An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay

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A dissertation submitted in fulfilment of the requirements for the award of the degree of Master of Science (MSc) in Properties Studies

2022/02/08

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ACKNOWLEDGMENTS

I would like to acknowledge my sincere gratitude to the following:

Associate Professor Kathy Michell, the Department of Construction Economics and Management, University of Cape Town (UCT), for your dedication, supervision, and mentorship during the course of my studies.

All the participants who took the time out of their busy schedules, to either complete a survey and/or consented to an interview, to make this dissertation possible.

Perseverance Industrialist Forum who provided minutes of meetings and other documents pertaining to Perseverance, identification of participants in Perseverance, including notification to their members of the case study research conducted in Perseverance.

NMBBC who assisted with identification of participants in the remainder of Nelson Mandela Bay.

The Construction Economics and Management Department at UCT for their valuable support since the start of my studies at UCT.

Family, friends, and colleagues whose support has been invaluable throughout my studies at UCT.

Lastly to Dylan, whose love and support, kept me motivated and pushed me past my comfort zone.

ABSTRACT

Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time (Eskom, 2019), and subsequently on the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas, including Perseverance, a suburb of Gqeberha (Port Elizabeth) in the district of Nelson Mandela Bay (NMB) with uninterrupted and preferential electricity supply since 2000.

As Industries in Perseverance have not been subjected to load-shedding since load-shedding commenced, the enterprises in Perseverance have not been incentivized to make allowance and/or budget for, any interruption to their industrial activities. The nature of many of the industries that subsequently invested in Perseverance, were industries, that are dependent on uninterrupted electricity, to manufacture their products cost effectively, and without harm to their employees or the environment.

This research aimed to investigate the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings, with a case study focused on Perseverance. An overarching qualitative case study with an embedded convergent parallel mixed method design, consisting of 20 quantitative survey questionnaires from participants in Perseverance and 11 qualitative semi-structured interviews with facility managers, plant engineers and/or managing directors of enterprises in Perseverance. A further 14 quantitative survey questionnaires were received from enterprises in the remainder of NMB. The findings revealed the shock and concern from facility managers to the threat of potential electrical load-shedding and revealed the operational and strategic decisions that was considered, since December 2019 as well as their way forward to manage the threat of electrical load-shedding in Perseverance. It was also revealed that sustained transparent communication needs to be initiated between industrialists and NMBM.

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ABBREVIATIONS

Auto-DR-	Automated Demand Response
CFL-	Compact Fluorescent Bulbs
COVID-19-	Coronavirus disease 2019
DR-	Demand Response
DSM-	Demand Side Management
DTIC-	Department of Trade, Industry and Competition
FM-	Facility/ies Management
kW-h-	Kilowatt- hour
LED-	Light Emitting Diodes
LSS-	Load-shedding Schemes/Systems
MWh-	Megawatt-hour
N/A-	N/A
NMB-	Nelson Mandela Bay
NMBBC-	Nelson Mandela Bay Business Chamber
NMBM-	Nelson Mandela Bay Municipality
OEM-	Original Equipment Manufacturer
PLC-	Programmable Logic Controller
S/A-	Service Agreement
SDGs	Sustainable Development Goals
UCT-	University of Cape Town
WTA-	Willing to Accept
WTP-	Willing to Pay

DEFINITIONS

Automated Demand Response - Automated Demand Response is initiated at a building or facility through receipt of an external communications signal – facility staff set up a pre-programmed load-shedding strategy which is automatically initiated by the system without the need of human intervention (Californian Energy Commission, 2005).

Load-shedding based on circuit breakers interlocking, micro-controllers and/or under-frequency relays - Technique for shedding pre-defined amount of load (power blocks) in order to reach balanced state of power, according to available electrical generation capacity, in order to provide faster more effective responses during sudden loss of power (Kucuk *et al*., 2018).

Load-shedding - Load-shedding has two operational criteria: load-shedding due to inadequate generation capacity (main) and load-shedding due to under-frequency (backup). In case one of these criteria is fulfilled, a sequence of load-shedding is triggered to restore stability of power systems to maintain normal operations (Kucuk *et al*., 2018).

Kilowatt-hour - The kilowatt-hour is a unit of energy equal to one kilowatt of power sustained for one hour or 3600 kilojoules. It is commonly used as a billing unit for energy delivered to consumers by electric utilities (Wikipedia).

Megawatt -hour - A megawatt-hour is 1 million Wh (MWh) (Wikipedia).

Nelson Mandela Bay Business Chamber – The Nelson Mandela Bay Business Chamber is a not-for-profit organisation representing a broad spectrum of businesses in and around Nelson Mandela Bay. It is one of the largest voluntary business associations in the Eastern Cape, with a membership of businesses across a wide array of sectors. The Nelson Mandela Bay Business Chamber's vision is to be a leading catalyst for economic development in the Bay. Its mission is to influence the key factors and stakeholders that create a competitive enabling business environment, and to collaborate with stakeholders towards achieving a collective goal of sustainable business growth (The Nelson Mandela Bay Business Chamber's Annual Business Guide, 2019).

Original Equipment Manufacturer is a company that manufactures and sells products or parts of a product that their buyer, another company, sells to its own customers while putting the products under its own branding. OEMs commonly operate in the auto and computer industries (Corporate Finance Institute n.d.).

1. CHAPTER 1: INTRODUCTION

1.1. Background to the Study

Due to the nature and expense of electricity supply its generally not a private good, consolidation of supply is essential to make delivery affordable and reliable for all consumers and it is also a heavily legislated industry (Adenikinju, 2003; Eberhard, 2004). In the early 1990's inefficiencies in the distribution and subsequent electrification back log was identified in the South Africa's state-owned, vertically integrated Eskom, which dominates the electricity supply in South Africa (Eberhard, 2004) and South Africa experienced extended load-shedding for the first time in 2008.

Industrial properties, however, cannot operate without reliable electricity supply (Adenikinju, 2003), and consequently, facility managers are placed under pressure to provide reliable electricity supply, as manufacturing processes have become less tolerable to power fluctuations and outages (Piper, 2010). All decisions related to energy consumption in industrial enterprises, is however strictly based, on maintaining competitiveness in the market (Christensen, Robinson & Simons, 2018) and providing a safe environment to work in (Jethwa, Bansal, Date & Vaishnav, 2010). Christensen *et al*. (2018) found that opportunities to better manage water and electricity, added value to the enterprises and formed the basis of many enterprises' strategy.

Industries therefore respond to unreliable electricity in various ways, including output reduction, private provision, choice of business and choice of location (Adenikinju, 2003). When national energy suppliers become unreliable, consumers both businesses and households, are forced to generate their own electricity in part or whole. Manufacturing costs increase substantially if generation must be added to the overall investment cost. Subsequent maintenance of backup systems also adds to the operating cost of the property (Adenikinju, 2003). Furthermore, this increases the production cost and reduce the competitiveness of the business both locally and internationally. Industrial enterprises will perform, some sort of cost-benefit analysis calculation in order to decide on their strategy going forward (Christensen *et al*., 2018). The cost of avoiding load-shedding either partial, back-up generation or own generation, can be seen as, an insurance premium against power outages (Beenstock *et al*., 1997).

Reliable energy and sustainable economic growth is also part of the United Nations' Sustainable Development Goals (SDGs) and this research addresses four of the seventeen goals set out in Agenda 2030 as discussed in their progress report dated the 23rd of July 2021: Goal (7) Ensure access to affordable, reliable, sustainable, and modern energy for all; Goal (8) Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all; Goal (9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; and Goal (12) Ensure sustainable consumption and production patterns.

1.2. A Brief Overview of Facility Management

Facility management (FM) is multi-disciplinary, and covers a wide variety of activities, duties, and intellectual capital (Isa, Kamaruzzaman, Mohamed, Japaar & Asbollah, 2016). Facility managers have two divergent roles, either managing the physical resource on behalf of an investor, or on behalf of the occupant (McLennan, 2000).

The fundamental, strategic role of facility managers is to ensure the sustained modification and upgrading of a building's performance, in response to outside stimuli (Min, Morgenstern & Marjanovic-Halburd, 2016). Critical activities which are characteristically managed by facility managers include: energy management, waste management and security (Meneghetti & Chinese, 2002). Planned pre-emptive maintenance has the ability to reduce both operational costs and energy consumption (Min *et al*., 2016). An advantage of having a facility manager, is that a property which is maintained properly and cost effectively, can provide an enterprise with a competitive edge (Pitt & Hicks, 2001).

As a result, facility managers are in the position to offer multiple firms, multiple operational services, which allows for benefitting from economy of scale and scope. In order to provide services to multiple firms, all services are planned and implemented in a co-ordinated manner by the facility manager (Meneghetti & Chinese, 2002).

During stable periods of organisational development, with low rates of change, operational concerns are predominant with FM practice focussing on routine, reactive or short-term functions. Strategic FM however is concerned with major organisational restructuring, when significant changes are made to business processes and working practices, and/ or during uncertain times with volatile market conditions or other external influences (Chotipanich & Nutt, 2008).

Operational FM's main concern is operational capabilities and reliability; overall operational compatibility; support services range and responsibilities; service delivery capability and local preference and practices. Support affordability tends to be secondary in operational FM (Chotipanich & Nutt, 2008).

Strategic FM's main concern is organisational policy and support and organisational resource requirements, while business operations, strategy and support and longer-term support capabilities is secondary in strategic FM (Chotipanich & Nutt, 2008).

1.3. Perseverance Industrial Township, in the district of Nelson Mandela Bay

Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted that industrial areas should be included in the load-shedding (NMBM, 2019).

On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time (Eskom, 2019). South Africans have never experienced anything further than Stage 4 (Nkanjeni, 2019) and NMBM responded on their Facebook page, that they have decided to keep the load-shedding at Stage 4 (NMBM, 2019). On the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8 (Appendix K), which included the previously excluded industrial areas, including Perseverance, an industrial township, with uninterrupted and preferential electricity supply since 2000.

Industries in Perseverance have therefore not been incentivized to make allowance and/or budget for, any interruption to their industrial activities. The nature of many of the industries that subsequently invested in Perseverance, were industries, that are dependent on uninterrupted electricity, to manufacture their products cost effectively, and without harm to their employees or the environment.

Perseverance, a suburb of Gqeberha (Port Elizabeth) is in the district of NMB in the province of Eastern Cape and is conveniently located between Gqeberha's harbour (26,04km or 27 minutes driving time), Coega Industrial Development Zone (23,32km or 25 minutes driving time) and Uitenhage (18.71km or 21 minutes driving time), where provincial main roads R367 and Chelsea Road meet (roadmap.com 2020).

Industrial activities in Perseverance include the manufacturing, distribution and/or transportation of household consumer goods, including food, alcoholic and non-alcoholic beverages, building materials - concrete & steel based, automotive components - ceramic, plastic and aluminium and tank containers (maps.google.com 2020).

There is limited research available which examines the decision-making habits of property owners and/or investors, regarding whether to invest in a green rated building. On the other hand, research investigating resources and energy impact of green buildings are readily available (Christensen *et al*., 2018).

The cost of load-shedding can be established using data on backup generators – cost of acquiring, running, and maintaining them, using the revealed preference method which is based on the actual behaviour of consumers, or the stated preference method using consumer surveys which can be biased (Beenstock *et al*., 1997). An additional way to establish the cost of load-shedding is via the contingent valuation method, however, this method would ask consumers "how much they would be willing to pay (WTP) to avoid an interruption or how much they would be willing to accept (WTA) in compensation for having one" (Diboma & Tamo Tatietse, 2013, p.584). Another method that may be utilised to establish the cost of load-shedding is by undertaking a case study that will analyse the after-the-fact impact analysis of the specific interruptions (Goldberg, 2015).

1.4. Statement of the Problem

The problem to be examined in this research study may be stated as follows:

Little is known as to the measures that facility managers are utilising to minimise the impact of load-shedding in the industrial properties. Load-shedding in industrial areas with a history of uninterrupted, preferential electricity supply, is likely to negatively impact industrial enterprises. Industrial enterprises will likely experience a loss of production, potential waste of raw materials, potential long start-up processes and risks to employees. The current load-shedding schedules (Stage 5-8) posted by NMBM does not take industrial processes into consideration and may result in effectively shutting down production.

The subsequent cost implication of providing backup electrical supply and/or self-generating of electricity, during periods of unsupplied electricity, including additional maintenance and operating cost in industrial properties (Linares & Rey, 2013).

1.5. Research Question

The research question to be addressed may be stated as:

What are facility managers putting in place to mitigate the effects of potential load-shedding on industrial operations?

1.6. Research Aim

The aim of this research study is:

Determine how facility managers are reacting to potential load-shedding in previously uninterrupted industrial areas.

1.7. Research Proposition

The research premise in this research study is:

Special built industrial properties reliant on uninterrupted electricity supply will need specialists' installations to mitigate against possible electrical load-shedding.

1.8. Research Objectives

The research objectives to be achieved are to:

1.8.1 Establish the nature and extent of own generation of electricity in Perseverance and other industrial areas in Nelson Mandela Metro.

1.8.2 Establish the capacity of industrial enterprises to invest in own generation of electricity.

1.8.3 Establish what facility managers are planning to mitigate the effect of potential load-shedding.

1.8.4 Examine the attitude of municipal officials to the needs of industrial enterprises in Nelson Mandela Metro.

1.9. Methodology

The research objectives will be achieved by adopting the following research method:

1.9.1. A critical literature review of the role of facility managers; strategic versus operational facility managers; contributing factors and mitigating measures to unreliable electricity supply internationally and in South Africa; including relevant Nelson Mandela Bay Municipal by-laws.

1.9.2. An overarching qualitative case study, with an embedded convergent parallel mixed method design of industrial enterprises in Perseverance Industrial Township, including the following:

- Face-to-Face and/or electronic semi-structured interviews with selected industrial enterprises in Perseverance and other similarly affected industrial areas in Nelson Mandela Metro and Nelson Mandela Bay Municipal officials.
- Survey questionnaires to members of the Perseverance Industrialist Forum and other industrialists in Nelson Mandela Metro.

1.9.3. Analysis and interpretations of the two data sets was conducted as follows:

- Quantitative data collected with the survey questionnaires was captured in a Microsoft Excel spread sheet, sorted according to questions and each question's data was displayed pictorially in histograms and pie charts and analysed statistically using Microsoft Excel.
- Qualitative data, recorded during semi-structured interviews was transcribed and thematically analysed using NVivo 12.
- The data collected from the two data sets was thematically merged, with other sources of information and summarised. Other sources included archival records of Perseverance Industrialist Forum and Nelson Mandela Bay Business Chamber (NMBBC), and observations made during the case study period.

1.9.4. Finally, conclusions were drawn, and recommendations made in terms of emerging themes in the literature and the case study of Perseverance Industrial Township.

1.10. Research Limitations

The research study was limited to the following:

1.10.1 The case study was limited to Members of the Perseverance Industrialist Forum to capitalise on the researcher's established network of contacts.

1.10.2 The face-to-face interviews and questionnaire survey was limited to industrialists and facility managers in Perseverance Industrial Township.

1.10.3 The research was conducted and limited to Nelson Mandela Bay and surrounds.

1.10.4 COVID-19 lockdown was a limitation on collection of data in person, therefore electronic methods of collection data had to be considered.

1.10.5 Not all industrial enterprises had facility managers, most industrialists in Perseverance had plant and/or maintenance managers instead of permanent facility managers.

1.10.6 Reluctance of NMB officials to commit to either Face-to-Face or electronic semi-structured interviews.

1.11. Structure of the Research Report

The research report was structured in five chapters.

Chapter 1 introduces the research topic, a concise statement of the problem, the research questions, and propositions. The objectives of the research are defined, including a brief explanation of the research methodology.

Chapter 2 includes a critical review of the literature relating to facilities management with particular emphasis on the role of facility managers, strategic versus operational facility management, including contributing factors to unreliable electricity, the cost of unsupplied electricity, mitigating measures put in place by businesses and finally the South African power sector and specifically Nelson Mandela Bay.

Chapter 3 addresses the research methodology, which drew the principal issues raised in the literature review *(Chapter 2),* and proposed a case study of Perseverance Industrial Township, previously an area with preferential, uninterrupted electrical supply, and an opinion survey-based research designed to address the research question: *What are facility managers putting in place to mitigate the effects of potential load-shedding on industrial operations?*

Chapter 4 presents the data, analysis, and discussion of the research findings and Chapter 5 concludes the findings of the research, together with a discussion on the extent to which the research objectives were achieved and any further recommendations to address the problem.

2. CHAPTER 2: THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1. Introduction

This chapter provides a critical review of FM literature, focussed on operational versus strategical operational management with emphasis on electricity supply issues. In addition, international and African electricity supply trends was reviewed, including the major contributing factors to unreliable electricity supply and the role of facility managers in managing power supply. Furthermore, the insurance methods they invest in to mitigate the effect of unreliable electricity is reviewed (Beenstock, 1991). This chapter further looks at the history of power sector in South Africa, ultimately contributing to the current situation of regular electrical load-shedding in South Africa (Eberhard, 2004) and closes with the current situation in NMB where this research will be based in.

2.2. The Role of Facility Managers

The primary role of FM is the effective management of facility resources, through the strategic objective of providing better infrastructure and logistical support to businesses (Nutt, 2000) in a continuously evolving business environment and therefore shifting customer needs (Jensen, 2010). When considering these evolving needs of customers, digitization and sustainability have been identified as core roles in the future of facilities managers (Bröchner, Haugen & Lindkvist, 2019). FM integrates with productive functions, for example, energy management is critical in food industry, waste management in manufacturing and security management in precious metal industry (Meneghetti & Chinese, 2002). Facility managers have two diverging paths, they can either manage the property on behalf of the owner or manage the property on behalf of the tenant (McLennan, 2000).

FM's body of information is based on knowledge of property, general management and facility design and management (Nutt, 2000) and the strategic value in FM is in creating value for clients, and dealing with shifting external factors (Loch, 2000). FM's origins can be traced back to the increased growth in the office administration market in the 1990's, when better management of facilities was required to handle the sophistication of infrastructure and equipment contents (Amaratunga & Baldry, 2001).

According to Min, Morgenstern, Marjanovic-Halburd (2016), facility managers play a fundamental role in continued adaptation and enhancement of a building's performance, and that retrofitting of existing facilities to be more energy efficient is a logical step in the objective of greener buildings, as buildings typically has a lifespan of 20 to 30 years. They found that a strategy composed of low-and no-cost strategies, continuous improvements, ongoing commissioning, and retrofits succeeded in significant reductions in energy consumption of buildings (Min *et al*., 2016), to meet the sustainable needs and goals of enterprises (Bröchner *et al*., 2019). Integrating sustainability into FM practices will improve services to customers as well contribute to economic, social, and environmental sustainability (Opoku & Lee, 2022). Sustainable energy supply and consumption forms a major part of the goals set out in the SDGs by the United Nations in their Agenda 2030 (United Nations, 2021).

The prospect of unreliable electricity is a significant external risk factor which has the potential of impacting negatively on productivity of businesses, facility managers should react to the prospect of unreliable electricity by generating new options and/or preparing contingencies and the means of responding to the external factor (Nutt, 2000). Unsupplied electricity is an immediate risk, and the facility manager will concentrate on disaster recovery by restoring production processes and minimizing the accompanying loss (ed. Alexander, 1996). Contingency measures need to take long-term uncertainty in consideration to reduce the functional obsolescence of the property (Nutt, 2000).

2.3. Operational Versus Strategic Facility Management

The fundamental role of both operational and strategic FM is organizational effectiveness, through resource management (Nutt, 2000). Resources comprise of people, space, and technology (Robertson, 2000). FM is the process by which an enterprise guarantee that its resources, back core operations and processes (operational FM) as well as contribute towards the enterprise's strategic objectives (strategic FM) (ed. Alexander, 1996). Operational FM is based on technical capabilities, compared to the managerial capabilities of strategic FM which is at the executive level (ed. Alexander, 1996).

Barrett (2000) unpacks a generic FM model, developed through a combination of research and industry consultation, that demonstrates that an enterprise's environment is arranged in terms of immediate and long term. Operational FM deals with the immediate and internal aspects of the environment, while strategic management deals with the long term and external influences or aspects.

Chotipanich and Nutt (2008) also found in their studies, that in practice, changes in FM practices are directed through anticipated changes, that is managed proactively, strategically and undertaken in parallel of any possible organizational changes. Their research found that emphasis will naturally shift between operational and strategic FM, as priorities and organizational requirements change.

Tay & Ooi (2001) found that the core function of FM is at a managerial strategic level, while overseeing the day-to-day operational matters. Tay & Ooi (2001) understands the strategic role to be professional versus the non-professional, operational role, and that the professional aspects include decisions on property location, space forecasting and usage, and that the result of FM should be a performing workplace. For the facility manager to perform the professional strategic role, they should be formally trained (Tai & Ooi, 2001).

Operational FM is at the lower level of FM, dealing with the everyday support of operations and is automatic and interim, managing, among others, cost effective building maintenance and/or rehabilitation, cleaning, waste removal and security (ed. Alexander, 1996), whereas strategic FM becomes critical once major organizational restructuring is necessary due to major changes in business processes, working practices and/or during periods of uncertainty about external developments or unpredictable market conditions (Chotipanich & Nutt, 2008).

Pertz (1995) researched the planning aspect of strategic FM, where the facility manager anticipates change and prepares for it. Strategic facilities planning provides techniques that can prepare a business for business environmental changes, or internal organizational changes. Buildings or physical assets, which can count for as much as 25% of a business's fixed asset, has the potential to contribute to the business, therefore it is important to recognize the extent of its contribution, and/or the building's ability to adapt to the changing needs of the business and its ability to further contribute to the overall productivity, profitability, and service of the business (ed. Alexander, 1996), as well as sustainability (Opoku & Lee, 2022).

Strategic FM has the potential to save property owners money in the long run, through either a combination of improved services at the same cost, or by delivering the same service for less. Savings can be measured through productive employees, lower occupancy cost and improved asset management (Jack, 1994). McDougall and Hinks (2000) found that customer satisfaction was also a high value assessment of successful FM. Strategic suggests a long-term objective, which requires management control and a broad understanding of the context in which facilities are utilized. Strategic FM does not get involved in operational detail, but it is not purely reactive either (Jack, 1994). An enterprise's ability to adapt to changing markets, restructuring and investment decisions are strategic decisions which are made at executive level (ed. Alexander, 1996).

Regular communication with core business, to identify current and potential long-term requirements is a vital strategic function of FM. Audits and evaluations are important tools to measure customer satisfaction and identify problem areas that need improvement (Barrett, 2000).

Identifying risks are part of strategic FM, as business managers will delegate the responsibility of effective risk management to the service providers, risks include health and safety at the operational level, environmental impact, and financial viability of the physical asset (ed. Alexander, 1996), as well as the risk involved in the actual retrofitting, refurbishing and renovation work, due to uncertainties in design and construction phases (Pheng, 1996). Li, Zhang, Wei & Han (2019) found that the integration of sustainability into FM's strategic and operational levels is key in the future of FM.

2.4. Contributing Factors to Unreliable Electricity Supply

Societies are becoming more and more dependent on reliable electricity and therefore are more at risk, due to unsupplied electricity (Reichl, Schmidthaler & Schneider, 2013).

Baarsma & Hop (2009) discussed the cost of a reliable electricity supply, and that in Western countries, the power grid provides electricity more than 99% of the time. Infrastructure was found to be an essential driver for economic development (Adenikinju, 2003). This reliability comes at a cost of continuous investment in electric transmission and distribution systems. Deferred infrastructure investments affect the security of electricity supply (Reichl *et al.,* 2013). Adenikinju (2003) found that public monopolies on the supplying of electricity are inefficient and affects the quality and reliability of the electricity supply.

In Europe, transformation in the production and the distribution networks, can affect the electricity supply security. Changes in regulations, the growing renewable electricity sector, and the growth of electricity consumption in developed countries can all negatively impact the supply of electricity in Europe, and capacity enhancement and innovative solutions are required to guarantee the continued supply of reliable electricity (Reichl *et al.,* 2013). Public opinion and technical development implementation of required mitigation measures are difficult (Reichl *et al.,* 2013).

In South Asia due to technical failures, insufficient electricity supply is commonplace with daily electricity load-shedding, which ultimately contributes to slow economic growth (Grainger & Zhang, 2019). Pakistan is one of the countries, hit hardest, with widespread unsupplied electricity periods, since 2006 due to a supply shortages (Grainger & Zhang, 2019). In Pakistan subsidized electricity created vast debt with suppliers, which led to suppliers freezing delivery of fuel and this ultimately contributed to the under supply of electricity (Grainger & Zhang, 2019). Approximately two thirds of companies in Pakistan declared unsupplied electricity as a major constraint to economic growth (Grainger & Zhang, 2019).

In Lebanon, the aftereffects of a civil war and political unrest, played a contributing role in the countries deteriorating infrastructure and insufficient supply of electricity. Since the civil war, the country has invested considerably in the electricity infrastructure, but as the growing demand cannot be met, they have consequently implemented rolling blackouts to deal with excess demand, resulting in the residents generating approximately 40% of their own electricity as a way of managing the unreliable electricity supply (Ghanem, 2018).

In Nigeria, major infrastructure constraints, including limitation in power generation, stagnating expansion investment and hydro and thermal plants which have exceeded their useful lifespan, are responsible for poor quality and extended periods of unsupplied electricity. The average business in Nigeria experiences roughly two hours of unsupplied electricity and/or voltage fluctuations approximately seven times per week (Adenikinju, 2003). Adenikinju (2003) additionally found that businesses were reluctant in paying increased tariffs for electricity supply, as past increases in tariffs did not lead to improved electricity supply, with corruption and inefficiency indicated as the possible cause.

Trotter & Abdullah (2018) found that the current electricity situation Sub-Saharan Africa is of major concern with approximately 675 million people without access to electricity; businesses experiencing 8,5 incidences of unsupplied electricity on average per month; and rural electrification at only 15%. In addition, electrification was found to be one of the drivers for economic and educational growth and access to better health care. Trotter & Abdullah (2018) further established that foreign investment in electrification of sub-Saharan Africa comes with conditions. These conditions relate to the development of non-African businesses and consists of several foreign stakeholders which have incentivized African governments to disinvest in electricity.

Decreased African ownership threatens household electrification and energy equity in sub-Saharan Africa (Trotter & Abdullah, 2018). In Zambia mining companies consume half the country's electricity supply, while only 22% of the country's households have access to electricity (Kesselring, 2017). Moyo (2013) found that Africa has a variety of energy sources, including coal, natural gas, petroleum, solar, hydro, geothermal and nuclear. Furthermore, that the cause of Africa's unreliable and/or underdeveloped electricity sector is lack of infrastructure, appropriate financing instruments and regulations. Poor technical and financial management, low electricity tariffs and fiscal limitations are typical of state-owned monopolies which are the dominant supplier of electricity in Africa (Moyo, 2013). In South-Africa the actual cost of supplying electricity, exceeded the income generated by ESKOM, which contributed to reduced capital expenditure which was needed to meet the growing demand for electricity (Goldberg, 2015).

In sub-Saharan Africa unsupplied electricity are mostly unplanned, as the outages are caused by unplanned disruptions due to faults in the poorly maintained electrical infrastructure. Warnings are only possible with scheduled maintenance or when its necessary to protect the electrical grid with load-shedding when demand exceeds supply (Moyo, 2013).

External environmental conditions can impact the reliability of electrical infrastructure, as it can increase the electricity demand of buildings, as in the case of the UAE, where buildings account for more than 70% of the electricity demand, and development of green, energy efficient buildings is of paramount importance (Lin, Afshari & Azar, 2018). In the United States of America severe weather can cause blackouts by damaging the electrical infrastructure (Mukherjee, Nateghi & Hastak, 2018). Heavy snowfall and rough storms have affected the reliability of Norwegian electrical supply in the last couple of years and brought attention to vulnerable electrical infrastructure, especially where trees are too close to grid lines (Wethal, 2020). In Zambia, decreased rainfall has caused electricity load-shedding as their hydro-electric power has become unreliable and unable to meet the demand for electricity (Kesselring, 2017).

2.5. The Cost of Unsupplied Electricity

Unsupplied electricity comes at a significant cost to the economy and these costs are mostly unrecovered losses (Baarsma & Hop, 2009). Economic activity stops when electricity is unsupplied, and losses are felt in businesses as well as in homes (Baarsma & Hop, 2009). The costs of unsupplied electricity are higher when the disruption is unanticipated, although if the production processes cannot be shifted, or alternative electricity supply is not available, both unanticipated and planned electricity outages will result in a loss in production (Linares & Rey, 2013). When the start-up costs and possible equipment damage is taken into consideration, a shorter period of unsupplied electricity could result in higher costs in the industrial sector, compared to other sectors (Linares & Rey, 2013). Production loss in industrial business can affect other sectors as well, as orders placed cannot be fulfilled (Linares & Rey, 2013).

Adenikinju (2003) found that unsupplied electricity costs smaller businesses substantially more than larger businesses in Nigeria. The establishment of private infrastructure, including generators, for small businesses is approximately 25% of their machinery and equipment cost, compared to 15% of a large business's. In Nigeria researchers included a ranking system from: 1 - No Obstacle to 3 - Major obstacle, to rate the influence infrastructure (electricity and water) on operations. Responses indicated that most regarded power and voltage fluctuations as a major obstacle to operations (Adenikinju 2003).

The cost of unreliable electricity supply involves two categories of costs, namely: the direct cost of not being able to run production, including loss of output, loss of data, loss of materials, perishable goods, and the cost of restarting processes; and the indirect cost of the mitigating measures put in place to continue production during power failures, including the cost of purchasing alternative sources of electricity (Beenstock, 1991; Moyo, 2013). Grainger & Zhang (2019) found that in Pakistan, labour productivity is also a cost to be considered, during periods of expected or unexpected unsupplied electricity.

When considering the cost of alternative sources of electricity, the running and maintenance costs should be added to the cost of acquiring the alternative sources of electricity (Beenstock,1991), which is in all probability, expensive generators that run on diesel (Grainger & Zhang, 2019). The business will also have to consider the loss of competitive advantage if pricier back-up electricity sources must be used in the production process for extended periods (Linares & Rey 2013). Companies may also choose to purchase at increased cost, instead of manufacturing, electricity extensive transitional inputs, which will also influence their competitiveness (Grainger & Zhang, 2019). Companies whose manufacturing processes are reliant on electricity, could switch to less electricity dependent, less technological advanced methods, which will also decrease long term yield and expansion (Grainger & Zhang, 2019). Adenikinju (2003) found that the majority of business in Nigeria will demand that their employees work overtime in order to make up for lost production during periods of unsupplied electricity.

Baarsma & Hop (2009) found that the value of supplied electricity is higher than the rate charged to the users. Reichl *et al*. (2013) found that effective infrastructure investment is only possible when this value of electricity to society is available.

The cost to businesses is much higher than to households due to higher opportunity costs of businesses (Baarsma & Hop, 2009) and the industrial businesses and other large electricity users have a good idea of the effect of unsupplied power (Linares & Rey, 2013). In Nigeria, the cost associated with 65% of working hours being without power did not only severely impact manufacturing businesses but also caused consumer goods to rise above the average household's ability to pay for the goods (Adenikinju, 2003).

The cost of an electricity failure in industrial buildings are amplified due to equipment losses and/or risk to employees when processes stop unexpectedly (Beenstock,1991). Furthermore, that back-up generators are utilized to prevent equipment loss, rather than output loss. The acquisition of back-up generators may be deemed as the insurance premium against power failure and the cost of unsupplied electricity is revealed by the costs of buying and running the back-up generators (Beenstock & Goldin, 1997).

The prevalent methodology for obtaining the cost of unsupplied electricity has been self-assessment data, such as business surveys (Beenstock & Goldin, 1997). Self-assessment surveys incentivize calculated distortions, to impress the need for reliable electricity (Beenstock & Goldin, 1997). Another method of revealing the cost of unsupplied electricity in the industrial sector is to calculate production losses, but this method does not take equipment loss, restart cost or wasted raw materials in consideration (Beenstock & Goldin, 1997). Another method would be to ask businesses how much they would be WTP to avoid electricity outages and/or WTA as compensation when an electricity outage occur (Beenstock & Goldin, 1997).

The type of industry and duration of unsupplied electricity will directly influence the cost of back-up generation (Grainger & Zhang, 2019). A warehouse will be considerably less dependent on electricity supply or have sufficient back-up generation to continue working, compared to a production facility with high electricity usage (Beenstock & Goldin, 1997). Goldberg (2015) found that the cost of unsupplied electricity varies dependent on the country and the sector being researched, as well as the duration of the interruption, time of day, season and methodology used to measure the cost.

One of the biggest costs to unsupplied electricity identified in South Africa is the change in investor confidence, and subsequent negative impact on the economy of South Africa (Goldberg, 2015).

2.6. Mitigating Measures Put in Place by Business

Literature investigating the efficiency of green building are readily available, whereas there is little literature available on the decision-making processes of owners and/or facility managers who operate in these buildings (Christensen, Robinson & Simons, 2018). Chotipanich & Nutt (2007) found that when changes to business processes and working practices need to be considered, or during periods of uncertain external developments, in this case unreliable electricity supply, the strategic functions of facility managers become critical. Strategic FM aims to provide better asset management, lower occupancy costs, and more productive employees, which in most industrial premises is not conceivable without reliable electricity supply (Jack, 1994). Electrical maintenance forms one of the key positions of a facility manager (Jack, 1994).

Christensen *et al*. (2018) investigated the motivation behind investing in green building while this research paper aims to study the decisions made by owners and/or facility managers to operate and function in periods of constraint or unsupplied electricity. Green buildings will have a competitive advantage during periods of constraint or unsupplied electricity and as a result could be motivation for facility managers to transfer their facilities in green buildings.

Most industrial facilities are owner occupied, with major investment in plant and other improvements, and therefore relocating of facilities are not easily considered (Pertz, 1995). Competitiveness is the main driver for retrofitting energy solutions on existing industrial buildings (Christensen *et al*., 2018). The number of electricity failures experienced by a company will directly influence the decision to invest into self-generation (Grainger & Zhang, 2019) and/or battery storage technologies (Kazmi, Mehmood, Tao, Riaz & Driesen, 2019).

Baarsma & Hop (2009) established that both business and households prefer to receive advance notice of periods of unsupplied electricity. Grainger & Zhang (2019) found that unreliable electricity supply forces businesses to operate on alternative time schedules, alter employment of inputs, and possibly change business activities.

For many industrial businesses uninterrupted electricity is of paramount importance as safety to employees can play as big a role as uninterrupted production (Jethwa, Bansal, Date & Vaishnav, 2010). The literature debates various methods for industrial facilities to manage their electricity usage. Businesses in response to unreliable electricity can choose to relocate to an area with reliable electricity supply, or utilize factor substitution, or consider own generation, choice of business and reduction of output (Adenikinju, 2003). Alternatively, when the business is not in the position to ratify any of these options, reducing the electricity load of industrial facilities are one of the first steps facility managers can take, this will not only reduce the operating cost of the industrial facility, but also reduce the specifications of back-up or alternative electrical supply. Gourlis & Kovacic (2016) looked at retrofitting and renovating existing industrial buildings with insulation construction materials to improve the buildings thermal performance, as a way of lowering the demand for electricity and lower operating costs.

Jethwa *et al*. (2010) and Kucuk *et al*. (2018) discuss load-shedding schemes (LSS) to protect the industrial facility from total loss of electricity and maintain critical loads in the facility, while switching of non-essential loads. Kastner, Lau & Kraft (2015) debate the possibility of cultivating symbiotic relationships in industrial parks, as a method of reducing the overall energy and material consumption within the industrial park, including methodologies that can be utilized to adapt exiting industrial parks into eco-industrial park systems with exchanges of water, heat, electricity, and materials.

LSS including circuit breaker interlocking, load-shedding design based on under-frequency relays, and load-shedding control systems based on PLC or micro-controllers has been developed to provide fast and effective responses during sudden loss of power, by shedding predefined loads, to reach a balanced power state with available electricity supply (Kucuk *et al*., 2018).

California, in response to their electricity crisis, which resulted in rolling blackouts and escalated electricity costs, conducted research on the feasibility of installing Automated Demand Response (Auto-DR) hardware and software technology in large facilities, their research did not address the costs and/or benefits of installing this technology in existing buildings and industrial facilities (California Energy Commission, 2005). Demand Response (DR) is a set of activities which send signals to customers to reduce electricity consumption or shift electricity use to assist electric grid reliability (California Energy Commission, 2005). Facilities with Energy Information Systems and Energy Management and Control Systems or LSS have the ability to be programmed, so that the systems automatically begin switching off non-essential electrical equipment when the cost of the electricity increases (California Energy Commission, 2005).

In Italy, Meneghetti & Chinese (2002) investigated the idea of a district orientated facility management development, evolving facility management from the individual business's perspective to an industrial district perspective, where through collaboration and sharing of resources, one business's waste can become another business's raw material. Utilities like energy and waste treatment can be shared and collaboration between companies regarding emergency planning, training or sustainability planning can be envisioned (Meneghetti & Nardin, 2012). The idea is of an Eco Industrial Park where different types of industries can group together and work together to lower energy and other resources consumption (Meneghetti *et al*., 2012).

In Nigeria, both businesses and households had to start generating their own electricity partially or even completely, this significantly raised the capital investment in manufacturing, in addition to the higher operational costs in running the production processes and facility (Adenikinju, 2003).

In South Africa, Monyei & Adewumi (2017) found that Demand Side Management (DSM) became a workable method for adjusting electricity usage patterns, based on the fact that savings can be realised from the consumer side and thus potentially eliminate the need for additional electrical generation. In 2008 Eskom initiated a campaign to exchange incandescent bulbs with more energy efficient CFL bulbs and in 2015/2016 rolled out the LED program, to attempt to reduce the electricity demand and avoid electrical load-shedding. However, this would not take into consideration, or eliminate the growth in electricity demand, therefore expansion of renewable energy capacity and new powerplants with improved efficiency and lower carbon emissions had to be considered (Monyei & Adewumi, 2017).

2.7. The South African Power Sector

Growth and consolidation, supported by economics of scale, capital backed by government guarantees, and governments industrialization strategy, were the foremost incentive for a dominant state-owned monopoly in the power sector in South Africa. Private ownership was unfavourable in the quest for industrialization, employment generating and economic growth (Eberhard, 2004).

However, in the 1980's poor investment decisions, general economic performance, non-accountability of management and political pressures, with majority of the South African population without electricity, called for restructuring of the electricity sector by government (Eberhard, 2004). New commercial principles were embedded in the operation of Eskom and governments financial guarantees was removed, after overhauling the governance of the power utility which improved the productivity of the power utility (Eberhard, 2004). After the 1994 elections, electrification and improvements to electrical distribution became a priority and Eskom played a central role in bringing electricity at low cost, to more people (Eberhard, 2004). For years Eskom was selling electricity at a price considerably lower than the true cost of generation, which resulted in Eskom not recovering the cost of its capital investment and thus not in the position to finance capital investment required to meet future demand (Goldberg, 2015).

Eberhard (2004) anticipated that South Africa was living on borrowed time with regards to electricity capacity, and that prices will have to rise to fund the increased demand expected from 2007 onwards, as analyst were predicting rolling blackouts if the required capacity was not planned for. Eskom appealed to government in the 1990's and early 2000's to finance additional generation capacity to meet the electricity demand of a growing economy, but government did not respond quick enough and as expected South Africa's electricity crisis became apparent in 2007 as a result of this predicted generational capacity shortage (Goldberg, 2015). Eskom, to protect the power system, introduced national rotational load-shedding in the last quarter of 2007 and a national emergency was declared in January 2008, with load-shedding lasting until March 2008. Eskom started with a recovery plan, supported by government and business (Goldberg, 2015).

Volkwyn & Kleynhans (2014) investigated alternative methods available to Eskom to manage the shortage of electricity, they focused on higher tariffs and load-shedding which are both detrimental to the South African economy, but when they compared the above two methods, increasing the consumer price of electricity would be preferable to load-shedding.

2.8. Nelson Mandela Bay Industry Sector and Electricity Consumption

According to the City of Port Elizabeth Electricity supply by-law (1990) the council shall not be held liable for any loss or damage suffered by the consumer because of the interruption of the supply of electricity (Clause 18) and that they can reduce the load on its electricity supply system, at times of peak load, or in an emergency, by discontinuing the supply of electricity without notice to the consumer (Clause 28).

On the 9th of December 2019 Eskom announced via Twitter that load-shedding has moved to stage 6 from stage 4 due to a shortage in capacity caused by coal feeding issues to the silos at Medupi power station, which resulted in a loss of several units. In addition, flooding at the Kriel mine and power station lead to no deliveries of coal via the conveyor belts, and abnormally high rain fall impacted the boiler, turbine hall and other critical infrastructure at Camden. Customers were requested to reduce demand to lessen the level of load-shedding while Eskom's emergency response command centre and technical teams worked through the night to restore the units.

NMBM, however, took the decision to stay at stage 4 and only posted new schedules that included stages 5 to 8 on the 11th of December 2019. In a letter addressed to business leaders in NMB, dated the 28th of February 2020, the NMBBC clarified that they had an agreement with NMBM that they will not load shed the industrial areas between Stages 1 to 4 in order to protect the critical role industry plays in the local economy. The schedules announced on the 11th of December 2019, however, included the industrial sector from stages 5 to 8 as per Appendix K. This was planned in four-hour windows which would negatively impact the larger businesses in the city, especially those in the manufacturing sector who are unable to manage continuous disruptions to their production processes.

Due to lengthy start-up and shutdown periods in many manufacturing industries, most of the industry in Perseverance, who employ an estimated 10 000 employees directly, will simply shut down production. The NMBBC has run a successful ripple control system in two manufacturing businesses in the Metro with positive results in terms of reducing load on the power grid. They reported that up to the 28th of February 2020, that thirty companies have signed up to voluntary shed between 6 to 8% of their power through this method, however they need to increase the number of businesses to more than 100 to significantly reduce the current load-shedding burden across the entire city and the risk of possible future load-shedding in industrial areas.

2.9. Conclusion

Internationally, electricity supply has been affected by delayed infrastructure investment in electrical infrastructure; unsustainable, subsidised electricity supply; growth in demand; regulatory changes, especially related to renewable electrical supplies, or lack of regulations; severe weather conditions, and conflict situations, like civil war. Unreliable electricity has a negative impact on economic development and societies dependant on electricity. FM's fundamental role is resource management, to support core business operations and processes. Therefore, unreliable electricity supply is of significant concern to both operational and strategic FM.

South Africa's unreliable electricity stems from poor investment decisions, general economic performance, non-accountability of management and political pressures as far back as the 1980's. Eskom appealed to the South African government in the 1990's to finance additional generation to meet a growing demand and a delayed response ultimately led to the predicted rolling blackouts or load-shedding in the last quarter of 2007 and again in 2019. This remains an unsolved problem to date. The following chapter documents the research methodology employed in the case study of

Perseverance, to identify the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings, which will aim to fill the gap in the literature, with regards to the decision-making habits of facility managers and/or owners when facing the real possibility of electrical loadshedding in an area which was previously exempt form electrical load-shedding.

3. CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter reflects on the researcher's philosophy and research approach, including the relationship of the researcher to the case study of Perseverance Industrial Township. The chapter further unpacks the researcher's epistemological assumptions and theoretical frameworks that have motivated, organised, and delineated the research methodology, and therefore the data collection and analysis.

The chapter further motivates the decision of undertaking a mixed-method study within an overarching case study, and the selection of Perseverance Industrial Township as the case study, to answer the research question. The research method and data collection design are described, and the reliability and validity of the research is unpacked. Finally, the ethical issues and limitations of the research is considered.

3.2. Research Philosophy

The philosophical foundation of mixed method research can be justified by pragmatism, which argues that quantitative and qualitative methods are compatible, with enough parallels in essential principles, to allow their mixing within a single study (ed. Maree, 2016). Other studies suggest the philosophies of post positivism, associated with quantitative research and constructivism, associated with qualitative research can be used within a mixed method study (ed. Maree, 2016). Pragmatism is the theory that the research question is more important than the methods used or their underlying philosophical views (ed. Maree, 2016).

As the overarching case study is qualitative in nature, the researcher's philosophy leans towards interpretivism, where the goal of the method is to interpret how individuals interact with events and actions to be investigated; in this case study - how facility managers are reacting to the threat of potential electrical load-shedding (Magnusson & Marecek, 2015). Face-to-Face interviews, structured by the researcher is an effective way to gather qualitative data, where the participant informs the interviewer of their views (Magnusson & Marecek, 2015). Elements of positivism is brought in by the quantitative survey questionnaire, which seeks the causal relationship between the event and actions (Amaratunga, Baldry, Sarshar & Newton, 2002).

A mixed method case study design, which falls under advanced mixed method designs category, was employed by the researcher, where the researcher collected, analysed, and integrated both qualitative and quantitative data entrenched within a qualitative case study design framework (ed. Maree, 2016).

This design is useful when the researcher needs to include quantitative summaries of contextual information to enhance the qualitative descriptions of the case (ed. Maree, 2016). Amaratunga *et al.* (2002) also found that the use of mixed methodology in the built environment, counteracts the weaknesses in either quantitative or qualitative methodologies. They also stated that a case study can utilise both positivism (quantitative) and phenomenological (qualitative) bases for research in the built environment. The philosophy behind mixed method research methodology is ultimately to create balance between positivism and realism, while objectives were formulated to recognise empirical evidence to tie with theoretical propositions (Amaratunga & Baldry, 2001).

Amaratunga *et al.* (2002) found quantitative methods can be artificial, inflexible, and not effective in understanding processes or significance that individuals attach to actions. Positivisms is also not helpful in generating theories, as they focus on what is, or was and does not look at the future. Strengths include speed and economics, large samples, and wide coverage of the range of situations.

In qualitative methods it can be harder to control the progress and endpoints, it's tedious and require more resources, while data analysis and interpretation can be more difficult with low credibility in qualitative results. Strengths include the ability to look at evolutionary processes over time, the method is more natural and the ability to understand individuals and adjust to new ideas and issues as they emerge and it can contribute to theory generation (Amaratunga *et al.,* 2002).

Combining of quantitative and qualitative methods establishes convergence, while providing richness and details, as well as prompting new interpretations and ultimately suggest areas of further exploration (Greene, Caracelli & Graham, 1989). The purpose of using a mixed method methodology embedded within an overarching qualitative case study is firstly expansion, to extend the scope, breadth and range of enquiry by using quantitative survey questionnaires and semi-structured qualitative interviews; secondly complimentary to elaborate, enhance and illustrate the results from the other method and lastly methodological triangulation to illuminate inherent weaknesses of each method, by counterbalancing the strength of the other (Greene *et al*., 1989; Amaratunga *et al.,* 2002).

Further the above, a convergent parallel mixed method design was embedded within the overarching qualitative case study, see *Figure 1*. The convergent parallel mixed method uses both quantitative and qualitative methods in order to find a more comprehensive and useable understanding of the phenomenon of interest, data is collected at the same time for both quantitative and qualitative in order to compare and contrast the emerging data and produce thorough conclusions and recommendations (ed. Maree, 2016).

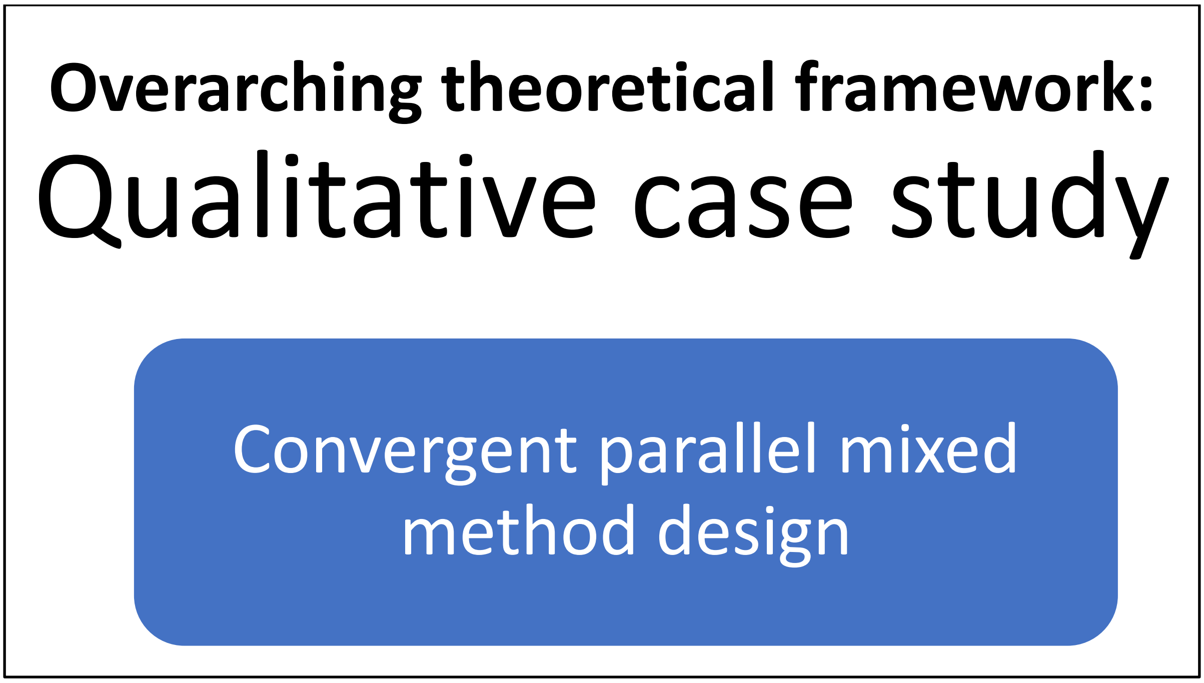

Figure 1: Advanced mixed method design (ed. Maree, 2016)

3.3. Research Approach

From the literature the researcher was able to determine that unsupplied electricity is not a matter of concern limited to South Africa, and internationally studies have explored the cause and effect of unsupplied electricity to industries as well as private households. The researcher was not able to find any studies that explored the threat of potential unsupplied electricity on facility managers strategic or operational FM, but the researcher was able to find studies on what was done to mitigate actual unsupplied electricity.

To determine how facility managers are reacting to potential load-shedding in previously uninterrupted industrial areas, an advanced mixed methodology was utilised in this study, combining quantitative and qualitative methods in a convergent parallel mixed method design, illustrated in *Figure 1 & 2*, within an overarching qualitative case study of Perseverance Industrial Township.

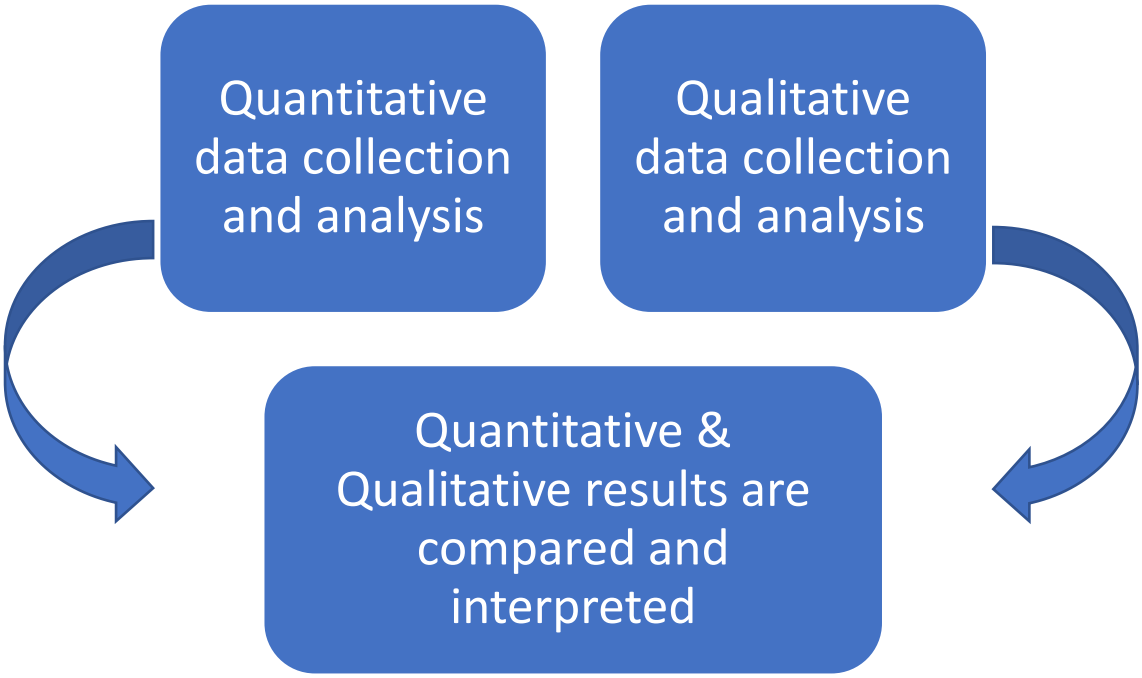

Figure 2: Convergent parallel mixed methods design (ed. Maree, 2016).

The case study was designed to answer the research question and reflect the interest of the enterprises situated in Perseverance (Yin, 2003). The mixed methodology was utilised in order to get a more complete answer to the research question.

A quantitative approach is concerned with defining an epistemological methodology for determining the truth value of propositions and allow for flexibility in data analysis and repeatability to verify reliability (Amaratunga *et al.,* 2002).

A qualitative approach with structured interview questions should be designed to understand the energy related strategies when choosing the investment property location, green buildings (Christensen *et al*., 2018), and/or investing in own generation. Therefore, interviewees should include both tenants, owner occupiers and property managers (Christensen *et al*., 2018). Qualitative data is a powerful strategy for discovery, exploring new hypothesis, including developing and testing hypotheses. Qualitative data is also useful in validation, explanation, or reinterpretation of quantitative data (Amaratunga *et al.,* 2002).

A quantitative survey questionnaire was distributed to all Perseverance Industrialists and selected industrial/commercial entities situated in NMB and surrounding area. The participants' particulars, in Perseverance were supplied by the Perseverance Industrialist Forum and the remainder was identified from the Nelson Mandela Business Chamber's Business Guide 2019.

Qualitative, Face-to-Face semi-structured interviews were then conducted with facility managers, plant engineers, managing directors and/or business owners of selected industrial enterprises in Perseverance, who consented to an interview.

Due to Covid-19 and/or reluctance of NMBM officials, it was not possible to meet Face-to-Face, or conduct electronic semi-structured interviews with Nelson Mandela Bay Municipal officials. However, information obtained in the public domain, including NMBM's social media content was integrated within the overarching qualitative case study and thematically analysed, while The City of Port Elizabeth Electricity supply by-law (1990) was reviewed as part of the literature review.

3.4. Case Study Methodology

3.4.1 What is the case study approach?

The research was conducted by a single investigator, the author and therefore, the role of protocols and formal preparation was not pertinent (Yin, 2003). Multiple sources of evidence were utilised in the case study, both quantitative and qualitative: archival records of Perseverance Industrial Forum, including minutes of meetings, survey questionnaires, interviews, information available on public domain (social media) and direct observation including participant observation (the researcher attended meetings held by Perseverance Industrialists Forum and Focus Group) (Yin, 2003). *Table 1* sets out the chronology of the case study of Perseverance – milestones, survey questionnaires and interviews conducted, including meetings attended by the researcher in Perseverance.

Table 1: Chronology of the Case Study of Perseverance Industrial Township

Date	**Milestones, interviews, and events attended by the researcher**
03 August 2020	Received Ethical Clearance - Email
12 October 2020	Send Survey Questionnaires and Interview Requests - Emails to Perseverance Industrial Forum contact list.
19 October 2020	Interview 1 - Face-to-Face Meeting
19 October 2020	Interview 2 - Face-to-Face Meeting
21 October 2020	Interview 3 - Face-to-Face Meeting
21 October 2020	Interview 4 - Face-to-Face Meeting
27 October 2020	Interview 5 - Face-to-Face Meeting
27 October 2020	Interview 6 - Face-to-Face Meeting
03 November 2020	Send Survey Questionnaires and Interview Requests - Emails to Enterprises in the remainder of NMB
02 December 2020	Interview 7- Face-to-Face Meeting
14 December 2020	Interview 8 - Face-to-Face Meeting
03 March 2021	Interview 9 - Face-to-Face Meeting

17 March 2021	Interview 10 - Face-to-Face Meeting
13 April 2021	Perseverance Industrialists - Meeting
10 May 2021	Emergency Electricity - Meeting
26 May 2021	Interview 11- Face-to-Face Meeting
17 June 2021	Perseverance Industrialist - Meeting
03 August 2021	Perseverance Industrialists Interest Group - Meeting
26 August 2021	Profile: Perseverance - Microsoft Teams Meeting
14 October 2021	DTIC Visit to Perseverance - Meeting & Bus tour of Perseverance
29 October 2021	Perseverance Focus Group (Industrial Park) - Meeting
12 November 2021	Perseverance Focus Group (Industrial Park) - Meeting
10 December 2021	Perseverance Focus Group (Industrial Park) - Meeting

3.4.2 Justification for single case study

Case studies are an empirical inquiry into contemporary phenomena set within a real-world context (ed. Maree, 2016). A case study can be based on either a single-case or a multiple-case, multiple-case studies included two or more cases within the same study, in this case the researcher decided on a single case study, focused on Perseverance (Yin, 2003), with supplementary quantitative data collected from the remainder of NMB and surrounds.

Perseverance was selected as the single case study by the researcher, as the researcher was well informed on the history of Perseverance, and to capitalise on the researcher's established network of contacts in Perseverance. Maree (ed), 2016 also found that boundaries on case studies can prevent researchers from going too broad and becoming unfocused in the research. Boundaries on case studies included time and place, which is applicable to the case study of Perseverance Industrial Township, during this period of unreliable electricity availability.

3.4.3 Unit of Analysis

The relevant population for this research was owners, plant, and facility managers of industrial and/or commercial enterprises in Perseverance specifically, with limited participants in remainder of NMB and surrounding area. Perseverance Industrial Township as seen in *Figure 3*, is a solely industrial suburb of Gqeberha (Port Elizabeth), in the district of NMB in the province of Eastern Cape and is conveniently centrally located between Gqeberha's harbour (26,04km or 27 minutes driving time), Coega Industrial Development Zone (23,32km or 25 minutes driving time) and Kariega (Uitenhage) (18.71km or 21 minutes driving time), where provincial main roads R367 and Chelsea Road meet (roadmap.com 2020), as seen in *Figure 4*.

Figure 3: Perseverance Industrial Township (Source: Google Earth,2021).

The unit of analysis was the measures that individual owners, plant, or facility managers of industrial and/or commercial entities in Perseverance Industrial Township and remainder of NMB, were putting in place to mitigate the effects of potential load-shedding on industrial operations in previously uninterrupted industrial areas.

3.4.4 Selection of the case (Perseverance)

Perseverance Industrial Township was selected as the focus of the case study, by the researcher based on the following reasons:

- The researcher is based in Perseverance and has prior knowledge and access to information and participants, as many qualitative studies rely on "convenience" to locate the sites to be observed or the participants to be interviewed (Morgan, 2014)
- Perseverance was previously exempted from electrical load-shedding, which caused conflict with the remainder of NMB, who was plagued with onerous load-shedding schedules during 2019. This became a major problem when stage 6 load-shedding was announced by Eskom

for the first time on the 9th of December 2019.

- A single case study of an industrial area's facility managers' strategic and operational decisions was deemed to be a relevant case to undertake, under these circumstances.

Figure 4: Nelson Mandela Bay (Source: Google Earth, AfriGIS (Pty) Ltd., 2021)

3.5. Data collection – Mixed Method.

Since 2008, Perseverance has had, an active Industrialist Forum, which met quarterly, to discuss issues that affect all Industrial companies, such as infrastructure (electricity, water, and roads), illegal dumping and security. The Industrialist Forum also enabled various companies to coordinate in emergency situations. *Figure 5* was supplied by the Perseverance Industrialist Forum, and it illustrates the broad range of industries that are based in Perseverance. A list of companies in Perseverance and NMB and surrounds was supplied by the Perseverance Industrialist Forum and NMBBC Annual Business Directory was also utilised in the sampling process.

This was not a complete list of industrial and commercial entities in NMB, as both the Perseverance Industrialist Forum and the NMBBC are voluntary associations. Although the Perseverance

Industrialist Forum list, was based on visual confirmation of companies in Perseverance, and therefore was an accurate representation of companies situated in Perseverance. As the research is primarily based in Perseverance, the sample size was meaningfully represented. The researcher endeavoured to include industrial and/or commercial entities of various sizes in the remainder of NMB and surrounds as additional information and further triangulation.

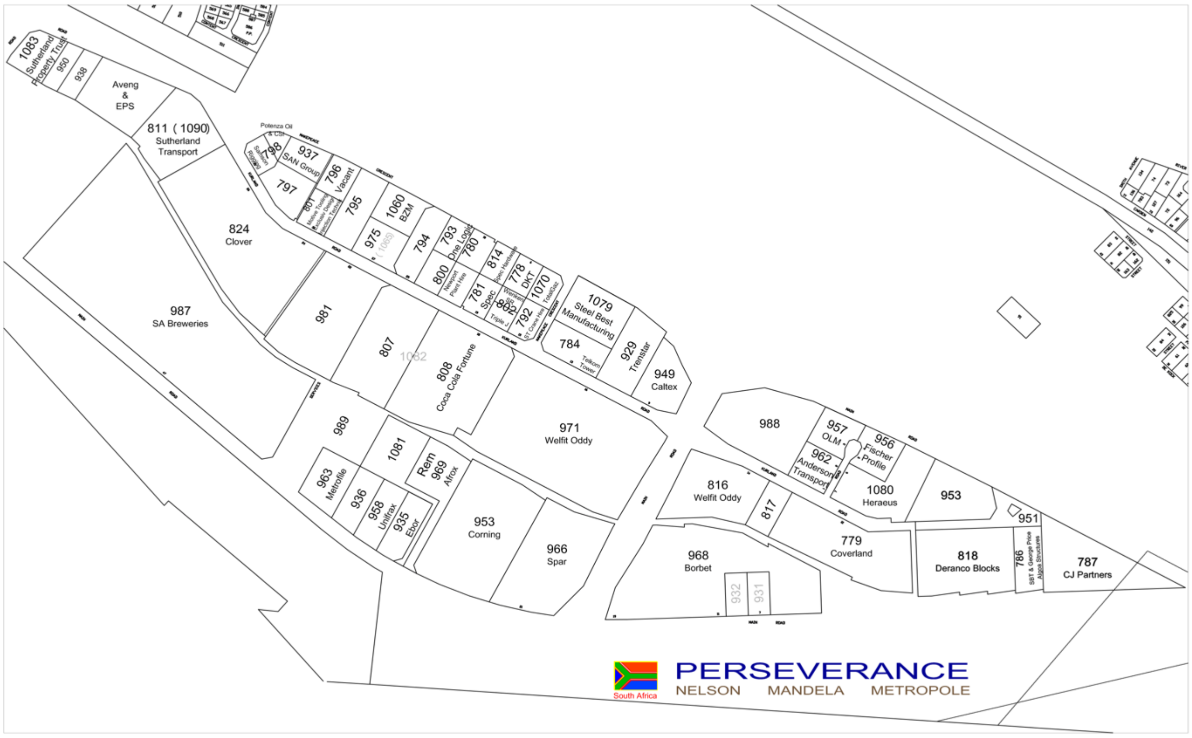

Figure 5: Perseverance Ownership Diagram (Source: Perseverance Industrialists Forum, 2021)

As a mixed method was used to collect the data and increase the accuracy of the research (Bowen, 2018). Data was collected through quantitative survey questionnaires and qualitative semi-structured face-to-face interviews. The qualitative interviews expanded on the quantitative information collected in the surveys (Bowen, 2018). The quantitative data collected with the survey questionnaires was captured and analysed in a Microsoft Excel spreadsheet, the data was sorted according to questions and each question's data was displayed pictorially in histograms and pie charts, using statistical tools available in Excel (Kirkup, 2011).

The quantitative data, in the form of interview transcriptions, were thematically analysed using NVivo 12. See Sample Interview Transcription in Appendix I. Initially, an inductive coding method was utilised as the files was analysed and coded, and the emerging themes was merged. Next the nodes were arranged in node hierarchies and compared to emerging themes in the literature review, after which some nodes were created utilising deductive coding (La Trobe University, n.d.).

3.6. Questionnaire design, sampling, and analysis

The survey questionnaires consisted of a list of seventeen questions for Perseverance Industrial Township and eighteen questions for the remainder of NMB and surrounds. The questions were formulated during the literature review process and designed to answer the research question: What are facility managers putting in place to mitigate the effects of potential load-shedding on industrial operations?

An interview consent form as shown in Appendix A, was accompanied by the survey questionnaires, which was emailed to all known Industrialists in Perseverance (Appendix B) and selected industrial and/or commercial enterprises in remainder of NMB (Appendix C). Perseverance has approximately 46 active commercial and/or industrial enterprises, from whom 20 completed surveys was received, listed in *Table 2*. The author emailed survey questionnaires to approximately 112 commercial and/or industrial enterprises in the remainder of NMB and received completed survey questionnaires from 14 participants, listed in *Table 3.*

Table 2 - Perseverance Participants

Participant Number	Interview Number	Category	Size of Facility	Number of Employees
1	7	Manufacturing	1 000 – 5 000 m²	15 - 50
2	N/A	Manufacturing	10 000 - 20 000 m²	≤ 15
3	N/A	Warehousing & Distribution	5 000 – 10 000 m²	15 - 50
4	10	Manufacturing	≥ 20 000 m²	100 - 500
5	5	Other: Fuel & Retail	1 000 – 5 000 m²	15 - 50
6	4	Distribution & Logistics	1 000 – 5 000 m²	100 - 500
7	1	Warehousing, Manufacturing & Distribution	≥ 20 000 m²	500 – 1 000
8	2	Manufacturing	10 000 - 20 000 m²	100 - 500
9	3	Manufacturing & Distribution	≥ 20 000 m²	50 - 100
10	N/A	Manufacturing & Electrical Contracting	≤ 200 m²	≤ 15
11	8	Manufacturing	10 000 - 20 000 m²	100 - 500
12	N/A	Other: Service Based	200 – 500 m²	15 - 50
13	6	Manufacturing & Refining of Metals	10 000 - 20 000 m²	50 - 100
14	N/A	Manufacturing	1 000 – 5 000 m²	15 - 50
15	9	Manufacturing	1 000 – 5 000 m²	100 - 500
16	N/A	Warehousing, Manufacturing & Distribution	≥ 20 000 m²	100 - 500
17	N/A	Warehousing, Other:	200 – 500 m²	15 - 50

		Mechanical Workshop & Service Based		
18	N/A	Warehousing & Distribution	≥ 20 000 m²	100 - 500
19	11	Manufacturing	≥ 20 000 m²	100 - 500
20	N/A	Distribution & Other: Transport	1 000 – 5 000 m²	15 - 50
21	N/A	Manufacturing	≥ 20 000 m²	500 - 1 000

Table 3 - Participants: Remainder NMB and Surrounding Area

Questionnaire Number	**Area**	**Category**	**Size of Facility**	**Number of Employees**
1	Neave Township	Manufacturing	≥ 20 000 m²	100 - 500
2	Westering	Other: Services	200 – 500 m²	≤ 15
3	Deal Party	Warehousing & Distribution	500 – 1 000 m²	≤ 15
4	Despatch	Other: Security	200 – 500 m²	≤ 15
5	North End	Other: Service & Maintenance Facility	200 – 500 m²	≤ 15
6	Newton Park	Warehousing & Distribution	200 – 500 m²	≤ 15
7	Sidwell	Manufacturing	200 – 500 m²	≤ 15
8	Humansdorp	Distribution	1 000 – 5 000 m²	15 - 50
9	Sidwell	Manufacturing	200 – 500 m²	15 - 50
10	Struandale	Manufacturing	≥ 20 000 m²	≥ 1 000
11	Neave Industrial	Manufacturing	10 000 - 20 000 m²	100 - 500
12	Deal Party	Manufacturing	1 000 – 5 000 m²	100 - 500
13	Sundays River Valley	Other	≥ 20 000 m²	50 - 100
14	Uitenhage	Manufacturing	≥ 20 000 m²	≥ 1 000

Question 2 of the questionnaire asked participants if they had a facility manager and if so, to provide the details of their facility manager, for the ensuing semi-structured face-face interview. Eleven participants from Perseverance took part in the face-face interviews.

3.7. Interview design, sampling, and analysis

Interview questions were formulated during the literature review process and designed to answer the research aim: Determine how facility managers are reacting to potential load-shedding in previously uninterrupted industrial areas. Interview participants were given the opportunity to review the questions before the interview commenced and the structure of the interview was followed for most of the interviews. Eleven participants consented to an interview, listed in *Table 4*. The profiles of the participants are defined in *Table 4*.

Table 4 - Interview Participants in Perseverance

Interview number	Category	Size of Facility	Number of Employees
1	Warehousing, Manufacturing & Distribution	≥ 20 000 m²	500 - 1000
2	Manufacturing	10 000 - 20 000 m²	100 - 500
3	Manufacturing & Distribution	≥ 20 000 m²	50 - 100
4	Distribution & Logistics	1 000 – 5 000 m²	100 - 500
5	Other: Fuel & Retail	1 000 – 5 000 m²	15 - 50
6	Manufacturing & Refining of Metals	10 000 - 20 000 m²	50 - 100
7	Manufacturing	1 000 – 5 000 m²	15 - 50
8	Manufacturing	10 000 - 20 000 m²	100 - 500
9	Manufacturing	1 000 – 5 000 m²	100 - 500
10	Manufacturing	≥ 20 000 m²	100 - 500
11	Manufacturing	≥ 20 000 m²	100 - 500

A list of 11 questions, as per the interview guide listed in *Table 5*, formed the outline for the interviews. All interviews were recorded and later transcribed for further analysis.

Table 5: Interview Guide

1	What was your reaction as a facility manager to the announcement of the new load-shedding schedules?
2	What impact did this have on your operational decisions?
3	What impact did this have on your strategic decisions?
4	Does this facility require uninterrupted electrical supply to run industrial processes?
5	Does this facility have back-up electricity generation?
6	Does this facility manage their own back-up electricity generation or is it part of a service agreement?
7	Is it possible to own-generate enough electricity to run industrial processes at this facility?
8	Is it possible to own-generate enough electricity to run administration and security and/or safety functions?
9	Will this facility consider installation of back-up power generation?
10	Which area is this facility based in, in Nelson Mandela Bay?
11	Under what category does this facility fall? Warehousing, manufacturing, distribution or other?
12	To contextualize your answers, please indicate the size of the facility and how many full-time employees work at this facility, managing the facility?

3.8. Reliability and validity of the research

Although the research was approached with a mixed methodology, the qualitative data inherent to the case study, exposed the research to subjective decisions by the researcher. To ensure reliability and validity of the research the following strategy (Noble & Smith, 2015), was implemented by the researcher:

- The researcher reflected on and considered personal biases while discussing the findings.
- Biases in sampling was addressed, in that the survey questionnaires and interview requests was sent to all enterprises in Perseverance.
- Meticulous record keeping was key in ensuring that all interpretations of data are consistent and transparent. Interviews was recorded for accuracy and transcribed.
- Analysis and findings were supported by verbatim quotations from the interview transcriptions.
- Use of mixed methodology, where the quantitative data and qualitative data produced a more comprehensive set of findings and recommendations. Methodological triangulation will also illuminate inherent weaknesses of each method.

3.9. Ethical considerations

Data was collected from human subjects and thus ethical consideration had to be considered. UCT aim to do research with respect for the dignity and self-esteem of individuals and for basic human rights, with reference to clearly specified standards of conduct and procedures ensuring proper accountability (UCT Code for research involving human subjects), with this in mind the author applied for ethical clearance on the 27th of July 2020, after which ethical clearance was received on the 3rd of August 2020. See Appendix J for signed ethics form.

Informed consent (Appendix E) was signed by interviewees and researcher before interviews was conducted, as per comments from the ethical clearance, the following clause was added to the consent form: "I agree to the interview being recorded in audio and/or video format." All participants were assured that their participation is voluntary and that they can withdraw from the research at any time.

The Perseverance Industrialists Forum sent out emails to all Perseverance Industrialists to request participation in the research and inform them about the research taking part in Perseverance. No feedback or objections was received from Perseverance Industrialists.

The information gathered from the survey questionnaires and during the interview process has been used solely for this research process and no company and personal information was mentioned during the recording of the interviews. Where interviewees mentioned their company name during the interview, the information was removed from transcriptions and not used in the research. All data captured is stored in a password protected computer and/or locked home office.

All Covid-19 protocols, including strict social distancing was observed during the interview process and Face-to-Face interviews only commenced once South Africa moved to alert level 1 of the national lockdown on the 20th of September 2020 (IOL, 2021).

3.10. Conclusion

Multiple sources of evidence were utilised in the process of collecting data, to strengthen the case study results. Evidence was collected from archival records supplied by Perseverance Industrial Forum and NMBBC, public domain information (social media), survey questionnaires from, and interviews with enterprises situated in Perseverance Industrial Township, supplemented with survey questionnaires from participants in the remainder of NMB and surrounds; and direct observations including participant observation (Yin, 2003).

Table 6: Summary of Research Methodology

Research Philosophy	• Pragmatism • Interpretivism • Positivism
Research Approach	• Advanced mixed method design, consisting of an overarching qualitative case study with an embedded convergent parallel mixed method using both quantitative and qualitative methods.
Case Study Methodology	• Single investigator • Multiple sources of evidence • Quantitative survey questionnaires • Qualitative semi-structured interviews • Archival records of Perseverance Industrialist Forum • Public domain information (social media) • Direct observation • Participation observation

The following chapter documents the case study of Perseverance Industrial Township.

4. CHAPTER 4: A CASE STUDY OF PERSEVERANCE INDUSTRIAL TOWNSHIP

4.1 Introduction

This chapter begins with an introduction to Perseverance and an overview of the case, derived from archival data from the Perseverance Industrial Forum. It then presents the data collected via the survey questionnaires, which was emailed to enterprises in Perseverance and the remainder of NMB and/or hand delivered to Industrialists situated in Perseverance and the semi-structured interviews conducted with participants in Perseverance. The quantitative data collected from the survey questionnaires is presented with descriptive statistics and the qualitative data collected from the semi-structured interviews and other sources of information are presented thematically.

Once all the data has been presented, the combined findings are analysed and presented, and discussed in terms of the literature.

4.2 Introduction to Perseverance Industrial Township and overview of the case

Perseverance Industrial Township, established in 1970, is a solely industrial suburb of Gqeberha (Port Elizabeth), in the district of NMB in the province of Eastern Cape. Perseverance has approximately 46 active commercial and/or industrial enterprises, comprising mainly of manufacturing, distribution and warehousing sectors, employing an estimated 10 000 employees, which is comparative to employment in Coega Development Zone (Perseverance Industrialist Meeting dated 14 October 2021). *Table 7* contextualise two of the main identified themes in this case study: if the participant requires uninterrupted electrical supply and if they have back-up generation available, relative to their category, size, and number of employees. Of note, is that there are seven participants, whose size is ≥ 20 000m² and that six of them require uninterrupted electrical supply, but only two of them have back-up generation. On the other hand, three out of six of the participants, whose size is 1 000 – 5000m² requires uninterrupted electricity supply and has back up generation.

Perseverance was exempted from electrical load-shedding in 2008, to safeguard employment. On the 9th of December 2019, Eskom implemented Stage 6 load-shedding for the first time and on the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas, including Perseverance, an industrial township, with uninterrupted and preferential electricity supply since 2000.

Table 7: Contextualised summary of participants in Perseverance Industrial Township.

Participants	Uninterupted Electricity?	Back-up Generation?	Category	Size of Facility	Number of Employees
1	YES	NO	MANUFACTURING	1 000 - 5 000 m^2	15 - 50
2	YES	NO	MANUFACTURING	10 000 - 20 000 m^2	≤ 15
3	YES	NO	DISTRIBUTION	5 000 - 10 000 m^2	15 - 50
4	YES	NO	OTHER	≥ 20 000 m^2	100 - 500
5	YES	YES	DISTRIBUTION & OTHER	1 000 - 5 000 m^2	15 - 50
6	YES	NO	WAREHOUSING, MANUFACTURING & DISTRIBUTION	1 000 - 5 000 m^2	100 - 500
7	YES	NO	MANUFACTURING	≥ 20 000 m^2	500 - 1 000
8	YES	YES	MANUFACTURING	10 000 - 20 000 m^2	100 - 500
9	YES	NO	MANUFACTURING & DISTRIBUTION	≥ 20 000 m^2	100 - 500
10	NO	NO	MANUFACTURING & OTHER	≤ 200 m^2	≤ 15
11	YES	NO	MANUFACTURING	10 000 - 20 000 m^2	100 - 500
12	NO	YES	OTHER	200 - 500 m^2	15 - 50
13	YES	YES	MANUFACTURING	10 000 - 20 000 m^2	50 - 100
14	YES	YES	MANUFACTURING	1 000 - 5 000 m^2	15 - 50
15	YES	NO	MANUFACTURING	1 000 - 5 000 m^2	100 - 500
16	YES	YES	WAREHOUSING, MANUFACTURING & DISTRIBUTION	≥ 20 000 m^2	100 - 500
17	NO	NO	WAREHOUSING & OTHER	200 - 500 m^2	15 - 50
18	YES	YES	WAREHOUSING & DISTRIBUTION	≥ 20 000 m^2	100 - 500
19	YES	NO	MANUFACTURING	≥ 20 000 m^2	100 - 500
20	YES	YES	DISTRIBUTION	1 000 - 5 000 m^2	15 - 50
21	NO	NO	MANUFACTURING	≥ 20 000 m^2	500 - 1 000

Industries establishing in Perseverance have previously not been incentivized to make allowance and/or budget for, any interruption to their industrial activities. The nature of many of the industries that subsequently invested in Perseverance, were industries, that are dependent on uninterrupted electricity, to manufacture their products cost effectively, and without harm to their employees or the environment.

On the 9th of May 2021, there was a fire in the Perseverance electrical substation, caused by alleged vandalism and theft, the fire damaged one of two functional transformers (there should be 3 functioning transformers feeding Perseverance and surrounding suburbs), which was in use at the substation and the available electrical load for the area was reduced to such an extent that there was not enough electricity available for all the industrial companies in Perseverance to run their operations at the same time. Monday the 10th of May 2021, all the large electricity users in Perseverance had a meeting and a load reduction strategy was planned to protect the remaining transformer from overloading, until such time as a second transformer could be re-commissioned. The plant engineers met every morning for 2 weeks to discuss load availability and rearrange production times to ensure that there was enough electrical load available to keep the lights on for everyone.

The concept of "WTP" was illustrated in this case, as from the incident in May 2021 up to the end of

October 2021, members of the Perseverance Industrialists has paid an amount in excess of

R 327 514.55 to secure the electrical substation, while the NMBM followed their procurement procedures to acquire new security guards and monitoring at the electrical substation. Beenstock & Goldin (1997) discussed how much businesses are WTP to avoid an interruption, as a method of costing reliable electricity supply and this is illustrated in this case, where one of the enterprises in Perseverance has contributed almost R 100 000.00 to the security cost at the sub-station between May 2021 and October 2021, to ensure that the safekeeping of the electrical supply.

4.3 Quantitative Data Analysis

A survey questionnaire was emailed, and a hard copy of the survey questionnaire was hand delivered to enterprises in Perseverance to encourage participants to complete the survey questionnaire. The survey questionnaire was distributed to 46 enterprises in Perseverance and 20 enterprises completed the survey. Hence a 43.5% response rate. The information for the participant who did not complete a survey but did consent to an interview, was captured from the interview transcript and meeting notes. Data from 21 participants in Perseverance Industrial Township was utilised in the analysis, hence a 45.7% response rate. An adapted survey questionnaire was sent to approximately 112 enterprises in the remainder of NMB and surrounding areas, 14 responses were received from this group. The survey directed to the remainder of NMB and surrounding area, was adapted to include the question: Are your enterprise affected by load-shedding during? Stages 1-4 and/or Stages 5-8, as not all industrial / commercial areas in NMB were exempted from electrical load-shedding in Stages 1-4, illustrating the iterative aspect of the research.

As the research is based on Perseverance and just under half of the enterprises situated in Perseverance completed a survey, the sample was deemed to be satisfactory, the 14 respondents from the remainder of NMB served as a comparison in the study between areas exempted from load-shedding and those that were load-shedded to expand on and enhance the research data collected.

4.3.1 Question 1: Does your Enterprise make use of a Facility Manager

Fourteen respondents in Perseverance responded that they make use of a facility manager. Three enterprises responded that they have a plant manager, engineering manager and a company manager who performs the duties of the facility manager.

4.3.2 Question 2: Would you provide me the details of Facility Manager, in order for me to interview them for my research?

Fifteen respondents supplied contact details of their Facility Managers or if they did not have a Facility Manager the details of their Plant Engineers, Plant Managers or Managing directors who performs the duties of a Facility Manager at their enterprise. According to Christensen *et al*. (2018) it's important to include both tenants, owner occupiers and property managers when you are questioning the strategies employed by facility managers with regards to investing in own generation. Seven respondents from the remainder of NMB provided contact details of Facility Managers. Eleven of the respondents in Perseverance consented to an interview, but none of the respondents in the remainder of NMB consented to an interview.

4.3.3 Question 3: Are your Facility Manager aware of the potential electrical load-shedding?

Twenty out of twenty-one respondents in Perseverance were aware of the potential electrical load-shedding in Stages 5-8, compared to eleven out of fourteen respondents in the remainder of NMB.

4.3.4 Question 4: Does the potential electrical load-shedding affect your enterprise?

All the respondents in Perseverance reported that the potential electrical load-shedding will affect their enterprise, compared to 85% of the participants in the remainder of NMB. *Figure 6* show the responses from participants in the remainder of the NMB, to the additional question aimed at them: Is your enterprise affected by load-shedding during? Stages 1-4 and/or Stages 5-8. Six of the respondents was already affected by load-shedding in Stages 1-4, while seven will be affected by load-shedding in Stage 5-8.

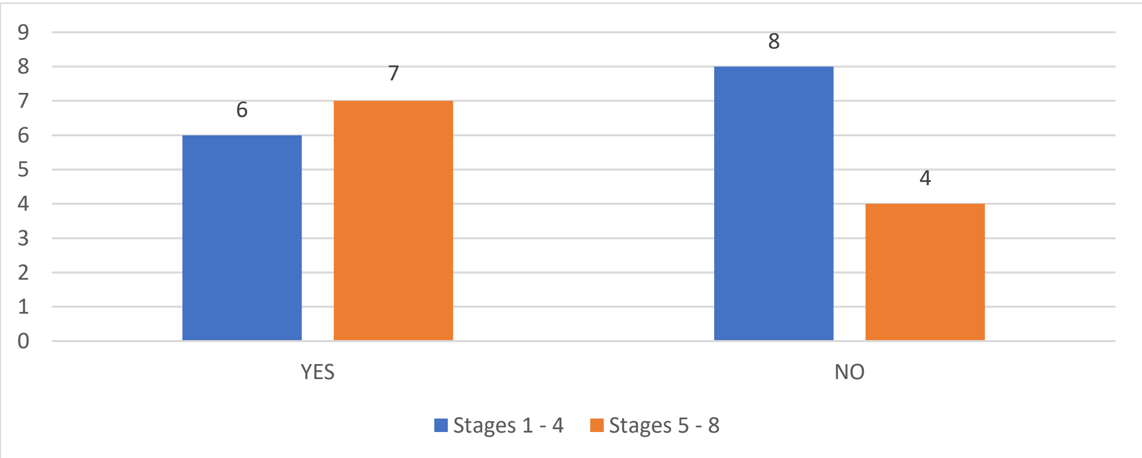

Figure 6: Participants in remainder of NMB affected by electrical load-shedding.

4.3.5 Question 5: Will the potential electrical load-shedding impact the Facility Manager’s operational decisions?

The number of Facility Manager’s whose operational decisions will be impacted is illustrated in *Figure 7*. Twenty (95%) of participants in Perseverance responded that their Facility Manager’s operational decisions will be impacted, one participant responded with not applicable (N/A) in contrast eleven (79%) of participants in the remainder of NMB, will be impacted, two (14%) responded that they will not be impacted, while one participant responded N/A.

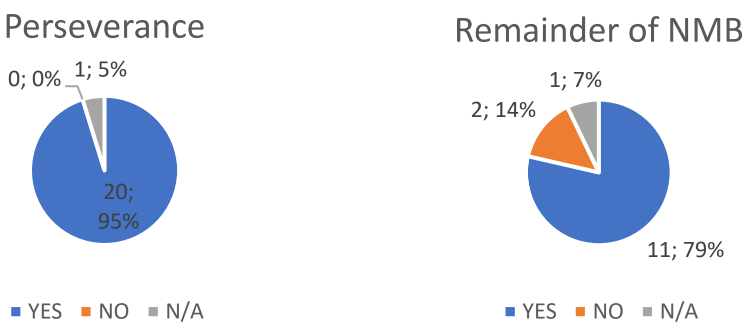

Figure 7: Participants whose Facility Managers' operational decisions will be impacted.

4.3.6 Question 6: Will the potential electrical load-shedding impact the Facility Manager’s strategic decisions?

The number of Facility Manager’s whose strategic decisions will be impacted is illustrated in *Figure 8*. Seventeen (81%) of participants in Perseverance responded that their Facility Manager’s strategic decisions will be impacted, one participant responded with N/A, one participant did not answer and two responded that it will not be impacted, correspondingly eleven (79%) of participants in the remainder of NMB, will be impacted, two responded that they will not be impacted, while one participant responded N/A.

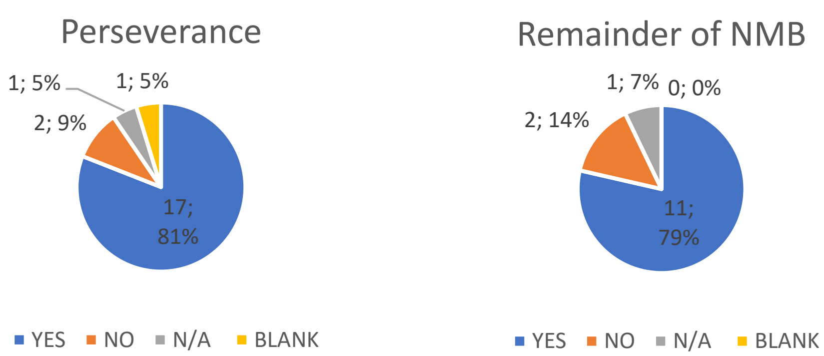

Figure 8: Participants whose Facility Managers' strategic decisions will be impacted.

4.3.7 Question 7: Does this enterprise require uninterupted electrical supply to run industrial processes?

Participants requiring uninterrupted electrical supply to run their industrial processes is illustrated in *Figure 9*. Seventeen (81%) of participants in Perseverance responded that they require uninterrupted electrical supply to run their industrial processes, four participants responded that they do not require uninterrupted electrical supply, whereas ten (72%) of participants in the remainder of NMB, require uninterrupted power supply, three responded that they do not need uninterrupted power supply, while one participant responded N/A.

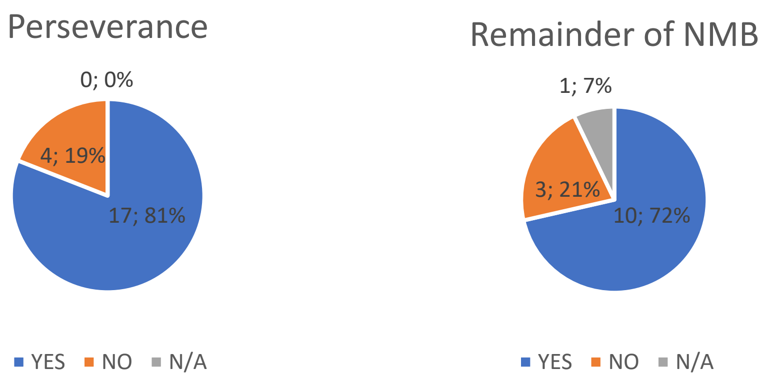

Figure 9: Participants whose industrial processes require uninterrupted electrical supply.

4.3.8 Question 8: Does this facility have back-up electricity generation?

Participants with back-up generation facilities is illustrated in *Figure 10*. Eight (40%) of participants in Perseverance responded that they have back-up electrical generation available, twelve (60%) of participants responded that they do not have back-up generation available, correspondingly, six (43%) of participants in the remainder of NMB, has back-up generation available, and eight (57%) responded that they do not have back-up generation.

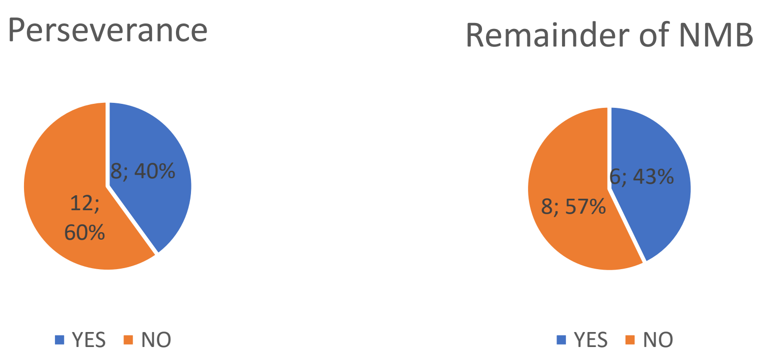

Figure 10: Participants with back-up or own-generation capacity.

4.3.9 Question 9: Does this facility manage their own back-up electricity generation or is it part of a service agreement?

Whether the back-up generation is own-managed, or part of a service agreement (S/A) is illustrated in *Figure 11*. Seven (33%) of total participants in Perseverance responded that their back-up electrical generation is own-managed, while three (14%) of total participants responded that their back-up generation is part of a S/A, whereas ten (71%) of participants in the remainder of NMB, back-up generation is own-managed, and four (29%) responded N/A.

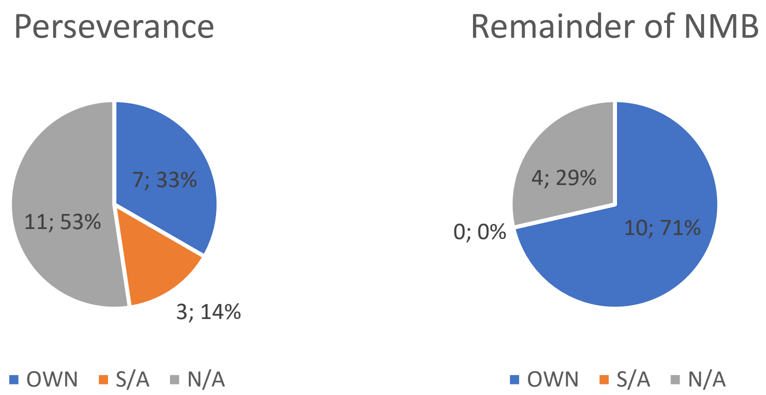

Figure 11: Management of back-up and own-generation capacity.

4.3.10 Question 10: Is it possible to own-generate enough electricity to run industrial processes at this facility?

Whether it's possible to own- generate enough electricity to run industrial processes is illustrated in *Figure 12*. Sixteen (76%) of participants in Perseverance responded that it's not possible to generate enough electricity to run industrial processes, while four (19%) of participants responded that it is possible and one participant did not respond, in contrast seven (50%) of participants in the remainder of NMB, can own-generate enough electricity to run their industrial processes, and six (43%) responded that it's not possible and one responded that it is N/A.

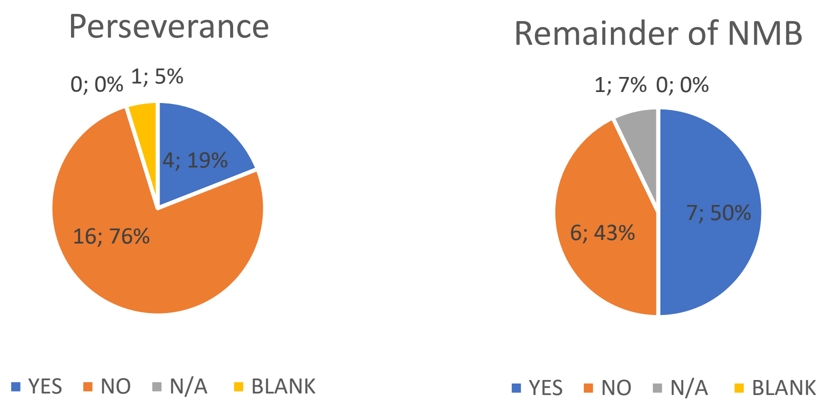

Figure 12: Is it possible to own-generate enough electricity to run industrial processes?

4.3.11 Question 11: Is it possible to own-generate enough electricity to run administration and security and/or safety functions at this facility?

Whether it's possible to own- generate enough electricity to run administration and security and/or safety function is illustrated in *Figure 13*. Sixteen (76%) of participants in Perseverance responded that it's possible to generate enough electricity to run administration and security and/or safety function, while four (19%) of participants responded that it's not possible and one participant did not respond, in contrast 14 (100%) of participants in the remainder of NMB, can own-generate enough electricity to run their administration and security and/or safety functions.

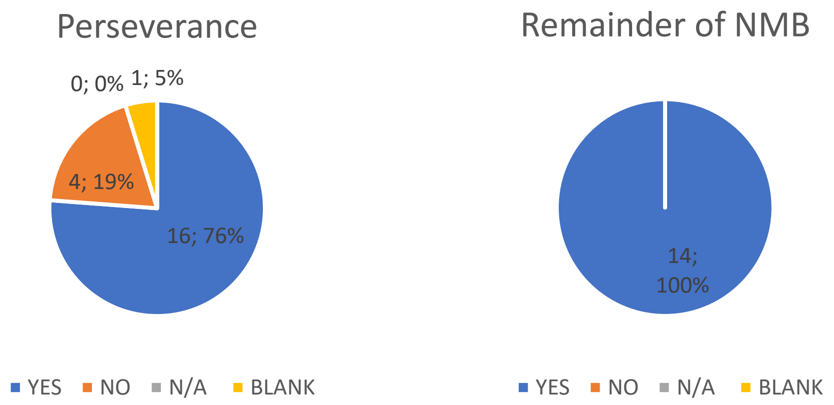

Figure 13: Is it possible to own-generate enough electricity to run administration and security and/or safety functions?

4.3.12 Question 12: Will this facility consider installation of back-up power generation?

Whether facilities will consider installation of back-up power generation is illustrated in *Figure 14.* Fourteen (67%) of participants in Perseverance responded that they would consider installation of back-up power generation, while 6 (19%) of participants responded no and one participant did not respond, correspondingly 9 (64%) of participants in the remainder of NMB, will consider installation of back-up power generation, while 5 (36%) responded no.

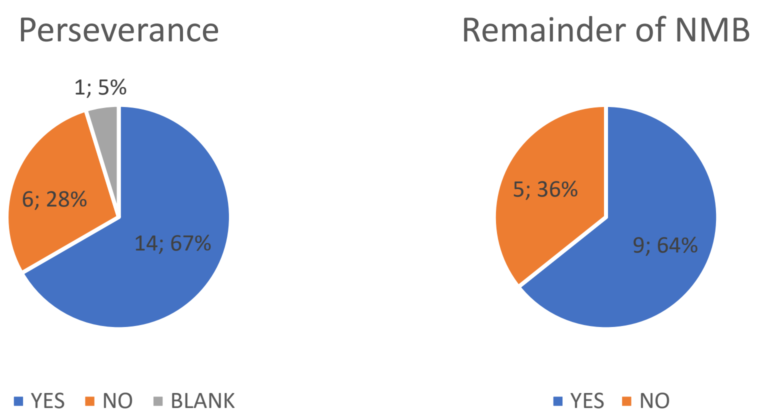

Figure 14: Participants who will consider installation of back-up power generation.

4.3.13 Question 13: Will this enterprise consider downscaling, closing, or relocating if electrical load-shedding should become a reality?

Whether facilities will consider downscaling, closing, or relocating if electrical load-shedding should become a reality is illustrated in *Figure 15*. Ten (48%) of participants in Perseverance responded that they would consider downscaling, closing, or relocating if electrical load-shedding should become a reality, while 8 (38%) of participants responded no and three (14%) participants did not respond, in contrast 4 (29%) of participants in the remainder of NMB, will consider downscaling, closing, or relocating if electrical load-shedding should become a reality, while 10 (71%) responded no.

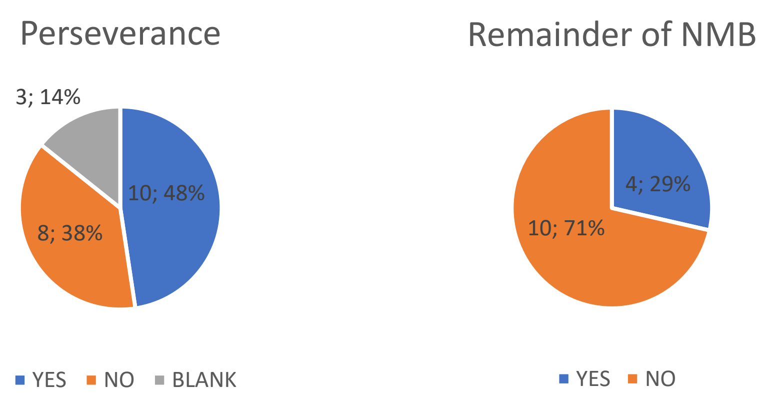

Figure 15: Participants who will consider downscaling, closing, or relocating if electrical load-shedding should become a reality.

4.3.14 Question 14: Which area is this facility based in, in Nelson Mandela Bay?

Figure 16 illustrates where the participants in the research study are based in. Twenty-one participants are based in Perseverance and fourteen participants is based in the remainder of NMB and surrounds.

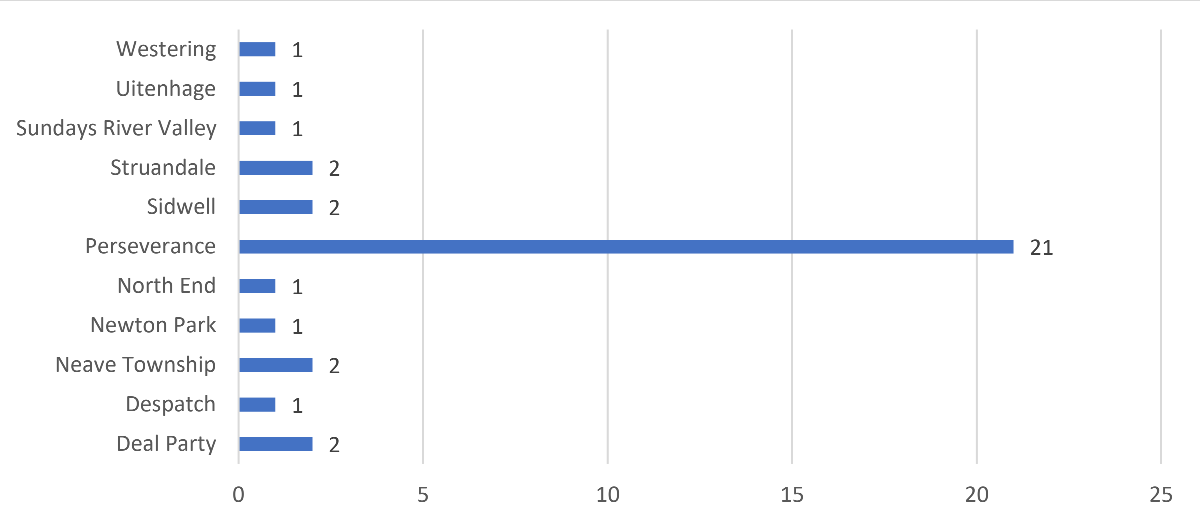

Figure 16: Areas that participants is based in.

4.3.15 Question 15: Please select the category which best describes the type of the facility? Warehousing, Manufacturing, Distribution or Other.

Figure 17 illustrates in which categories participants fall under. Under other, the following categories were specified: Fuel and Retail; Logistics, Refining of Metals, Electrical Contracting, Mechanical Workshop and Service Based. Manufacturing is the predominant category in participants in Perseverance.

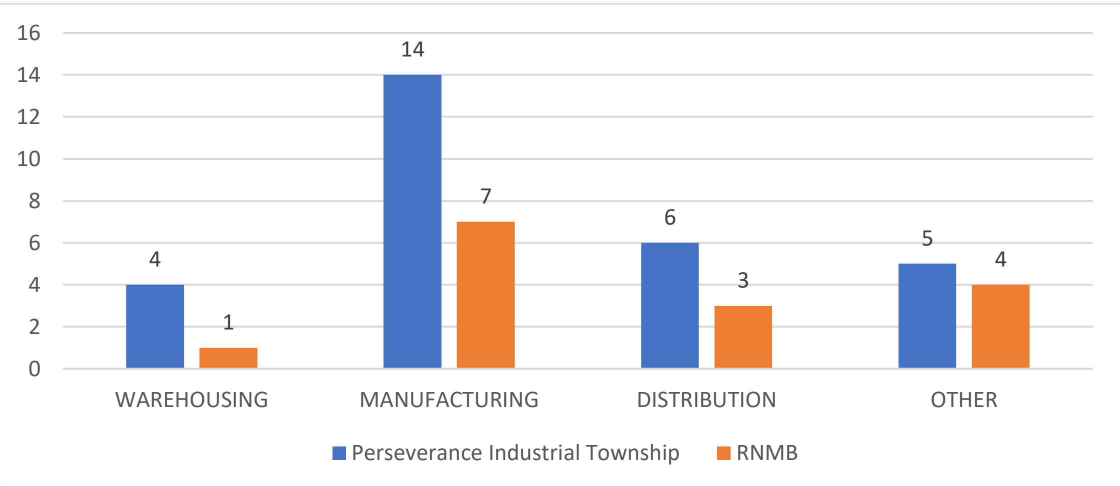

Figure 17: Categories represented by participants.

4.3.16 Question 16: To contextualise your answers, please indicate the size of the facility?

Figure 18 illustrates the sizes of facilities of participants. The majority of facilities in Perseverance is greater than 20 000m², whereas the majority of facilities of participants in the remainder of NMB is between 200 and 500m².

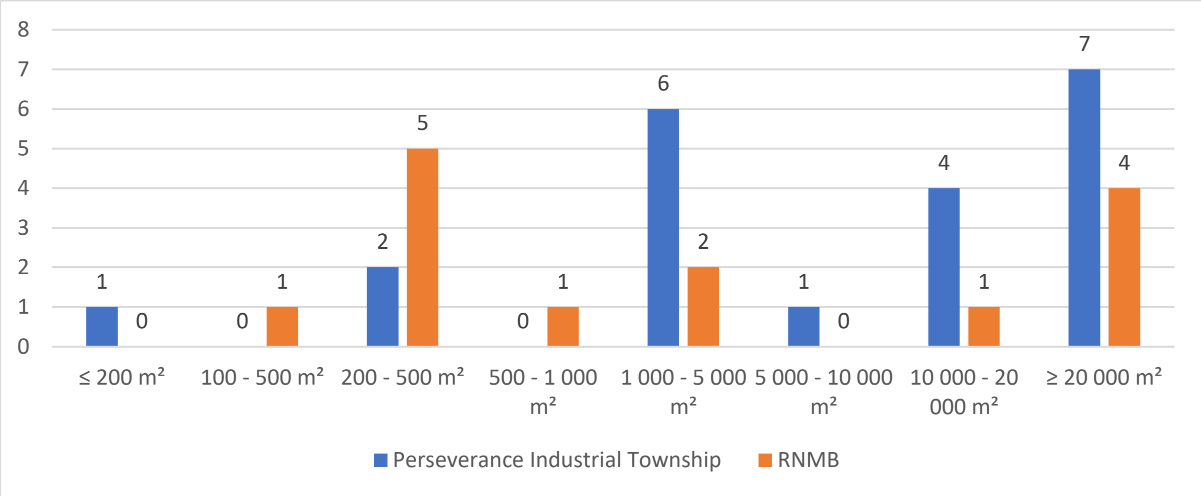

Figure 18: Average size of participating enterprises.

4.3.17 Question 17: How many full-time employees work at this facility?

Figure 19 illustrates the average number of employees of participants. The majority of participants in Perseverance employs between 100 and 500 employees, in contrast the majority of participants in the remainder of NMB employs less than 15 employees, but two participants employ more than 1000 employees, while none of the participants in Perseverance employs more than 1000 employees.

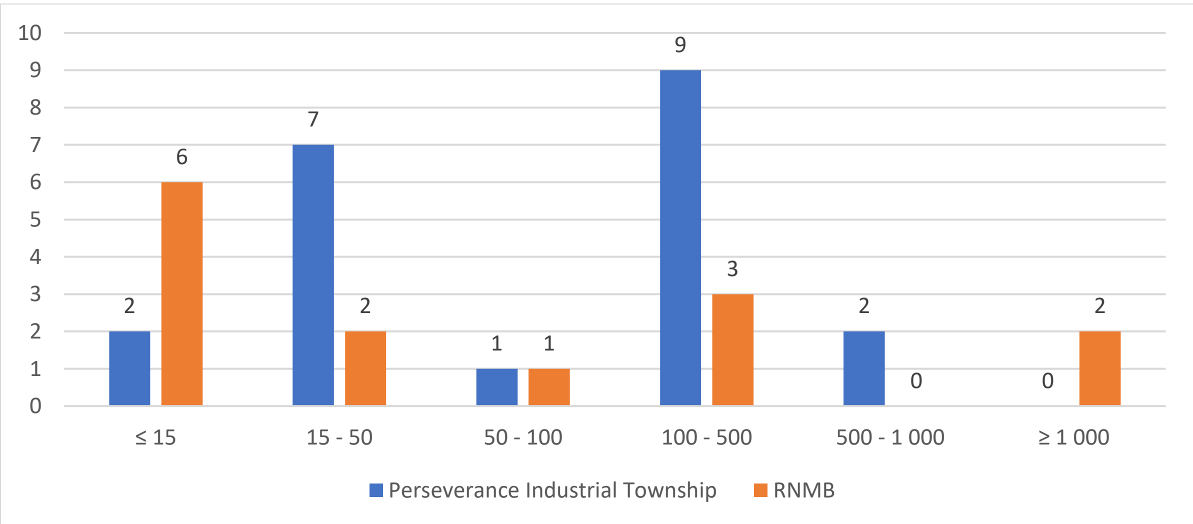

Figure 19: Average number of employees in participating enterprises.

4.3.18 Summary of quantitative findings

54% of respondents in Perseverance responded that they make use of a Facility Manager. Three enterprises responded that they have a Plant Manager, Engineering Manager and a Company Manager who performs the duties as their Facility Manager.

95% of respondents in Perseverance were aware of the potential electrical load-shedding in Stages 5-8, compared to 79% of respondents in the remainder of NMB.

100% of the respondents in Perseverance reported that the potential electrical load-shedding will affect their enterprise, compared to 85% of the participant in the remainder of NMB. 43% of the respondents was already affected by load-shedding in Stages 1-4, while 50% will be affected by load-shedding in Stage 5-8.

95% of participants in Perseverance responded that their Facility Manager's operational decisions will be impacted, one participant responded with N/A, in contrast 79% of participants in the remainder of NMB, will be impacted, 14% responded that they will not be impacted, while one participant responded N/A.

81% of participants in Perseverance responded that their Facility Manager's strategic decisions will be impacted, one participant responded with N/A, one participant did not answer and two responded that it will not be impacted, correspondingly 79% of participants in the remainder of NMB, will be impacted, 14% responded that they will not be impacted, while one participant responded N/A.

81% of participants in Perseverance responded that they require uninterrupted electrical supply to run their industrial processes, 19% of participants responded that they do not require uninterrupted electrical supply, whereas 72% of participants in the remainder of NMB, require uninterrupted power supply, 21% responded that they do not need uninterrupted power supply, while one participant responded N/A.

40% of participants in Perseverance responded that they have back-up electrical generation available, 60% of participants responded that they do not have back-up generation available, correspondingly, 43% of participants in the remainder of NMB, has back-up generation available, and 57% responded that they do not have back-up generation.

33% of participants in Perseverance responded that their back-up electrical generation is own-managed, while 14% of participants responded that their back-up generation is part of a S/A, whereas 71% of participants in the remainder of NMB, back-up generation is own-managed, and 29% responded N/A.

76% of participants in Perseverance responded that it's not possible to generate enough electricity to run industrial processes, while 19% of participants responded that it is possible and one participant did not respond, in contrast 50% of participants in the remainder of NMB, can own-generate enough electricity to run their industrial processes, and 43% responded that it's not possible and one responded that it is N/A.

76% of participants in Perseverance responded that it's possible to generate enough electricity to run administration and security and/or safety function, while 19% of participants responded that it's not possible and one participant did not respond, in contrast 100% of participants in the remainder of NMB, can own-generate enough electricity to run their administration and security and/or safety functions.

67% of participants in Perseverance responded that they would consider installation of back-up power generation, while 19% of participants responded no and one participant did not respond, correspondingly 64% of participants in the remainder of NMB, will consider installation of back-up power generation, while 36% responded no.

48% of participants in Perseverance responded that they would consider downscaling, closing, or relocating if electrical load-shedding should become a reality, while 38% of participants responded no and 14% of participants did not respond, in contrast 29% of participants in the remainder of NMB, will consider downscaling, closing, or relocating if electrical load-shedding should become a reality, while 71% responded no.

Manufacturing is the predominant category in participants in Perseverance. Under other, the following categories was specified: Fuel and Retail; Logistics, Refining of Metals, Electrical Contracting, Mechanical Workshop and Service Based. The majority of facilities in Perseverance is greater than 20 000m^2, whereas the majority of facilities of participants in the remainder of NMB is between 200 and 500m^2.

The majority of participants in Perseverance employs between 100 and 500 employees, in contrast the majority of participants in the remainder of NMB employs less than 15 employees, but two participants employ more than 1000 employees, while none of the participants in Perseverance employs more than 1000 employees.

4.4 Qualitative Analysis

Data was collected through face-face semi structured interviews with 11 participants from Perseverance. A list of 12 questions listed in the interview guide formed the guideline for the interviews. 10 of the 11 participants completed a survey questionnaire as well, and the answers to questions 10 to 12 was picked up from the completed survey questionnaires. Due to Covid-19 protocols at companies, face-to-face interviews was problematic and difficult to organise, notwithstanding during the interviews, all Covid-19 protocols was observed.

After 10 interviews, saturation was achieved, no new information was observed during the 11th interview. All interviews were recorded and transcribed for further analysis. Transcriptions of the interviews were analysed, initially through inductive coding method, as the files was analysed and coded, the emerging themes was merged. Next the nodes were arranged in node hierarchies and compared to emerging themes in the literature review, after which some nodes were created utilising deductive coding (La Trobe University, n.d.). The final analysis of the interviews resulted in three emerging themes: Facility Management reactions & decisions; Implications of potential electrical load-shedding; and Mitigation of potential electrical load-shedding. See Appendix H: Tree node structure – Perseverance Industrial Township study.

4.4.1 Emerging theme 1: Facility Management Reactions & Decisions

4.4.1.1 Reactions

When asked “What was your reaction as a facility manager to the announcement of the new load-shedding schedules?”, the following descriptive words and phrases was expressed by participants: shock, shocked, ball changer, concern, concerning, disapointed, disaster, disruptive, fairness, havoc, scary, severe, spanner in the works, surprised and unbudgeted. Shock and concern has the highest frequency of use, while only one participant expressed that its fairness to the rest of the city, for the industrial areas to be included into the load-shedding as well:

> *I think in the first part, Ehm…. disappointed. For the fact that eh obviously in each industrial area, each industry in the area is quite different in the way they actually operate, and why I am saying that is, for instance, if our plant is load-shed for I min, just for 1 min, we will lose 10hrs of production time. So, for us it’s actually quite*

severe if we are actually going to have load-shedding but I must reiterate; the Business Chamber's involvement with the municipality's involvement, its's actually extremely positives, in that ehm… certain undertakings have been made with regards to load-shedding at which stage the industry will be load-shedding …. So (Interview 1).

4.4.1.2 Operational Decisions

When interviewees were asked what impact proposed electrical load-shedding will have on their operational decisions, the following concepts was revealed: load reduction, resource management, alternative electricity sources, production shifting, failed processes, and split processes between sites.

Load reduction was specified in five of the interviews, during interview 1, the interviewee stated that if the electrical load-shedding should move from Stage 4 to Stage 5, they can prioritise their plant and shed approximately 50% of their load, by shutting down critical loads like cold rooms and ammonia cooling to keep the main lines in production operational. During interview 2 the interviewee stated that they can reduce their production, but that it can result in missed shipments, as they do not have other sources of electricity to continue with their production if electrical load-shedding should occur. Interviewee 5 stated that they would have to prioritise available services to clients, in order to reduce their load. Interviewee 5 stated that their alternative sources of electricity is for cost saving and to reduce their electricity load. Interviewee 12 stated that their biggest request to the municipality was not to load-shed Perseverance, but to give the industrialists notice to reduce their own load to an agreed upon minimum load, they stated that they could potentially reduce their load to 25%, but that it's not possible to reduce to zero:

And I think one if the big request we had, also to the municipality that at that point in time is, that in the case of ……., you can't switch us off. We have to reduce the load ourselves and we need to agree on what is that minimum load. Ehm, so I think there was scenarios done that you know in the case we could reduce by75%, 50% and 25% but technically we could not reduce to zero, as such (Interview 10).

Resource management was implied in five interviews. Interviewee 4 stated that the logistics of getting staff to work and complete the work during periods when electricity is available would be massive, with possible overtime to be considered as well. Interviewee 5 stated that planning becomes an issue when load-shedding have to be considered. Interviewee 8 commented that the load-shedding schedules would have to be followed exactly in order for them plan shut-down protocols for the machinery and that it will be difficult managing shut-down and start-up protocols during periods of load-shedding. Interviewee 9 reported that they will have downtime as a result of load-shedding. Interviewee 11 reported difficulty in planning around load-shedding:

> *And now what do you do with those operators when the plant is standing, you can't send them home for 2 to 3 hours (Interview 8).*

Alternative electricity sources were mentioned in three interviews, Interviewee 5 stated that they would not be able to find a generator that can run their whole site, in order to continue to provide a service to their clients. Interviewee 9 responded that as they manufacture generators, that they have generators available, and Interviewee 10 stated that they are converting, where possible, the production processes to gas.

Production shifting were mentioned in three interviews, Interviewee 3 stated that the company would have to be run production according to the load-shedding schedules. Interviewee 4 also stated that work hours will have to be scheduled in-between load-shedding periods. Interviewee 10 stated that they had meetings with shop stewards and unions to discuss the legalities of whether the load-shedding periods will be unpaid or not and advance notice to staff that there will be periods of no work:

> *Well, what we had to do was look at what load-shedding schedules would be and then obviously drive the company around those times by shifting the timing of production to suite the load-shedding, so what we do, we'll just spread our load over times that power would be available (Interview 3).*

Failed processes were mentioned by Interviewee 6, who expressed that it's not possible to stop or pause a process in the middle, as it will result in a failed product, that would need reprocessing, which would ultimately increase costs:

> *As mentioned, it is pretty difficult to stop the process in the middle to say you going to pause it for 2 hrs or 3 hrs and in most cases, this will result in a failed product that you going to have to reprocess. So operationally, this eh…is very difficult; it's only going to increase your cost because you going to have to reprocess that (Interview 6).*

Split operations were mentioned by Interviewee 7 who is able to split their operations over two sites in different load-shedding areas, they would transfer the work between the two sites, depending on which one is load-shedded at the moment:

> *We actually split our operational environments to exist between the two sites. The one in greater Perseverance, where we generally did not have load-shedding until you know, the municipality, you know in December 2019 came to a different conclusion. And the second site that we have is also ehm….it falls within the Despatch eh…zone, so there was periodic, eh…load-shedding and what that meant is we would then, transfer work between the two eh…you know, places, so that we could where we had power, basically we would move the work for that purpose (Interview 7).*

4.4.1.3 Strategic Decisions

When interviewees were asked what impact proposed electrical load-shedding will have on their strategic decisions, the following concepts was revealed: back-up electrical supply, alternative energy sources, resource management, expansion projects, location, and supply chain.

Back-up electrical supply were mentioned in nine interviews, Interviewee 1 stated that back-up generation was on the program in two years' time, as in terms of return of investments its quite expensive to install compared to the use of it. Interviewee 2 only had a small generator at the moment, so will have to consider increasing the generator size, consider other energy options for air conditioners and similar appliances, as well as the installation of ripple relays. Interviewee 3 is also looking at alternative sources of power to run various sections of the plant individually instead of running everything from one source. Interviewee 4 is only getting quotes for back-up generators, but at this stage it's not on the table, as there has not been any actual load-shedding in Perseverance. Interviewee 5 will consider back-up generation if load-shedding actually becomes a reality. Interviewee 8 will only consider installation of back-up generation for emergency and basic administration functions. Interviewee 9 will also only consider back-up generation if it becomes a reality as investing in generators will be a massive capital expenditure, and it will only be considered for administration and not for industrial processes. Interviewee 10 has considered building their own power station, which will take approximately 20 years to pay back. According to Interviewee 11, strategic decisions involve setting up a back-up generation facility to ensure that their operations run without interruption:

At some point if it, if we were running and the load-shedding becomes really bad, then we would have to, yes, but I mean to...to put up a generator just to catch the load-shedding of two hours, every now and then it's a massive capital to invest ehm, we more than likely won't back up the ehm for the process, but for the offices, we definitely will keep them running (Interview 9).

Alternative energy sources were mentioned in three interviews as part of strategic decisions. Interviewee 6 already have their own solar plant, which is grid-tied and thus does not serve as back-up generation, but rather to lower their electricity usage and costs. They are considering options to use this solar plant to take them of the municipality electrical grid. Interviewee 9 has small generator that runs their offices at the moment and have not considered anything more than this for the moment. Interviewee 10 has moved sections of their production on to gas and is considering options and feasibility of converting their largest user of electricity, their heat treatment plant to an alternative source as well:

So, for long term, I mean what we look at, should we continue receiving electricity from the municipality? Which then eh…we have our own solar plant, but which is currently connected to the grid, so we will be affected irrespectively (Interview 6).

Resource management were mentioned in three interviews. Interviewee 4 are considering alterations to operating hours to coincide with the load-shedding schedules. Interviewee 5 stated that management of resources to run the site will become very difficult, should load-shedding go ahead. Interviewee 8 will have to plan their start-up and shut-down processes of their machinery to accurately coincide with load-shedding schedules, which would need to be followed precisely as not to stop processes in the middle of a run.

Expansion projects was mentioned in one interview. Interviewee 1 stated that they are going to continue with their expansion projects as discussions between the NMBBC and the NMBM has been positive in the handling of the load-shedding matter:

Er…. I think the relationship between the Municipality and the Business Chamber ehm…. as actually been taken by the company is extremely positive, to such an affect that ehm…… we would still continue with the expansion program. We are due to spend approximately R 100, 000,000. 00 in the next two years on this site, ehm... and our executives or EXCO, was with the feedback of the positive handling *of the load-shedding by, by all involved; has agreed that we would continue with that (Interview 1).*

Location was mentioned in one interview. Interviewee 7 stated that they are in the process of reviewing lease agreements and alternative sites, as they receive orders from clients that assume that they will be exempt from load-shedding and able to supply as per agreements:

Well! As a business, we were forced now, we were currently forced into reviewing leasing agreement that we have, reviewing the site that we are going to be placed at, because we have customers who are intent on placing significant amount of work with us, and by implication or the assumption is that we are going to have uninterrupted power supply (Interview 7).

Supply chain was mentioned in one interview. Interviewee 10 stated that they are a strategic partner in the automobile industry and if they are load-shedded, it will impact the remainder of the supply chain as they supply four of the OEMs in the automotive industry.

4.4.2 Emerging theme 2: Implications of Potential Electrical Load-shedding

4.4.2.1 Cost of Proposed Electrical Load-shedding

Nine interviewees discussed the implication of potential electrical load-shedding and whether it would be feasible to invest in back-up or own-generation capabilities.

Investment in own generation has to be compared with the cost of lost production – product and production hours as stated by Interviewee 1, who have installed a R4 million UPS system to protect them from power dips, as a millisecond loss in electricity could mean that they lose the whole plant and approximately 10 hours of production, this does not begin to address actual load-shedding, therefore they are investigating and motivating capital expenditure in own-generation in the next two years. Interviewee 2 will consider increasing their generator capacity and the installation of ripple relays. Interviewee 5 will consider costly generators to supplement their grid-tied solar installation and UPS's (limited to a couple of minutes of back-up) to possibly run whole site during load-shedding. They might consider smaller generators rather than expensive large capacity generators. Interviewee 6 stated that they currently have a 400 kW-h solar plant which gives them approximately one hour, they are considering increasing the capacity to 1 MWh, if they can get approval and including a battery back-up system. Interviewee 11 is investigating the feasibility of installation of own generation as a capex investment.

Four interviewees stated that its **unfeasible** to invest in own generation of electricity. Interviewee 1 stated that it's possible to generate your own electricity at between R6 to R8 million, but how often will they actually need it, and with the experience of no load-shedding in the past, it doesn't make sense. Interviewee 4 has also stated that it is not on the table with the current situation. Interviewee 7 responded that anything more than what they already have in place, will be too expensive. Interviewee 10 straight up said that it's not feasible, as it will take 20 years to recover costs:

> *Ja it's not feasible. I mean we actually have to build our own power station, which is something we have also looked at, but I mean the cost for that; the pay back is something like 20 years, no investor will do that (Interview 10).*

4.4.2.2 Uninterrupted Electrical Supply

Two interviewees stated that they do not need uninterrupted electrical supply. Interviewee 7 and 9 stated that they do not need 24/7 electrical supply to run their production facility. On the other hand, nine interviewees stated that they require uninterrupted power to run their industrial processes. Interviewee 1 stated that their production system is so sensitive, that it cannot handle a millisecond break in electrical supply, without suffering from a 10-hour loss in production, it is also impossible to own generate enough electricity to become self-sufficient, they have spent R4 million to protect them from power dips, but anything more than that is not possible. Interviewee 2 stated that their ovens cannot run without electricity and it's not possible to move them onto generators. Interviewee 3 stated that their process is uninterruptable, it would result in wasted product – loss of material and cleaning of machinery. Interviewee 4 stated that they require uninterrupted power most of the time, they can go without power for short periods. Interviewees 5, 6, 8 and 11 did not expand on their answers. Interviewee 11 stated that if their melting furnaces freeze up due to unsupplied electricity, that it could take months to get back in production. Any disruption in supply of electricity would create large additional costs to the products:

> *Ja, we don't have backup facilities, we actually cannot, we cannot be self-sufficient in electricity supply, although our back up facility entails to prevent us, or to protect us against power dips of a, normally these kinds of dips are approximately a second, but the facility that we have got can carry us for half an hour, and to prevent all of that (Interview 1).*

4.4.3 Emerging theme 3: Mitigation of Potential Electrical Load-shedding

4.4.3.1 Alternative Electricity Sources

Alternative electricity sources mentioned by enterprises consists of generators, solar systems and power grid-tied systems, server or UPS systems, own power stations and wind turbines.

Generators were mentioned in eight interviews, where it was stated that they either had generators, planned to acquire generators, or increase their existing generator capacity. Interviewee 1 stated that they are planning the installation of generators. Interviewee 2 stated that they have a small generator, which does not supply 100% of the facility. Interviewee 3 stated that they hire generators when needed at the moment, to run compressors and systems in the plant. Interviewee 5 stated that they might consider getting a generator to run their entire site, in order to serve clients during load-shedding, even though it would be costly. Interviewee 6 stated that all their administration and security is on essential power and powered with generators when required. Interviewee 8 stated that they will consider acquiring a generator to facilitate the whole plant or consider breaking it down to run critical machines on smaller generators. Interviewee 9 stated that they have a small generator that they use as a rental and connect it up when required to supply power to the offices only. Interviewee 10 stated that they do have some generators in place.

Solar systems and power grid-tied systems: Solar systems were mentioned in five interviews: Interviewee 1 stated that they are busy with a program to install solar systems. Interviewee 5 stated that they have a grid-tied solar system that is not capable of running the whole site, but which lowers their electricity consumption. Interviewee 6 stated that also have grid-tied solar system, but they will investigate the options of acquiring a three-hour battery back-up system to store solar energy for use during periods of unsupplied electricity. Interviewee 7 stated that they have grid-tied solar panels on their roof which reduce their electricity usage but does not serve as back-up generation. Interviewee 8 stated that they are looking into introducing solar system to run the administration and emergency requirements, but not the machines:

> *Ja, I think a way of answering that question is that we got solar, but ehm, it's…it's not a massive part of our…. like I mean, we couldn't use our solar power to run our whole site, it's more of electricity, another way of generating electricity to save on running cost (Interview 5).*

Server or UPS systems were mentioned in three interviews. Interviewee 1 stated that they have spent R4 million on an UPS system to protect the plant from power dips and that they are planning more server system installations. Interviewee 2 stated that they have UPSs for office equipment. Interviewee 5 stated that they have short term UPS systems in place. Interviewee 6 stated that they are considering online UPS to handle power dips only:

> *Yes, it's extremely sensitive to such an extent that we have put ehm! Approximately a R 4, 000,000.00 UPS system in to protect us, just from power dips, I'm not even talking about load-shedding because a millisecond power dip is enough for us to lose the whole plant and that will entail us to lose production of approximately 10hrs (Interview 1).*

Own power station was mentioned by Interviewee 10, who stated that they have considered to build their own power station, but that the payback period would be 20 years and it would not be feasible for investors:

> *Ja it's not feasible. I mean we actually have to build our own power station, which is something we have also looked at, but I mean the cost for that; the pay back is something like 20 years, no investor will do that (Interview 10).*

Wind turbines was also mentioned by Interviewee 10, who stated that they would need to have 8 or 9 wind turbines running continuously to feed their plant. They have considered wind turbines on farms in the Karoo, but the problem is that it would still have to be channelled through the municipal infrastructure, which negates the benefit of the wind turbines.

4.4.3.2 Own Generation Capacity

When asked if it's possible to own-generate enough electricity to run either **administration, health, and security functions** the interviewees answered as follows: Interviewee 1 said that it is possible and that they are considering server systems, solar systems, and generators to run these functions. Interviewee 2 stated that they do have UPSs for office equipment as well as a generator that can supply more. Interviewee 3 stated that it would be possible with renewables. Interviewee 4 stated it will be possible. Interviewee 5 stated that they will be able to get a small generator to run a couple of plug points. Interviewee 6 stated that their administration and security functions is on their essential power supplied by a generator. Interviewee 7 stated that it should be possible to run their servers which run the network for the machines from their solar installation, if required.

Interviewee 8 will consider installation of solar back-up to run the administration, health, and security functions. Interviewees 9 and 11 said yes and did not expand on their answers. Interviewee 10 stated yes, they have generators in place:

> *No, it will purely for your emergency stuff, just make sure that your PC's are running and your basic functions as a plant can take place (Interview 8).*

When asked if it's possible to own-generate enough electricity to run industrial processes, the interviewees answered as follows: Interviewee 1 stated that you obviously can, but as a huge cost of about 6 to 8 million rand. Interviewees 2 said no. Interviewee 3 stated that it could be possible with a generator. Interviewee 4 stated that it's not within their budget, so it would not be possible. Interviewee 5 stated that they would have to consider a generator which would be costly. Interviewee 6 stated that its possible if they increase the size of their solar system, but that it would be very expensive. Interviewee 7 stated that it highly unlikely. Interviewee 7 stated that they are tenants and would not be able to own generate enough electricity as it would be too costly. Interviewee 8 stated that with a big enough generator it would be possible, they might have to stagger production of critical products, if the generator is not big enough. Interviewee 9 said yes and did not expand on his answer. Interviewees 10 and 11 said no and did not expand on their answer.

4.5 Discussion of the findings in terms of the literature

With regards to the cost of proposed electrical load-shedding or periods of unsupplied electricity the literature backs the findings in this research. Cost is one of the main drivers for participants to consider in their operational and strategic decisions. Baarsma & Hop (2009) explained the mostly unrecoverable cost of unsupplied electricity to the economy and its ultimately felt at businesses and homes. The majority of interviewees spoke about the costs of loss of production and that they are busy investigating options and applying for capital expenditure for installation of various mitigating measures.

The literature indicated that costs of unsupplied electricity are higher when the disruption is unanticipated (Linares & Rey, 2013) and Interviewee 6 confirmed that it's not possible to stop their processes in the middle, as this will result in a failed process, which will ultimately increase the cost of production. Linares & Ray (2013) found that shorter periods of unsupplied electricity could result in higher costs in the industrial sector, compared to other sectors and the findings in the study confirm this, many of the participants in Perseverance spoke about the start-up and shutdown processes and short 4 hours load-shedding periods, multiple times per day as indicated in the load-shedding schedules posted on 11th of December 2019 (Appendix K), will be catastrophic. Interviewee 10 expressed shock at the 4-hour load-shedding time frames, as they have four industrial technological processes running in a continuous process, and any interruption in the process will be disastrous. Interviewee 10 also expressed concern regarding the supply chain management as they are a strategic partner in the automotive industry and as Linares & Rey (2013) pointed out production loss in industrial business can affect other sectors as well, as orders cannot be fulfilled.

Adenikinju (2003) found that most responses, regarded power and voltage fluctuations as a major obstacle to operations, correspondingly Interviewee 1 stated that they have spent R 4 million on a UPS system to protect their industrial process from power dips.

Grainger & Zhang (2019) found that in Pakistan, labour productivity is also a cost to be considered, during periods of expected or unexpected unsupplied electricity. Interview 4 stated that the logistics of getting staff at work and complete the work in between load-shedding periods would be massive. Interviewee 5 also indicated that planning becomes an issue. Interviewee 9 stated that there will be downtime during load-shedding periods and Interviewee 10 pointed out that they have already had meetings with shop stewards and unions to discuss the logistics around 4-hour load-shedding periods. Adenikinju (2003) found that majority of businesses in Nigeria, will demand that their employees work overtime, to make up for lost production during periods of unsupplied electricity, which was suggested by Interviewee 3, 4 and 10 who stated that they would have to shift production around periods of load-shedding.

Grainger & Zhang (2019) found that companies whose manufacturing processes are reliant on electricity, could switch to less electricity dependent, less technological advanced methods, which will also decrease long term yield and expansion. Interviewee 10 stated that they have started converting their processes from electricity driven, to gas.

Baarsma & Hop (2009) established that the value of supplied electricity is higher than the rate charged to the users, this was illustrated in May 2021 when enterprises in Perseverance paid for security guards and camara monitoring out of their own pockets, additionally to their normal municipal accounts to secure the supply of electricity to Perseverance and surrounding areas, the concept of what a company is "WTP" to avoid periods of unsupplied electricity was revealed in the case study of Perseverance (Beenstock & Goldin, 1997).

Pertz (1995) found that most industrial facilities are owner occupied, with major investment in plant and other improvements, and therefore relocating of facilities are not easily considered, only one interviewee stated that they are reviewing their lease agreements and alternate sites, although ten participants said that they would consider downscaling, closing, or relocating if electrical load-shedding should become a reality. Grainger & Zhang (2019) found that the number of electricity failures experienced by a company will directly influence the decision to invest into self-generation, which is illustrated by Interviewee 4, who stated that they are only getting quotes for generators at the moment, as there is no actual load-shedding at the moment, the same with Interviewee 5, who will also only consider back-up generation if load-shedding actually becomes a reality.

Baarsma & Hop (2009) established that both business and households prefer to receive advance notice of periods of unsupplied electricity, Interviewee 8 reiterated that load-shedding would have to be followed precisely according to the schedules, in order for them to plan their start-up and shut-down procedures.

Jethwa *et al.* (2010) found that for many industrial business, uninterrupted electricity is of paramount importance, as safety to employees can play as big a role, seventeen of participants in Perseverance indicated that they require uninterrupted electricity supply to run their industrial processes.

Adenikinju (2003) found that the literature debates various methods for industrial facilities to manage their electricity usage. Businesses, in response to unreliable electricity, can choose to relocate to an area with reliable electricity supply – one participant was actively reviewing lease agreements and location, factor substitution, own generation – was considered by fourteen participants, choice of business and reduction of output. Alternatively, when the business is not in the position to ratify any of these options, reducing the electricity load of industrial facilities are one of the first steps facility managers can take, which is supported by the number of participants who has grid-tied solar installation which as indicated in the literature will not only reduce the operating cost of the industrial facility, but also reduce the specifications of back-up or alternative electrical supply.

Jethwa *et al*. (2010) and Kucuk *et al*. (2018) discussed load-shedding schemes to protect the industrial facility from total loss of electricity and maintain critical loads in the facility, while switching of non-essential loads, this is also the case in Perseverance, as many high electricity users are planning around critical loads; and the NMBBC has launched a pilot program to run ripple control systems at two major manufacturing enterprises, which had a positive results in reducing load to the power grid, they are looking for 100 enterprises in NMB to voluntarily sign up for this project, as at January 2020, they had 30 companies on board.

In Italy, Meneghetti & Chinese (2002) investigated the idea of a district orientated facility management development, evolving facility management from the individual business's perspective, to an industrial district perspective, where through collaboration and sharing of resources, one business's waste can become another business's raw material; utilities like energy and waste treatment can be shared and collaboration between companies regarding emergency planning, training or sustainability planning can be envisioned. The idea is of an Eco Industrial Park where different types of industries can group together and work together to lower energy and other resource consumption (Meneghetti & Nardin, 2012). A group of Perseverance Industrialist with the assistance of the NMBBC is actively working on the possibility of creating a Perseverance Industrial Park, this was discussed with stakeholders at a meeting held on the 14th of October 2021 and is actively investigated and pursued in regular focus group meetings, as noted in *Table 1*.

Adenikinju (2003) found that in Nigeria, both businesses and households had to start generating their own electricity partially or even completely, this significantly raised the capital investment in manufacturing, in addition to the higher operational costs in running the production processes and facilities, which is supported by the action of participants in the Perseverance.

The findings in Perseverance largely agrees with the international and national literature with regards to cost of unsupplied or in this case the proposed electrical load-shedding in Perseverance as well as the mitigation methods considered in the Facility Manager's operational and strategic decisions.

4.6 Summary

All participants in Perseverance were aware of the potential electrical load-shedding and interviewees expressed shock and concern when asked what their reactions to the potential electrical load-shedding was and that they would all be affected by the load-shedding. In contrast, not all the respondents in the remainder of NMB responded that they are aware of/or affected by the potential load-shedding.

Majority of participants in Perseverance as well as the remainder of NMB, responded that their operational and strategic decisions will be impacted by the potential electrical load-shedding. The following chapter revisits the objectives, aim and research question that was discussed in Chapter 1 and concludes with the authors recommendations.

5. CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This research set out to determine the operational and strategic decisions made by facility managers, when faced with the prospect of electrical load-shedding, in areas previously exempted from electrical load-shedding. An overarching qualitative case study, with an embedded convergent parallel mixed method design, consisting of quantitative and qualitative data collection and analysis methods, was the approach undertaken by the researcher. Data collection methods included quantitative survey questionnaires, qualitative semi-structured interviews, archival material supplied by Perseverance Industrialists Forum, NMBBC, minutes of meetings, information available on public domain (social media) and direct observations by the researcher, as well as analysis of the literature and NMBM by-laws.

Using pictorial graphs and statistical tools available on Microsoft Excel and thematic analysis tools in NVivo 12 to analyse, interpret and present the findings of each data collection method, after which the overarching findings of the research were presented.

Data saturation was achieved during the qualitative research, with the 10th interview and the emerging themes was clear in the qualitative data collected.

The emerging themes assisted with meeting the objectives of the research and the objectives will be briefly discussed below.

5.2 Revisit research objectives

5.2.1 Objective 1

Establish the nature and extent of own generation of electricity in Perseverance and other industrial areas in Nelson Mandela Metro.

The extent of the own-generation electrical capacity was explored through quantitative survey questionnaires aimed at enterprises in Perseverance and in the remainder of NMB and surrounds and expanded on by qualitative semi-structured interviews with participants in Perseverance.

Objective one was achieved by analysing the survey questionnaires and interview transcriptions in Chapter 4 and summarised as follows: only 40% of participants in Perseverance responded in the survey questionnaire that they have back-up electrical generation available, correspondingly 43% of the remainder of NMB responded that they have back-up electrical generation available. Out of the participants in Perseverance with back-up generation capacity, 70% managed their own back-up generation 30% had a S/A while in the remainder of NMB, 71% responded that they managed their own, while 29% responded that it's N/A.

76% of participants in Perseverance responded that it's not possible to own generate enough electricity to run industrial processes or administration and security and/or safety functions; while 50% of the participants in the remainder of NMB responded that it is possible to generate enough electricity to run industrial processes and 100% responded that they can generate enough to run administration and security and/or safety functions. The interviews revealed that increasing of back-up generation has been explored by those that have capacity, and quotations and budgets are obtained by participants who do not have back-up electrical generation capacity.

5.2.2 Objective 2

Establish the capacity of industrial enterprises to invest in own generation of electricity.

The capacity of industrial enterprises to invest in own generation of electrical was explored through quantitative survey questionnaires aimed at enterprises in Perseverance and in the remainder of NMB and expanded on by qualitative semi-structured interviews with participants in Perseverance.

Objective two was achieved by analysing the survey questionnaires and interview transcriptions in Chapter 4 and summarised as follows: of the participants in Perseverance, 67% responded in the survey questionnaire that they will consider installation of back-up power generation, while 19% responded that they will not consider it. In the remainder of NMB, 64% responded that they will consider installation of back-up electrical generation, while 36% responded no.

During the interviews it was revealed that 8 of the 11 interviewees either had generators, planned to acquire generators, or increase their existing generator capacity. Grid-tied solar systems were also mentioned in the interviews by 5 interviewees, these systems were installed by the interviewees as a method of lowering their electricity usage and not as back-up generation, one interviewee did mention that they are investing back-up batteries to store solar energy.

Costs and feasibility of installation of back-up generation facilities were revealed as a barrier to investment in own generation of electricity during the interviews.

5.2.3 Objective 3

Establish what facility managers are planning to mitigate the effect of potential load-shedding.

In the literature review in Chapter 2, mitigating measures put in place by business was reviewed and key measures found was, retrofitting energy solutions and renovating existing industrial buildings with insulation, in order to reduce the electrical load, especially in the case of owner-occupied buildings, relocation to areas with reliable electricity, factor substitution, own generation, choice of business and reduction of output.

Objective three was achieved by analysing the interview transcriptions in Chapter 4, including participant observations, and summarised as follows: during the interviews with participants in Perseverance the following operational decisions was revealed: load reduction, resource management, alternative energy sources, production shifting, split processed between site and the possibility of failed processes to be considered. When asked about their strategic decisions the following concepts was revealed: back-up electricity supply, alternative energy sources, resource management, the feasibility of future expansion projects, location, and the effect on their supply chain. The extent of collaboration between enterprises in Perseverance, to avoid loss of electricity supply was not found in any of the literature reviewed.

5.2.4 Objective 4

Examine the attitude of municipal officials to the needs of industrial enterprises in Nelson Mandela Metro.

Due to Covid-19 and/or reluctance of NMB officials, it was not possible to meet Face-to-Face, or conduct electronic semi-structured interviews with Nelson Mandela Bay Municipal officials. Due to these constraints objective four was only partially achieved by reviewing the decisions made by NMBM, which was publicly made available on their website and social media posts. The City of Port Elizabeth Electricity supply by-law (1990) was reviewed as part of the literature review. According to the City of Port Elizabeth Electricity supply by-law (1990) the council shall not be held liable for any loss or damage suffered by the consumer because of the interruption of the supply of electricity (Clause 18) and that they can reduce the load on its electricity supply system, at times of peak load, or in an emergency, by discontinuing the supply of electricity without notice to the consumer (Clause 28).

Still, their historical actions in protecting industrial areas from load-shedding to protect jobs needs to be considered: NMBM made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted, that industrial areas should be included in the load-shedding (NMBM, 2019). However, it was only when Eskom implemented Stage 6 load-shedding for the first time on the 9th of December 2019, that NMBM, after initially keeping the load-shedding at Stage 4, posted on the 11th of December 2019 new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas, including Perseverance.

5.3 Revisit research aim and question

The aim of this research study is:

> *Determine how facility managers are reacting to potential load-shedding in previously uninterrupted industrial areas.*

During the qualitative semi-structured interviews, it was revealed that facility managers where mostly unprepared and shocked at the prospect of electrical load-shedding in Perseverance, and that their operation decisions and strategic decisions was impacted.

The overarching question that this research aimed to answer is:

> *What are facility managers putting in place to mitigate the effects of potential load-shedding on industrial operations?*

To answer the above research question, this research focused on Perseverance, an industrial suburb of Gqeberha (Port Elizabeth), in the district of NMB in the province of Eastern Cape, the remainder of NMB was included in the quantitative research to contextualise and support the information gathered in Perseverance. Two sub-questions were identified and included in the qualitative semi-structured interview, addressed to facility managers, to answer the research question:

1. What impact did this have on your operational decisions?

2. What impact did this have on your strategic decisions?

In terms of the above questions the following impacts was identified in the research.

Table 8: Identified impacts of potential electrical load-shedding on operational and strategic decisions.

Operational decisions	- Load reduction, prioritising of critical loads in production and administration. - Resource management, especially labour resources. - Alternative energy sources, mostly generators under operational decisions. - Production shifting, where the work schedules is adjusted according to load-shedding schedules, where unions need to be consulted, as work hours will be affected. - Failed processes are an operational concern during electrical load-shedding. - Split operations, where an enterprise has multiple facilities in different load-shedding areas they can shift production from one facility to the other.
Strategic decisions	- Back-up electricity supply, budgeting and planning for possible future capital investment into back-up electricity capacity. - Alternative energy sources, solar and gas installations to lower electricity consumption and potentially take some facilities of the municipal electrical grid. - Resource management, alterations to operating hours, including start-up and shutdown sequences. - Expansion projects, if enterprises expansion projects are still viable. - Location, reviewing of lease agreements and looking for alternative sites. - Supply chain, how major enterprises' production, or reduced production will impact the remainder of the supply chain.

5.4 Recommendations for future research areas

The literature revealed what facility managers around the world are doing to mitigate the effects of actual unsupplied electricity, focussing on operational versus strategical operational management decisions. On the other hand, this thesis explored the effect of potential electrical load-shedding on industrial areas, previously excluded from electrical load-shedding. The impacts and mitigation revealed in the thesis is very similar, to what was found in the literature review. This research revealed that many facility managers will only consider the installation of back-up generation, if and when actual load-shedding occurs, as its not feasible to spend money on something that has not happened yet.

The research revealed that municipalities should communicate with businesses and negotiate load-reduction strategies, rather than load-shedding of industrial areas. Transparency and collaboration would go a long way to mitigate job losses and possible business closures, and ultimate loss of revenue to the municipality.

In the literature, Meneghetti & Chinese (2002) investigated the idea of a district orientated facility management development, evolving facility management from the individual business's perspective, to an industrial district perspective, where through collaboration and sharing of resources, one business's waste can become another business's raw material; utilities like energy and waste treatment can be shared and collaboration between companies regarding emergency planning, training or sustainability planning can be envisioned (Meneghetti & Nardin, 2012). The idea is of an Eco Industrial Park where different types of industries can group together and work together to lower energy and other resources consumption (Meneghetti *et al*., 2012). Li *et al.* (2019) found that more research in understanding sustainability in FM, especially how to integrate sustainability in strategic and operational levels is needed. In Perseverance, concerned industrialists has created a focus group to investigate the creation of an Industrial Park, with multiple landowners. Future research into the process of creating sustainable industrial parks with multiple owners is recommended.

5.5 Conclusion

This research aimed to investigate of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings, with a case study focused on Perseverance Industrial Township, NMB, which was previously exempted from electrical load-shedding. An overarching qualitative case study with an embedded convergent parallel mixed method design, consisting of 20 quantitative survey questionnaires and 11 qualitative semi-structured interviews with facility managers, plant engineers and managing directors of enterprises in Perseverance. A further 14 quantitative survey questionnaires were received from enterprises in the remainder of NMB and surrounds. The findings revealed the shock and concern from facility managers to the threat of potential electrical load-shedding and revealed the operational and strategic decisions that was considered since the release of the new load-shedding schedules and their way forward to manage the electricity supply to Perseverance. It was also revealed that transparent communication needs to be initiated between industrialists and NMBM.

This research also addresses four of the seventeen goals set out in the SDGs by the United Nations in Agenda 2030, as discussed in their progress report dated the 23rd of July 2021: Goal (7) Ensure access to affordable, reliable, sustainable, and modern energy for all; Goal (8) Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all; Goal (9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; and Goal (12) Ensure sustainable consumption and production patterns (United Nations, 2021).

These goals were heavily impacted by COVID-19, during 2020 and has set back the goals and targets for 2030. To get back on track with the goals, governments, cities, business, and industries must take advantage of the recovery shown in 2021, to adopt low-carbon, resilient and inclusive development pathways that will reduce carbon emissions, conserve natural resources, and create better jobs (Economic and Social Council, 2021).

APPENDICES

Appendix A: Interview consent form

Dear Sir / Madame

I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay, as part of fulfilling the requirements for the award of the degree of MSc Property Studies at the Faculty of Engineering & the Built Environment, Department of Construction Economics and Management, University of Cape Town.

The research objectives will be achieved by adopting the following research method:

a) Survey questionnaire to be completed by selected industrial enterprises in Perseverance and other similarly affected industrial areas in Nelson Mandela Metro.

b) Face-to-Face and/or electronic semi structured interviews with selected industrial enterprises in Perseverance and other similarly affected industrial areas in Nelson Mandela Metro

I would like to invite you to participate in this research. I would like to discuss the effects of load-shedding on your strategic and operational facility management decisions. The interview should last about 30 minutes. Alternatively, an electronic questionnaire could be completed. Your participation is voluntary and there is no penalty for withdrawing from this research. In order to accurately capture the information during a face-to-face interview, I will be recording the interview.

All data will be kept 100% confidential and no mention will be made, of any company details in the research results.

Any concerns may be discussed with my supervisor or myself, as per below contact details.

Position:	Researcher	Supervisor
Name:	Anelle Bailey	Associate Professor Kathy Michell
Email:	anelle.bailey@sbtsa.co.za	kathy.michell@uct.ac.za
Contact Number:	082 490 9417	(+27) 021 650 3444

I agree to the interview being recorded in audio and/or video format.

Signature of participant: ____________________________

Date: ____________________________

Signature of researcher: ____________________________

Date: ____________________________

Appendix B: Survey questionnaire aimed at industrial and/or commercial facility management – Perseverance

Dear Sir / Madame

I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay, as part of fulfilling the requirements for the award of the degree of MSc Property Studies at the Faculty of Engineering & the Built Environment, Department of Construction Economics and Management, University of Cape Town

I would like to invite you to participate in this research. This questionnaire aims to explore the effects of load-shedding on your strategic and operational facility management decisions. The questionnaire should take about 10 minutes to complete. Please answer all questions truthfully and fully by ticking the applicable box or by writing your answer in the shaded space provided. Your participation is voluntary and there is no penalty for withdrawing from this research.

All data will be kept 100% confidential and no mention will be made, of any company details in the research results. Any concerns may be discussed with my supervisor or myself, as per below contact details.

Position:	Researcher	Supervisor
Name:	Anelle Bailey	Associate Professor Kathy Michell
Email:	anelle.bailey@sbtsa.co.za	kathy.michell@uct.ac.za
Contact Number:	(+27) 082 490 9417	(+27) 021 650 3444

Introduction: Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted that industrial areas should be included in the load-shedding.

On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time. Initially NMBM made it known that they have decided to keep the load-shedding at Stage 4.

On the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas.

Question 1: Does your Enterprise make use of a Facility Manager?

YES	
NO	

Question 2: Would you provide me the details of Facility Manager, in order for me to interview them for my research?

YES	
NO	

If yes, please provide name and contact details.

Facility Manager:	
Email Address:	
Contact Number:	

Question 3: Are your Facility Manager aware of the potential electrical load-shedding?

YES	
NO	

Question 4: Does the potential electrical load-shedding affect your enterprise?

YES	
NO	

Question 5: Will the potential electrical load-shedding impact the Facility Manager's operational decisions?

YES	☐
NO	☐

Question 6: Will the potential electrical load-shedding impact the Facility Manager's strategic decisions.

YES	☐
NO	☐

Question 7: Does this enterprise require uninterrupted electrical supply to run industrial processes?

YES	☐
NO	☐

Question 8: Does this facility have back-up electricity generation?

YES	☐
NO	☐

Question 9: Does this facility manage their own back-up electricity generation or is it part of a service agreement?

OWN	☐
SERVICE AGREEMENT	☐

Question 10: Is it possible to own-generate enough electricity to run industrial processes at this facility?

YES	
NO	

Question 11: Is it possible to own-generate enough electricity to run administration and security and/or safety functions?

YES	
NO	

Question 12: Will this facility consider installation of back-up power generation?

YES	
NO	

Question 13: Will this enterprise consider downscaling, closing, or relocating if electrical load-shedding should become a reality?

YES	
NO	

Question 14: Which area is this facility based in, in Nelson Mandela Bay?

Question 15: Please select the category which best describes the type of the facility?

WAREHOUSING	

MANUFACTURING	
DISTRIBUTION	
OTHER	

(Please specify) ______________________________

Question 16: To contextualise your answers, please indicate the size of the facility?

≤ 200 m^2	
200 – 500 m^2	
500 – 1 000 m^2	
1 000 – 5 000 m^2	
5 000 – 10 000 m^2	
10 000 – 20 000 m^2	
≥ 20 000 m^2	

Question 17: How many full-time employees work at this facility?

≤ 15	
15 – 50	
50 – 100	
100 - 500	
500 – 1 000	
≥ 1 0000	

Appendix C: Survey questionnaire aimed at industrial and/or commercial facility management – remainder of Nelson Mandela Bay

Dear Sir / Madame

I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay, as part of fulfilling the requirements for the award of the degree of MSc Property Studies at the Faculty of Engineering & the Built Environment, Department of Construction Economics and Management, University of Cape Town

I would like to invite you to participate in this research. This questionnaire aims to explore the effects of load-shedding on your strategic and operational facility management decisions. The questionnaire should take about 10 minutes to complete. Please answer all questions truthfully and fully by ticking the applicable box or by writing your answer in the shaded space provided. Your participation is voluntary and there is no penalty for withdrawing from this research.

All data will be kept 100% confidential and no mention will be made, of any company details in the research results. Any concerns may be discussed with my supervisor or myself, as per below contact details.

Position:	Researcher	Supervisor
Name:	Anelle Bailey	Associate Professor Kathy Michell
Email:	anelle.bailey@sbtsa.co.za	kathy.michell@uct.ac.za
Contact Number:	(+27) 082 490 9417	(+27) 021 650 3444

Introduction: Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted that industrial areas should be included in the load-shedding.

On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time. Initially NMBM made it known that they have decided to keep the load-shedding at Stage 4.

On the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas.

Question 1: Does your Enterprise make use of a Facility Manager?

YES	
NO	

Question 2: Would you provide me the details of Facility Manager, in order for me to interview them for my research?

YES	
NO	

If yes, please provide name and contact details.

Facility Manager:	
Email Address:	
Contact Number:	

Question 3: Are your enterprise affected by load-shedding during?

STAGE 1 - 4	
STAGES 5 - 8	

Question 4: Are your Facility Manager aware of the potential electrical load-shedding during Stages 5 -8?

YES	
NO	

Question 5: Does the load -shedding during Stages 1 - 4 or the potential electrical load-shedding during Stages 5 -8 affect your enterprise?

YES	
NO	

Question 6: Will the potential electrical load-shedding impact the Facility Manager's operational decisions?

YES	
NO	

Question 7: Will the potential electrical load-shedding impact the Facility Manager's strategic decisions.

YES	
NO	

Question 8: Does this enterprise require uninterrupted electrical supply to run industrial processes?

YES	
NO	

Question 9: Does this facility have back-up electricity generation?

YES	
NO	

Question 10: Does this facility manage their own back-up electricity generation or is it part of a service agreement?

OWN	☐
SERVICE AGREEMENT	☐

Question 11: Is it possible to own-generate enough electricity to run industrial processes at this facility?

YES	☐
NO	☐

Question 12: Is it possible to own-generate enough electricity to run administration and security and/or safety functions?

YES	☐
NO	☐

Question 13: Will this facility consider installation of back-up power generation?

YES	☐
NO	☐

Question 14: Will this enterprise consider downscaling, closing, or relocating if electrical load-shedding should become a reality?

YES	☐
NO	☐

Question 15: Which area is this facility based in, in Nelson Mandela Bay?

Question 16: Please select the category which best describes the type of the facility?

WAREHOUSING	
MANUFACTURING	
DISTRIBUTION	
OTHER	

(Please specify) ______________________________

Question 17: To contextualise your answers, please indicate the size of the facility?

≤ 200 m^2	
200 – 500 m^2	
500 – 1 000 m^2	
1 000 – 5 000 m^2	
5 000 – 10 000 m^2	
10 000 – 20 000 m^2	
≥ 20 000 m^2	

Question 18: How many full-time employees work at this facility?

≤ 15	
15 – 50	
50 – 100	

100 - 500	
500 – 1 000	
≥ 1 0000	

Appendix D: Semi structured Interview schedule aimed at Facility Manager at Industrial Facility

Purpose: In my letter requesting this interview, I have indicated that I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay.

You have consented to this interview. I would like to reiterate that the aim of this interview is to discuss the effects of load-shedding on your strategic and operational facility management decisions. Your participation is voluntary and there is no penalty for withdrawing from this research. The information obtained will be used only for research purposes and will remain confidential. All data will be kept 100% confidential and no mention will be made, of any company details in the research results.

Do you have any questions before we start the interview? May I record the interview, in order to accurately capture the information for data-analysis purposes?

Introduction: Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted that industrial areas should be included in the load-shedding.

On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time. Initially NMBM made it known that they have decided to keep the load-shedding at Stage 4.

On the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas.

1. What was your reaction as a facility manager to the announcement of the new load-shedding schedules?
2. What impact did this have on your operational decisions?
3. What impact did this have on your strategic decisions?

4. Does this facility require uninterrupted electrical supply to run industrial processes?

5. Does this facility have back-up electricity generation?

6. Does this facility manage their own back-up electricity generation or is it part of a service agreement?

7. Is it possible to own-generate enough electricity to run industrial processes at this facility?

8. Is it possible to own-generate enough electricity to run administration and security and/or safety functions?

9. Will this facility consider installation of back-up power generation?

10. Which area is this facility based in, in Nelson Mandela Bay?

11. Under what category does this facility fall? Warehousing, manufacturing, distribution or other?

12. To contextualise your answers, please indicate the size of the facility and how many full-time employees work at this facility, managing the facility?

Appendix E: Interview consent form – Nelson Mandela Bay Municipal Official

Dear Sir / Madame

I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay, as part of fulfilling the requirements for the award of the degree of MSc Property Studies at the Faculty of Engineering & the Built Environment, Department of Construction Economics and Management, University of Cape Town

The research objectives will be achieved by adopting the following research method:

a) Face-to-Face and/or electronic semi structured interviews with Nelson Mandela Bay Municipal officials regarding the decision to include previously uninterrupted, preferential electricity supply.

I would like to invite you to participate in this research. I would like to discuss the effect of load-shedding on industrial facilities in Perseverance and other industrial townships in Nelson Mandela Bay. The interview should last about 30 minutes. Your participation is voluntary and there is no penalty for withdrawing from this research. In order to accurately capture the information during a face-to-face interview, I will be recording the interview.

All data will be kept 100% confidential and no mention will be made, of any personal details in the research results.

Any concerns may be discussed with my supervisor or myself, as per below contact details.

Position:	Researcher	Supervisor
Name:	Anelle Bailey	Associate Professor Kathy Michell
Email:	anelle.bailey@sbtsa.co.za	kathy.michell@uct.ac.za
Contact Number:	082 490 9417	: (+27) 021 650 3444

Signature of participant: ____________________________

Date: ____________________________

Signature of researcher: ____________________________

Date: ____________________________

Appendix F: UCT Student confirmation

Department of Construction Economics and Management

Head: Associate Professor Kathy Michell

University of Cape Town, Private Bag X3, Rondebosch 7701
5th Level, Snape Building Upper Campus
Tel: +27 (0) 21 650 3443 Fax: +27 (0) 21 689 2746

Internet: http://www.cons.uct.ac.za
Email: CON-cem@uct.ac.za

27 October 2020

Nelson Mandela Bay Municipality
City Hall,
Vuyisile Mini Square
Govan Mbeki Avenue
Nelson Mandela Bay

TO WHOM IT MAY CONCERN

Dear Sir / Madam

RE: AN INVESTIGATION OF THE EFFECTS OF POTENTIAL ELECTRICAL LOAD-SHEDDING ON FACILITY MANAGER'S STRATEGIC AND OPERATIONAL DECISIONS IN INDUSTRIAL BUILDINGS: A CASE STUDY OF PERSEVERANCE INDUSTRIAL TOWNSHIP, NELSON MANDELA BAY

The study has been primarily motivated by the proposed electrical load-shedding of previously exempt industrial areas, in this case Perseverance Industrial Township and other industrial nodes in Nelson Mandela Bay. This study will become an invaluable addition to the body of knowledge in the facility management field in Nelson Mandela Bay.

The research study is to be conducted by Mrs Anelle Bailey, an MSc student at the University of Cape Town. I have known her for a combined period of 4 years since 2017 as a post-graduate student in the Department. I am the research supervisor of her study to which I can affirm that the results of the study will be presented to the Department of Construction Economics and Management in partial fulfilment of the requirements for the **Master of Science in Property Studies.**

To undertake this exercise, Mrs Anelle Bailey will be conducting an independent assessment of the subject matter. Part of the research objectives will be achieved by Face-to-Face and/or electronic semi structured interviews with Nelson Mandela Bay Municipal officials regarding the decision to include previously uninterrupted, preferential electricity supply.

Should you require any additional information, please do not hesitate to contact me.

Yours sincerely

K.A. Michell

Kathy Michell (Dr)
Associate Professor & Head of Department
BSc (QS) MPhil PhD MRICS PrQS (Reg. no. 3330) PMAQS

Appendix G: Semi structured interview schedule aimed at Nelson Mandela Bay Municipality Officials

Purpose: In my letter requesting this interview, I have indicated that I'm conducting research titled: An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay.

You have consented to this interview. I would like to reiterate that the aim of this interview is to discuss the effects of electrical load-shedding on previously exempt industrial areas. Your participation is voluntary and there is no penalty for withdrawing from this research. The information obtained will be used only for research purposes and will remain confidential. All data will be kept 100% confidential and no mention will be made, of any company details in the research results.

Do you have any questions before we start the interview? May I record the interview, in order to accurately capture the information for data-analysis purposes?

Introduction: Nelson Mandela Bay Municipality (NMBM) made the decision in 2008 to exempt industrial areas from load-shedding to avoid job losses. However, during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents, and small business owners in other areas, protested this. In response, NMBM created a poll on Facebook, to test the public's opinion; 54% voted to keep the current system excluding the industrial areas, compared to 46% who voted that industrial areas should be included in the load-shedding.

On the 9th of December 2019, Eskom announced on Twitter, and implemented Stage 6 load-shedding for the first time. Initially NMBM made it known that they have decided to keep the load-shedding at Stage 4. On the 11th of December 2019, NMBM posted new load-shedding schedules for Stages 5 to 8, which included the previously excluded industrial areas.

1. Would you please share your opinion on the issue of load-shedding of previously excluded industrial areas?
2. Were enterprises in previously excluded industrial areas consulted before, or during the planning of load-shedding schedules for Stages 5 -8 was done?
3. Was consideration given to shut-down and start-up periods of industrial manufacturing

processes considered, when planning the published load-shedding schedule of Stages 5 to 8?

4. Would the Municipality be interested in meeting with the industrial enterprises to discuss their concerns regarding the proposed load-shedding for Stages 5 to 8, and possibly find a solution that will require less electricity, without load-shedding the previously uninterrupted industrial area?

5. What does the Municipality think about industrial enterprises possibly generating their own electricity? Would that potentially negatively impact the income generated by the Municipality?

6. What does the Municipality think, about the possibility of industrial enterprise's downscaling, closing, or relocating if electrical load-shedding should become a reality?

Appendix H: Tree node structure – Perseverance Industrial Area Research

Name	Description	Files	References
Facility Management Reactions & Decisions	Mitigation measures considered and or put in place by facility managers and/or enterprises	11	12
Operational Decisions		11	11
Alternative Electricity Sources		3	5
Failed Processes		1	1
Load Reduction		5	6
Production Shifting		3	3
Resource Management		5	8
Split operations between sites		1	1
Strategic Decisions		11	11
Alternative Energy Sources		3	4
Back-up Electrical Supply		9	10
Expansion Projects		2	2
Location		1	1
Resource Management		3	4
Supply Chain		1	1

Name	Description	Files	References
Implications of Proposed Electrical Load-shedding.		0	0
Cost of Proposed Electrical Load-Shedding		9	13
Investment in own generation		5	8
Unfeasible	The scope of the electricity requirements makes it unfeasible for the facility to install own generation, in the event of load-shedding.	4	4
Uninterrupted Electrical Supply	Certain industrial processes require uninterrupted electricity to run.	11	14
No, it's not necessary	The facility does not require uninterrupted electricity supply.	2	2
Yes, it's a requirement	Industrial processes require uninterrupted electricity supply to run.	10	11
Mitigation of potential load-shedding		11	22
Alternative Electricity Sources		1	1
Generators		7	10
Own PowerStation		1	1
Power grid tied system		3	5

Name	Description	Files	References
Server or UPS Systems		4	5
Solar Systems		5	18
Wind Turbines		1	2
Own Generation Capacity		11	17
Administration, Health & Safety Functions		11	12
Industrial Processes		11	13

Appendix I: Sample interview transcript

Interviewer: Thank you very much for agreeing to this interview, this is interview number 10, today's date is 17th of March 2021.

In my letter requesting this interview, I have indicated that I'm conducting research titled: An investigating of the effects of potential electrical load-shedding on facilities managers, strategic and operational decisions on industrial buildings. A case study of Perseverance Industrial Townships, Nelson Mandela Bay……. I am also ehm... interviewing and sending out surveys to the rest of Nelson Mandela Bay as well, to compare and see what is happening in the rest of Nelson Mandela Bay as well.

Ehm! Thank you for consenting to this interview.

I would like to reiterate that the aim of this interview is to discuss the effects of load -shedding on your strategic and operational facility management decisions, your participation is voluntary and there is no penalty for withdrawing from this research. The information obtained will be used only for research purposes and will remain confidential. All data will be kept 100% confidential and no mention will be made of any company details in the research results.

Do you have any questions before we start off the interview?

Interviewee: No

Interviewer: And you have no problem with me recording the interview?

Interviewer: No

Interviewer: Thank you very much.

Ehm…. Nelson Mandela Bay Municipality made the decision in 2008, to exempt Industrial areas from load-shedding to avoid job losses, however during 2019, when South Africa was experiencing prevalent periods of load-shedding, residents and small business owners in other areas protested this, in response, NMBM created a poll on Facebook to test the publics' opinion, 54% voted to keep the current system excluding the Industrial areas, compared to 46% who voted that Industrial areas should be included in the load-shedding, on the 9th of December 2019, ESKOM announced on twitter and implemented Stage 6 load-shedding for the first time. Initially, NMBM made it known that they have decided to keep the load-shedding at Stage 4, on the 11th of December 2019, NMBM, posted new load-shedding schedules for Stages 5 to 8, which included previously excluded industrial areas.

Interviewer: Eh, what was your reaction as a facility manager to the announcement of new load-shedding schedules?

Interviewee: Ehm...I think it was a shock to us because we, ehm... in the, in the current company that we are running this would be a total disaster, for (RETRACTED – IDENTIFYING COMPANY NAME) particularly ......ehm…main reason because we are basically running almost four different technologies in one, in a continuous process. Ehm... ja…. We, we are melting about seventy tonnes of aluminium a day, 7days a week 24 hours. Ehm, and any disruption in that, would of cause ehm, have a huge effect on, impact on our businesses as such. Ehm and with the load-shedding schedules where ehm certain 4 hours would be kept, ehm… of course, we were very much involved with the Business Chamber. I attended, personally a couple of meetings ehm at the Chamber where we discussed, on how do we respond and NMBM was also present, ehm because ehm, how do we... how do we stop a company that’s got a continuous process and what do we do with employees, because four hours later they need to be back on shift. Ehm… so that ehm our biggest request actually was at that point in time is not to, not to, had the schedules implemented ehm there was of course a lot of ehm we were saying after...ehm okay level four...... we would sort of being protected and only at stage five would it impact us, so the big request at that point in time was that we needed to look at ripple control and most ripple control units to be put in place so (RETRACTED – IDENTIFYING COMPANY NAME) itself, I think we looked at about 55 ripple control units that was implemented, beginning of last year, January, February and March. Ehm…. And ehm, ja and that should protect us for at least stage five. Beyond stage 5 stage 6,7 and 8, that of course is of a big concern. And our request at that point in time was, rather load shed us for a day, a week, than 4 hours a day, that was sort of the biggest request from industry. I think we were about 30 40, 50 industry leaders there, ehm, so ja, I think ehm, with having a German shareholder, off course the reaction also was “What?”

Interviewer: Okay let’s go further, I’ve got … so you’ve covered some of the further questions, but we can quickly go through it, then if its’s covered, you don’t, we can see how it goes. What impact does it have in your operational decisions?

Interviewee: Ehm, operationally, I think, we’ve already tried to move our processes more to gas ehm.... we in 2013, we already moved our melting department to gas, in 2018, we moved our paint ovens also to gas, which was previously electricity ehm... off course we are one of, ten to one, one of the biggest users in Perseverance I'm sure ...ehm and I think within the top ten of PE perhaps. So ehm we are at this point in time also looking at ehm our 3rd biggest user process which is our ...heat treatments ehm to actually even convert that to gas ehm, but the investment is quite a substantial investment and ehm ja we are looking at it, but at this point in time it's quite it's quite a big challenge for us.

Ehm operationally I think you know also, we've tried to also last year February actually met with our shop stewards and unions ehm which I think, they were very shocked to even understand that this could impact them, so directly. Ehm because we would not technically done you know. Ehm, Ja! I think we … Labour laws etc needs to be looked at more in detail and see what ehm…. especially where you need to give them like notice of these things, so our intention was to actually give them upfront notice ehm the problem is what, in the case of the 4 hours is that unpaid or not, that was such a big impact for our employers as such. The other the other impact for us is also regarding ehm, slowing down I mean, putting off and starting up again. And I think one if the big request we had, also to the municipality that at that point in time is, that in the case of (RETRACTED – IDENTIFYING COMPANY NAME), you can't switch us off. We have to reduce the load ourselves and we need to agree on what is that minimum load. Ehm, so I think there was scenarios done that you know in the case we could reduce by75%, 50% and 25% but technically we could not reduce to zero, as such. Ehm so, ja ehm. I think the negativity off course is also just from shareholder's investment, future investments you know this does of course have a question mark...

Interviewer: Well, this will go through to the next question, then what impact does that have on your strategic decisions?

Interviewee: I wouldn't say it has any direct impact yet, as such. Ehm and is mainly because we, you know. we, we need to really, we are a strategic partner to the OBM industry, we supply 6 of the 7 OBM's in South Africa and ehm...we need to stay on the forefront of technology, and productivity to be competitive. So, yes, I think, if we go down, I think the OBM's will also go down, so it would have a ripple effect, as such. Ehm yes, that they could perhaps start up, easier than us, having, I mean, we recently have four technologies; we are sitting with foundry, we are sitting with heat treatments, we are sitting with machining, and then you are sitting with paint. So, its four different technologies in one, in a continuous process ehm and that impacts us ehm, so, so, also, we are taking, we are taking raw materials to final product, so it’s not an assembly plant as such, where we you know, we add stuff to something, we actually get raw material and we con, and we convert it into a finished real product at the end of the day. Ehm, I think it is in our back, in the back in our backgrounds, of course especially when it comes to strategic decisions, like our heat treatment ehm which is now currently our biggest user of electricity. Ehm, so, yes, it’s on the cards but it’s also a question or rather a question mark, are we really going to do that.

Interviewer: Does this facility requires uninterrupted electrical supply to run industrial process? Which you've previously basically answered.

Interviewee: Yes, I mean, the thing is just that we are sitting with… the problem is that we, we’re casting 4000 wheels a day and there are wheels in a, in our, in our, we've got a melt okay, now the melt is currently gas, but of course it needs some electrical panels to run. So, off course, if we have to get to a point where we cannot empty the melting furnaces, and they would then freeze up. I mean that would be months to get back into production, of course we wouldn’t allow that to a point in time where we actually start decanting them and making as much as we can, big blocks of aluminium, just to avoid that we have a total freeze. So, we have got contingencies in place for those, the problem we have is more in our heat treatment department where wheels are in a process in about seven, seven hours in an oven, so if the power is disrupted in that stage, it means we have to repeat the process. So that's 7 hours of baking of wheels ehm where there is at any given point in time, more than 1000 wheels in the heat treatment and that process is going to be repeated and that is a huge on- cost for us. Ehm, if I then look at our machining side, machining of course, there is a lot of CNC machines, with a lot of ehm robotic, robots and ehm, what do you call It ehm electronic cards that can get damaged ehm, so start-up, in a case of a disrupt, ehm abrupt disruptions, we will definitely have a huge cost on loss of equipment, ehm electronic cards etc. Our fourth process our paint plant, and our paint plant again, is a process where ehm wheels are running through a paint plant ehm and it’s a five-hour process. So, where the wheels are given a powder, ehm first going through a pre-treatment to clean the wheel, we then powder wheels, then we bake that powder or cure it, as we call it, then we basically, go...ehm. That goes through ovens, then we paint wheels with a silver paint and then also a clear coat and off course that also need to be cured in another oven etc. So again, five and half hours of wheels in the process, ehm and that is at any point in time, there's basically two and a half thousand wheels in the process and that sort of ehm makes it a little bit ehm difficult for us. And that's why our …really our works, you can’t, you can’t switch us off. We need to, we need to lower our down but that off course it’s got a huge on-cost for us because now that means 5 hours needs to run out that means to get it back in again. takes as 5 hours process. So......

Interviewer: Does this facility have back up electrical facilities generation?

Interviewee: Ehm for this size of facility, I think (laughs) it's not possible to get electricity back up as such. Ehm yes, we do have you know our normal UPS's, on critical, just to ride it through but I mean, that's not going to...in thus size plant, Ehm currently I think we... this is a 15 NVA plant but currently, we are using about between 6 and 7 NVA and ja, I think we would, ten-to-one need windmills, I think we may need to have at least 8 or 9 windmills running continuously to even feed at least the plant as such

Interviewer: Okay, does this facility manage their own, ok, well, that the 6 is then, is N/A because you don't have onsite back-up electricity generation, question 7 is…

Interviewee: I mean, we've looked at various options, I mean, there's been various players that came to see us about, what to do, but it's., still ehm…. We could buy a couple of windmills that's sitting somewhere, in the Karoo, …. somewhere on a farm. But the problem is, it still has to be channelled through the infrastructure, of the municipality which will still at the end of the day, there is no benefit as such.

Interviewer: Is it possible to own generate enough electricity to run industrial processes at this facility? Which you've answered previously

Interviewee: No

Interviewer: is it possible to own generate enough electricity to run administration and security and safety functions?

Interviewee: Yes, I think we've got we've got ehm, we do have some generators in place but ja, but not for that ....

Interviewer: Ehm will this facility consider the installation backup power generation? You have basically touched on it

Interviewee: Ja, I think it's ehm... the answer is no, because of the size of it

Interviewer: It's not feasible

Interviewee: Ja it's not feasible. I mean we actually have to build our own power station, which is something we have also looked at, but I mean the cost for that; the pay back is something like 20 years, no investor will do that. So….

Interviewer: Which area is this facility based in?

Interviewee: Perseverance

Interviewer: And ehm, under which, what category does this fall: warehousing, manufacturing distribution and other?

Interviewee: Manufacturing

Interviewer: Ehm to contextualise your answers; please indicate the size of the facility and how many full-time employees work in the facility, managing the facility.

Interviewee: At the moment we've got 370 employees, Ehm of which we will by the end of the year be about 440. So, we are in a growth ehm growth phase for 2020 as such

Interviewer: And approximate square meters of the area

Interviewee: The land, we are on the land of 76 000 squares and buildings close to about 30 000 squares and the roof.

Interviewer: Thank you very much.

Interviewee: Thank you.

Interviewer: And that's the end of the interview

Appendix J: Ethics form

EBE Faculty: Assessment of Ethics in Research Projects

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. For more info regarding the procedure of completing the form please log onto **http://www.ebe.uct.ac.za/research/ethics/**.
When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zulpha Geyer (**Zulpha.Geyer@uct.ac.za**; Chem Eng Building, Ph 021 650 4791).
Students must include a copy of the completed form with the thesis when it is submitted for examination.

Name of Principal Researcher/Student: *Anelle Bailey*

Department: *Construction Economics and Management*

If a Student: Degree: *MSc Property Studies* Supervisor: *Assoc Prof Kathy Michell*

If a Research Contract indicate source of funding/sponsorship: Employer: *Strydom Basson & Tait (Pty) Ltd*

Research Project Title: *An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay*

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	NO
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES	NO
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	YES	NO
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	NO

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:	Anelle Bailey	15 July 2020

This application is approved by:

Supervisor (if applicable):		17 July 2020
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.	Louie van Schalkwyk	29 July 2020
Chair : Faculty EIR Committee		
For applicants other than undergraduate students who have answered YES to any of the above questions.	Louie van Schalkwyk	29 July 2020

Appendix K: Sections of Nelson Mandela Bay electrical load-shedding schedules stage 5 – 8, posted on the 11th of December 2019, including group 10, area 26 applicable to Perseverance.

GROUPS 9 – 16 SEMI-INDUSTRIAL & INDUSTRIAL AREA

GROUP 9
AREA 25
Charles Goodyear Campus
De Mist
Dr Braun
Eric Dodd
Mario Levi
Union Cotton

GROUP 10	GROUP 10
AREA 26	**AREA 27**
Alloy Wheels	De Villiers St
CCBSA Coca Cola	Edgar Street
Redhouse	Hancock Street area
SA Breweries	Prince Alfred Road
Welfit Oddy	Section of Holland Park
	Section of Kensington
	Section of Lower North End
	Sydenham
	Todd Street area
	York Road area

GROUP 11	GROUP 11
AREA 28	**AREA 29**
Aberdare	Aloes
Aspen Pharmacare	Amsterdamhoek
Ferguson	Dumbrody
Kensington (section)	Markman Industrial
Neave Industrial	Plastiform
Perl Road	Wells Estate

Stage 5 (25%) - Domestic & Industrial

9th December 2019 - 15th December 2019

Time	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
02:00-06:30	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
06:00-10:30	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10
10:00-14:30	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
14:00-18:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
18:00-22:30	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
22:00-02:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14

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Stage 6 (30%) - Domestic & Industrial

9th December 2019 - 15th December 2019

Time	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
02:00-06:30	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
06:00-10:30	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
10:00-14:30	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
14:00-18:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
18:00-22:30	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
22:00-02:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9

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Stage 7 (35%) - Domestic & Industrial

9th December 2019 - 15th December 2019

Time	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
02:00-06:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
06:00-10:30	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
10:00-14:30	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
14:00-18:30	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16
	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
18:00-22:30	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
22:00-02:30	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11

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Stage 8 (40%) - Domestic & Industrial

9th December 2019 - 15th December 2019

Time	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
02:00-06:30	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
06:00-10:30	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16
10:00-14:30	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
14:00-18:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16
	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10
18:00-22:30	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers	Geysers
	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2	Group 1
	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3	Group 2
	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4	Group 3
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13
	Group 13	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
22:00-02:30	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5	Group 4
	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6	Group 5
	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7	Group 6
	Group 5	Group 4	Group 3	Group 2	Group 1	Group 8	Group 7
	Group 12	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14
	Group 15	Group 14	Group 13	Group 12	Group 11	Group 10	Group 9
	Group 9	Group 16	Group 15	Group 14	Group 13	Group 12	Group 11
	Group 11	Group 10	Group 9	Group 16	Group 15	Group 14	Group 13

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Appendix L: Turnitin report

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An investigation of the effects of potential electrical load-shedding on facility manager's strategic and operational decisions in industrial buildings: A case study of Perseverance Industrial Township, Nelson Mandela Bay

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A dissertation submitted in fulfilment of the requirements for the award of the degree of Master of Science (MSc) in Properties Studies

2022/01/01

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