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Investing in Decentralised Power Generation – Financial Success Factors in South Africa's C&I Sector

A **Research Proposal**

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by

Zack Fineberg
FNBZAC001

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Supervisors: Dr Peter Twesigye and Dr Wikus Kruger

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Abstract

In the context of a national energy crisis that has resulted in extreme load-shedding and constrained economic growth, the South African Government has introduced legislation and policies to enable private sector investment into power generation. This includes recent amendments to the Energy Regulation Act (ERA), the most important of which is an exemption from licensing requirements for generation facilities. As the largest power consumer, dominated by private ownership, the Commercial and Industrial (C&I) sector's investment in power generation represents the opportunity to increase the country's generation capacity with limited impact on the national fiscus. Using an exploratory multiple-case-study design, this study analyses and identifies the financial factors, mechanisms and barriers that enable or inhibit investment in decentralised generation (DG) by South Africa's C&I sector. The results indicate that (1) the reducing costs of photovoltaic technologies, (2) the emergence of specialised financial arrangements, such as Power Purchase Agreements (PPAs), and (3) tax incentives, enable investment by the C&I sector into DG by lowering financial barriers. Similarly, (4) increasing municipal electricity tariffs, and (5) the increasing intensity of load-shedding encourage the substitution of municipally supplied power for more affordable and reliable DG. In contrast, (1) the cost of battery technology, and (2) relatively low municipal feed-in tariffs constrain investment by disincentivising investment in DG at capacities required for the C&I sector to become entirely self-sufficient or net exporters of power. Finally, the results indicate that capital expenditure policies amongst business in the C&I sector, which are traditionally aimed at procuring production machinery, are not well suited to enable investment in DG.

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List of Abbreviations

CBA	Cost Benefit Analysis
CEO	Chief Executive Officer
CG	Centralised Generation
CO2	Carbon Dioxide
COD	Commercial Operation Date
CPI	Consumer Inflation Price
CPT	Cumulative Perspective Theory
CSP	concentrating solar-thermal power
DBSA	Development Bank of South Africa
DG	Decentralised Generation
DMRE	Department of Mineral Resources and Energy
EAF	Energy Availability Factor
EBITDA	Earnings before interest, tax, depreciation, and amortisation
ERA	Energy Regulation Act
ES	Electrical System
ESG	Environmental, Social and Governance
EV	Electrical Vehicle
FI	Financial Instrument
FIs	Financial Institutions
FNB	First National Bank
GDP	Gross Domestic Product
GHG	Green House Gasses
GW	Gigawatt
HVAC	Heating, ventilation, air conditioning
IDC	Industrial Development Corporation of SA
IFRS	International Financial Reporting Standards
IPP	Independent Power Producer
IPPPP	Independent Power Producer Procurement Programme
IRP	Integrated Resource Plan
KII	Key Informant Interview
KW	Kilowatt
LCOE	Levelised Cost of Energy
LSE	London Stock Exchange
MW	Megawatt
NERSA	National Energy Regulator of South Africa
PPA	Power Purchase Agreement
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RMB	Rand Merchant Bank
ROI	Return on Investment
SALGA	South African Local Government Association
SAPIA	South African Petroleum Industry Association
SAPP	Southern African Power Pool

SAPVIA,	The South African Photovoltaic Industry Association
SME	Small Medium Enterprises
SOE	State Owned Entity
SPV	Special Purpose Vehicle
TPO	Third-Party Ownership
TSO	Transmission System Operator
UPS	Uninterrupted Power Supply
US	United States
VAT	Value Added Tax
WMA	Wier Minerals Africa

1 INTRODUCTION.

Electricity security is a precursor to economic development and poverty alleviation (Le & Nguyen, 2019). Reliability of supply and affordability are defining factors of electricity security, yet in most of the world, power security remains a concern, with South Africa being no exception (APRC, 2007). South Africa finds itself in a prolonged energy crisis that has lasted for well over a decade. Under-investment in the sector has led to shortages in generation capacity and the country's primary energy producer, Eskom, unable to meet South Africa's growing energy needs. This has resulted in a state of sporadic energy rationing known as load-shedding that has had widespread economic implications with estimated costs to the economy of R169bn to R338bn (Wright & Calitz, 2020).

Recognising the need to address generation constraints and diversify the country's energy mix, The Department of Mineral Resources and Energy (DMRE) introduced legislation and policies to enable private participation in what has historically been a state-run industry. This has seen wide success in private investment into generation capacity through a deliberately structured procurement programme known as the 'Renewable Energy Independent Power Producing Procurement Programme (REIPPPP)', which has resulted in 6 422 MW of bulk generation capacity procured over the course of five bid windows (REIPPP, 2021). The REIPPPP has also offered a clear route to market for IPPs. Enabling regulation, decreasing technology costs, ambitious emission goals and increasing investor interest in environmental, social, and governance (ESG) linked assets have all played a role in the REIPPPP's success. Yet, despite the programme's achievements, South Africa still experiences a shortage in generation capacity.

As the largest electricity consumer in South Africa, the commercial and industrial (C&I) sector has been identified as an important part of the country's immediate efforts towards energy security (DMRE, 2021). Dominated by private ownership and consuming 61% of South Africa's total electricity production, the C&I sector's involvement in electricity production provides the opportunity to increase the country's generation capacity with little to no burden to the State's fiscus. This has led to the emergence of a decentralised power generation (DG) industry that has grown with the reduction in technology costs, increasing electricity prices and enabling regulations, the most recent of which being the promulgation of an amendment to

Schedule 2 of the Electricity Regulation Act (ERA) on 12 August 2021, which increases the threshold for DG without a licence from 1 MW to 100 MW (GreenCape, 2022a). However, despite all the enabling factors, investment by the C&I into DG has still not reached the critical levels needed to ensure South Africa's energy security. There is therefore a need to understand the critical factors impacting the adoption of DG technologies by the C&I sector in South Africa.

1.1 Research Problem

Several studies explore the technical, environmental, regulatory and financial success factors for adopting DG in South Africa (Lutchman, 2018; Nhamo & Mukonza, 2016; Pandarum et al., 2018; Wiley & Bick, 2018a). Most notably, Wiley and Bick's, (2018) findings lay the foundation for critical success factors and role players for C&I's adoption of rooftop photo voltaic (PV) in South Africa. These studies note two broad factors: financial and non-financial consideration. Financial factors tend to focus on the economics of investment decisions, such as return on investment and access to financing. In contrast non-financial considerations focus mainly on regulations around system registration, the climate change agenda, and aspects of available technology.

In South Africa's case, despite amendments to the ERA, and historically low costs of generation technology, investments by the C&I sector into DG have been relatively low when compared to the sector's power demands, with only 134 MW of new capacity having been registered as of December 2021 (National Treasury, 2023) This suggests that while improvements in the conditions surrounding non-financial considerations have been made , additional unidentified financial barriers may be deterring investment.

Despite the noted importance of financial considerations, there is a current gap in their understanding. In particular, existing literature does not specifically focus on the financial factors impacting capital budgeting and investment decisions undertaken by the C&I sector when deciding to invest in DG. These factors play an important role in private corporation investment decision. Furthermore, existing literature has not been updated since the promulgation of the amendment to Schedule 2 of the ERA, a shift in policy that many believed would open the flood gates to investment.

1.2 Research Question

In the light of the gaps identified above, this research aims to address the following research questions:

1. What capital investment considerations do South Africa's C&I sector take when deciding to invest in DG?
2. What factors enable or discourage investment by the C&I sector into the DG?

Primary qualitative data collection will ensure this research provides a current understanding of the financial considerations and an up-to-date body of evidence.

1.3 Research Objectives

This research aims to build on existing literature by proving an in-depth analysis of financial considerations for C&I investment in DG in South Africa.

The research objectives are:

- To identify financial barriers and enablers faced by C&I to investment in DG.
- To make recommendations that enable C&I to overcome the financial barriers to investment in DG.
- To make recommendations that enable financial institutions (FIs) to develop financial products that promote investment by the C&I into DG.

2 LITERATURE REVIEW

The formal participation of the private sector in South Africa's power landscape is relatively nascent, and is characterised by the emergence of new technologies, terminologies, and frameworks that delineate the sector's role and influence. This literature review serves as an overview of these key players, delves into the changing legislations and policies shaping its trajectory, and establishes a conceptual framework to understand the private sector's emerging participation. In addition, this section introduces the key corporate finance principles required to understand investment decision making and provides a foundation for evaluating financial success factors to enable investment into DG.

2.1 The South African Energy Sector

South Africa has a 'hybrid power' sector model that combines elements from the sector's historical state-owned vertically-integrated arrangement with elements of private sector participation and commercialisation (Gratwick & Eberhard, 2008). To understand the drivers and challenges of addressing South Africa's power issues, one must first understand the sector's institutional arrangements and key role players.

2.1.1 Structure and key role players

Overview

South Africa's power sector is dominated by the vertically integrated state-owned entity (SOE), Eskom. Eskom controls much of the country's generation, transmission, and distribution capabilities, generating over 91% of South Africa's total electricity, 84% of which is derived from coal (DMRE, 2021). The remaining 9% of South Africa's electricity demand is imported via the Southern African Power Pool's (SAPP) interconnected grid (3%) or supplied by IPPs (6%) (DMRE, 2021).

South Africa's IPP generate power from a combination of renewable sources, including onshore wind (52%), photovoltaic (36%) and concentrating solar-thermal power (9%). The country's distribution network is shared between Eskom (58%) and municipalities (42%) that purchase power from Eskom to distribute to households and businesses under their respective jurisdiction (Anna Filipova et al., 2019).

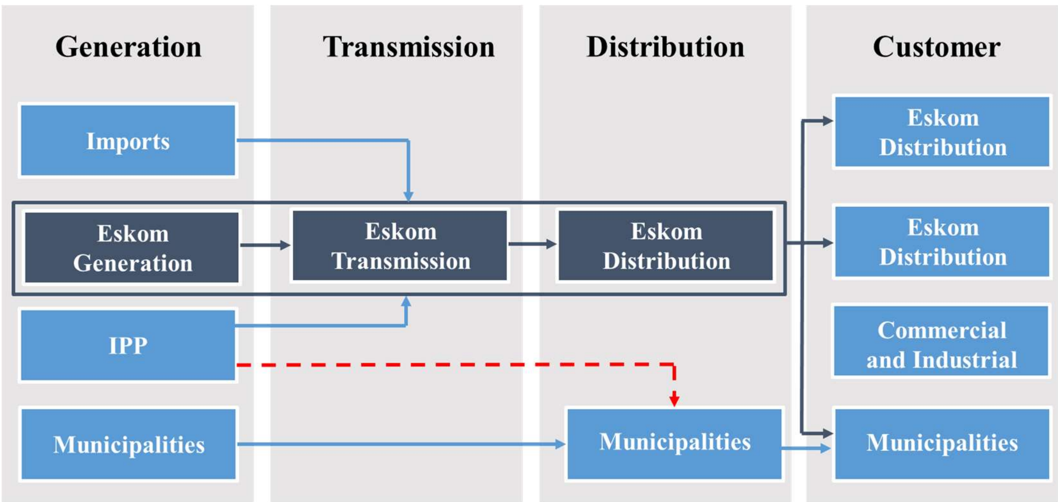


Figure 1: Organization of the South African Power Sector

Adapted from: Renewable energy prospects: South Africa (IREA, 2020)

Municipalities

South Africa has 278 municipalities, comprising 8 metropolitans, 44 districts and 226 local municipalities (Department of Government Communications and Information Systems, 2020).

The South African Constitution places the responsibility of electricity reticulation on local governments to ensure adequate provision of services to residents and businesses within their jurisdiction. South African municipalities account for 43% of Eskom's electricity sales, with the country's 8 metropolitans accounting for the majority of these sales (Eskom, 2021a). These municipalities are reliant on Eskom for the majority of their electricity supply, with a relatively small supply of electricity from municipal-owned generation and local IPPs (Akinbami et al., 2021).

Independent Power Producers (IPP)

South Africa has several IPPs that supply electricity to Eskom and local municipalities. The number of IPPs has grown significantly in the last decade due to the country's REIPPPP. Introduced in 2010, the IPPPP is a structured competitive tender process to enhance the country's generation capacity by securing 'Utility-scale' renewable and non-renewable generation from the private sector (REIPPP, 2021). Under the IPPPPP four programmes have emerged; (1) The Renewable Energy IPP Procurement Programme (REIPPPP) to procure large renewable sources, (2) The Small Projects IPP Procurement Programme (SP-I4P) to procure renewables between 1-5 MW from South African SMEs, (3) The Coal Baseload IPP Procurement Program, to procure new coal-fired capacity and (4) The Risk Mitigation IPP procurement program to procure 2 000 MW of technology agnostic generation capacity by June 2022 (IPP, 2022, 27 March). As of March 2021, 5 078 MW of electricity generation capacity from 79 IPP projects had been connected to the national grid (REIPPP, 2021).

The National Energy Regulator of South Africa (NERSA)

The National Energy Regulator of South Africa (NERSA) was established in 2004 to regulate the electricity, piped gas, and petroleum pipelines industries. In the context of power, NERSA is responsible for setting tariffs, licensing and registration, dispute resolution, setting guidelines as well as monitoring and enforcing regulations (National Energy Regulator of South Africa, 2020). As an industry watchdog and regulator, NERSA is, therefore, integral to South Africa's electricity sector's performance and the issuing of electricity generation licenses. However, its ability to issue generation licenses is limited by determinations of the DMRE according to its Integrated Resource Plan (IRP).

The Department of Mineral Resources and Energy (DMRE) and the Integrated Resource Plan (IRP)

The DMRE is a national department responsible for policy oversight and promotion of South Africa's minerals and energy sector. The Department oversees the country's integrated resource plan (IRP), which provides a coordinated schedule for South Africa's power generation expansion and demand-side intervention programmes (DMRE, 2011). Key strategic objectives of the IRP are affordable electricity, GHG emissions, reduced water consumption, diversified electricity generation sources, localisation, and regional development. The IRP is currently in its third iteration and covers the proposed generation fleet for South Africa for the period from 2010 to 2030 (refer to Table 20 in Appendix I).

Eskom

Eskom finds its origins in the establishment of the Electricity Supply Commission (ESCOM) per the Electricity Act, No 42 of 1922, with the primary objective to supply power at the lowest possible cost (Eberhard, 2009). Since its establishment, Eskom has expanded to become the country's largest power producer through the construction of new generation capacity and the acquisition of competitors. Eskom has also come to oversee the country's transmission network, which since 1973 has been interconnected and nationally controlled. The expansion and prominence of Eskom in the South African power sector has resulted in a power sector dominated by a single integrated SOE, which now controls much of the country's power generation, transmission, and distribution. As of December 2021, Eskom has 30 power-generating stations with a combined nominal capacity of 47 204 MW, most of which are coal-fired (refer to Table 1).

Table 1: Eskom owned power generation stations as of December 2021.

Technology	**No. of power stations**	**Total Nominal Capacity (MW)**	**The proportion of Total Nominal Capacity**
Coal-fired	15	39 456	84%
Nuclear	1	1 854	4%
Gas/liquid fuel turbine stations	4	2 409	5%
Pumped storage schemes	3	2 724	6%
Hydroelectric stations	2	600	1%
Wind energy	1	100	0,2%
Other hydroelectric stations	4	61	0,1%
Total	**30**	**47 204**	**100%**

Adapted from: Capacity tables 01 December 2021 (Eskom, 2021b).

2.1.2 Eskom and load-shedding

As the largest producer and distributor of electricity, South Africa's power security is inherently linked to the stability of Eskom. Eskom has suffered from chronic shortages in the supply of power since 2007, with demand outstripping available supply, forcing the entity to introduce 'load shedding ' – a controlled reduction in the power supply required to prevent system collapse (Rakotonirainy, 2015). This can be attributed to Eskom's financial and operational deterioration (Refer to **Error! Reference source not found.**).

Eskom faces financial challenges from both an income statement and a balance sheet position. Despite demand outstripping supply, Eskom's sales have steadily declined while operating costs have increased disproportionality. Financing costs place an additional burden on available cash and profitability of the entity with a deteriorating interest cover (refer to **Error! Reference source not found.**). Gross debt has grown by 350% since 2007 to R392 billion despite generation capacity declining 4.36% for the same period. Eskom's deteriorating financial position has resulted in the State having to extend financial support to the entity to the tune of R164.5 billion over the past 14 years (National Treasury, 2019, 2021).

Table 2: Key operational and financial indicators for Eskom's performance for the years 2005, 2007, 2014 and 2021.

Indicator	**2005**	**2007**	**2014**	**2021**
Operational				
Nominal Generation capacity (GW)	36.20	42.60	41.99	47.20
Energy Availability Factor (%)	0.91	0.87	0.72	0.59
Load shedding (days)	0	0	14	21
No. of employees	31,475	32,674	46,919	42,325
Financial				
Sales volume (GWh)	256,959	218,120	217,903	100,901
Revenue (R billion)	42.90	40.07	139.51	134.98
EBITDA (R billion)	13.21	11.01	23.50	44.80
Gross debt (R billion)	86.59	86.95	281.00	392.10

Interest cover*	6.03	3.38	0.65	2.20

In addition to its financial challenges, Eskom has been the centre of a political battle that has resulted in mismanagement and poor governance. Political patronage and rent-seeking have been at odds with the State's role in Eskom as the custodian of public interest (Bowman, 2021). Since 2007, Eskom has seen its Chief Executive Officer (CEO) change 14 times along with an exodus of skills and technical expertise. The combination of the financial and managerial challenges has culminated in an energy sector dominated by an entity that now experiences generation availability below 60% of its 47,204 MW nominal capacity, maintenance delays and budget overruns in the construction and upgrade of its infrastructure (refer to Figure 2) .

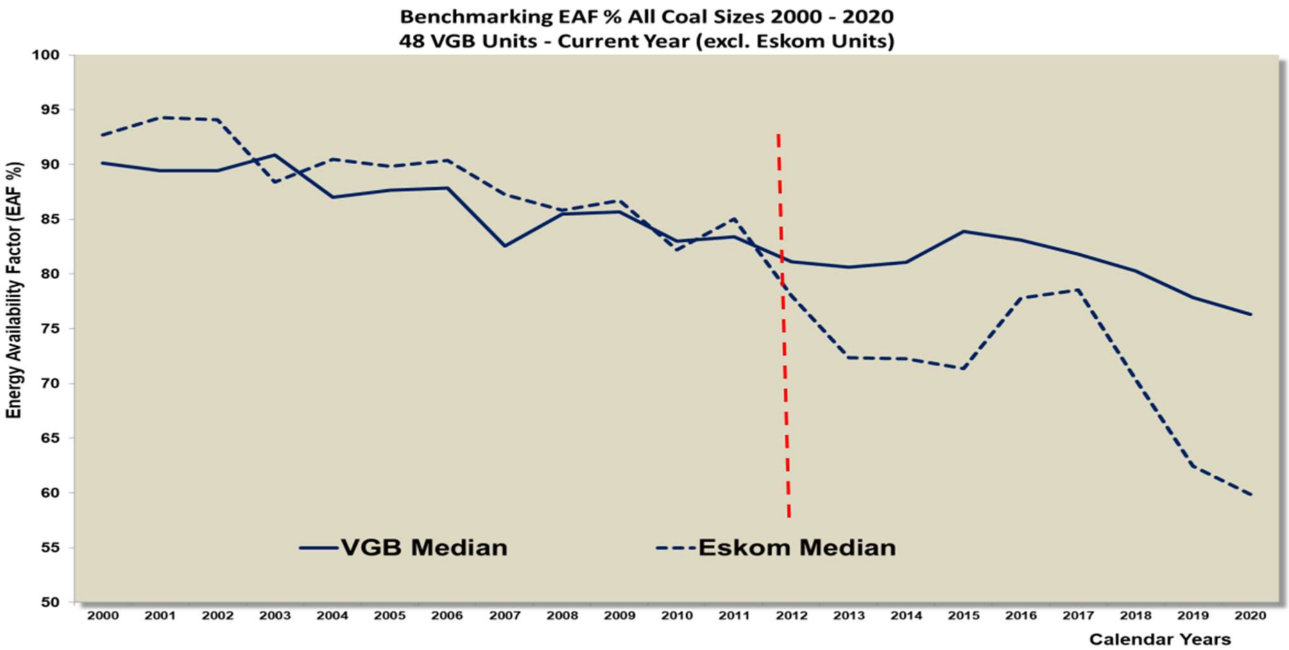


Figure 2: Eskom's plant availability measured by energy availability factor (EAF)

Source: (Eskom, 2022b)

2.2 Private sector participation in electricity generation

2.2.1 Historical arrangement of power sectors

Much of the 20th century, electricity sectors have been characterised by large state-owned vertically integrated monopolies. The rationale for government involvement centred on three arguments. Firstly, the nature of electricity infrastructure meant that electrification projects typically had a high degree of risk and required significant investment before production and supply could begin. This necessitated the need for the state to provide funding and guarantees to develop and grow the country's electricity sector (Brew-hammond, 2010). Secondly, the belief that the vast network required to meet a country's energy demands benefited from economies of scale resulting in the development of monopolistic entities to undertake all generation and distribution activities (Joskow and Schmanlensee, 1983). Finally, electricity security was, and remains, widely viewed as strategically important for economic development (Samad & Zhang, 2016). The state's involvement was, therefore, an extension of its governing mandate. The combination of these factors resulted in energy sectors in most of the world being dominated by vertically integrated monopiles that controlled the electricity value chain from generation through to transmission and distribution. In South Africa's case, this monopoly was Eskom.

2.2.2 Policies and legislation toward private sector participation

Since the first piece of legislation relating to electricity in South Africa, the Electricity Act of 1922, sanctioning private sector participation in electricity generation, has gone through multiple iterations. A common requirement of this legislation is granting a licence by the relevant authority to operate, with generation capacity often being a determining factor. South Africa's approach to energy policy changed along with the birth of its democracy in 1994. Prior to 1994, energy policy was state led, with little participation from the general public or stakeholders. The newly democratic South African government adopted the approach of stakeholder engagement and policy transparency (Eberhard & Godinho, 2017). This is evidenced by the National Energy White Paper, which sought to promote transparency, inclusiveness, and accountability in energy policy transformation. The 1998 Paper was the first expressed intention to develop policies encouraging the 'entry of multiple players into the generation market' (DMRE, 1998). The paper also gave rise to an integrated resource planning approach to energy in South Africa with the aim of evaluating investment in energy supply and demand through an economic, social, and environmental lens. This policy led to the formulation of the Integrated Resource Plan (IRP) 2010-2030.

As expressed in the Energy White Paper, the National Electricity regulator can only license new facilities upon completion of an IRP. The policies expressed in the Energy Policy White Paper and the subsequent White Paper on Renewable Energy laid the foundation for South Africa's energy policy related to private generation. The ERA of 2006 provides NERSA with the jurisdiction to grant generation licences on condition that the licences comply with the IRP. Private electricity generation was, therefore, limited by licencing requirements and conditional on meeting the IRP's quota for generation capacity. This remained the status quo until 2017 when legislation was amended to exempt licensing for generation units with a capacity of less than 1MW and again in 2021, when this was increased to 100MW (refer to Table 3).

Table 3: South Africa's electricity generation regulation and related policies from 1922 – 2021.

Date	**Legislation or Policy**	**Regulation**	**Reference**
1922	Electricity Act, No. 42 of 1922	Licence required for operation of private generators with the exception of municipal undertakings.	(Eberhard, 2009)
1985 and 1987	Electricity Act, 1987, s. 6.1	Licence required for private generation with sale of more than 1 GWh of electricity per annum.	(The Electricity Act 41 of 1987, 1987)
1989	Electricity Amendment Act 58 of 1989	Enabled the transfer of existing generation assets and capacity without permission	(Electricity Amendment Act 58 of 1989, 1989)
1994	The Electricity Amendment Act 46 of 1994	Amendment to private licence requirements for private generation with sale of more than 5GWh of electricity per annum	(The Electricity Amendment Act 46 of 1994, 1994)
1995	The Electricity Amendment Act 60 of 1995	National Electricity Regulator of South Africa (NERSA) established	(Republic of South Africa, 1995)
1998	National Energy Policy White Paper, s7.1.5.8	Expressed intention to develop policies relating to NERSA approved tariffs for the purchase of co-generated and independently generated electricity on the basis of full avoided costs.	(DMRE, 1998)
2003	White Paper on Renewable Energy, s7.2.2 & s7.3.1	• Recognised Private industry as a key role player in renewable energy generation. • S7.2.2 – Acknowledges the need for regulatory measures to create an enabling environment.	(DMRE, 2003)

		• S7.3.1 Reiterates NERSA's jurisdiction over issuing licenses.	
2006	ERA Act 4 of 2006	s8 – No person may operate any generation, transmission, or distribution facility without licence caveated by Schedule 2 which makes exception for: 1. Any generation plant constructed and operated for own use. 2. Non-grid connected supply of electricity except for commercial use. S10(2)(g) – licence application must be accompanied by evidence of compliance with any integrated resource plan.	(Electricity Regulation Act No. 4 of 2006, 2006)
2011	Integrated Resource Plan (IRP) 2010-2030	• 200MW of embedded generation capacity allocated each year from 2018-2030. • S6.15 – net metering should be considered for all consumers. • S6.16 – The IRP should not limit activities behind the meter where consumers take up energy efficiency and other measures to improve their demand exposure, inclusive of co-generation and residential/commercial PV.	(DMRE, 2011)
2016	Integrated Resource Plan (IRP), first revision	No mention of private participation of embedded generation.	
2017	ERA Act 4 of 2006 (second amendment)	Schedule 2 – activities with capacity of <1MW exempt from licensing	(Electricity Regulation Act No. 4 of 2006, 2006)
2019	IRP 2019 – 2030	Updated IRP allocation embedded generation capacity as follows:	(DMRE, 2019b)

		• 2019 – 2022: "allocation to the extent of the short term capacity and energy gap" • 2023 – 2030: 500 MW per annum	
2021	ERA 4 of 2006 (third amendment)	Schedule 2 – operation of a generation facility with or without storage with capacity of <100MW exempt from licensing but is required to be registered with NERSA.	(Electricity Regulation Act 4 of 2006, Ammendment of Government Notice No. 737, 2021)

Source: Authors own.

2.3 Decentralised private power generation.

Increased participation of the private sector in electricity generation is changing the design of electricity systems (ES) across the world. As electricity markets have been liberalised and technology advancements lower the barriers to generation, it has become increasingly important to distinguish between types of ES arrangements. A framework is therefore used to provide structure and context to guide the scope of the research area. This will be based on ES characteristics of (1) arrangement typology, (2) scale and (3) financial phase as well as accounting for the concept of electricity wheeling.

2.3.1 Typology of ES arrangements

Two broad terms are used to distinguish between ES arrangements, 'decentralised' and 'centralised'. Funcke and Bauknecht (2016) attempted to develop a framework to distinguish between these two ES arrangements using the characteristics of generation infrastructure. This framework is premised on the characteristics of (1) the location of infrastructure to the end-user (proximity and connectivity) and (2) the flexibility and degree of control over the infrastructure's operation (refer to Table 4). While these dimensions offer one of the first frameworks for an ES typology, the introduction of wheeling and the nature of South Africa's transmission network is such that privately owned and operated generation infrastructure is often located significant distances from its load, with electricity wheeled via the transmission grid. The location criteria of Funcke and Bauknecht (2016) framework are therefore not relevant in a South African context. However, the operation model criteria still hold relevance given the role of Eskom as South Africa's sole transmission system operator

(TSO). Applying the operational model criteria classifies any generation infrastructure that is Eskom owned or where Eskom is the primary off-taker as 'centralised', as this infrastructure is controlled by a TSO and balanced using large-scale infrastructure. This includes IPPs procured under the REIPPPP, where Eskom is the primary off-taker. As for decentralised Ess, application of the 'operation' criteria means that any generation infrastructure that is municipal or privately owned, where Eskom is not the primary off-taker and is connected to the regional distribution grid.

Table 4: Typology of centralised and decentralised electricity generation.

Infrastructure Dimension		Decentralised Generation (DG)	Centralised Generation (CG)
Location	Connectivity	Connected to the distribution grid.	Connected to the transmission grid.
	Proximity	Generation infrastructure is located near load.	Generation infrastructure is located near resource.
Operation model	Flexibility	Generation infrastructure is balanced through demand side management.	Generation infrastructure is balanced through large-scale power generation, storage, and transmission grid.
	Controllability	Infrastructure is controlled by controlled by DSOs and/or prosumers and coordinated through regional markets.	Infrastructure is controlled by TSOs and coordinated through national or international markets.

**DSO = distribution system operator , TSO = transmission system operator.*

Adapted from Typology of centralised and decentralised visions for electricity infrastructure (Funcke & Bauknecht, 2016).

An additional classification of electricity generation is that of 'embedded generation'. Embedded generation is referred to broadly in literature as generation infrastructure that sits behind the electricity meter (Ana Filipova & Morris, 2018; Electricity Regulation Act No. 4 of 2006, 2006). The IRP 2018 further refined the definition of 'embedded generator' to constitute installed capacity of between 1MW-10MWs, with the generator undertaking activities that fall within the definition as laid out in Annexure E of the report (Refer to Table 5). For the purposes of this study 'embedded generation' falls within the classification of decentralised generation infrastructure.

Table 5: Criteria for classification of embedded generator in South Africa.

Embedded Generation	Capacity	Connectivity	Customer
Type 1	1MW-10MW	to national grid with wheeling	single customer with approval from distributor
Type 2	1MW-10MW	to national grid with no wheeling	single customer who is the holder distribution licence
Type 3	1MW-10MW	Not connected to the national gird	single customer who is related to/or owner of the generator

Adapted from (Integrated Resource Plan 2018, 2018)

2.3.2 Scale

DG and CG can further be categorised by type of technology and scale, measured by generation capacity. This study is technologically agnostic and therefore only scale will be used in determining its scope.

The scale of DG infrastructure is not strictly defined but is often categorised as micro, small, medium, and large, with large infrastructure often referred to as 'Utility-scale' (El-Khattam & Salama, 2004). Literature on South Africa's power sector differs in its definition of 'small', with some authors citing any system with a capacity <100KW while others citing less ES <1MW (GreenCape, 2021; SALGA, 2020; Wiley & Bick, 2018a). Legislation and the IRPs provide little guidance on system size classification. However projects under the Government's Small Projects IPPPP (SP-IPPPP) are required to be between 1-5MW in order to be classified as small (IPP Procurement Programme 2012, 2012). As for large-scale ES, Eskom's smallest generating unit (excluding peaking load hydroelectric stations) is the Sere wind farm with a total nominal capacity of 100MW (Eskom, 2021b). Based on these facts, the following system scale classification is proposed (refer to Table 6). For the purposes of this study generation units that fall within the small and medium range will be considered.

Table 6: Classification of electricity generation system size.

Classification	Micro	Small	Medium	Large (Utility)
Generation Capacity	<1MW	1MW-5MW	>5MW-<100MW	>100MW

Source: Author

2.3.3 Electricity Wheeling

Wheeling is defined as the transmission of power from a power producer (seller) to a consumer (buyer) through a transmission or distribution network owned by a third party (Sood et al., 2002). Wheeling does not mean the precise electrons entering the transmission network from the generator will be transported to the end-user. Rather, wheeling provides a framework that guides the balancing of energy from the generator with the end-user consumption through a financial transaction.

Given the arrangement of South Africa's power transmission and distribution system (refer to section 2.1.1), this refers to electricity transmitted using either Eskom or municipal owned transmission infrastructure by an independent party to another independent party. Wheeling regulation and legislation is a key deliverable in South Africa's White Paper on RE and although it has been permitted in principle for several years, clear national regulations and frameworks have yet to be developed (DMRE, 2003). However, the Cities of Tshwane, Nelson Mandela Bay Metropolitan and the City of Cape Town are some major municipalities currently implementing legislation allowing wheeling (GreenCape, 2022b).

2.3.4 Project phase

DG projects are broken down into manageable project components or phases. This accommodates the multiple stakeholders and complex interdependencies of tasks required to deliver the final product. Determining the project phasing of DG projects is necessary to determine the projects that will fall within the scope of this study. The DMRE's REIPPPP procurement process and timelines will be used to inform the scope.

The REIPPPP 'procurement process' comprises six distinct stages and milestones. The process provides a framework for the private sector procurement of DG in accordance with principles of project financing (refer to Table 7). Based on the project phase and milestones, only projects that have completed stage four, the financial close phase, will fall within the scope of this study.

Table 7: Project phase and milestones of the REIPPPP.

Stage and milestones	Key activities
Stage I: Request for proposal	Bid round opened with request for proposals issued to market

Stage II: Bid preparation and submission	Interested bidders submit bids
Stage III: Bid evaluation and preferred bidder announcement	Bids are evaluated and preferred bidders announced
Stage IV: Financial close	Preferred bidders are required to finalise and sign financial and project agreements required to reach financial close.
Stage V: Construction	Construction beings
Stage VI: commercial operation	Commercial operation date (COD) as agreed to in the financial close phase.

Adapted from "Understanding the REIPPPP, SAPVIA, 2020. (SAPVIA, 2020)

2.4 Commercial and Industrial (C&I) Sector in the context of power

South Africa is home to the second largest economy in Sub-Saharan Africa (SSA), with a GDP of $419,4 Billion (World Bank, 2022). The C&I sectors are integral to the country's economy and, as of 2021, were collectively responsible for 68% of South Africa's GDP (Maluleke, 2022) . The country's 'Industrial' sector is made up of chemical, mining, iron and steel, food, and tobacco industries. The 'commercial' sector is made up of financial services, information technology, retail, tourism and the service industry, with agriculture and agro-processing falling under a separate 'Agricultural' classification (DMRE, 2021). Owing to its economic importance and energy demands, the C&I sector has been identified as a crucial part of the country's immediate efforts towards energy security (DMRE, 2021).

2.4.1 Electricity demand in the C&I sector.

South Africa's C&I sectors represent a substantial portion of the country's total power demand, collectively consuming 140,584,771 MWh per annum. The sector accounts for 71% of South Africa's total annual power consumption with industry accounting for the majority of consumption between the two sectors (Refer Table 8). Most of the sector's electricity demand, 77,568,000 MWh (55%), is met by power supplied directly from Eskom, with the remainder being supplied either indirectly via municipal distributors or self-generation (Eskom, 2021a). The reliance of the industry on Eskom leaves the C&I sector heavily exposed to shortages in Eskom's generation capacity and, thereby the economic implications of load shedding.

Table 8:Total Energy Consumption in South Africa by Sector

Sector	Electricity consumption*		
	TJ	MWh	Percentage
Industrial Sector	372,905	103,584,771	52%
Transport Sector	11,527	3,201,807	2%
Agriculture	21,485	5,968,000	3%
Commerce and Public Services	133,200	37,000,000	19%
Residential	174,683	48,522,999	24%
Non-specified (Other)	2,686	746,000	0%
Total	716,485	199,023,577	100%

Adapted from (DMRE, 2019a)

2.4.2 DG in the C&I sector.

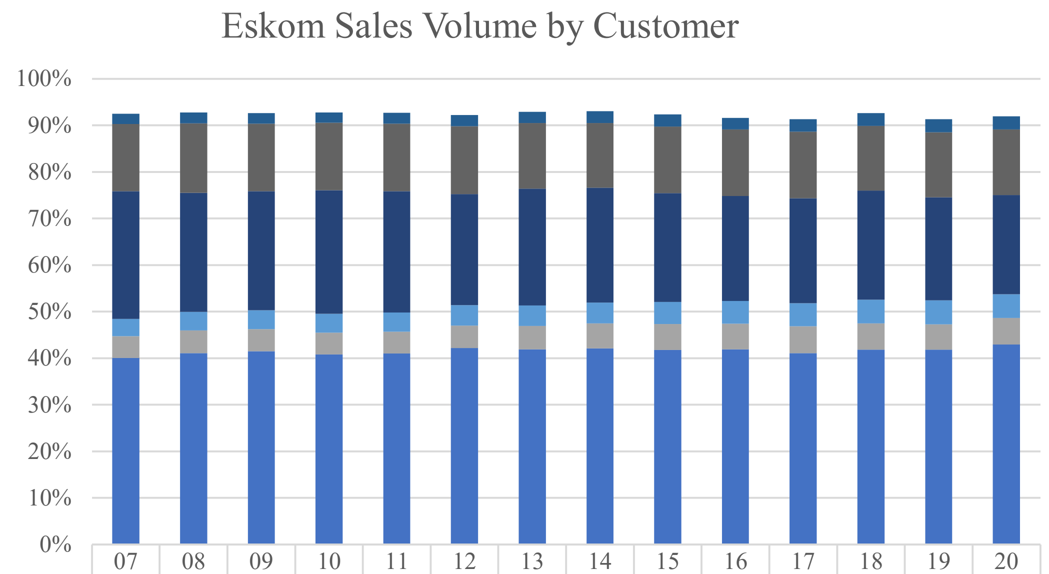
The C&I sector's reliance on Eskom to supply power has recently changed with the increased adoption of DG. In particular, Eskom's direct sales to industrial consumers have declined since 2010 (refer to Figure 3). This has been attributed to four major drivers: rising Eskom electricity tariff prices, falling costs of RE technologies, supportive policies and regulation and energy financing and incentives (GreenCape, 2022a).

Rising electricity tariffs

Eskom's average tariff has risen by 485% from 18,06 c/kWh in 2007 to 105,62 c/kWh in 2021. The annual increase in tariffs has exceeded South Africa's consumer price index (CPI) for 11 of the 15 years since 2007 (refer to Figure 4). Eskom has indicated that double-digit price hikes will be pursued in the coming years to reach tariffs that are more cost-reflective (GreenCape, 2022b). As a major cost of production in the C&I sector, the increase in electricity prices created an increased demand for alternative electricity sources.

Falling cost of RE

The cost of RE has continued to fall across technologies since 2010, with onshore wind and PV providing the cheapest levelized cost of electricity (LCOE) for utility-scale projects (refer to Figure 5). Small-scale DG prices have also declined with the cost of a 400KW system, a proxy for microgrids, declining 45%, from 164 c/kWh in 2017 to 90 c/kWh in 2021 (IRENA, 2020). Reducing technology costs has improved the economic viability of private sector investment in DG, in turn making self-generation a competitive alternative to Eskom-generated power (Pandarum, 2019).



	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Agriculture	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%	3%	3%	3%
Mining	14%	15%	15%	15%	15%	15%	14%	14%	14%	14%	14%	14%	14%	14%
Industrial	27%	26%	26%	27%	26%	24%	25%	25%	23%	23%	23%	23%	22%	21%
Commercial	4%	4%	4%	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%
Residential	5%	5%	5%	5%	5%	5%	5%	5%	6%	6%	6%	6%	5%	6%
Local gov.	40%	41%	41%	41%	41%	42%	42%	42%	42%	42%	41%	42%	42%	43%

Figure 3: Eskom sales volumes by customer type for from 2027 to 2020.

Adapted from: (Eskom Holdings Ltd, 2022)

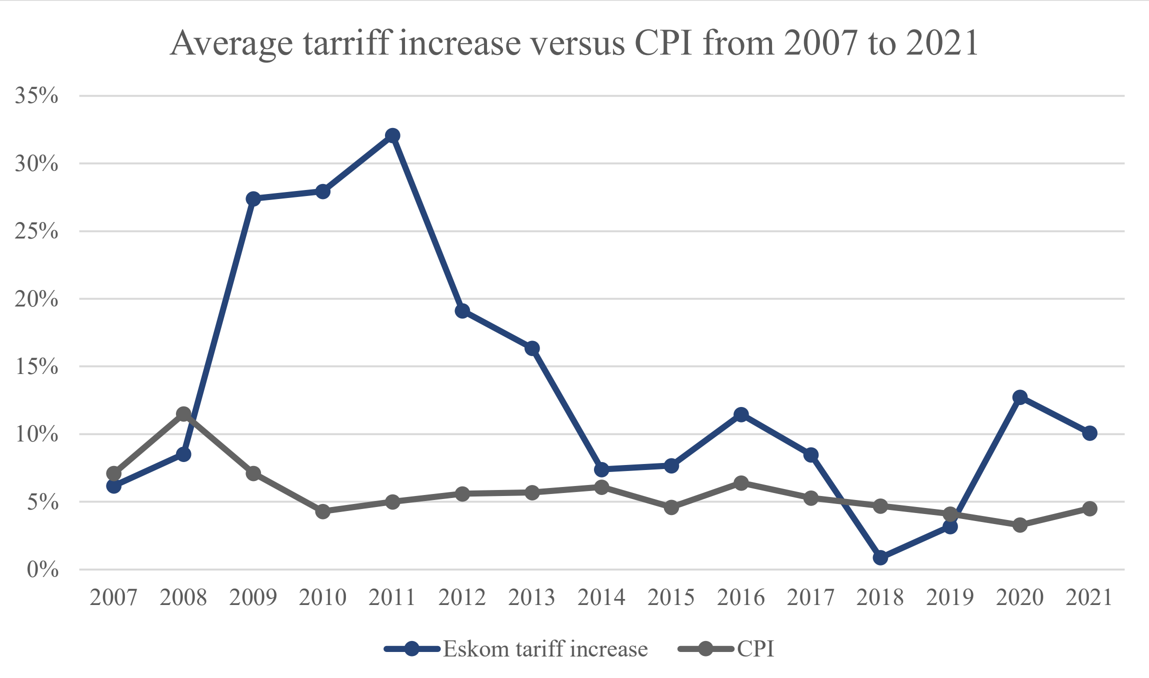


Figure 4: Average Eskom tariff increase versus inflation (CPI) from 2007 to 2021.

Adapted from (Eskom, 2022a) *and* (Stats SA, 2022)

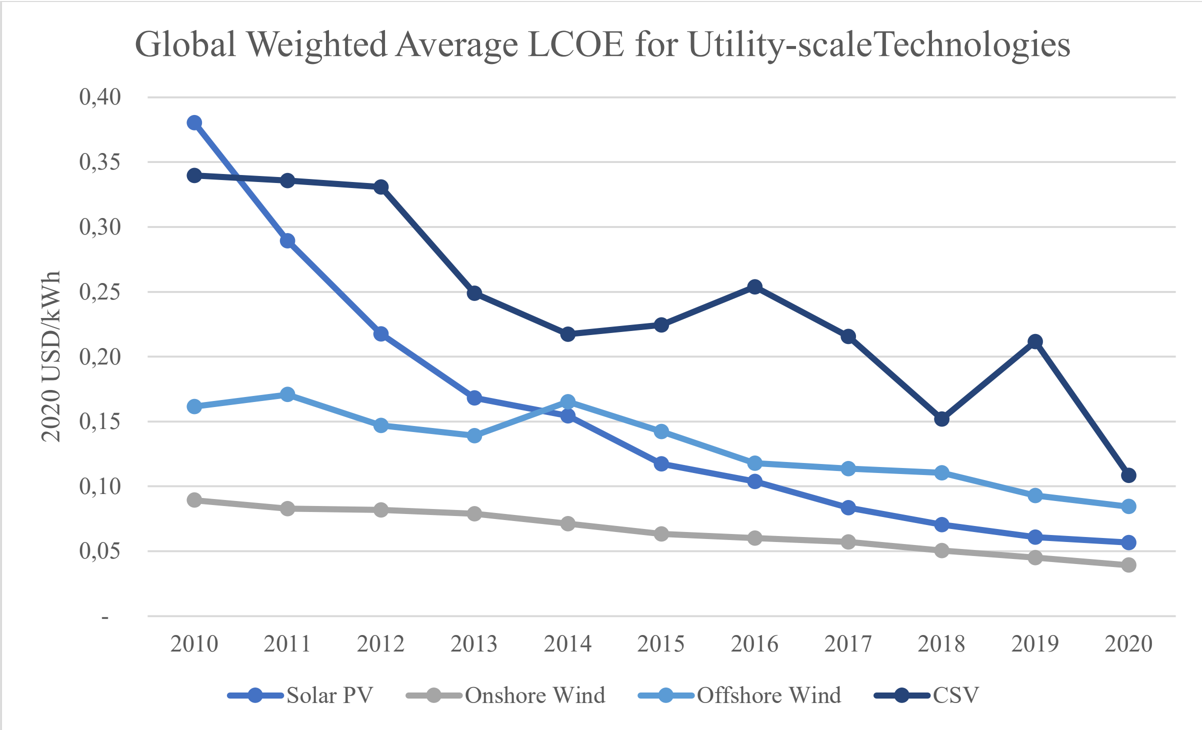


Figure 5: Global LCOEs from newly commissioned renewable power generation technologies, 2010-2020.

Adapted from (IRENA, 2020)

2.4.3 Installed capacity in the C&I sector.

The current installed generation capacity of the C&I sector needs to be clarified owing to unregistered generation units. However, NERSA has recently started to register C&I generation applications, potentially providing reliable data in the future. Since the amendments to Schedule 2 of the ERA, there is a clear appetite for investment into private sector participation in power generation, with estimates placing the potential market size at approximately 500MW per annum. This has been supported by the announcement of investment in major projects led by the mining sector, with a reported pipeline totalling 2GW that could be bought online by 2022/2023 (GreenCape, 2022b). The below table of selected projects provides an indication of the appetite of the private sector (refer to Table 9).

Table 9: Pipeline of private sector power generation projects for selected C&I entities.

Private entity	Industry		Generation Capacity (MW)	Technology	Project Phase
Goldfields Ltd	Mining		40	Solar	Feasibility
Royal Bafokeng	Mining		30	Solar	Prefeasibility
Sibanye Stillwater	Mining		50	Solar	Feasibility
Anglo	Mining		100	Solar	Feasibility
Exxaro	Mining		70	Solar	Feasibility
Amazon	E-commerce and Cloud storage		10	Solar	Commercial operation

Source: authors

2.4.4 Export Feed-in Tariffs and Net metering

Municipal export feed-in-tariffs refer to the tariff set by the municipality and approved by NERSA for every kilowatt-hour (kWh) of surplus electricity a customer's DG system exports to the municipal distribution grid (NERSA, 2015). Export feed-in frameworks and tariffs enable would-be-consumers to generate revenue from the sale of excess DG power systems and in some cases allow for "Net metering". This is the practice of off-setting electricity consumed with the electricity supplied by the consumer within the same billing period. As of the 2022/2023 financial year, the development of a national framework and rules by NERSA for the determination of municipal export-feed in tariffs remains underway, however, NERSA requires municipalities to undertake a 'Cost of Supply' study in preparation for its upcoming determination. Until such time that a framework has been developed, the determination of municipal feed-in-tariffs remains within the power of municipalities with the approval of NERSA, as is the case for all municipal electricity tariffs (NERSA, 2022).

Despite the absence of a national feed-in-tariff guideline, several municipalities have developed an export feed-in-tariff. While the development of these export tariffs is promising, uncertainty around the application of these tariffs still remains in some municipalities (SALGA, 2020). In addition, current variable feed-in-tariffs remain low relative to the LCOE in most provinces for the most system sizes (refer to Table 10).

Table 10: Net Financial Impact of Municipal feed-in tariffs per province for supply power from PV DG systems without battery storage.

<table>
<tr><th rowspan="2">Province</th><th rowspan="2">Proportion of Municipalities with feed-in tariff*</th><th rowspan="2">Average Variable Commercial feed in tariff (R/kWh)^</th><th colspan="3">LCOE from PV system without battery storage by power generation capacity (R/kWh)**</th><th colspan="3">Net financial impact of variable feed-in-tariff by power generation capacity (R/kWh)</th></tr>
<tr><th>1kW-10kW</th><th>10kW - 2MW</th><th>2MW-100MW</th><th>1kW-10kW</th><th>10kW - 2MW</th><th>2MW-100MW</th></tr>
<tr><td>Eastern Cape</td><td>5%</td><td>1,03</td><td rowspan="9">1,51</td><td rowspan="9">1,33</td><td rowspan="9">0,84</td><td>-0,48</td><td>-0,30</td><td>0,19</td></tr>
<tr><td>Free state</td><td>no data</td><td>no data</td><td>no data</td><td>no data</td><td>no data</td></tr>
<tr><td>Gauteng</td><td>18%</td><td>0,49</td><td>-1,02</td><td>-0,84</td><td>-0,35</td></tr>
<tr><td>Kwazulu-Natal</td><td>2%</td><td>1,43</td><td>-0,08</td><td>0,10</td><td>0,59</td></tr>
<tr><td>Limpopo</td><td>4%</td><td>1,00</td><td>-0,51</td><td>-0,33</td><td>0,16</td></tr>
<tr><td>Mpumalanga</td><td>15%</td><td>0,83</td><td>-0,68</td><td>-0,50</td><td>-0,01</td></tr>
<tr><td>Northern Cape</td><td>10%</td><td>1,14</td><td>-0,37</td><td>-0,19</td><td>0,30</td></tr>
<tr><td>North West</td><td>0%</td><td>0,00</td><td>-1,51</td><td>-1,33</td><td>-0,84</td></tr>
<tr><td>Western Cape</td><td>63%</td><td>0,71</td><td>-0,80</td><td>-0,62</td><td>-0,13</td></tr>
</table>

**Adapted from* (SALGA, 2020)
^ Authors own research based off municipal tariffs for the 2022 financial year for standard consumption during high demand (inclusive of VAT)
*** 2022 LCOE prices Adapted from* (Pandarum, 2019)

2.5 Review of existing literature on critical factors influencing EG

The importance of the private sector's contribution to South Africa's energy security has resulted in several studies on the critical factors influencing private sector participation in power generation. However, the majority of existing literature is limited in scope to include only the adoption of PV generation technology and has, to a large extent, excluded other technologies & sources like gas, hydro, coal, hydrogen. This has been cited as a result of South Africa's high PV potential, ease of access to the technology and low investment cost relative to other technologies at a small and micro-scale (Lutchman, 2018; Nhamo & Mukonza, 2016; Pandarum et al., 2018; Wiley & Bick, 2018b). Prevailing literature has also tended to focus on systems with system capacities classified as micro to small scale. This is likely due to the legislative barriers to private participation in generation in excess of 1 MW prior to recent amendments. Regardless of the difference in scopes, previous findings on success factors provide valuable insights into the typology and relevance of factors that impact private sector participation electricity generation.

These findings highlight two broad areas of considerations by stakeholders, financial and non-financial (refer to Table 11). The type and emphasis of the consideration varies from stakeholder to stakeholder. Regulatory bodies tend to focus on non-financial considerations (except for economic tariff determination purposes), while behind the meter customers and FIs tend to focus on financial considerations. This highlights the importance of financial factors in determining investment into DG.

Table 11: Summary of literature exploring critical factors to the adoption of EG in South Africa

Study	Scope	Financial			Non-Financial					
		Availability of financing	Cost of technology	Relative cost of electricity	Knowledge (awareness)	Macroeconomic stability	Green image	Regulation	Quality of installation	Aesthetic
(Wiley & Bick, 2018a)	Rooftop PV, South Africa	X	X	X	X	X	X	X	X	X
(Lutchman, 2018)	DG, South Africa	X	X	X		X		X		
(Pandarum et al., 2018)	Solar PV DG in South Africa	X	X	X				X		

(Nhamo & Mukonza, 2016)	Solar PV DG in South Africa		X		X			X		
(GreenCape, 2022a)	Solar PV, C&I	X	X	X				X	X	

Source: Authors own

2.6 Finance and investment by the private sector in power infrastructure

Finance is commonly regarded as a primary driver for private investment in the power sector (Williams & Ghanadan, 2006). Although regulation and technology costs also play significant roles, the primary driver for private investment decisions in competitive markets, as opposed to government-owned markets, is financial risk and the potential return on investments (ROI) (Gross et al., 2010). To assess the critical success factors for distributed generation (DG) adoption, it's essential to gain a deeper understanding of investment decision-making in the private sector.

2.6.1 Private participation in the energy sector in the context of investment decision making.

The study of financial decision-making within a corporate or business setting is known as corporate finance. Corporate finance holds that the primary objective of any private entity (corporation) is to maximise the value of the firm. This is achieved using a combination of investment, financial or dividend decision theory (Damodaran, 2015). The decision by a private entity to invest in electricity-generation infrastructure requires that an entity apply the principles of investment decision theory first and foremost.

Traditional investment decision theory maintains that investment decisions should be purely financial and that corporations should only invest in assets that earn a financial return greater than the acceptable hurdle rate. This requires the corporation to consider two key elements: (1) the expected rates of the investment's profit and associate risk and (2) the cost of finance (Virlics, 2013). Two economic theories have come to explain investment theory, 'Portfolio Theory' and 'Cumulative Prospective Theory' (CPT) (BB Consultants, 2018). Portfolio theory holds that investors are risk averse and, therefore, prefer lower risk investments for any given level of return (Markowitz, 1952). CPT further builds on this to explain that investor's risk appetite changes relative to the level of expected gains or losses (Tversky & Kahneman, 1992). While a detailed study on investment theory is not the primary objective of this study, it is clear that in addition to return and capital needs, risk plays a significant role in a corporation's/firm's investment decision-making process. It can, therefore, be argued that the private C&I segment follows the same investment decision criteria in deciding whether or not to invest in DG's.

2.6.2 Financial arrangements

Power infrastructure projects differ from other types of investment in that they typically span long periods, require significant upfront capital before cash flow yield begins, are immobile, and are vulnerable to regulatory changes (Bond & Carter, 1995). This results in investors managing a unique risk profile when investing in power generation infrastructure. Two financial arrangements are available when financing infrastructure: (1) project finance and (2) corporate finance. These arrangements allocate the associated financial risk of power infrastructure in different ways, and the selection of financial arrangement depends on the nature of the corporation undertaking the investment.

Project finance

Project finance has been used to finance IPPs since the 1970s with the introduction of legislation in the United States, which encouraged the development of generation plants by allowing them to sell power based on long-term contracts (Yescombe, 2014). Its use in power infrastructure was accelerated during the 1980s and 1990s owing to growing sources of private capital underpinning privatisation and market liberalisation of the power sectors. In South Africa's case, the majority of projects within the REIPPPP are financed using the principles of project finance (Eberhard & Naude, 2018).

Project finance involves the creation of a separate purpose vehicle (SPV), which is a separate legal entity that is funded using non-recourse debt and equity in order to finance a single-purpose asset (Esty & Sesia, 2007). In a project finance arrangement each party's obligation and non-performance recourse is contractually defined (refer to Figure 6). Sound contractual agreements spread and mitigate the risk associated with long-term infrastructure projects, specifically within uncertain regulatory environments. Another critical element of project finance is that the risk associated with debt financing lies with the SPV rather than with the primary risk taker or 'promotor.' This requires that the project has certainty of long-term revenues through an off-take or purchase agreement and in doing so, debt repayments are ensured. Using these mechanisms, project finance is able to attract private investment in long-term assets such as electricity infrastructure.

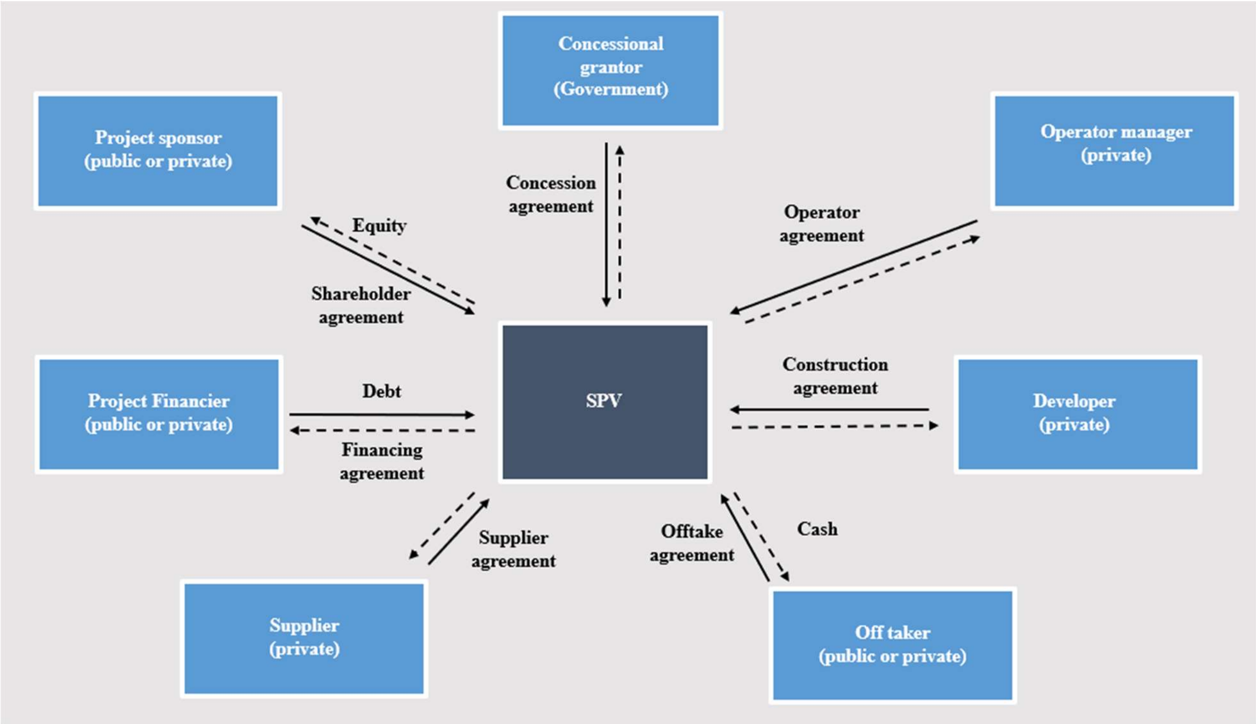


Figure 6: Typical Project finance Structure.

Adapted from (Yescombe, 2014)

Corporate finance

In the context of infrastructure financing, corporate finance describes a typical financial structure whereby equity, debt and cash reserves are used to finance a project. Corporate finance models differ from project finance most notably in the allocation of project risk. In a project finance arrangement the primary project risk is contained between the relevant party and the SPV, while in a corporate finance arrangement, the primary project risk sits with the project promotor (refer to Figure 7). As a result, the ability to raise sufficient debt is dependent on the financial soundness or balance sheet position of the promotor, as opposed to a project finance arrangement where the ability to raise debt is dependent on the project's future revenues.

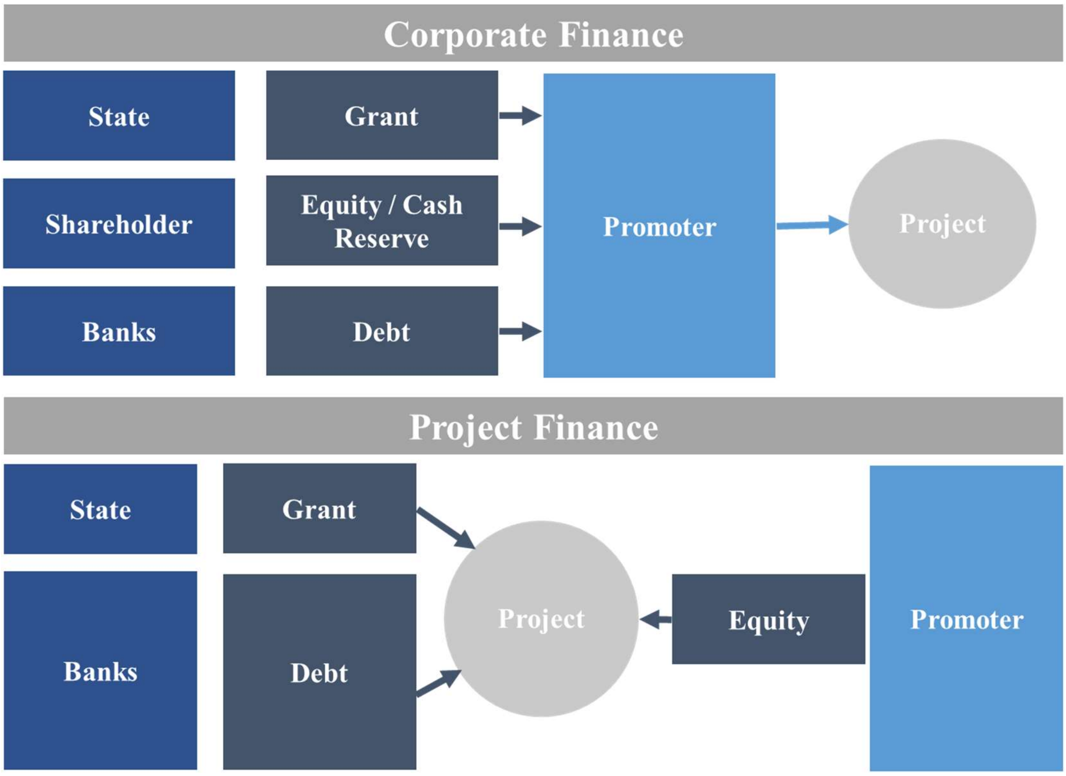


Figure 7: Corporate Finance versus Project Finance.

Source: Authors

2.6.3 Financial landscape as it relates to DG financing in the South Africa C&I sector.

Private investment in DG projects in South Africa are typically funded using commercial debt, cash reserves or purchase power agreements (PPA) (GreenCape, 2022a). In terms of commercial debt, South Africa's commercial lenders and development finance institutions have played a pivotal role in financing large-scale utility projects under the REIPPPP. This includes South Africa's four largest commercial banks: Standard Bank, ABSA, Rand Merchant Bank (RMB), Nedbank, and the Development Bank of South Africa (DBSA). The scale of these projects has meant that the financial arrangement and terms of each project is considered on an individual basis and that no particular 'off-the-shelf' financial product has been developed. Little is known about the financial arrangements available to the C&I sector at the scale required to meet the sector's needs. However the commercial banks have provided an indication of the types of products available to the sector should they wish to invest in DG (refer Table 12).

Table 12: Financial institutions providing specialised financing for decentralised generation in South Africa

Institution	**Institutional classification**	**Products**	**Reference**
ABSA	Commercial Bank	Amortised debt	(GreenCape, 2021)
First National Bank (FNB)	Commercial Bank	Amortised debt	(GreenCape, 2021)
Nedbank	Commercial Bank	Amortised debt	(GreenCape, 2021)
Standard Bank	Commercial Bank	Dependent on situation	(GreenCape, 2021)
Development Bank of South Africa (DBSA)	Development Bank	Amortised debt	(DBSA, 2022)
Industrial Development Corporation (IDC)	Development Bank	Amortised debt	(IDC, 2022)

Source: Authors Own

2.7 Summary

The growing involvement of the private sector in South Africa's power industry is occurring against a backdrop of challenges faced by the predominantly state-owned power sector, which has struggled to meet increasing demand due to political interference and mismanagement. This paradigm shift challenges the long-standing norm of a state-owned, vertically integrated monopoly that has persisted for over half a century. The emergence of the private sector as a significant player has introduced novel concepts and frameworks, defining its role and paving the way for increased investments, notably in areas such as electricity wheeling and DG.

Private sector participation necessitates a distinct approach to power investment compared to the methods employed by public sector State-Owned Enterprises (SOEs). Key financial principles, particularly those related to corporate finance, such as return on investment and risk assessment, underpin this approach. Project finance and corporate finance arrangements serve as the guiding frameworks for facilitating private sector investments, offering a departure from the rules traditionally applied by government entities.

In conclusion, the evolution of South Africa's power sector with increased private sector involvement signals a significant departure from the historical status quo. This transformation introduces innovative concepts and financial frameworks, offering opportunities for substantial investments while demanding a revaluation of traditional government-driven investment strategies.

3 METHODOLOGY

3.1 Research approach

The purpose of this chapter is to detail the selected approach and design used to answer the research question. The research methodology was designed using the 'research onion' framework, which provides decision-making criteria against which the appropriateness of research theories is evaluated (refer to Figure 8).

Six criteria are used to develop a robust research methodology, namely: 1) research philosophy, 2) approach to theory development, 3) methodological choice, 4) research strategy, 5) time horizon and 6) techniques and procedures. Using the research onion framework, a qualitative research methodology with exploratory multiple case study design has been selected for purpose of answering the research question. The following sections detail the application of the research onion framework used to arrive at the selected methodology.

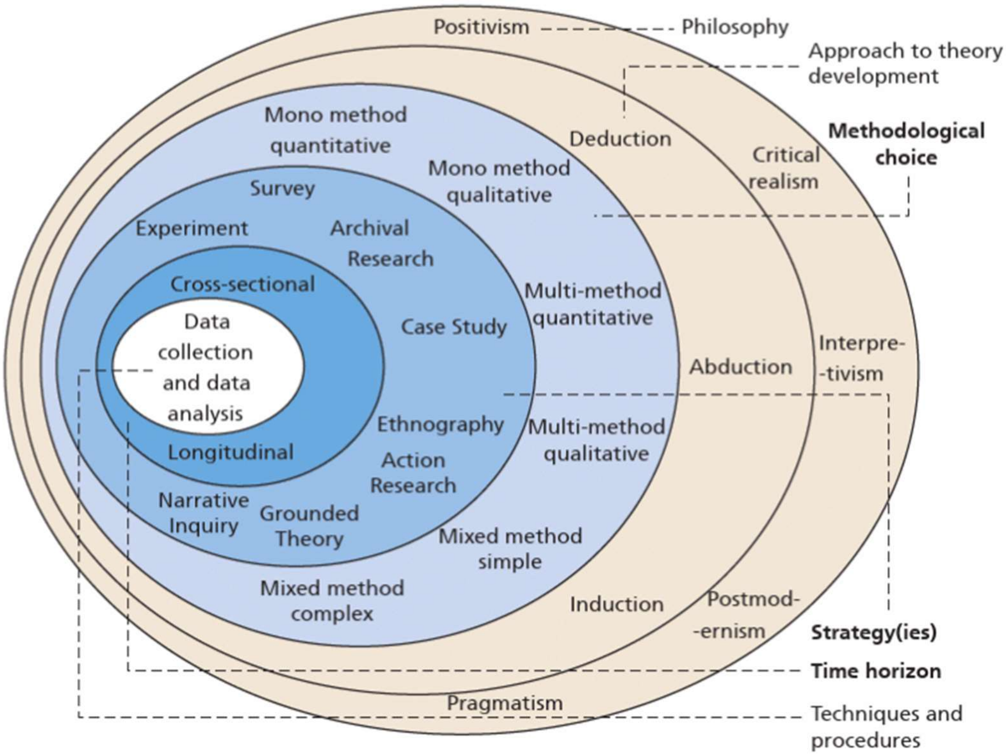


Figure 8: The Research Onion.

Source: (Saunders et al., 2019).

3.1.1 Research philosophy

This research aims to understand the barriers and critical success factors that enable or inhibit private sector investment into DG in new regulation. The research is therefore attempting to critically evaluate the real-life experiences of investors and play a practical role in promoting investment into DG by the C&I sector, given that the 'obvious' or 'known' regulatory barriers have been removed. The research is, therefore, trying to provide insights that inform actionable solutions to real-life problems. This speaks to a pragmatic philosophical orientation towards the research question as the research tries to provide actionable solutions to real-life problems (Cersosimo, 2022).

Pragmatism is seen as a method for uncovering contextual truth (Coghlan & Brydon-Miller, 2014). The researcher begins by identifying a problem with the intention of producing practical solutions that will inform future practices (Saunders et al., 2019). Given the research question and intention of this study, pragmatism is the appropriate philosophical approach orientation.

3.1.2 Research approach to theory development

An abductive approach to theory development will inform the study design. In an abductive approach, the research process begins with 'surprising facts' and is devoted to uncovering their explanation (Kovács & Spens, 2005).

The research hopes to explain the 'surprising fact' that while known significant factors constraining investment by the C&I sector have been addressed, investment still lags. Such factors include the relaxation of ERA licensing requirements, increased load-shedding in combination with the C&I sector's reliance on Eskom for power, and the reduced cost of power generation technology. The research is therefore seeking to identify real-life issues experienced by the C&I sector that are currently not explained by existing financial, economic and management theories. Elaboration of existing theories and concepts is therefore required with the use of empirical data.

Theory elaboration, which uses empirical data to make logical inferences, speaks to an abductive approach (Mitchell, 2018). In an abductive approach, the interplay of research components is used to elaborate theory rather than to strictly develop new theory (induction) or test existing theory (deduction). This is not to say that an abductive approach cannot be carried out with an initial theoretical frame. Instead, the approach facilitates the exploration of phenomena by examining individual cases (Thomas, 2010).

3.2 Methodological choice and research strategies

The research methodology has been developed in line with this study's pragmatic philosophy and abductive research approach. This allows for the use of methods most suitable to the type of research being conducted with the emphasis being on producing practical solutions (Cersosimo, 2022). Therefore, a methodology that results in practical outcomes to promote investment into DG by the C&I sector has been developed.

Abduction uses both deductive and inductive research approaches by placing emphasis on all four components of research design, namely, (1) theory, (2) the empirical world, (3) frameworks, and (4) case studies (refer to Figure 9). The selected research methodology considers all four of these components. Economic and investment theory provides a theoretical base to evaluate investment by the C&I, while data and case studies from existing investments provide evidence from the empirical world. Corporate finance and DG frameworks are also used to guide and elaborate existing theories. This is further supported by additional literature found to be relevant during data collection to help interpret data from the empirical world. This process is known as 'systematic combining' whereby theorising occurs based on an iterative process of combining existing literature and empirical evidence to confirm observations and assumptions (Charmaz, 2020).

The selected methodology lends itself to case study design. This will allow for empirical evidence from existing investment cases to provide real word experiences of the C&I sector, supported by existing frameworks and literature. Through the process of systematically combining, inferences will be developed to explain the 'surprising facts' around investment in DG and propose practical solutions to address any barriers.

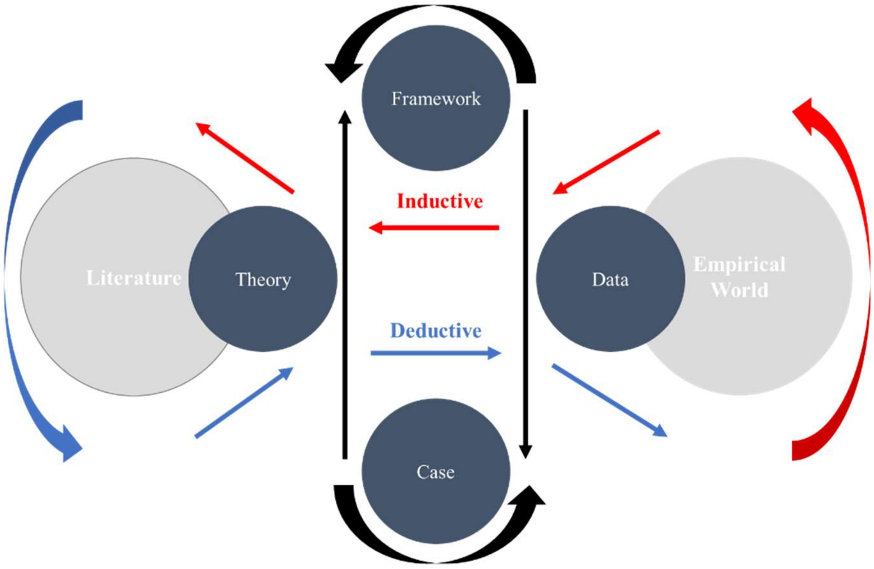


Figure 9: An abductive approach to theory development.

Adapted from (Alrajeh et al., 2013)

3.2.1 Case study Research design

Case studies are a detailed analysis of a single phenomenon using one or more methods. The case(s) that form the subject of enquiry "enable the topic of theoretical interest to be illuminated, analysed and explicated" (Thomas, 2019). Case studies thereby provide an in-depth understanding of the interaction between a complex phenomenon, such as investment in the power generation C&I segment, and its context, such as in the South African power sector (Dubois & Gadde, 2002). Given that case studies explore real-world examples, they align with the philosophical approach of pragmatism. Furthermore, case studies are aligned with an abductive approach as they support in-depth analysis of interactions between the empirical world and the theoretical world, such as that of the relationship between South Africa's C&I investors and economic and corporate investment theories that help to deepen our understanding of financial enablers and barriers to advancing C& I investments in the country (Conaty, 2021).

Exploratory case study

Yin (2009) proposes three types of case studies: exploratory, explanatory, and descriptive, with variations between multiple and single case studies. Central to determining the research design is understanding the nature of the research question (Yin, 1999). Based on the research question, this study seeks to understand the 'how' and the 'what' of the phenomena around investment by the C&I sector into DG within the South African context. This speaks to the exploratory role that the cases must play in theorising as the research remains open to all possibilities, and no single set of outcomes is expected (Hancock & Algozzine, 2016). Therefore, an exploratory case study design is most appropriate.

Multiple case study

Case studies can have a single or multiple-case design. Given the complex nature of private sector investment into power generation and the variability across South Africa's C&I sector a multiple case study design has been selected. This will allow the study to account for multiple variables such as industry type, system capacity, generation technology and geographical location. Evidence from multiple case studies is also seen as more persuasive and will improve the practical application of any findings across South Africa's C&I sector (Tellis, 1997).

Mille et al., 2012 argue that multiple case studies require the examination of at least three distinct cases (Mills et al., 2012). While there are multiple cases of private sector investment into DG in South Africa, in the interest of time and for practicality reasons, only three cases will be examined. The three selected cases will sufficiently consider the range of variabilities across the C&I sector whilst accounting for the common issues facing investment into DG.

Case selection criteria

Selection criteria are required to provide boundaries for including or excluding cases relevant to the study area (Stake, 1995). Bounding the cases helps to determine scope of data collection while strengthening the link between the case and the research question.

Based on the research question's focus on the C&I sector in South Africa and frameworks identified in the literature review, 5 criteria are used to determine case boundaries: (1) Geography, (2) economic sector, (3) ES typology, (4) ES scale and (5) project phase completed (refer to Table 13). These criteria ensure that the selected case is relevant to the research question.

Table 13: Case Study selection criteria

Criteria	Boundary	Relevant section in the literature review
Geography	South Africa	n/a
Economic Sector	C&I	2.4
ES typology	Decentralised Generation	2.3.1
ES scale (MW)	Small and Medium (1MW- <100MW)	2.3.2
Project Phase completed	Stage 4 - Financial Close or near financial close	2.3.4

Source: Authors Own

Case Study selection

The exploratory design of this study makes case study selection challenging, in addition to the fact that within the boundaries of this research, multiple cases exist. Three cases of C&I investment into DG have been selected: case 1: Weir Minerals Africa (WMA), case 2: Boxlee Pty Ltd and case 3: PKFOctagon. All three cases fall within the study's boundaries (refer to Table 14).

Table 14: Application of Selection Criteria against cases

Criteria	Selected cases		
	Wier Mineral Africa	Boxlee Pty Ltd	PKF Octagon
Geography, location with South Africa	Isando, Ekurhuleni	Industria, City of Johannesburg	Waverly, City of Johannesburg
Economic Segment	Industrial	Industrial	Commercial
ES typology	DG	DG	DG
ES scale	1MW	368 kW	148-185 kW
Project Phase completed	Commercial Operation	Commercial Operation	Financial Close

These cases represent 'diverse' case selection as they vary, to some degree or another, in location within South Africa, ES scale, project completion phase and industry within the C&I sector. WMA is located in the Municipality of Ekurhuleni, while both Boxlee and PKF Octagon are located in the Municipality of Johannesburg. Each of the cases also differs in economic activity within the C&I sector, with WMA and Boxlee representing heavy and light industries. In contrast, PKF Octagon represents the commercial segment of the C&I sector. The diversity between the cases is also evident in the scale of each ES, providing evidence across the spectrum of small to medium ESs. Finally, there is also diversity in the project completion phase, with one of the cases being in financial close, while the other two being in commercial operation.

The similarities and dissimilarities between the selected cases allow for inferences to be drawn, resulting in a higher likelihood of representing the broader population (Seawright & Gerring, 2008). This will ensure that any results are applicable across South Africa's broad C&I sector.

Data collection

Data was collected using unstructured key informant interviews (KIIs), secondary data and grey literature.

KIIs

KIs were selected using purposive sampling based on their expertise in finance or engineering and intimate knowledge of the investment under question. Initial interviews led to additional being identified KIs using snowball sampling. KIs interviewed included, financial managers, managing engineers, chief financial officers, and associated partners. In total 7 KIs were interviewed.

These KIs were contacted via email or telephonically and invited to participate in the study. Once the participants agreed to be interviewed, a meeting was arranged and held over conferencing software (MS Teams v1.5.00.9163). The 45-minute interview was recorded using the MS Teams recording feature after the participant's consent was obtained. In some instances, interviews were recorded by hand due to the sensitive nature of the content. Recordings were transcribed verbatim and stored in MS Excel for analysis.

Documentation

Secondary data was collected during KIIs. This included business/investment cases, presentations, financial models, and ES readings. These documents provided empirical evidence of relevant business decisions, investment rationale and technical details of each of the cases DG systems. These documents are highly confidential and required approval from upper management. Grey literature, such as municipal electricity tariffs, minutes of municipal council meetings, reports from relevant institutions such as GreenCape and NERSA were also used to confirm electricity tariff structures and regulations.

Data analysis

The research design is informed by an abductive theory development, as detailed in section 3.1.2. Central to an abductive approach is the continuous movement between the empirical and theoretical work, known as ‘systematic combining’. Two processes make up systematic combining (1) matching theory with reality and (2) direction and redirection. Matching theory with reality is the process of moving back and forth between the research elements of framework, data, and analysis while direction and redirection refers to the reflective and iterative process of using multiple sources of evidence to develop theory (Alrajeh et al., 2013). This is also referred to as the ‘abductive research cycle’ as theory and empirical data are recursively analysed using fitting and matching (Timmermans & Tavory, 2012). Based on the nature of systematic combining research is carried out over three stages as follows:

Stage 1: Exploratory (deductive) – Following an initial literature review, existing theories, frameworks, and literature are used to direct data collection.

Stage 2: Data collection (inductive) - Data from the empirical work is collected, documented and analysed using coding to identify key themes. Coding occurs at an individual case level as well as a collective case level.

Stage 3: Systematic combining – Additional literature and theory are used to explain phenomena identified in case studies and the empirical world. This process is iterative and leads to additional coding at both the individual and collective case level.

Stage 4: Individual – Case phenomena are analysed and discussed followed by cross case analysis. The cross-case analysis is used to identify similarities and dissimilarities between cases to explain phenomena identified. These are coded and form the basis for the discussion of findings.

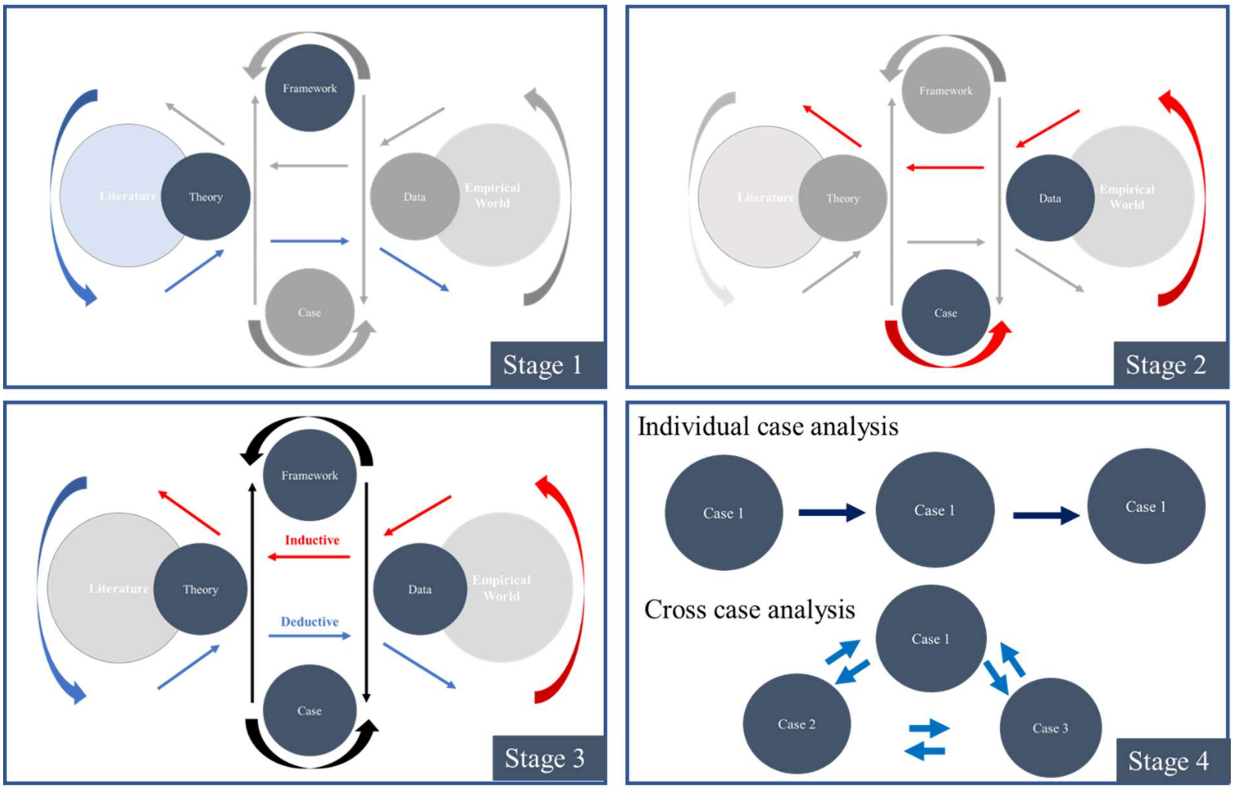


Figure 10: Data Analysis Design

Source: Authors Own

Presentation of empirical findings

Empirical evidence will be presented on a case-by-case basis, noting (1) the background and nature of the enterprise's operations, (2) the rationale for the adoption of DG, (3) the DG system's specification and (4) selected financing arrangement. Followed by an individual case analysis according to the analysis protocol set above. A separate section will present the cross-case analysis.

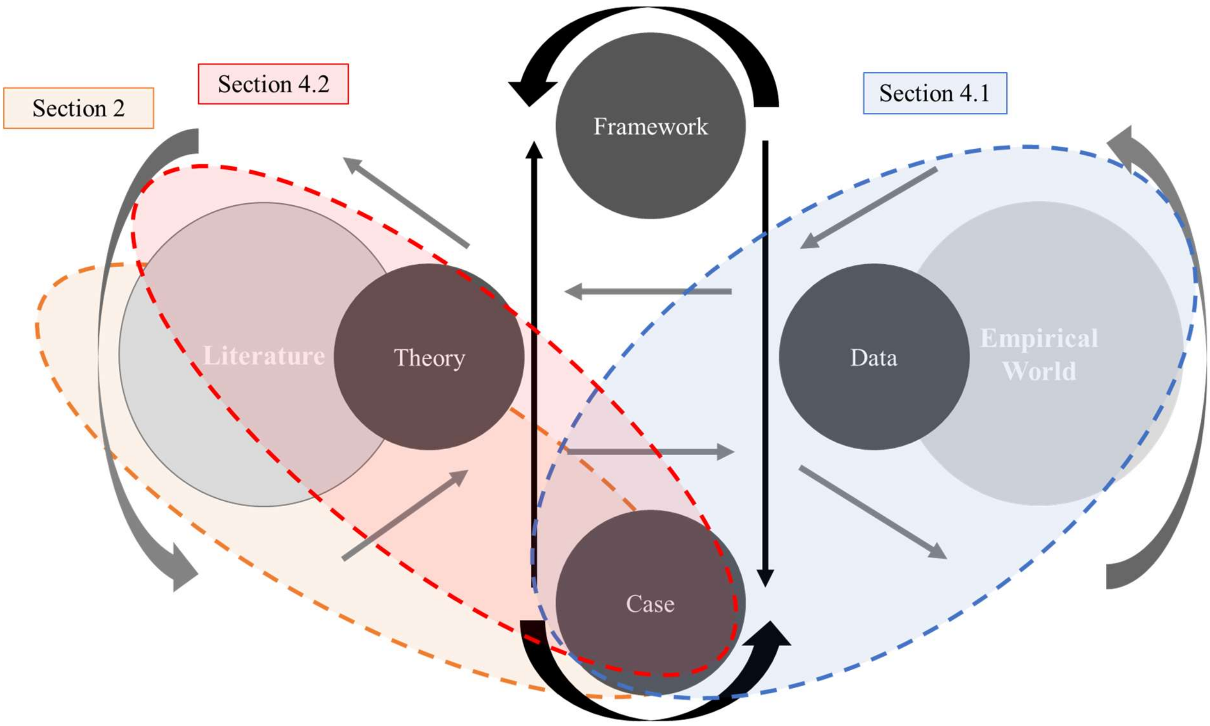


Figure 11: Application of Abductive approach in the study.

Computer-assisted qualitative data analysis software (CAQDAS)

Computer-assisted qualitative data analysis software (CAQDAS) was used. Interviews were transcribed and uploaded into the CAQDAS software package NVivo 11. CAQDAS is effective in ensuring qualitative data is correctly stored and coded in a consistent and well-defined manner (Frey, 2022).

3.2.2 Addressing concerns about case studies

Two criteria are used to ensure quality in case studies (1) reliability and (2) validity (Yin, 2009). In addition to these two criteria, the issue of generalisability is also addressed to ensure research quality.

Research Reliability

Research reliability refers to the degree to which the data collection techniques and analysis procedures have ensured consistent and stable findings (Remenyi et al., 1999). Reliability in research can be ensured with the use of transparency and replication (J. Farquhar, 2014). Transparency is ensured with the use of careful documentation of the details of each case and references to the relevant data bases, where possible. Tables are also used where necessary to provide the reader with easy access to data. Replication is addressed by clear documentation of research protocols to enable the study to be reproduced by others (refer to section 3.2.1).

Research Validity

Research validity consists of (1) construct validity, the extent to which the study ultimately investigates what it claims to investigate, and (2) internal validity, the presence of causal relationships between variables and results (J. D. Farquhar, 2012). It is not necessary to address internal validity in an exploratory case study such as this, as internal validity generally applies to explanatory studies that attempt to establish a causal link (Yin, 2009). Therefore only construct validity is addressed.

Two methods can be used to address construct validity: triangulation of data and establishing a clear chain of evidence (Stake, 1995). Triangulation of data is achieved through the use of the iterative process of pattern matching and coding of cases on an individual as well as cross-case basis. In addition to triangulation, a clear chain of evidence is presented based on the fact that first descriptive data on each individual case is presented, followed by an individual analysis and then a cross case analysis.

Generalisability

Generalisability (external validity) is a common threat to case study research and refers to the fact that theories should be shown to account for phenomena both within the context they are studied and elsewhere (Gibbert & Ruigrok, 2010). Generalisability is addressed with the use of multiple cases representing a diverse perspective of the C&I sector both by nature and size of operations and geographical location.

4 ANALYSIS AND RESULTS

4.1 Case Study 1: Weir Minerals Africa, Isando plant South Africa

Entity Background

Weir Minerals Africa (WMA) is a specialised engineering and mineral processing equipment manufacturer in South Africa. The company is part of the larger London Stock Exchange (LSE) listed Weir Minerals Group (the Group), headquartered in Glasgow, Scotland (The Weir Group, 2021). This case focused on WMA's Isando factory, located in Isando, an industrial area within the municipality of Ekurhuleni (CoE).

WMA's Isando factory is responsible for manufacturing specialised mining components that service South Africa's mining industry. The Isando factory site is equipped with three heavy-duty manufacturing functions: a rubber plant, induction furnace, and heavy machinery casting. The plant operates 24 hours a day, 7 days a week (24/7), with a total power consumption of approximately 2.2MW daily. The site is connected and supplied by the CoE's distribution grid, responsible for the reticulation and on-sale of Eskom-produced power.

Rational for adoption of DG

Three key factors motivated WMA's decision to invest in DG at its Isando plant. First and foremost, the rising input cost of electricity; second, the amendment to the ERA, which enabled the entity to produce power at a financially feasible scale; and lastly, the Group's commitment to reduce Carbon Dioxide (CO_2) emission.

Rising input cost of electricity

Electricity is a key input into the production process at WMA's Isando plant, given its use of heavy machinery and induction furnaces. This results in the unit cost of manufactured goods being susceptible to shocks from municipal electricity price increases, which in turn threatens the operation's profitability and price competitive advantage.

As highlighted in section 2.4.1, Eskom has increased wholesale electricity prices in excess of consumer inflation for the majority of the last 15 years. This has, in turn, resulted in municipal distributors having to increase electricity supply tariffs to cover the costs of wholesale electricity purchase from Eskom whilst maintaining electricity resale as a core revenue stream for South African municipalities (Statistics South Africa, 2022). In the case of the CoE, electricity tariffs have increased by an average of 10,87% over the past 5 years, exceeding the average CPI of 4,84% for the same period (refer to Table 15). This persistent increase in municipal electricity tariffs has had a significant impact on the cost of production and is therefore one of the primary driving factors behind WMA's decision to invest and source DG.

Table 15: City of Ekurhuleni Tariff D Electricity Prices from 2018-2022

Tariff D electricity tariff (R/kWh)						
Energy Charge category	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Average
High demand season*	R1,29	R1,46	R1,55	R1,78	R1,95	
High demand change		*13,07%*	*6,23%*	*14,59%*	*9,61%*	10,87%
Low Demand season**	R0,90	R1,01	R1,08	R1,23	R1,35	
Low Demand change		*13,07%*	*6,23%*	*14,59%*	*9,61%*	10,88%
Consumer price index	*4,70%*	*4,10%*	*3,30%*	*4,50%*	*7,60%*	4,84%

**High demand season (June, July, August) **Low demand season (September to May) Prices used are for Voltages >11KV*
Source: (City of Ekurhuleni, 2022)

Commitment to reduce CO^2 emissions (CO^2e)

As of 2021, the Weir Minerals Group's sustainability strategy has committed to reduce the Group's CO^2e by 30% by 2024 (The Weir Group, 2021). Initial efforts to achieve this targeted a reduction in the Group's energy intensity and increased the proportion of energy sourced from renewables (The Weir Group, 2021). In line with this strategy, the Group issued an R13,072 million ($800 million converted at R/$ 16,34) 2.20% sustainability linked bond (SLB) in May 2021 to finance its working capital. The SLB requires that Weir Minerals meet its CO^2e targets by 1 January 2025, failing which, the Group's cost of financing will increase by 25 basis points (bps). The installation of a RE DG system at the Group's Isando plant is therefore aligned to the Group's strategic goal of increasing its proportion of energy sourced from renewables and contributes to the achievement of conditions under SLB.

Issuing the Group's SLB mirrors global climate and sustainability finance trends. SLBs tie general-purpose debt financing to the issuers' performance against predetermined sustainability-linked targets. In this regard, SLBs seek to promote sustainable practices by aligning the cost of financing with achieving measurable sustainability outcomes (ICMA, 2020). Evidence suggests that issuers of sustainable debt on average have lower borrowing costs (Mahtani et al., 2020). This creates incentives for entities within the C&I sector to shift their energy usage patterns in order to access more favourable financing terms.

Rational for ES design and specifications

Following the initial decision to explore investment into a DG system, WMA undertook a cost-benefit analysis (CBA) and the development of a business case. This was done to determine the most suitable ES specifications and financing arrangement.

Given the scale of the Isando plant operations, the Group's intention to source energy from RE sources, and the considerable onsite rooftop space, a DG system powered by roof-mounted photovoltaic (PV) panels was considered most suitable to meet the plant's needs. Three DG system arrangements were considered: (1) direct supply – whereby power is consumed as it is produced; (2) supply and storage – whereby power is consumed and stored for later usage; and (3) storage and not pay peak – whereby power is stored and only consumed only during periods of peak consumption.

The CBA indicated that a direct supply arrangement with a capacity of 1MWh was ultimately the most financially feasible option owing to two key factors: (1) the inhibitive cost associated with battery technology, which eliminated options 2 and 3 above, and (2) unfavourable municipal feed-in-tariffs, which meant that financing a DG system with capacity that exceeded the plant's average daily usage was not financially viable as excess power unused by the plant could not be sold back to the municipal grid at a profitable price.

Cost of batteries and Balance of System

The installation of PV systems is broken down into two cost components (1) PV System costs and (2) Balance of System (BOS). Depending on system size, BOS costs contribute between 65% and 51% of overall system costs (Pandarum, 2019). Battery storage makes up a considerable portion of BOS costs in PV systems and battery capacity to store excess power is often installed alongside RE DG systems to overcome the limitations of RE's variability of supply. The inclusion of battery storage in the design of DG systems has increased with a reduction in the price of battery technology, owing to a growing consumer market and increased adoption of electric vehicles (EV) (IRENA, 2019). This is evidenced by the price of widely used Lithium-ion batteries which has fallen by 79,37% from 2010 to 2022 (BloombergNEF, 2022).

Despite the reduced price of batteries, their high upfront costs, limited lifespan, and reduced efficiency over time mean that the LCOE associated with PV DG systems that include battery storage in their design remains uncompetitive. This remains the case when comparing the price competitiveness of PV + storage DG systems to both (1) the LCOE of PV systems without storage and (2) Eskom's current tariffs. Studies suggest this trend is forecasted to continue until 2030, whereafter Eskom's forecast tariff increases will result in PV + storage being able to compete with Eskom-supplied power (Pandarum, 2019).

Rational for selected financing arrangement

WMA reached the financial close of its DG system in December 2022. The entity is subject to a Group-wide capital management policy that requires all capital expenditure on manufacturing equipment to have a maximum payback period of 2 years. Three financing arrangements were considered by WMA management: (1) purchasing the DG system outright, (2) a lease-based purchase agreement and (3) a Power Purchase Agreement (PPA).

A PPA was chosen to secure the entity's investment in DG, owing to a Group-wide capital management policy. Financial arrangements 1 and 2 constitute capital expenditure as they result in an entity including the cost of the PV system on its balance sheet for financial reporting purposes in terms of International Financial Reporting Standards (IFRS). In the case of WMA's investment in a DG system, considering an outright purchase arrangement or leased-based purchase arrangement would require the business case to indicate a financial return on investment (ROI) 2 years following the DG system's installation. WMA's financial modelling suggested that the designed PV system would require a minimum of 8 years before a positive ROI was realised. Therefore, a PPA was chosen in order to comply with the Group's financial management policies.

Third Party Power-Purchase Agreement (PPA's)

A Power Purchase Agreement (PPA's) is a contractual agreement between two parties in which the one party, the power producer, undertakes to sell electricity to another party, the "off-taker", for a specified amount and over a specified period (The World Bank, 2021). PPA's are key to securing project financing for power projects as they bind parties by stringent contractual terms that spread and mitigate the risks associated with power projects (refer to 2.6.2) (Reiter et al., 2021). Large-scale PPA's are a cornerstone of South Africa's REIPPP and are characterised as non-negotiable, South African Rand-denominated, 20-year agreements between an IPP and Eskom (Eberhard & Naude, 2018). PPAs have also successfully been used in South Africa's C&I sectors to secure large-scale power projects using the principles of project finance (refer to Table 9). The use of PPA type mechanisms for smaller scale DG systems was first applied in the US and are known interchangeably as third-party PPAs or Third Party Ownership (TPO) PPAs (Donovan, 2020; Kollins et al., 2010). These PPAs are distinctly different from other PPAs as they involve a system locate behind the meter with generation infrastructure located on the premises of the off taker (Gevorkian, 2016).

Third-Party PPA's are beneficial as they enable the off taker to receive the benefits of a DG system while the other third party provider takes on the upfront capital costs and receives remuneration in the form of a tariff, as well as the associated tax and municipal feed-in tariff benefits. From a financial reporting standpoint, a PPA does not require the off-taker to include the cost of DG system on its financial statements, as would be the case under an outright purchasing of a lease-based purchase arrangement. Third Party PPA's therefore enable individuals to overcome the barriers of capital expenditure policies that inhibit investment in large capital assets such as DG infrastructure, which is often cited as one of the largest barriers to investment (Kollins et al., 2010).

Concluding analysis

This section presents and analyses findings based on the case of WMA (empirical data) and the additional literature identified. This is in keeping with the study's abductive approach described (matching, direction, and redirection). A summary of data related to WMA is provided below (refer to Table 16).

Table 16: Summary of Empirical Data - Case 1: WMA

Entity name	Weir Minerals Africa
Location	Isando, Ekurhuleni
Nature of operations	Manufacturing of specialised mining components
Power supplier	City of Ekurhuleni (CoE)

Power demands	2.2 MW per day
Operating hours	24/7
DG System Capacity	1MW
DG Storage Capacity	0MWh
DG system technology	Rooftop mounted PV
Financial Arrangement	PPA

DG is commercially competitive with municipal tariffs for WMA.

The case of WMA is an example of an entity in the C&I sector whose day-to-day operations and profitability are inherently linked to the price of electricity. This is as a result of the electricity demanding nature of the entity's operations and the resulting impact on its unit production cost. For this reason, the rising cost of municipal-supplied electricity is noted as the primary driving factor for prompting the entity to investigate investing in a DG system.

The combination of rising municipal electricity costs in contrast to the reducing LCOE from PV DG systems, has resulted in conditions where self-generation is more financially viable for an entity of Wier Minerals nature. Whilst the larger Weir Group's commitment to reduce CO^2e also contributes to the decision to invest in RE DG his does not play a role in the project's financial feasibility, but rather the commercially competitive condition of DG as the primary driving factor.

The cost of battery technology inhibits WMA investment in generation capacity.

While DG is commercially competitive with municipally supplied power, this is only the case for a DG system without battery storage. The upfront cost and limited lifespan of battery storage technology have a resulting impact on the design of the DG system's capacity, as WMA's system is only financially viable without a battery storage system. The entity's DG systems are, therefore, unable to store excess power and are designed to meet a minimum daily demand of 1MW rather than accommodating the operation's total demand of 2,2MW despite the site having ample rooftop space for additional generation capacity and the recent amendments to the ERA allowing for such capacities without licensing. Therefore, The entity cannot eliminate its demand and reliance on municipal-supplied power.

Unfavourable municipal feed-in-tariffs constrain WMA's investment in excess generation capacity.

In addition to the inhibitive cost of battery storage, unfavourable municipal feed-in tariffs also limit the system's designed capacity. The CoE's feed-in tariffs are insufficient to incentivise WMA to increase its DG system capacity beyond its operation's minimum daily power demand despite the site's ability to accommodate additional PV panels. From WMA's perspective, this represents a missed opportunity for the entity to reduce its exposure to municipal price hikes, increase its security of power supply and reduce its operations CO2e. From the CoE's perspective, this represents a missed opportunity for the municipality to source additional electricity and reduce its exposure to Eskom's Loadshedding activities.

PPA's help overcome WMA's financial barriers.

The upfront cost associated with WMA's DG system prevents the entity from being able to purchase or own such a system. This is not only a result of cash availability but also cash management policies that prevent WMA's from being able to finance capital assets with long-payback periods and where significant upfront capital is required. The emergence of PPA arrangements for DG systems enables WMA to overcome the financial barriers associated with investment in DG by remaining financially competitive with municipal tariffs whilst precluding the WMA from including the DG system in its balance sheet.

4.2 Case Study 2: Boxlee

Entity Background

Boxlee Pty Ltd (Boxlee) is a specialised manufacturer and supplier of corrugated packaging to multiple industries across South Africa. The entity is one of the largest privately owned manufacturers of its kind in South Africa, producing over 28,000 tons of packaging per annum.

Boxlee's production plant is located in Industria, an industrial area within the metropolitan municipality of Johannesburg, known as the City of Johannesburg (CoJ). Boxlee's Industria-based site operates 24/7 and is responsible for the majority of the entity's operations. The site has a total power consumption of 0.83 MW per day (830 KW) and is supplied by City Power, the CoJ's department responsible for the reticulation and on-sale of power within the metropolitan.

Rational for adoption of DG

Boxlee was prompted to investigate investing in a DG system in 2014/2015 following disruptions to its operations due to Eskom's load-shedding activities. The entity had experienced load-shedding in 2007 and 2008; however, at the time, this was noted as having a relatively lower impact on business operations. Following Eskom's load-shedding activities in 2014/2015, Boxlee's management believed that national load-shedding would worsen in coming years and, therefore, wanted to mitigate the impact of load-shedding on business disruption.

In addition to business disruptions, Boxlee's management indicated that electricity represents a significant cost to the entity's operations. While increasing municipal electricity tariffs did not prompt the entity to explore investment in a DG system, management indicated that it did strengthen the business case for the investment and improve the financial viability of the proposed DG system.

Loadshedding and business disruptions

As mentioned in section 2.1.2, South Africa's electricity demand has exceeded supply since as early as 2007, with Eskom having to introduce loadshedding to prevent a collapse of the National ES. Since 2007, load-shedding has increasingly intensified, with total annual GWh shed growing at a compounded rate of 98% per annum from 2018 to 2022, resulting in businesses experiencing up to 48 days of loadshedding for the 2021 calendar year (refer to Figure 12). Studies have estimated the daily cost of load-shedding to South Africa's manufacturing industry to range between R11 million and R152 million per hour, depending on the stage and nature of manufacturing operations (Akpeji et al., 2020). This is owing to disruptions to business activity as well as the relative cost of having to use alternative power sources.

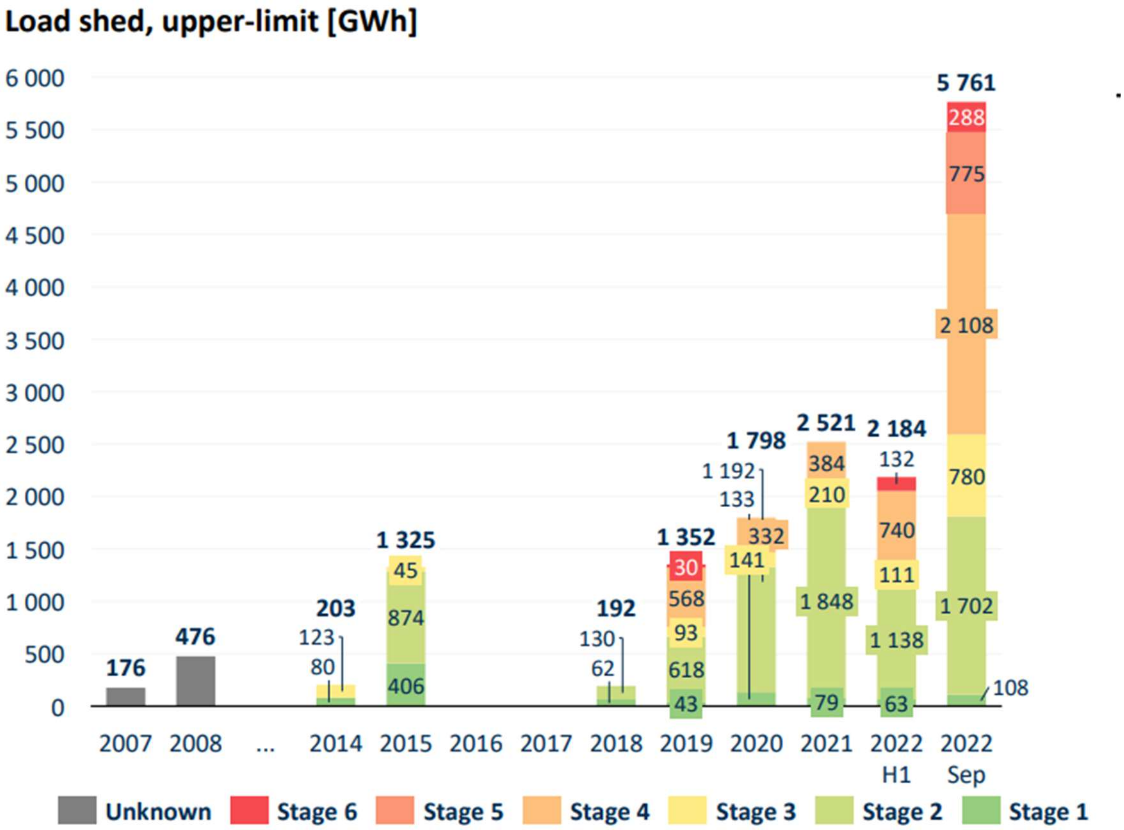


Figure 12: Actual Loadshedding in South Africa from January 2007 to September 2022.

Source: (Pierce & Le Roux, 2022)

Rational for ES design and specifications

Boxlee undertook a cost-benefit analysis (CBA) to build a business case for an investment in DG as well as to determine the system design specification that would cater to its operation's needs. A 368kW direct supply rooftop mount PV system was ultimately installed and commissioned in 2018.

The selected system's design specifications were chosen to account for the most financially viable system design given the site's power demands. A roof-mounted PV DG system was selected based on the relative cost of PV technology and the site's approximately 10 000 square meters of available roof space, of which, only 3 000 square meters was required to accommodate the PV panels. A direct supply DG system without battery storage was selected based on the inhibitive cost of battery technology. As a result of the cost of battery storage and the need to balance load, the DG system's 386kW capacity is designed to meet the average daily demand of the site's operations.

Rational for financing arrangements

Boxlee's capital management policy requires that all capital equipment be procured using a rental lease agreement (operating lease). This policy ensures that all available funds are reserved for meeting the operation's working capital needs, as is common in the manufacturing industry. Owing to this policy, Boxlee's management could not finance its DG system using an outright purchase or lease-to-purchase financing arrangement. Therefore, a PPA financing arrangement was the only viable option for financing Boxlee's investment.

Management noted that the inclusion of financing the refurbishment of the site's rooftop structure in the PPA, which has been degraded due to corrosion, enabled a reduction in the associated insurance costs of the system and has improved the business case for investment in the DG system. The inclusion of financing the mounting structure, in this case, the roof structure, is not a common feature of a standard PPA of this nature. However, the third-party supplier could be included as part of the total DG system's financing (Gevorkian, 2016).

Concluding analysis

This section seeks to present and analyse findings based on the case of Boxlee (empirical data) as well as the additional literature identified. This is in keeping with the study's abductive approach (refer to section 3.2). A summary of data related to Boxlee is provided below (refer to Table 17).

Table 17: Summary of Empirical Findings - Case 2: Boxlee

Entity name	Boxlee Pty Ltd
Location	Industria, Johannesburg
Nature of operations	Corrugated packaging
Power supplier	City Power
Power demands (daily)	0,83 MW
Operating hours	24/7
DG System Capacity	368kW
DG Storage Capacity	0MWh
DG system technology	Rooftop mounted PV
Financial Arrangement	PPA

Loadshedding impact on business disruptions

Business disruptions caused by loadshedding is the primary factor for Boxlee's decision to invest in DG. The timing of Boxlee's decision to explore investment in DG in 2014 corresponds to a period of increased loadshedding in South Africa (refer to Figure 12). The increased intensity and frequency of business disruptions of loadshedding not only results in investment in DG being more financially viable, but also more convenient.

The cost of battery storage inhibits investment in scale.

Boxlee indicated that a DG system with battery storage was not financially viable. As a result the commissioned DG system's capacity is limited to the entity's average power demands despite only occupying approximately 30% of the site's available roof space. Boxlee is therefore not only reliant on municipally supplied power for the remainder of its power needs but remains exposed to load-shedding during the hours when its PV DG system does not produce sufficient power. The inhibitive cost of battery storage therefore prevents Boxlee from being able to invest in a DG system that meets its operation's entire power demands.

Of interest is the fact that Boxlee continued with the investment in DG despite its system's inability to fully insulate its operations from loadshedding. This indicates that Boxlee's benefit from security of power supply is able to offset the relative cost of municipally supplied power in combination with the cost of business disruptions from loadshedding, even if only for a fraction of the entity's operating time. Therefore despite the inhibitive cost of batteries and the system's inability to meet 100% of the sites energy demands or insulate the Boxlee entirely from loadshedding, investment in Boxlee's DG system remained financially viable.

Absence of municipal feed-in-tariffs inhibits investment in scale.

In addition to the impact of the cost of batteries on Boxlee's system's designed capacity, it can be argued that the absence of municipal feed-in-tariffs and net metering also inhibited Boxlee's investment in greater DG capacity. At the time of Boxlee's investment, no net metering or feed-in-tariff existed in the CoJ, with the first tariff of this type being approved in the 2022/2023 financial year (City of Johannesburg, 2022). However, the existence of a feed-in tariff in combination with sufficient roof space may have been sufficient to justify an investment in a DG system that exceeds the current 386kW capacity.

PPA arrangement help to overcome capital expenditure policies.

The contractual and financial mechanisms under a PPA enable Boxlee to overcome the limitations of its capital investment policy. Unlike lease-to-purchase arrangements or outright purchase arrangements, PPAs do not result in an asset being recognised on an entity's balance sheet. From a financial standpoint, Boxlee's PPA agreement simply results in the entity substituting its payment to the City Power rather than the entity having to purchase or lease the DG system.

4.3 Case Study 3: PKF Octagon

Entity Background

PKF Octagon is a professional services firm specialising in accounting, audit, taxation, and other business related advisory services across South Africa. The entity is part of PKF International Limited, a global network of professional service firms. PKF Octagon is one of the 10 largest firms of its kind in South Africa and employs a total of 280 people.

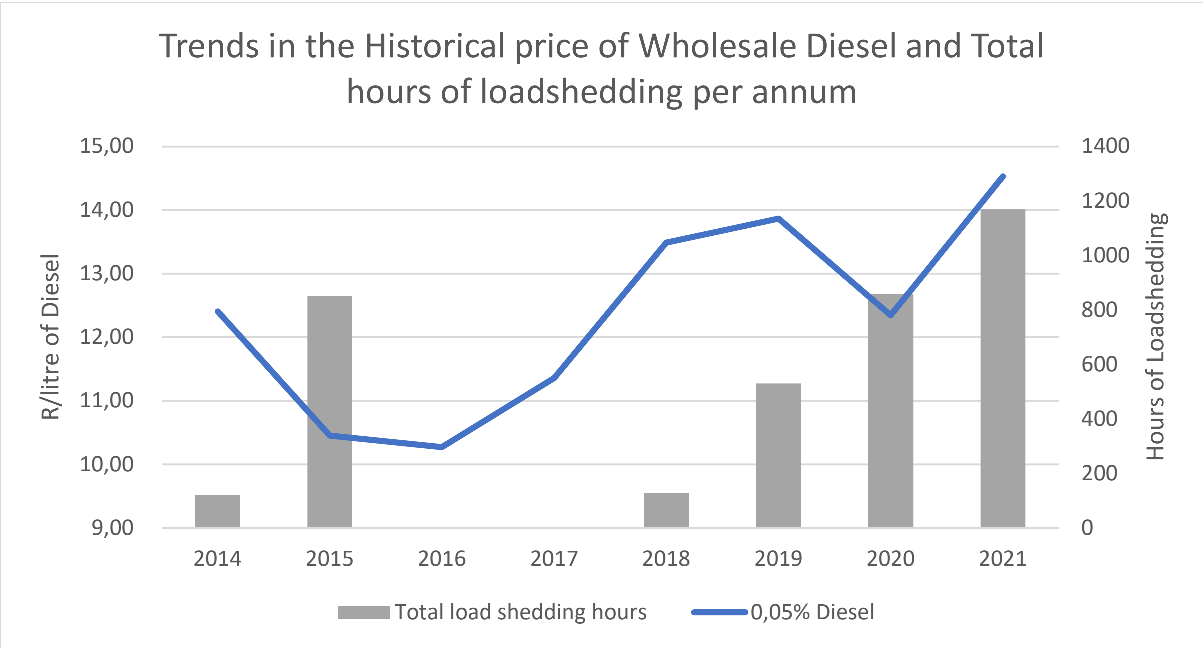
PKF Octagon operates from a commercial building located in Waverly, a mixed-use commercial and residential area within the CoJ. The entity leases additional space in its building to other professional service firms in return for rental income. PKF Octagon's office hours are between 8am and 5pm, Monday to Friday with its' offices housing the entity's staff, computer equipment, heating, ventilation, and air-conditioning (HVAC) system. Like many modern office buildings, PKF Octagon's building has no opening windows and relies heavily on its HVAC system for ventilation and air conditioning. The building's total power consumption is 0,2 MW per day (200 kW) with the bulk of this power demand coming from the building's HVAC system. City Power, the CoJ's department responsible for the reticulation and on-sale of power within the metropolitan, is currently the sole supplier power to building.

Rational for migration to DG

PKF Octagon's building has an existing DG system of a 0,8 MW (800kW) diesel backup generator. The generator provides power during load-shedding and is programmed to start automatically whenever the building experiences a disruption in its power supply. The generator consumes between 1 488 and 2 021 litres of diesel per hour of operation. Due to the generator's consumption of diesel, operating the generator represents a significant cost to PKF Octagon. Management has indicated that the increasing cost of operating the building's generator over the past calendar year (2021-2022) is the primary reason for prompting the entity to investigate investing in an alternative DG system to supplement the building's power supply during load-shedding.

Increasing price of diesel and frequency of loadshedding

South Africa has no known oil production capacity and is therefore reliant on oil imports to meet it diesel and petroleum demands. The price of diesel in South Africa is regulated by the DMRE and is driven by international oil prices as well as national taxes and levies. The price of diesel in South Africa increased by 17% between 2021 and 2022 owing to an increase in international oil prices as well as increases in the relevant fuel levies (SAPIA, 2022). Increases in the price of diesel have an inherent impact on the cost of operating a diesel generator. In cases where a diesel generator is used to supplement an Eskom-supplied grid, the increase in generator operating expenses due to fuel price hikes is further compounded by increased load-shedding (Figure 13).



Average annual Diesel wholesale coastal diesel price used, adapted from (South African Petroleum Industry Association, 2021). *Total load shedding hours adapted from* (Pierce & Le Roux, 2022).

Figure 13: Trends in the historical price of Wholesale Diesel and Total Hours of Loadshedding per annum in South Africa from 2014 to 2022.

Rational for ES design and specifications

Given the impact of the increasing cost of diesel and petroleum on its operations, PKF Octagon sought to investigate the feasibility of other DG technologies. PKF Octagon undertook to develop a CBA and business case to determine the most suitable DG system to meet its operation's energy requirements.

PKF Octagon's initial research suggested that the relative cost of a PV system would be financially competitive with operating a diesel generator during disruptions to the building's power supply. In addition to supplementing the entity's diesel consumption, a PV system would supplement a portion of the building's daily demand on the municipal power grid, thereby insulating PKF Octagon from load-shedding and increasing municipal electricity tariffs. Given the entity's available roof area and limited ground space, a roof-mounted PV system was selected as the most viable DG system design.

Whilst the decision has been made to invest in a DG system, PKF Octagon is still in the financial close phase of the project. The entity is currently deciding between two roof-mounted PV systems: one with a capacity of 0,14 Mw (148 kW) and another with a capacity of 0,18 Mw (185,25 kW). Given the variable nature of RE and that PKF Octagon operates primarily between 8 a.m. and 5 p.m., Monday to Friday, both systems include battery storage in their design. Once installed, the system is expected to offset PKF Octagon's daily power consumption by 44% while reducing the entity's diesel consumption by up to 95% and providing up to 3 hours of backup power supply. Both systems are financially competitive compared to operating the PKF Octagon's current diesel generator.

Rational for financing arrangements

PKF Octagon is estimated to reach financial close of their DG investment by January 2023. The entity has limited capital management policies, and investments in capital assets are assessed on a case-by-case basis. Three financial arrangements were initially considered to finance the investment in the DG system: (1) purchasing the DG system outright, (2) a lease-based purchase agreement and (3) a Power Purchase Agreement (PPA).

PKF Octagon's management indicated that early discussions with providers suggested that a PPA financial arrangement was not viable for the entity. This is due to the fact that the majority of PKF Octagon's power consumption occurs during limited periods in the week and that PPA arrangement for a system with such specifications is more suited to a system that requires power supply 24 hours, 7 days a week. This leaves the entity deciding between two financial arrangements: (1) a lease-to-purchase arrangement or (2) an 'outright purchase' of the DG system.

PKF Octagon has indicated it is likely to finance investment in a DG system using its own 'outright purchase' arrangement. This is due to financial modelling, which indicated that an 'outright purchase' of the DG system yields a greater ROI than a lease-to-purchase arrangement. This is owing to two factors: 1) the inclusion of capital allowances under s12B and 2) PKF Octagon's ability to secure a lower corporate lending rate than the effective rate under the lease-to-own option.

Financial modelling also revealed an investment payback period of 4 years for the system under an outright purchase arrangement. While PKF Octagon does not have a minimum capital expenditure policy for its investments, management indicated that the short payback period, compared to an 8 year lease-to-purchase agreement, increased the business case in favour of an outright purchase arrangement. As a result of these combinations of factors, the business case for an outright purchase is stronger than a lease-to-purchase arrangement.

s12B Tax benefit

Section 12B (s12B) of the South African Income Tax Act No. 58 of 1962 provides for a capital allowance on the cost of moveable assets used in the production of income. S12B requires that the asset be new and owned (not leased) by the taxpayer to qualify. In 2013 S12B was amended to include assets used in the production of RE which enables a taxpayer to claim a portion of RE system's cost over 3 years on a 50/30/20 basis (50% of the cost in year one, 30% in year two and so on for tax purposes (Steenkamp, 2016). As of 2015, a taxpayer can claim 100% of the cost of a RE DG system with capacity up to 1MW in the first year of DG system's commissioning (South Africa, Income Tax Act No 58 of 1962). s12B thereby seeks to provide tax incentives to promote investment in RE by enabling taxpayers to claim a portion of the capital cost of assets which in turn improves the business case for investment in RE.

Concluding analysis

This section seeks to present and analyse findings based off the case of PKF Octagon (empirical data) as well as the additional literature identified. This is in keeping with the study's abductive approach (refer to section 3.2). A summary of data related to Boxlee is provided below (refer to Table 18).

Table 18: Summary of Empirical Findings - Case 3: PKF Octagon

Entity name	PKF Octagon
Location	Waverly, Johannesburg
Nature of operations	Professional Services
Power supplier	City Power
Power demands (daily)	0,2 MW
Operating hours	8am and 5pm, Monday to Friday
DG System Capacity	148 kW - 185,25 kW
DG Storage Capacity	200 kWA
DG system technology	Rooftop mounted PV
Financial Arrangement	Outright purchase

Loadshedding and fuel prices

A combination of diesel price hikes and increasing frequency of load-shedding has resulted in the increasing cost of operating PKF Octagon's current diesel-fuelled DG system. In contrast, the relative cost of a PV roof-mounted DG system with battery storage has declined. These factors result in conditions where the cost of a PV roof-mounted DG system is now commercially more competitive than the cost of operating a diesel generator.

Unintended substitution effect on municipal power demand

In addition to a PV DG system being commercially competitive, the installation of a PV system has the unintended consequence of supplementing PKF Octagon's current municipal power supply by an estimated 44%. This is owing to the fact that the designed PV DG system will passively generate and store power throughout the day as opposed to a diesel-fuelled system, which only supplies power when prompted during a disruption in power supply. Whilst this substitution effect of the PV DG system is not a driving factor for investment, it adds to the business case in favour of investment in PV DG.

PPAs are not suited to irregular power demand.
The nature of PKF Octagon's operations means that the bulk of the entity's power consumption occurs for 5 days during the work week (Monday to Friday) and is relatively lower over the weekend. This results in a relatively high LCOE under a PPA arrangement as the cost of the proposed DG system must now be spread over fewer kWh within a specified period. This presents a problem for the financial and economic fundamentals of PPAs, which rely on economies-of-scale from sales of power to arrive at a relatively lower LCOE over a specified period. As a result a PPA is not considered a financially viable option to finance PKF Octagon's investment in DG.

Tax incentives contribute to a greater ROI in outright purchasing arrangements.
Section 12B of the Income Tax Act allows PKF Octagon to deduct 100% of its' DG system's costs in its first year of operation if the system is 'owned'. Under a lease-purchase agreement, PKF Octagon does not effectively own the DG system for tax purposes and can therefore not claim the available capital allowance. The tax incentive therefore improves the financial viability of an outright purchase arrangement. However, whether the tax incentive is effective in promoting investment into DG systems is uncertain as PKF Octagon indicated that the lease-to-purchase arrangement, under which no s12B allowance is received, is still financially viable.

The effective lease rate cannot compete with corporate lending rates.
A lease-to-purchase arrangement is in principle a form of long-term lending. In the case of PKF Octagon, for example, the third party provider is offering to put down the upfront capital for the cost of the DG system in return for regular repayments from PKF Octagon, on which interest is charged, for an period of time. This is similar to the terms of a corporate loan under which a bank provides upfront financing in return for a regular repayments and interest. Lease-to-purchase agreements are therefore evaluated based on an effective rate similar to that of a lending rate. In PKF Octagon's case the effective rate of the lease-to-purchase-agreement does not compete with the interest rate that PKF Octagon is able to obtain from its lenders.

The more competitive corporate interest rate suggests two things. Firstly, it indicates that commercial banks are willing to provide lending to entities to invest in DG systems, conditional to the financial position of the entity. Secondly the rate that suggests that in PKF Octagon's case corporate financing is relatively cheaper than the specialised financing available to the PKF Octagon's third party system provider.

5 DISCUSSION OF CASES AND FINDINGS

The previous sections analyse the financial factors at an individual case level. The following section seeks to provide a comparative analysis across all three cases. This is achieved by classifying common themes (codes) identified during data collection and individual case analysis. Within each theme, cross-case similarities and dissimilarities are identified, and an inference is developed to address the research question positioned at the outset of this paper.

5.1 Revisiting the Research Question

Revisiting the research question allows for the positioning of the analysis and discussion within the research. It also enables the research to account for additional relevant questions identified during the data collection and analysis phases.

At the beginning of this study, it was noted that, despite recent amendments to the ERA and a national energy crisis, investment by the C&I sector into power generation remained constrained. To better understand why this is the case, the following questions were posed:

1. What capital investment considerations do South Africa's C&I sector take when investing in DG?
2. What factors enable or discourage investment by the C&I sector into the DG?

These questions all contribute to an evaluation of factors that influence decisions when deciding to invest in DG. This was confirmed by coding of empirical evidence, which resulted in three overarching themes that describe the phenomenon in question.
(refer to Table 19).

Table 19: Case Study Themes

No.	Investment Factors	Impact on investment decision		
		Initiate Investment Decision	Strengthen/Enable Investment Decision	Constrain Investment Decision
1	Increasing municipal tariffs	X	X	

2	Increasing frequency of loadshedding	X	X	
3	Reducing Cost of PV technology		X	
4	Constrained commercial viability under PPA		X	
	4.1 Inhibitive Cost of Battery technology			X
	4.2 Feed-in-tariffs			X
5	Tax incentives		X	
6	Capital expenditure policies			X

5.2 Factor 1: Increasing Municipal Tariffs

DG-generated power is commercially competitive with municipally supplied power.

Increasing municipal tariffs is a common theme across all three cases. In the case of WMA, the resulting LCOE is commercially competitive relative to CoE municipal tariffs. This forms the basis for the entity's investment decision. In Boxlee's and PKF Octagon's respective cases, substituting municipal power for relatively cheaper DG-generated power is not the primary reason for investment but strengthens the business case for investment. This suggests that increasing municipal tariffs is not only an investment decision consideration but positively impacts the decision to invest in DG.

Improved profitability on the resale of DG-generated power.

In the case of PKF Octagon, increasing municipal tariffs has the benefit of increasing the potential profit on the entity's power resale to tenants. Other landlords can replicate this business model and further strengthen the business case for investment in DG for similar entities. Again, in this instance, all else equal, increasing municipal tariffs positively impacts the decision to invest in DG.

5.3 Factor 2: Increasing frequency of Load-shedding

Loadshedding is cited as prompting Boxlee's and PKF Octagon's investment in DG. The increasing frequency of loadshedding presents a growing cost to both entities. In Boxlee's case, this cost is the cost of business disruptions, while in PKF Octagon's case, this is the cost of operating a diesel-fuelled DG system to meet its building's power demands. These cases suggest that increased frequency and intensity of load-shedding is both a consideration in the investment decision process as well as having a positive impact on the investment in DG.

5.4 Factor 3: Reducing the cost of PV technology.

All three cases employ PV technology in the design of their DG systems. Three common reasons are cited for this: (1) the relative cost of PV technology, (2) the suitability of PV to meet power demands, and (3) the practicality of PV given available space on each entity's site. While the power demands and system arrangement of each of the three cases vary, it is evident that reducing cost and relative capabilities of PV technology enable the financial viability of investment in DG.

5.5 Factor 4: Constrained commercial viability under PPA.

Two cases, WMA and Boxlee, illustrate constraining factors to the scale of investment in DG. In both cases, investment in the entity's respective DG system was only commercially viable at a generation capacity where management could be confident that its power output did not exceed its operational demand. Despite ample space at both sites to accommodate additional PV capacity. Both cases cite 1) the inhibitive cost of battery storage and 2) inadequate municipal feed-in tariffs as constraining factors. Both cases also employ a PPA arrangement to finance their investment, and the business cases for each investment are therefore evaluated based on the LCOE relative to municipally supplied power.

Factor 4.1 The inhibitive cost of batteries

In instances where a PPA is used, the cost of battery storage limits the commercial viability of the system's capacity. This is because PPA's are evaluated based on relative LCOE. LCOE relies on economies of scale to compete with municipal tariffs. The high cost of battery technology results in an average per unit cost of electricity (R/kW) that is not commercially viable at a capacity required to meet all of the operation's power demands. The resulting investment in DG is thereby limited to a system scale that ensures only power that management is confident will be consumed in real-time is produced, and no excess power goes unconsumed.

Factor 4.2 Constraining municipal feed-in-tariffs

Inadequate municipal feed-in-tariffs, or the absence thereof, limit the scale of commercially viable DG systems under a PPA. Current municipal feed-in tariffs are below the relevant DG system's LCOE. As a result, there is a net financial loss on any power produced by the DG system over the entity's real-time consumption. Therefore, neither of the entities is incentivised to invest in a DG system that will produce more power than its operation will consume at any one point in time.

5.6 Factor 5: Tax incentive

PKF Octagon's case illustrates how tax allowances can be used to improve the commercial viability of investment in DG. In an entity like PKF Octagon with little to no capital expenditure limitations, tax incentives such as the s12B make investment commercially viable and result in higher ROI for outright purchase agreements when compared to PPAs and lease-to-own agreements.

5.7 Factor 6: Capital expenditure policies.

Capital expenditure policies guide management in the practical and prudent allocation of capital and are, therefore, inherently linked to investment decisions. Each of the entities investigated makes mention of their capital expenditure policies, with the relevant policies varyingly affecting the outcome of the investment decision.

In the case of WMA and Boxlee, both entities' capital expenditure policies are examples of prudent liquidity and solvency practices commonly seen in the manufacturing and industrial sectors. These policies limit the potential financing arrangements available to management when making an investment decision. As a result, in both cases, a PPA is the only financial arrangement that can be employed.

In contrast, PKF Octagon has little to no capital expenditure policies, and investments in capital assets are assessed on a case-by-case basis. This is indicative not only of the entity's strong financial position but also of the nature of the professional services industry, which relies largely on intellectual property and human capital, as opposed to significant capital assets (machinery and equipment). Investment in capital assets is generally less frequent among professional service firms, and there is less of a need to manage working capital when compared to the industrial and manufacturing sectors. As a result, PKF Octagon can finance its investment using multiple financial arrangements.

These similarities and dissimilarities between cases suggest that capital expenditure policies impact investment in DG in various ways depending on the individual policy. The case of WMA and Boxlee suggests that capital expenditure policies limit investment in DG in the industrial and manufacturing sectors. However, capital expenditure policies are entity-specific, so a generalised conclusion cannot be drawn.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Policy recommendations

6.1.1 Recommendations for Government and policy makers

Municipal Feed-in-tariffs

The study indicated that relatively low municipal feed-in-tariffs constrain investment in DG capacity. At a national government level (NERSA and DMRE), a clear and appropriate national feed-in-tariff framework would provide policy certainty and enable municipalities to improve and develop municipal feed-in-tariffs. At a municipal level, policy makers should seek to set feed-in tariffs at a rate that strikes a balance between securing additional power supply and protecting municipal revenues. This has the potential improve not only the commercial viability for the resale of excess capacity into the municipal gird, but also improve municipal power security.

Tax allowances on the cost of batteries

Findings suggest that the cost of batteries represents a barrier to scaled investment in DG. From a policy-maker perspective, reducing import duties and related taxes, such as value-added tax (VAT), on batteries may assist in further lowering the cost of batteries in South Africa. In addition, tax incentives such as the s12B allowance could be amended to include the cost of batteries. These measures would further lower barriers to scaled investment in DG by improving the commercial viability of larger DG systems with storage capacity.

6.1.2 Recommendations for financial institutions and third party suppliers

More appropriate financial arrangements

The study indicated that specific financial arrangements, such as project-specific commercial loans, general commercial loans, structured financing, and project financing, still need to be made available for some entities in the C&I sector. This inhibits investment in the scale of DG due to limitations associated with PPAs. Financial institutions and third-party providers should look to lower the barriers to alternative financing arrangements by providing more specialised financing that accounts for the entity's capital expenditure policies and potential tax incentives, as the nature of operations.

Power Pooling and trading

Without adequate municipal feed-in tariffs and inhibitive battery costs, the on-sale of electricity from one private entity to another could enable investment in increased DG system scales. This could be facilitated using the principles of power pooling and trading between neighbouring entities or over long distances with mechanisms such as wheeling agreements. This would improve the financial viability of investment in larger capacities and increase overall revenues for third-party suppliers under PPAs.

6.1.3 Recommendations for financial C&I sector stakeholder

Tailored Capital expenditure policies.

Capital expenditure policies, such as prohibiting investment in manufacturing capital or requiring a project payback period within a relatively short timeframe, were noted as barriers to investment in specific DG arrangements. While these policies effectively manage and govern cash flow, management should consider altering policies to account for investment in specialised assets such as DG. This would enable entities to invest in DG using multiple financial arrangements other than PPAs, which may, in turn, allow for investment in additional generation capacity or improved ROIs. This would further insulate entities from the impact of load-shedding and municipal tariff increases.

Improved financial modelling and business cases.

The case studies illustrate that many factors can be considered when costing and determining the ROI of DG investments. Some of these factors are entity-specific, such as capital expenditure policies, system design and the potential on-sale of electricity to tenants. However, most are applied to all entities, such as the relative cost of diesel generator operating, potential municipal feed-in-tariffs, business disruptions and available tax incentives. Investment decision-makers should ensure that all possible variables and opportunity costs have been accounted for when making a final investment decision into DG.

6.2 Implications for Future Research

Research approach

This study employed a qualitative approach to explore phenomena impacting investment in DG within the C&I sector. Future studies could benefit from an explanatory quantitative approach that investigates the relationship between the barriers and enabling factors identified in this study. This would allow for findings on the causal relationship between investment and the factors identified in this study.

Sample size and diversification

This study followed the recommended sample size of 3 cases for a multiple-case study. Future studies could benefit from a larger and more diverse sample size to improve the generalisability of findings. In particular, the inclusion of cases from a diverse group of municipalities may reveal additional findings.

Framework development

A framework to assess the financial factors, financial arrangement and system arrangement could be developed. This would aid in the analysis of data in future studies and identify potential new findings whilst improving reliability of the study.

6.3 Limitations of Study

The limitations of this study are those common to case studies and relate largely to threats to generalisation. The research design attempts to mitigate these threats as detailed in section 3.2.2 and further elaborated below.

Geographical limitation

The selected cases cover only 2 of the 278 municipalities within South Africa, the City of Johannesburg and Ekurhuleni. This limits the ability to generalise findings across municipalities. This is an important distinction owing to municipalities' role in power distribution within South Africa (refer to section 2.1.1).

Nature of entity limitation

The C&I sector is a diverse economic sector with varying operational and financial requirements. The selected cases represent a sample of 2 manufacturing entities and 1 professional services entity. This limits the ability to generalise findings cross the sector. However, the similarity between 2 cases and dissimilarity with 1, allows for a more robust cross-case analysis and discussion.

Unstructured KII

Unstructured KII is aligned with the exploratory approach to theory development and allows for the flow of new ideas and information. However, the unstructured nature of interviews may reduce the ability to generalise and treat the validity of findings—the use of iterative coding and sequencing of interviews attempted to address this limitation. Care was also taken to ensure that views from various stakeholders from multiple technical backgrounds within each entity were considered.

The number of KII

While utilising 7 Key KIIs in this study was justified by factors such as resource constraints and the qualitative nature of the research, it is important to acknowledge that this sample size might raise concerns about the potential limitations in adequately triangulating the results. With a relatively small number of informants, there is a risk that certain perspectives or nuances within the research context may not have been fully explored. Future research in this area may benefit from a larger and more diverse pool of key informants to enhance the robustness of triangulation and provide a more comprehensive understanding of the subject matter.

6.4 Conclusion

While the relaxing of regulations has played a part in promoting investment in DG by the C&I sector, obstacles remain. These barriers impact the C&I sector's decision to invest in DG and the scale at which investment is made. Notably, the inhibitive cost of batteries and inadequate municipal feed-in-tariffs limit the scale of investment in DG systems by preventing investment at capacities required to fully isolate businesses from load-shedding or meaningfully increase the country's overall power supply. Financing arrangements that are not suited to the C&I sector also play a role in inhibiting investment. The existing suite of available mechanisms and instruments does not accommodate the capital expenditure policies unique to the C&I sector, particularly the cash-hungry industrial segment. This results in limited financing arrangements available to businesses and reduced investment viability. Despite these barriers, the reduced cost of PV technology and tax incentives increase the financial viability of investment in DG. These factors, in combination with the increasing intensity of load-shedding, increasing the price of diesel and increasing municipal electricity tariffs, all improve the business case for increased investment in DG by South Africa's C&I sector.

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Appendix I

Table 20: Integrated Resource Plan (IRP) 2019.

	Coal	Nuclear	Hydro	Pump Storage	PV	Wind	CSP	Gas/Diesel	Other	Embedded Generation
	Capacity in MW									
2018	39 126	1 860	2 196	2 912	1 474	1 980	300	3 830	499	n.a.
2019	2 155					244	300			200
2020	1 433				114	300				200
2021	1 433				300	818				200
2022	711				400					200
2023	500									200
2024	500									200
2025					670	200				200
2026					1 000	1 500		2 250		200
2027					1 000	1 600		1 200		200
2028					1 000	1 600		1 800		200
2029					1 000	1 600		2 850		200
2030			2 500		1 000	1 600				200
Total installed	**33 847**	**1 860**	**4 696**	**2 912**	**7 958**	**11 442**	**600**	**11 930**	**499**	**2 400**
Installed capacity mix	**44,7%**	**2,5%**	**6,2%**	**3,8%**	**10,5%**	**15,1%**	**0,8%**	**15,8%**	**0,7%**	

Key
- Installed capacity
- Committed/contracted capacity
- New/additional capacity