitate solar PV technology adoption in sectional-title and townhouse community schemes segment of the residential market in South Africa?

- Given the current power outages and load-shedding level in South Africa, how would you describe the effects on sectional title and townhouse community schemes? What specific aspects are most affected and why?
- Are you aware of any alternative energy resources being utilised to mitigate the effects of power outages and load-shedding in these community schemes? If so, what are they, and why were they chosen?
- What factors do you think influence the choice of alternative energy resources in these community schemes? How do these factors come into play, and why are they important?
- In your opinion, are the alternative energy resources currently in use sufficient to sustain these communities during periods of load-shedding or power outages? Why or why not?
- What do you perceive as the benefits and disadvantages of the alternative energy resources being used? How do these benefits and disadvantages impact the community schemes?
- To what extent do you believe sectional-title and townhouse community schemes have adopted solar PV technology as an alternative energy resource? Why do you think this level of adoption has been achieved?
- What do you perceive as the primary obstacles to adopting solar PV technology in these community schemes? How do these obstacles manifest, and why do they pose a challenge?

A probing follow-up question, if not covered by the participant's response:

  - What factors can delay or prevent these community schemes from adopting solar PV?
  - How do government policies hinder the adoption of solar PV technology in South Africa?

- In your view, what factors could potentially encourage the adoption of solar PV technology in these community schemes? How could these factors be leveraged to increase adoption?

A probing follow-up question, if not covered by the participant's response:

- What are mechanisms that can be used to overcome the factors that prevent sectional-title and townhouse community schemes from adopting solar PV?
- How can government policies promote the adoption of solar PV technology in these communities?
- How can other stakeholders contribute to promoting the adoption of solar PV technology?

In Summary,

- what factors do you believe hinder solar PV technology adoption in the sectional-title and townhouse community schemes segment of the residential market in South Africa? How do these factors manifest, and why do they pose a challenge?
- What factors facilitate solar PV technology adoption in this market segment? How do these factors contribute to increased adoption, and why are they effective?

RESEARCH QUESTION TWO:

What are the elements of the identified responsive business model that can facilitate solar PV system installation in the residential sectional-title and townhouse community schemes in South Africa?

- What specific offerings can solar energy companies provide to help overcome the challenges and drive the uptake of solar PV technology in sectional title and townhouse community schemes?

A probing follow-up question, if not covered by the participant's response:

- Why would these offerings be compelling, and how could they be implemented?
- What are some of the benefits and drawbacks of the suggested offerings?
- How do these benefits and drawbacks impact the adoption of solar PV technology?

- What financing or payment mechanisms can be used for sectional title and townhouse community schemes for the suggested offering?

A probing follow-up question, if not covered by the participant's response:

- Why would these mechanisms be effective, and how could they be implemented?

- What resources do you think solar energy companies require to offer their services to sectional title and townhouse community schemes?

A probing follow-up question, if not covered by the participant's response:

- Why are these resources necessary, and how could they be acquired?

- What communication channels do you believe the sectional title and townhouse community schemes would prefer to engage solar energy companies?

A probing follow-up question, if not covered by the participant's response:

- Why would these channels be preferred, and how can they be effectively utilised?

- What kind of relationship should sectional title and townhouse community schemes have with solar energy companies?

A probing follow-up question, if not covered by the participant's response:

- How can trust and satisfaction be built and maintained in this relationship?
- Why are these factors important?

- Who do you think the solar energy companies need to partner with to drive the uptake of solar PV technology in sectional title and townhouse community schemes?

A probing follow-up question, if not covered by the participant's response:

- How can these partnerships be established and managed effectively?
- Why would these partnerships be beneficial?

- What suggestions or improvements can you make to increase the adoption of solar PV technology in the sectional-title and townhouse community schemes in South Africa?

A probing follow-up question, if not covered by the participant's response:

- Why would these suggestions improve adoption rates, and how could they be implemented?

APPENDIX B: PARTICIPATION SHEET

Participant Information Sheet (PIS)

Dear Sir / Madam

My name is Howard Nkuna. I am a master's student in Master Business Administration at the University of the Witwatersrand, Johannesburg. My supervisor is Dr Nomusa Mazonde. I am conducting a research study about the adoption of solar PV technology by residential customers, Body Corporates and managing agents in sectional-title properties and townhouse community schemes in South Africa to assist in reducing the burden of load-shedding or power outages, increasing costs of electricity and contribute to country goals to reducing greenhouse gas emissions. The study title is Adoption of Solar Photovoltaic (PV) Technology in Residential Sectional-title and Townhouse Community Schemes Market in South Africa.

I am inviting you to take part in an interview and participation in this research study will last about 45 - 60 minutes. The interview will take place in-person or online via Zoom / MS Teams during work hours or at a suitable time per your availability. With your permission, I would like to audio record the interview for my purpose of analysing the interview and listening to it again to capture any details I may have missed. When I share the research study results, I will not include your name or anything else that could identify you. Therefore, the content of the interview will remain confidential, and the location of where it will be saved will use a suede name. This data will be stored in Wits SharePoint and deleted after five (5) years. Only the researcher will have access to the data.

Your participation is voluntary, with no financial incentives or monetary benefits. You can stop to take part in the study anytime. You do not have to answer any questions that you're uncomfortable with. The risks for this research study are no more than what happens in everyday life. This research study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will gladly send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor at the details listed below. Suppose you have any concerns or complaints about the ethical procedures of this research study. In that case, you can contact the University Human Research Ethics Committee (Non-Medical) by telephone at +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,

Howard Nkuna

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APPENDIX C: CONSENT FORM

Consent Form for Academic Research Project

My name is Howard Nkuna. I am a master's student in Master Business Administration at the University of the Witwatersrand, Johannesburg. My supervisor is Dr Nomusa Mazonde. I am conducting a research study about the adoption of solar PV technology by residential customers, Body Corporates and managing agents in sectional-title properties and townhouse community schemes in South Africa in order to assist in reducing the burden of load-shedding or power outages, increasing costs of electricity and contribute to country goals to reducing greenhouse gas emissions. The study title is Adoption of Solar Photovoltaic (PV) Technology in Residential Sectional-title and Townhouse Community Schemes Market in South Africa.

I am inviting you to take part in an interview.

I, ………………………………………..., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I volunteered to take part in the study.	YES	NO
I agree that the interview may be audio-recorded.	YES	NO
I agree that the researcher may use direct quotations from my interview in the research report.	YES	NO
I agree that my participation will remain confidential (the researcher will not use my name or other identifying data in their research report).	YES	NO

Name of the Participant: ……………………………………
Signature: ……………………………………
Date: ……………………………………

Name of the Researcher: ……………………………………
Signature: ……………………………………
Date: ……………………………………

APPENDIX D: ETHICS APPROVAL CERTIFICATE

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

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

Ethics Clearance Certificate

Ethics protocol number: WBS/BA0504038T/847

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

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

Project title	Adoption of solar photovoltaic technology in the residential sectional-title and townhouse community schemes market in South Africa
Investigator / Researcher	Mr Howard Nkuna
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2023/09/27
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

Declaration by Researcher

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

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

Signature

27 September 2023
Date: