INVESTIGATING THE DRIVERS AND BARRIERS TO IMPLEMENTING GREEN BUILDING FEATURES AND INITIATIVES (GBFIs) IN SOUTH AFRICA'S PRIVATE RESIDENTIAL HOUSING SECTOR

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Abstract

The construction industry has long been criticised for being a significant contributor to global carbon emissions and a large consumer of energy. Economies around the world, however, have taken an active role in addressing the construction industry's carbon footprint and high energy demands by incorporating green technologies and practices in construction projects. Over the years, Green Building Features and Initiatives (GBFIs) have provided a solution to the construction industry's challenges, particularly in the building sector which is a notable consumer of energy. The Green Building Council of South Africa (GBCSA) manages and applies tools such as Green Star, EDGE, and Net-Zero to assist in the incorporation and certification of GBFIs in buildings. The study seeks to identify the drivers and barriers of implementing GBFIs in South Africa's private residential sector. A literature review was conducted to identify key drivers and barriers for the adoption of GBFIs from a global perspective. The study employed a qualitative research approach comprising multiple case study analysis, where semi-structured interviews were conducted with key stakeholders in the construction industry. The case studies (limited to South Africa) involved five major residential developments in municipalities located in the Western Cape and Gauteng provinces. The study highlighted socio-cultural factors such as client awareness, enhanced standard of living, and developer initiative as being the key drivers to the adoption of GBFIs, followed by increased international investment. However, the study yielded numerous barriers, with key barriers being government-related barriers in the form of inadequate renewable energy (RE) green building regulations and low levels of municipal involvement; followed by human related barriers in the form of a lack of education concerning GB principles and practices by construction stakeholders; and lastly market related barriers in the form of high financial cost of RE generation. The study identified key strengths and weaknesses of the green building rating tools that in turn contribute to the drivers and barriers. This study adds to the existing literature pertaining to GBFIs by providing insight within the context of the private residential property sector in a developing country.

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List of Abbreviations

^{o}C	Degree Celsius
CO_2	Carbon Dioxide
COP	Conference of the Parties
ESGB	Evaluation Standard for Green Building
FIT	Feed-in Tariff
GB	Green Building
GBCSA	Green Building Council of South Africa
GCC	Global Climate Change
GGR	Greenhouse Gas Removal
GHG	Greenhouse Gas
IEP	Integrated Energy Policy
IRP	Integrated Resource Plan
JSE	Johannesburg Stock Exchange
NERA	National Energy Regulator Act
NERSA	National Energy Regulator South Africa
NZE	Net-Zero Energy
PV	Photovoltaic
REFIT	Renewable Energy Feed-in Tariff
SA	South Africa
TA	Thematic Analysis
UK	United Kingdom
USA	United States of America
UNFCCC	United Nations Framework Convention on Climate Change
WCED	World Commission on Environment and Development

CHAPTER 1: INTRODUCTION

1.1 Introduction

The study seeks to investigate the drivers and barriers to the implementation of Green Building Features and Initiatives (GBFIs) in the private residential real estate sector of South Africa. The study begins by providing a global perspective of the current energy crisis and the role that Global Climate Change (GCC) initiatives play in the energy crisis. The study provides further background on the role that the construction sector, primarily the private residential sector, has in addressing the challenges brought about by the energy crisis. The Green Building (GB) concept is introduced thereafter, identifying the need to investigate the drivers and barriers to GBFI uptake in the residential sector. The chapter proceeds to present the problem statement, research question and the research proposition. The research objectives are then stated followed by an overview of the methodology and data analysis employed. The chapter concludes by highlighting the scope and limitations of the study and by providing the structure for the remainder of the study.

1.2 Background

The energy sector has long been regarded as one that has a significant impact on the global environment (Pretorius *et al.*, 2015). Coyle and Simmons (2014) highlight that the continuous dependence on fossil fuels for energy production and transportation, and the increase in global population are some of the reasons for the energy crisis that the world is facing. The extensive use of burning fossil fuels for energy generation, however, has resulted in the depletion of natural resources thereby causing a steady increase in the levels of carbon dioxide (CO_2) emissions, also referred to as greenhouse gas (GHG) emissions (Coyle and Simmons, 2014). The global climate change (GCC) challenge posed by the burning of fossil fuels has led economies around the world to implement GCC mitigation measures to address the global challenge. GCC mitigation further requires the cooperation and innovation of all key players involved in the construction industry. Environmental Management Systems (EMS) were developed in light of the increased awareness of the negative effects that the construction industry has on the environment at large. To this effect, green buildings and practices were developed as a tool to promote the development of energy-efficient buildings throughout the entire building lifecycle (Howe, 2011). Green building (GB) practices have long since gained momentum in developed and developing economies, with various certification measurements and tools being employed to measure the greenness of a building.

The Green Building Council of South Africa (GBCSA) which oversees the certification of GB in South Africa (SA), uses various tools such as Green Star, Net Zero, and Edge rating tools, to measure different

types of buildings' compliance with green practices and ultimately provide green certification for the buildings. The concept of GBs is characterised by two components, namely the green building features and green building initiatives, collectively referred to as green building features and initiatives (GBFIs). A feature is defined as "A building component that reduces resources consumption" (Michell and Nurick, 2014: 8) and an initiative is defined as "A building component that increases resources consumption but results in a decrease in the carbon footprint of a building's occupants." (Michell and Nurick, 2014: 8) GBFIs can therefore be seen as an important tool(s) to be implemented in the building sector to address the current GCC crisis and the water and energy challenges faced in SA.

1.2.1 Water scarcity in South Africa

South Africa has been experiencing a severe water crisis due to a combination of natural water scarcity, climate change, and growing urbanization. This crisis is amplified by uneven water distribution and aging infrastructure, which strain the country's already limited resources. Green building initiatives, including rainwater harvesting systems, greywater reuse, water-efficient fixtures, and drought-resistant landscaping, can significantly reduce reliance on municipal water supplies and promote sustainable water management (Pereira et al.,2022). These measures are essential for alleviating the pressures on water resources, particularly in urban areas. The potential of green buildings to enhance water resilience by incorporating sustainable practices that decrease water consumption and improve efficiency is significantly high (Mann & Zibert, 2020; Ehlers et al., 2021). Furthermore, water-saving technologies integrated into building designs can contribute to long-term environmental sustainability and economic benefits (Pereira et al., 2022). GBFIs therefore can address the challenges brought about by water scarcity and those posed by the energy crisis.

1.2.2 The energy crisis in South Africa

The energy crisis in SA is primarily characterised by a reduction in the electricity reserve, which is essentially the amount of reserve energy in place in the electric power system after the consumer supply has been met at all points in time (Pretorius *et al.*, 2015). The electricity reserve further acts as an indicator of the pressure faced by the electricity supply system, as when demand is high, the reserves run low, indicating that demand is greater than supply (Pretorius *et al.*, 2015). The consequence of the depletion of the electricity reserve is characterised by load-shedding cycles that the country has been facing since the mid-2000 period. SA witnessed over 200 days of loadshedding during the 2022 calendar year, making a record for the most power cuts witnessed in its history (Nguyen, 2023).

SA's economy continues to suffer loadshedding due to the energy crisis. The ageing coal plants have been overworked thus resulting in the increased scheduled blackouts (Hartley and Mills, 2023). These blackouts could likely cost the SA economy more than 4.1 billion Rand a day (Hartley and Mills, 2023). The effect of the increased loadshedding is further perceived by investors as a lack of energy security which in turn demotivates potential investors (Hartley and Mills, 2023).

1.2.3 Implementation of renewable energy sources and GCC mitigation

The SA Department of Mineral Resources and Energy (DMRE), in their strategic plan for 2020-2025, have expressed plans of integrating the provisions set out in the integrated Resource Plan (IRP) 2019 by embracing all forms of energy available in the country (DMRE, 2023). The DMRE therefore maintains that coal will remain a pivotal source of energy within the country but that as per the IRP 2019 provisions, movement must be made from higher carbon to lower carbon emissions by implementing cleaner coal technology such as Carbon Capture, Utilisation, and Storage (CCUS) (DMRE, 2023). According to Bohlmann and Inglesi-Lotz (2018), the residential sector is one of the largest consumers of electricity in SA, with its percentage consumption expected to increase as the population increases. Amidst the energy crisis that SA has been facing, businesses and private households have increasingly invested in the solar Photovoltaic (PV) market to meet their energy needs (Pretorius *et al.*, 2015).

The use of solar PV technology in SA households creates the opportunity for one of the largest consumers of energy to produce clean energy and an opportunity for users to sell the surplus back to the national power grid, as highlighted in the Feed-In Tarif (FIT) policy discussion (Odeku *et al.*, 2011). SA currently implements the Integrated Energy Policy (IEP) which aims to provide a roadmap to develop energy supply options and the increased exploitation of renewable sources of energy (Akom *et al.*, 2021). The regulatory body for energy in SA is the National Energy Regulator (NERSA), which also oversees the regulation of electricity from renewable sources (Lawrence and Lawrence, 2020). NERSA was established under the National Energy Regulator Act No. 40 of 2004 (NERA) (National Regulator Energy Act 40 of 2004). Despite SA having the IEP and the regulatory body NERSA, various municipalities around SA have not allowed private household developments the opportunity to sell surplus electricity back to the grid and this may be owing to policy barriers that do not speak to the production and sale of energy generated via renewable technology in the housing sector.

The introduction of private investors to the SA energy supply and generation sector has managed to release the monopoly that Eskom had as the sole energy generator in SA. Private investors are only permitted to produce 100MW which is enough to produce energy for a small town (International Trade Administration, 2021). The national grid however remains the vital source for many corporate

energy users and households in SA (International Trade Administration, 2021).The installation of PV systems in the housing sector is one solution that can help to address the issues surrounding energy security and realising net-zero energy (NZE) houses. Miller *et al.* (2018) explain the concept of NZE buildings broadly as being dwellings that produce as much energy as they consume. Miller *et al.* (2018), in a study involving occupants in net-zero energy solar housing retrofits, highlighted some of the benefits of PV installation, where retrofitted dwellings achieved a solar-based energy generation of 19.6KWh whilst the household itself consumed an annual average daily consumption of 20.1KWh.

A study by Li *et al.* (2022) investigating carbon-budget compliant retrofit measures in UK households, emphasizes the contribution the residential building sector has towards GHG emissions, which is approximately 16% of total UK emissions, as of 2019. Li *et al*. (2022) further addresses the need to achieve NZE homes in the UK by decarbonizing the existing residential homes. Decarbonization of the homes can be achieved by the use of a net zero carbon energy supply, which is energy generated from renewable sources such as offshore wind, biomass and repurposing the existing gas networks for hydrogen (Li *et al*., 2022).

The potential for the residential sector to generate clean energy and not rely on the national grid is immense as evidenced in the study conducted by Sow *et al.* (2019), where the government supported a program initiated by the Canadian Solar Industry Association to implement PV systems in the residential sectors. The result has been the ability for residents to sell back to the national energy grid, but this has only been possible owing to effective supporting policies and price reduction of PV systems (Sow *et al*., 2019). The potential of harnessing the residential sector's contribution to GCC mitigation however has resulted in identifying the gap highlighted in the problem statement, relating to SA's private residential sector. This has led to development of the research question, research proposition and objectives.

1.3 Problem statement

The housing sector is considered one of the largest consumers of energy and therein lies a possible solution to implement renewable energy generation in households, with the surplus to be sold back to the national energy power grid. GBFIs exist in a bid to increase the greenness of developments within the building sector. The implementation of GBFIs in the private housing sector could provide solutions to alleviating the effects of the energy crisis on households in an environmentally friendly manner. GFBIs could further provide ways of decreasing water usage, thereby providing a means of a consistent water supply for households as water scarcity is another challenge faced in SA today. The literature however does not provide a framework to understand the drivers and barriers to

implementation of GBFIs in the private residential sector of SA that may aid in addressing the water, energy, and overall GCC challenges.

1.4 Research question

The research question to be answered in this study can be stated as follows:

What are the drivers and barriers to implementing Green Building Features and Initiatives (GBFIs) in SA's private residential housing sector?

1.5 Research proposition

There are governmental, human, and market-related barriers to the adoption of GBFIs in SA's private residential housing sector. There further exists, socio-cultural drivers, stakeholder drivers, and environmental factors, that serve as drivers to the adoption of GBFIs in the private residential housing sector.

1.6 Research objectives

The objectives of this study are to:

- Provide an overview of GBFIs in global and local developments as well as tools and standards applied to GBFIs
- Determine the role of GBFIs in the private residential housing sector
- Identify the drivers and barriers to implementation of GBFIs in the private residential housing sector
- Provide a framework to understanding the drivers and barriers to GBFIs in SA's private residential housing sector

1.7 Research design

The qualitative research method was used in this study, employing the use of a multiple case study approach. The multiple case study approach allows for an in-depth exploration of the research question. The case study approach is further supported by similar research conducted by Barry *et al.* (2011) and Martiskainen and Kivimaa (2019) who successfully employed the case study analysis method. The case studies centre around the GBFIs employed by a developer, in the private residential housing sector, in the areas of Cape Town, Pretoria and Johannesburg. The case study approach makes use of semi-structured interviews with the relevant stakeholders involved in GBFIs in the private residential sector. The research takes on a constructivism epistemological perspective as the

qualitative nature of the data collected provides knowledge through interactions and experiences with stakeholders.

1.8 Data analysis

The information gathered from the case-study interviews, highlighted in the research method, was analysed by means of a thematic analysis, as it is regarded as one of the most common methods of qualitative data analysis. Thematic analysis involves the generation of themes from the gathered qualitative data. Thematic analysis is considered both deductive and inductive, as the themes emerge from the collected data. Thematic analysis allows for the most frequent themes arising from the collected data to be grouped and thereby answer the research question and address the research proposition.

1.9 Scope and limitations of the research

The research is restricted to a single private residential estate developer within SA. The research does not address the upgrading of existing residential developments. The interviews are conducted with stakeholders directly involved in the implementation of GBFIs in the private residential sector. The limitations of the research however relate to the sample size as respondents for each case study was limited to one individual as data saturation had been achieved. The collected data was further limited to the Gauteng and Western Cape provinces.

1.10 Research structure

The second chapter comprises a literature review unpacking the global energy crisis, focusing on the various causes of the crisis and the solutions presented by the international community to tackle this challenge. The chapter further focuses on the probable solution that is presented by the private housing sector amidst the energy crisis and how this sector may allow for cleaner energy generation and alleviate energy demand. The literature review section draws on some existing international and local policies to compare the regulations surrounding the roll-out of renewable energy generation in the housing sector, to meet increased levels of energy demand in growing economies such as SA. The third chapter, methodology, details the multiple case study approach undertaken to investigate the application of existing renewable energy policies in three of SA's largest metropolitan municipalities, and identify barriers to the efficient generation and use of renewable energy in the housing sector. The fourth chapter constitutes data presentation and analysis ultimately leading to the fifth chapter which draws conclusions from the analysed data in the previous chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the need for renewable sources of energy in the private housing sector, through the implementation of GBFIs in residential housing developments. GBFIs play a role in minimising the effects of the loadshedding cycles brought about by the ongoing energy crisis, and to provide further solutions to GCC mitigation. The chapter further provides an overview of the evolution of GBs, describing the origins of GBs, the need for GBs and the subsequent adoption of GBs in SA. The international standards used to rate GB developments are highlighted leading to the development of the local SA GB rating tools and standards which have been developed based on international GB rating tools and standards. The chapter provides further details on the development of GBs in SA and a summary of the rating tools employed in the commercial and residential sector of SA's real estate industry. The drivers and barriers to the adoption of GBFIs are identified with the use of case studies from developed and developing countries leading to the development of a theoretical framework that may be applied to SA's residential sector, to determine the drivers and barriers to the adoption of GBFIs in SA's private housing sector.

2.2 Overview of the energy crisis and global climate change mitigation

The drastic increase in gas prices has resulted in many markets, such as the United States of America (USA), Europe and Asia, switching to coal rather than natural gas for energy generation (Berahab, 2022). The subsequent high demand placed on coal has therefore caused a record increase in coal prices that has not been witnessed since the early 2000s (Pescatori *et al.*, 2021; Berahab, 2022). The disruption in the energy markets has raised the question of energy security. The European Commission defined energy security as, "the uninterrupted availability of energy resources at an affordable price" (Policy, 2011; Berahab, 2022: 4)

The global energy crisis has resulted in countries around the world facing energy shortages. Major developing economies in Asia and Africa have experienced severe energy shortages including African countries such as SA. The SA electricity tariff witnessed a drastic increase in the face of the energy crisis. Nguyen (2023) further emphasises the increased frequency of loadshedding periods in SA that has caused significant disruption to people's daily lives and economic activity.

Poudyal *et al.* (2019) highlight that with a nation's increased dependency on electricity coupled with challenges in supply-demand management, widespread power outages will likely occur. According to Poudyal *et al.* (2019), there are a variety of key factors that contribute to the energy crisis faced in developing countries. These factors include overconsumption; where energy demand increases faster

with a growing population and energy is not utilised optimally, and inadequate infrastructure and inefficient exploitation of renewable sources of energy (Poudyal *et al.*, 2019). The key factors highlighted by Poudyal *et al.* (2019) have been evidenced by Pretorius *et al.* (2015) in the case of the SA energy crisis. The increased reliance on fossil fuels such as coal, however, have caused economies around the world to explore RE sources of power in a bid to decrease GHG emissions produced by burning fossil fuels.

In June 2019, the United Kingdom (UK) passed legislation committing to bring GHG emissions to net-zero by 2050 (O'Beirne *et al.*, 2020). In passing this legislation, the UK became the first developed economy in the world to take a step further in addressing the GCC challenge. The UK recognised that to meet their greenhouse gas removal (GGR) goals, further action had to be taken to target CO_2 emission levels within the country (O'Beirne *et al.*, 2020). GGR can be described as the removal of greenhouse gas from the atmosphere and facilitating the long-term storage thereof (O'Beirne *et al.*, 2020). The net-zero target has since been viewed as an essential part of the solution of GCC mitigation.

The UK further hosted the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow, on 31 October – 13 November 2021. The main goal was to secure net zero by 2050 and keep a maximum of 1.5^{o}C within reach by accelerating the phase-out of coal, encouraging investment into renewables, curtailing deforestation, and accelerating the transition to electric vehicles (Smith *et al.*, 2022). One of the agreements of COP26 is the phasing out of the use of coal for energy generation. This is one of the key objectives of the UK presidency which resulted in 190 countries agreeing to phase out the use of coal for power generation. The agreement further recognised a 76% decrease in planned new coal power plants and, over 40 countries declared their support for the global "coal to clean power transition statement" (Smith *et al.*, 2022: 1).

COP27 was held in Sharm El Sheikh, Egypt, in November 2022. The key takeaways from the conference however were not in exact alignment with the goals of COP26 as four key themes were established to address GCC namely, mitigation; adaptation; finance; and collaboration (UNFCC, 2023). Finance was labelled as being the cornerstone of world efforts to address GCC mitigation (UNFCC, 2023). COP28, held in Dubai, United Arab Emirates in 2023, identified that global progress has been slow in addressing climate change challenges highlighted under the Paris Agreement (United Nations, 2023). The COP28 agreement includes a call to governments to speed up the transition away from the use of fossil fuels and embrace RE energy sources such as solar and wind (United Nations, 2023).

2.3 Overview of green buildings internationally

The 1990s witnessed the movement towards GB development. GBs are viewed as a direct response to gross energy inefficiencies in buildings, including the vast quantities of waste produced in the construction process and operation, and the large quantities of pollutants and GHG omitted in the construction process (Howe, 2011). The construction sector is considered to be the largest contributor to GHG and pollution (Dwaikat and Ali, 2016). The building sector has been known to be one of the largest consumers of energy generated in economies and one of the leading consumers of total global resource consumption (Dwaikat and Ali, 2016). GBs therefore seek to efficiently use land and energy, incorporate renewable energy sources in building construction and design, improve air quality inside and outside the building, and conserve the use of water and other resources used in the construction process (Howe, 2011).

There are several definitions of what constitutes a green building as the concept is consistently evolving. One of the earlier definitions presented by Yudelson (2010) defines green buildings as ”A high-performance property that considers and reduces its impact on the environment and human health” (Yudelson, 2010: 3). A further definition presented by the Office of Federal Environmental Executives defines green buildings as “the practice of (1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and (2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal—the complete building life cycle.” (Howe, 2011: 4). A study by Wen *et al.* (2020) further supports the earlier definitions of GBs by reiterating that the GBs aim to improve the environmental performance of buildings in their life cycle.

GB practices aim to create structures that are environmentally friendly and resource efficient throughout the building’s life cycle, which comprises the design, construction, operation, maintenance, renovation, and deconstruction of the building. Table 2.1 provides a summary of the categories in the built environment that GBs aim to address during the building’s life cycle. Table 2.1 highlights the key aspects of resource consumption that GBs aim to address and the subsequent environmental effects that arise from inefficient use of resources in the building sector. GBs are therefore designed to curb the ultimate effects listed in table 2.1 by efficiently using the resources highlighted under “consumption” and thereby reducing the environmental effects.

Table 2.1 Categories that GBs address during a building's life cycle

Aspects of built environment	**Consumption**	**Environmental effects**	**Ultimate effects**
Siting	Energy	Waste	Environmental degradation
Design	water	Air pollution	Loss of resources
Construction	Materials	Water pollution	Harm to human health
Operation	Natural resources	Indoor pollution	
Maintenance		Noise	
Renovation		Stormwater run-off	
Deconstruction			

(Source: U.S Environmental Protection Agency, 2019: 1)

The GB initiative around the globe gained momentum in the 1990s with countries such as China launching the building energy saving design standards in 1986 (Zhang *et al.*, 2017). Alongside the progression of increasing the energy efficiency in buildings, the GB concept has gradually increased in China. The long and mid-term development strategies developed by China in May of 2006 included the involvement of GB developments which were subsequently included in China's Eleventh Five-Year plan (Zhang *et al.*, 2017). The evaluation of GBs in China however began in 2003 with the issuing of the Green Olympic Building Assessment System (GOBAS) (Zhang *et al.*, 2017). The Ministry of Housing and Urban-Rural Development (MOHURD) further issued a voluntary building environmental assessment scheme known as Evaluation Standard for Green Building (ESGB) in 2006 (Zhang *et al.*, 2017). The revised standard was issued in 2014, abbreviated as ESGB 2014, aimed at addressing the conservation of resources such as water, energy and other building materials (Zhang *et al.*, 2017).

Developers in China however undergo additional building assessments using standards developed by other countries in a drive to increase international investment (Zhang *et al.*, 2017). The Building Research Establishment Environmental Assessment Method (BREEAM) is one such method that has been employed by several countries across the world including China (Zhang *et al.*, 2017). The BREEAM building evaluation standard was developed in 1990, launched by the Building Research Establishment (BRE) in the United Kingdom (UK) (Dwaikat and Ali, 2016). The BREEAM method assesses and evaluates buildings using a scale of Good, Very Good, Excellent, and Outstanding (Dwaikat and Ali, 2016). The Code for Sustainable Homes (CHS) however, developed in 2008, is regarded as the national

authoritative standard in the UK, with the aim of reducing CO_2 emissions and achieving environmental sustainability of buildings (Zhang *et al.*, 2017).

The development of GB standards and practices occurred in the United States with the formation of the United States Green Building Council (USGBC) founded in 1993 (Dwaikat and Ali, 2016). Preceding the founding of the USGBC was the launch of the Energy Star Program by the United States Environmental Protection Agency (EPA) and the Department of Energy (USGBC, 2019). The Energy Star program is aimed at encouraging the use and manufacture of energy efficient products for use in residential and commercial buildings (USGBC, 2019). The USGBC later launched the Leadership in Energy and Environmental Design (LEED) green building rating system in 2002 (Howe, 2011). The LEED system contains a multilevel rating system for green buildings, certified as Silver, Gold, or Platinum (Dwaikat and Ali, 2016). According to Zhang *et al.* (2017) the LEED system is regarded as one of the most recognised GB environmental assessment systems in the world, thereby forming a model for other countries to create their individual GB assessment criteria.

Developed economies around the world have developed various building environmental schemes, such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, the German Sustainable Building Council (DGNB) in Germany, ESCALE in France and GB Tool in Canada (Zhang *et al.*, 2017). BREEAM and LEED however are regarded as the two most prominent building environmental schemes (Zhang *et al.*, 2017).The introduction of the building environmental schemes across the globe highlights the pivotal role the building sector plays globally regarding energy and resource consumption, including the effect the building sector has on GCC mitigation.

A study by Doroudchi *et al.* (2018) emphasises the role that buildings play in energy consumption by highlighting the 2010 statistics of energy consumption in Europe that evidenced the building sector being the largest end user of final energy consumption, followed by transportation and industry. Recent statistics on the European Union's (EU) energy consumption, however, evidenced a slight difference in final energy consumption in major sectors, with transportation consuming 29.2%, households 27.9% and industry 25.6%. The statistics emphasise the high energy use evident in the housing sector which is consistent with arguments presented by Hache *et al.* (2017) that detail the residential sector as being a high end user of final energy production. The United Kingdom (UK) further evidenced households as being the largest consumer of power at 35%, followed by industry at 30% and services at 29%. The USA evidenced a similar trend to the UK statistics, with 2021 data denoting the residential sector as the highest consumer of electricity, followed by the commercial sector and the transportation sector.

A study conducted by Adamu *et al.* (2020), in the developing country of Nigeria, highlights the household sector as accounting for the majority share of energy usage in the country, approximately 65%. (Oyedepo, 2012; Adamu *et al.*, 2020). Recent energy usage statistics for Nigeria's residential sector, maintain similar usage levels as indicated by Adamu *et al.* (2020), with the residential sector being responsible for approximately 68% of power consumption, followed by commercial and public services. The high share in energy usage, contrasted with the sector wise energy consumption highlighted in the developed nations of the EU and UK, is attributed to the increased rate of urbanisation and lack of access to clean energy resources in developing nations. (Adamu *et al.*, 2020). Bohlmann and Inglesi-Lotz (2018) state that the total energy consumed in the residential sector is influenced by a variety of factors including energy prices, income levels, households' characteristics and access to energy, to mention but a few (Bohlmann and Inglesi-Lotz, 2018).

The amount of energy consumed by the building sector globally has therefore led economies around the globe to develop systems such as GB initiatives aimed primarily at increasing energy efficiency during a building's lifecycle and decreasing finite resource consumption. Developing countries such as SA have introduced the concept of GBs in a drive to play their part in GCC mitigation and to address the energy restraints brought about by the energy crisis in the country.

2.4 Adoption of green building features and initiatives in South Africa

SA is the first African country to join the World Green Building Council (WGBC) (World Green Building Council, 2022). The Green Building Council of South Africa (GBCSA) was founded in 2007 and has developed locally relevant GB rating tools. SA is in the top 30 of the world's largest countries by land mass, with a high urban growth rate estimated to be approximately 67.4% (Agbajor and Mewomo, 2022). The building sector in SA contributes significantly to the Gross Domestic Product (GDP) (Agbajor and Mewomo, 2022). According to Cowling (2024), the SA construction sector contributed an added value of approximately 109.5 billion rands to the economy's GDP, highlighting the significant contribution it makes to the growth of the economy. The construction and real estate sector of SA (mainly industrial, commercial, and institutional buildings) is known to be highly energy dependent as the sector consumes a significant amount of the total energy generated in the country (Agbajor and Mewomo, 2022). Furthermore, residential buildings are known to be one of the largest consumers of electricity generated in SA after the industrial sector (Bohlmann and Inglesi-Lotz, 2018).

Figure 2.1 highlights the residential sector as being one of the largest consumers of electricity in SA. This is consistent with literature presented by Wang *et al.* (2011), Hache *et al.* (2017) , and Doroudchi *et al.* (2018) on the extent of demand that the sector exerts on energy supply and shows that it is a sector capable of contributing to the alleviation of the energy crisis and the realisation of clean energy generation.

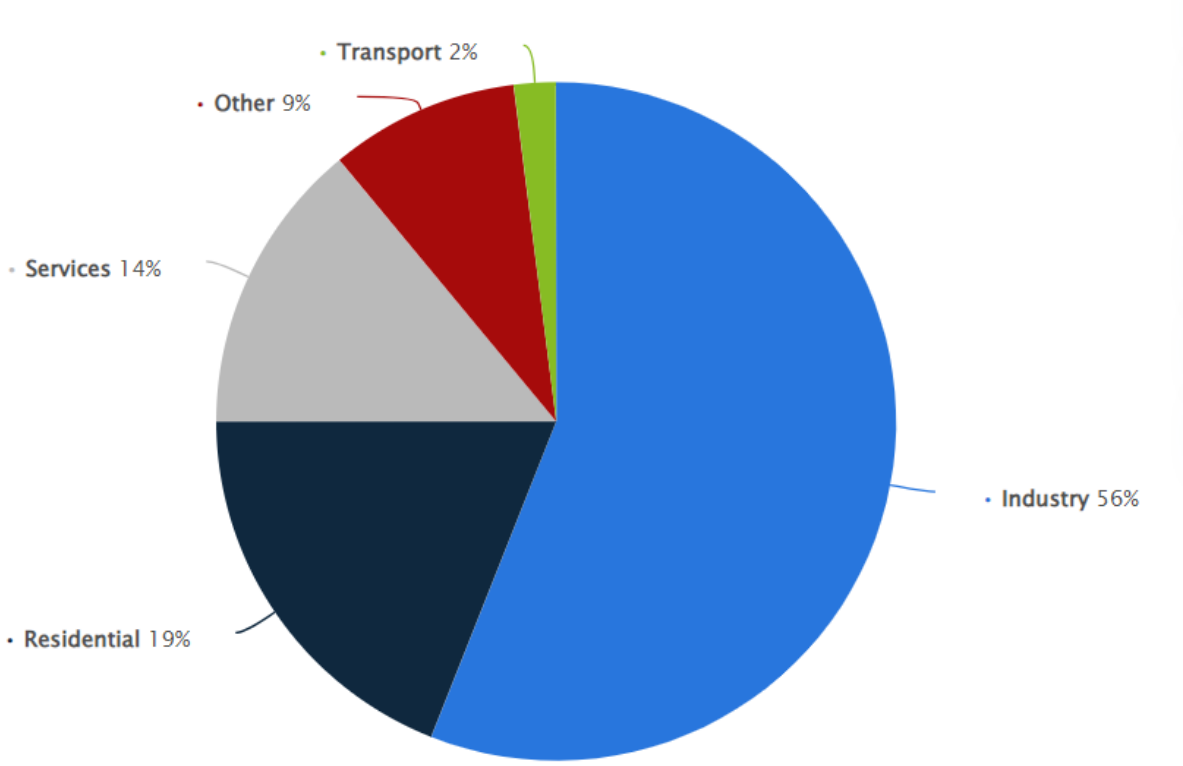

Figure 2.1 Sector wise electricity consumption in SA. Source: Bohlmann and Inglesi-Lotz (2018: 3)

Bohlmann and Inglesi-Lotz (2018) further state that the consumption by the residential sector is on a continual increase owing to the consistent rise in the population. According to Bohlmann and Inglesi-Lotz (2018), analysis of the residential sector's energy consumption is important as it consumes a significant share of energy on a global scale. Hache *et al.* (2017) further states the need to design policies that are aimed at curbing residential energy consumption or reducing the sectors' carbon footprint significantly.

Agbajor and Mewomo (2022) further reiterate the importance of GBs or sustainable construction (SC) owing to the predicted increase in urban growth, whereby 90% of urban growth is expected to occur in Asia and in Africa. The continual evolution of the GB concept however has allowed for a more detailed understanding of what makes up GBs. A GB can therefore be seen as a structure that uses construction processes and features that are environmentally responsible and resource efficient through the entirety of the building's lifecycle. Green Building Features and Initiatives (GBFIs), as

defined earlier, are however found in both green certified and non-green certified buildings. The GBFIs aid in making a building more resource efficient, and in reducing the overall carbon footprint of the building's tenants.

2.5 Green building certification tools in South Africa

The GBCSA provides tools and training to better promote the implementation of green practices in building development (GBCSA, 2017). The involvement of the GBCSA in recent years has encompassed the residential sector by creating GBFIs certification systems for residential projects in addition to the long existing certification systems for commercial projects, thereby encouraging developers to incorporate green practices in the building sector (GBCSA, 2017).

2.5.1 Green Star certification

The GBCSA is responsible for the development of the Green Star SA rating tool which is used as an objective measurement tool for commercial buildings s in SA (GBCSA, 2017). The Green Star rating tools award points across nine categories, namely, Management, Energy, Indoor Environment Quality (IEQ), Transport, Water, Materials, Land Use & Ecology, Emissions, Innovation, and an additional category known as Socio Economic (GBCSA, 2017).

2.5.2 Excellence in Design for Greater Efficiencies (EDGE)

The Excellence in Design for Greater Efficiencies (EDGE) is a rating tool employed by the GBCSA to certify buildings in SA's residential sector (GBCSA, 2017). The EDGE certification standard sets a minimum of 20% reduction in a building's energy consumption, water consumption and embodied energy (GBCSA, 2017). The EDGE-Residential standard allows for key players in the construction industry, developers, and investors to construct energy and water efficient spaces. Isimbi and Park (2022) state that the primary purpose of EDGE certified buildings is to reduce buildings' negative environmental impact by supporting sustainable design and construction and therefor providing official validation through the form of certificates that reduction standards have been met. Projects developed according to the EDGE-Residential standard provide reductions in the carbon emissions, increase water savings and in turn lower the cost of living (GBCSA, 2017). The EDGE certification passes through two stages, the first being the preliminary stage which occurs during the design stage of the building, whereby the feasibility of the green measures is established using the EDGE software (GBCSA, 2017). The second stage of the EDGE certification is the post construction, where an EDGE auditor inspects the site post construction, and verifies the project's green credentials (GBCSA, 2017).

2.5.3 Net-Zero

The GBCSA Net-Zero rating tool can be viewed as the end goal of GBFIs in SA. The Net-Zero/Positive rating tool is awarded to projects which have managed to go above and beyond the requirements of the aforementioned rating tools, thereby completely neutralizing the impacts that the rating tools are seeking to mitigate (GBCSA, 2017). According to the GBCSA (2017), projects can achieve Net-Zero/Positive Ratings in carbon, water, waste and ecology. The concept of Net-Zero energy homes (NZEH) developed in response to the amount of energy consumed by the residential sector. NZEH implies that the primary energy the house uses throughout the year is generated from renewable sources of energy (Leckner and Zmeureanu, 2011). The NZEH therefore must be equipped with systems, in or around the house, that will enable the conversion of the renewable sources of energy, into the energy consumed by the house (Leckner and Zmeureanu, 2011). Peak energy demand times, however, may require more energy than can be supplied by the NZEH systems, therefore electricity should be purchased from the national utility grid and then sold back to the grid when the homes produce excess electricity (Leckner and Zmeureanu, 2011).

The concept of NZEH, also referred to as Net Zero Energy Buildings (NZEB), is further defined by the U.S Department of Energy (DoE) building technology programs as "a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies" (Hassoun and Dincer, 2014: 2). Hassoun and Dincer (2014) highlight an earlier case study conducted by Wang *et al.* (2009) on zero energy houses in the UK, where a typical household in the UK, occupied by two people, was analysed in terms of yearly electricity consumption and compared to levels of electricity that can be generated via renewable means to service that household. The case study estimated the total yearly electricity consumption to be 6008.9 kWh for that specific household and evidenced approximately 7305.9 kWh electricity generated via renewable means of PV and wind turbines (Wang *et al.*, 2009; Hassoun and Dincer, 2014). The case study evidenced that it is possible to achieve NZEH in the UK if the correct renewable energy technologies are implemented and the correct energy efficiency measures are taken (Wang *et al.*, 2009; Hassoun and Dincer, 2014).

The NZEB concept has gained traction on a global scale with governments intervening by setting energy legislation to control energy use and, thereby curb the negative environmental effects arising from energy production and use (Doroudchi *et al.*, 2018). Residential buildings themselves, being responsible for a significant amount of energy consumption, led the EU member states to agree to have all new buildings to achieve a net zero energy use (Doroudchi *et al.*, 2018). The aim of the zero-energy concept is to aid in design and construction of homes and communities that will place less

dependence on power from the utility and create a self-sufficient energy system based on renewable energy sources (Doroudchi *et al.*, 2018). The net-zero energy concept is grounded in the theory that a building consumes as much energy as it generates and further emphasises that this can be applied to a neighbourhood or a community where an integrated renewable system is applied to all homes in that area (Doroudchi *et al.*, 2018).

Ahmed *et al.* (2022), in a recent study on renewable energy towards a net zero approach, provide an illustration of a NZEB in figure 2.2, that provides a visual of the concept of net-zero consumption of energy, or zero carbon emission. Ahmed *et al.* (2022), in figure 2.2, present a two-way grid system that can deliver energy to a building and further receive from it, which is either an on-site or off-site grid. The green arrow represents the opposite, which is the energy delivered to the building via an on-site or off-site RE grid. A building can achieve NZE in several ways, such as retrofits or integrated building design (Ahmed *et al.*, 2022). The primary method however of achieving NZEBs is via the use of RE sources, such as wind, solar, geothermal and bioenergy (Ahmed *et al.*, 2022). The NZEB concept has been widely regarded in literature as one of the most innovative concepts to achieve energy saving and aid in the reduction of CO_2 emissions.

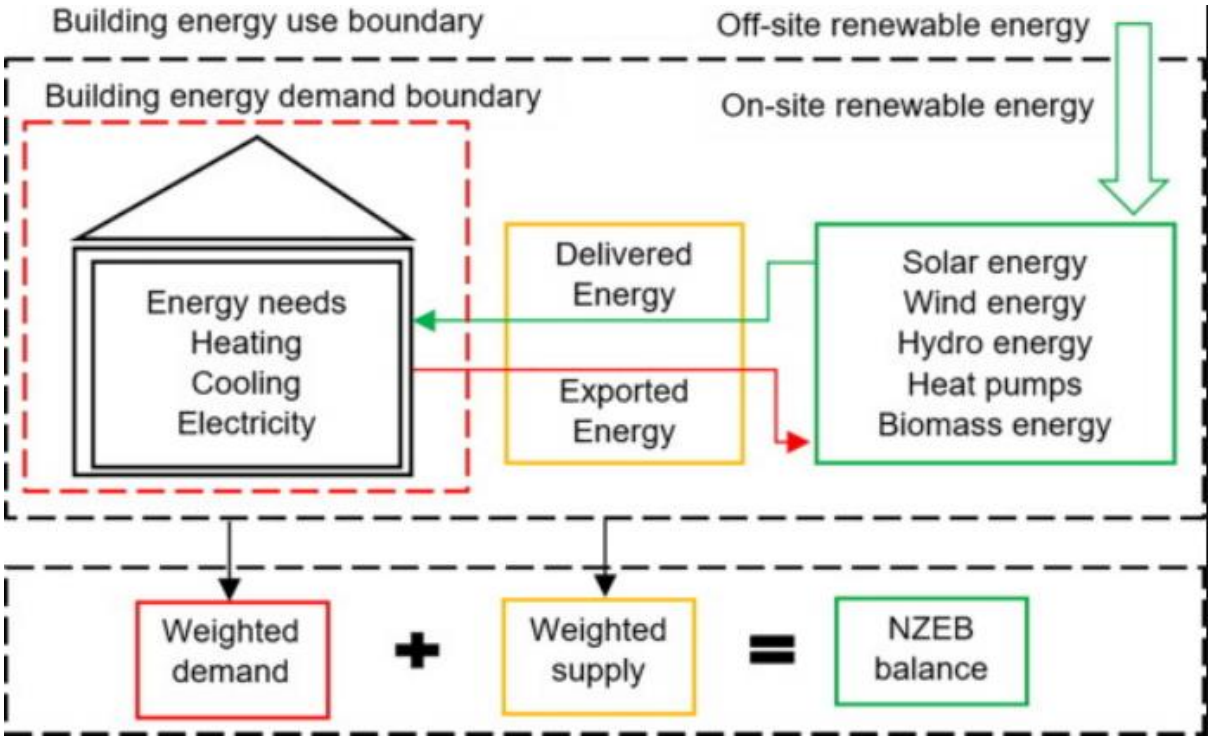

Figure 2.2 Visual representation of NZEB. Source: (Ahmed et al., 2022: 2)

The realisation of NZEB however, depends on the availability of RE sources that can be harnessed optimally in the area. SA for example has several suitable and common sources of RE, namely, solar, wind, hydroelectric and biomass (Thopil *et al.*, 2018). The use of RE however has one major drawback

detailed by Thopil *et al.* (2018), which is the widespread availability of the RE source. Thopil *et al.* (2018) however states that for SA, there is sufficient availability of RE throughout parts of the country, mainly in the form of solar and wind.

Ibrahim *et al.* (2021) support the data provided by earlier scholars on the availability of RE in SA by providing dominant sources of RE in SA's provinces. Seven of the nine provinces evidence solar as the most abundant source of RE, with Mpumalanga and KwaZulu Natal having biomass as the primary source of RE. Wind energy is the second most available RE source in several provinces namely, Western Cape, Eastern Cape, and Northern Cape. Hydropower energy, however, is evidenced to be in use in the Eastern Cape, Free State, and Northern Cape, at lower levels compared to the aforementioned RE sources (Ibrahim *et al.*, 2021). The uptake of RE sources indicates that SA is moving in the right direction with regards to RE as data showed that in June 2015, RE capacity increased from 7 to 1860MW which was approximately 287MW below the planned capacity (Ibrahim *et al.*, 2021). The majority of the RE increase, 1850MW, came from solar PV and wind, with hydro generating approximately 10MW (Ibrahim *et al.*, 2021).

2.5.4 Energy Water Performance

The Energy Water Performance (EWP) rating tool was developed by the GBCSA in 2011 in response to the SA Property sector in a drive to address energy and water consumption in existing buildings with office buildings being the initial recipients of this tool (GBCSA, 2017). The EWP tool allows office building owners to compare their office building performance to other similar office buildings in the sector. The tool further allows for more efficient decision making regarding which office buildings to sell or retrofit and provides prospective tenants and buyers with important information to make decisions (GBCSA, 2017).

The EWP tool functions as an operational performance measurement tool that assesses the entire office building by comparing energy and water usage figures against a national "average" benchmark that is adjusted for climate, the number of computers, the number of occupants, annual vacancies, and operating hours (GBCSA, 2017). The building is then rated on a 10-level scale based on the performance according to the national benchmark (GBCSA, 2017).

2.6 Green building practices in the private real estate sector

The successful integration of GBFIs in the building sector relies on support from the government in terms of policies and the adherence to these guidelines by key players in the construction sector (Ho *et al.*, 2013). Numerous studies have been conducted in developed and developing countries to identify the barriers to green building practices and provide solutions to these barriers (Nikyema and

Blouin, 2020). The top five barriers in the US included long payback periods, cost, preference for traditional building practices over advanced ones, high costs, and limited users' knowledge with green practices and technology (Nikyema and Blouin, 2020). Further studies in developed countries such as Singapore and Australia have experienced similar barriers to the US and added more barriers including lack of research on barriers to green building practices and technologies, lack of team communication on green building projects, lack of government support for green projects, among others (Hwang and Tan, 2012; Hwang and Ng, 2013; Nikyema and Blouin, 2020). Several earlier studies in developing countries such as Malaysia, Turkey, China, and India have affirmed the barriers highlighted in studies conducted in developed countries and added other barriers including a lack of databases and lack of information on GB practices and technologies (Bin Esa *et al.*, 2011; Zhang and Wang, 2013; Nikyema and Blouin, 2020).

GBFIs have proven to not be as simple to implement in developing countries as compared to developed countries. Chang *et al.* (2016), in a study on facilitating the transition to sustainable construction, highlights that developing countries face challenges in meeting some of the green building standards owing to resource constraints. In the case of China, the challenges lie in the ineffectiveness of certain pivotal policies such as the Environmental Impact Assessment (EIA) Policy (Chang *et al.*, 2016). In a study conducted by Nikyema and Blouin (2020), in the developing country of Burkina Faso in West Africa, it was found that there are several barriers that limit the adoption of efficient GBFIs in their building sector thereby inhibiting the economy from keeping up with the global standards on GCC mitigation.

The findings from Nikyema and Blouin (2020) uncovered that the major barriers included government-related barriers (comprised of ineffective government regulations and policies), human-related barriers (comprised of a lack of financial funding to back green initiatives), market-related barriers (owing mostly to a lack of access to green technologies) and knowledge and information-related barriers (which primarily speak to the lack of knowledge in sustainable construction by the professionals in the industry) in Burkina Faso. The barriers highlighted in the above-mentioned Burkina Faso case study were adopted from the condensed barriers to implementing green building practices and technologies as categorized by Chan *et al.* (2018). Chan *et al.* (2018), through an extensive review of the literature surrounding the barriers to green building practices and technologies, identified 26 recurring barriers that were then grouped into the five categories mentioned by Nikyema and Blouin (2020), and can be applied to developing countries alike (Chan *et al.*, 2018). The barriers therefore reflect some of the major challenges faced by developing countries in Africa today when trying to adopt GBFIs and meet international GCC mitigation standards. Aktas and Ozorhon (2015) however

stress the need for countries to undertake in-house studies on barriers to implementation of GBFIs to produce local solutions to the country-specific barriers.

2.7 Drivers to implementing GBFIs in South Africa

Marsh *et al.* (2020) provides five main categories, each containing sub-themes, highlighting the main drivers to the implementation of GBFIs in SA. The categories were derived from an extensive review of literature from both developed and developing countries as well as articles published within SA (Marsh *et al.*, 2020). The five main categories are Socio-cultural drivers, Environmental drivers, Stakeholder drivers, Political drivers, and Technological drivers.

Political drivers are comprised of financial incentives and several other market-based incentives that the government can employ to stimulate the adoption of GBFIs (Marsh *et al.*, 2020). Land use regulations and policies form part of the political drivers as these must be updated to stay abreast of developments relating to GBFIs.

2.7.1 Political initiatives

The political drivers include government's encouragement of GBFIs through financial and several other market-based incentives (Marsh *et al.*, 2020). An earlier study by Oguntona *et al.* (2019) revealed that GB development is driven by government involvement by means of providing more economic incentives thereby increasing the availability of financing options by investors. Oguntona *et al.* (2019) further suggest that there is an increase in GB developments when the government provides support to key stakeholders in the construction industry. Updated land use policies and building regulations were further identified as drivers under the political initiatives. Updating the regulations and policies further allows developers to implement GBFIs more efficiently and encourages stakeholders to familiarise themselves with GB technology and principles (Marsh *et al.*, 2020). Additionally, enforcement of mandatory GB policies was identified as another way government drives the adoption of GBFIs as well as tax relief offered to developers who adhere to the policies and adopt GB technologies in their developments. The introduction of performance-based measurements, such as Green Star rating tools forms part of the political drivers in the adoption of GBFIs.

2.7.2 Stakeholder drivers

Stakeholder drivers relate to the corporate image and reputation that GBFIs provide to firms in the construction industry and, GBFIs provide an integrated building design approach with the multiple project stakeholders (Marsh *et al.*, 2020). Stakeholders are further encouraged to provide committed resources and expertise regarding procurement and decision making for GBFIs. Darko et al. (2017)

emphasises that increased attention on sustainability matters in the construction industry in recent years, has driven stakeholders to implement green principles in their developments. Anzagira *et al.* (2019) in a study on the uptake of GBs in Ghana, identified good company image as a driver in the uptake of GBFIs which forms part of the stakeholder drivers.

2.7.3 Environmental drivers

The Environmental drivers primarily speak to the protection of the environment through promotion of GBFIs and the promotion of waste reduction in the construction development process (Marsh *et al.*, 2020). Increased sensitivity from organisations on the environmental benefits of adoption of GBFIs in developments further creates a positive corporate image and encourages other industry practitioners to adopt GB practices. Preservation of natural resources forms part of the key environmental drivers, which were identified by (Anzagira *et al.*, 2019).

2.7.4 Socio-cultural drivers

The findings from the study conducted by Oke *et al.* (2019) deemed client awareness to be one of the key drivers of the adoption of GBFIs. The client is an important stakeholder as demand for GBs plays a crucial role in achieving an adequate GB (Oke *et al.*, 2019). In addition, Marsh *et al.* (2020) extend awareness to other construction stakeholders, including contractors and consultants who are responsible for design and development. Increased education programmes surrounding GBFIs and the adoption of GB practices allow for a high return on the investment if GBFIs are implemented (Marsh *et al.*, 2020). Education and training on GBFIs to stakeholders therefore ranked as an important driver to the adoption of GBFIs in developments.

2.7.5 Technological drivers

The technological drivers consist of the availability of GB products and materials for innovation purposes and research and development (Marsh *et al.*, 2020). Similarly, Oguntona *et al.* (2019) highlights that improvement of green technology is one of the crucial drivers to adopting GBFIs. Darko et al. (2017) further states that one of the key features of GBs is the reduced whole lifecycle cost of the building. Reduction in the lifecycle cost is further achieved via implementation of innovative green technologies, such as water-saving appliances and permeable water-saving technologies that reduce water and energy usage without compromising efficiency (Darko et al., 2017).

2.8 Barriers to implementing green building initiatives

2.8.1 Government related barriers

The extensive government related barriers highlighted in the Burkina Faso pilot case study included the inefficient adaptation of GB policies and regulations to meet the local needs, ineffective government programs that are geared towards GB developments, lack of efficient government policies relating to green construction and a lack of government tax incentives for the general public regarding green construction (Nikyema and Blouin, 2020). Chan *et al.* (2018) argues that government incentives are the most important aspect of government related barriers to adoption of green building technologies (GBTs). Incentives act as key motivators for construction stakeholders to adopt GBFIs in construction projects. The lack of incentives therefore leads construction stakeholders and practitioners to resist adoption of GBFIs (Chan *et al.*, 2018). The findings from the Ghana case study by Chan *et al.* (2018) identified several government related barriers to the adoption of GBTs including the lack of institutions geared at research and development (R&D) of GBTs, a lack of demonstration projects and a lack of GBT technology training for staff, on top of the government related barriers highlighted by Nikyema and Blouin (2020).

2.8.2 Human-related barriers

The human-related barriers uncovered by the Burkina Faso pilot case study indicated a lack of awareness by the general public regarding the benefits of building green, and a severe lack of efficient network systems that provide information on GBs that are geared towards the public (Nikyema and Blouin, 2020). Chan *et al.* (2018) in their findings from a case study in Ghana, highlight similar critical human-related barriers to the Burkina Faso case study. The critical human related barriers uncovered by Chan *et al.* (2018) include the unfamiliarity of GBTs by the construction stakeholders, lack of importance placed on GBTs by senior management, attachment to traditional technologies as opposed to GBTs and a lack of financing schemes. The lack of financing schemes is considered a major barrier to the adoption of GBTs as it is closely related to the barrier of higher cost of GBTs. The lack of financing schemes creates an unsteady foundation for organisations to invest in costly GBTs (Chan *et al.*, 2018).

2.8.3 Market-related barriers

The unavailability of green technologies in the market was highlighted as the most prevalent market-related barrier in the Burkina Faso case study (Nikyema and Blouin, 2020). Studies have highlighted that a lack of access to GB technologies is one of the primary market-related barriers to the adoption of GB practices and technologies in developing countries, particularly if there is a need for the

developing country to import the materials required (Aktas and Ozorhon, 2015; Nikyema and Blouin, 2020). Chan *et al.* (2018) further identified three critical market related barriers in the case study conducted in Ghana namely, lack of interest from clients and market demand, inaccessibility of GBTs in the Ghanaian market and inexperience with procurement methods that stray from traditional means. The adoption of GBFIs in a developing country is critically influenced by consumers' interest and demand in GB products (Chan *et al.*, 2018).

2.8.4 Cost and Risk Related Barriers

Studies have indicated that cost related barriers in developing countries may arise from the need to import the resources required to meet GB standards (Aktas and Ozorhon, 2015). Green materials therefore appear to have a higher initial cost compared to traditional building materials. The cost is further increased by the installation cost of GB technologies (Aktas and Ozorhon, 2015). Nikyema and Blouin (2020) further highlight that in the Burkina Faso case study, the aforementioned cost related barriers have prevented the adoption of GBFIs in the developing economy (Nikyema and Blouin, 2020). Chan *et al.* (2018), in a case study on the critical barriers to green building technology (GBT) adoption in Ghana, emphasize the role that cost has in the adoption of GBFIs in developed and developing countries. The findings from the case study highlighted that the high costs associated with GBTs are responsible for hindering the adoption of GBTs in the developing country of Ghana (Chan *et al.*, 2018). The cost barrier has further been closely associated with other barriers such as, a lack of awareness of GBTs and related benefits, lack of government incentives and a lack of adequate financing schemes.

2.9 The link between GBFIs and the private residential housing sector

The drivers and barriers to the adoption of GBFIs in the SA economy have primarily been in reference to the commercial side of the building sector. The drivers of the uptake of GBFIs collated by Marsh *et al.* (2020), primarily relate to the commercial sector of buildings as this was the initial focus of GB implementation. The barriers to the uptake of GBFIs however, were identified in the study by Nikyema and Blouin (2020), that primarily targeted developing countries. A framework of the key barriers was developed and employed in the study by Nikyema and Blouin (2020). The identified barriers however related primarily to the commercial space owing to the economic importance that the commercial space has in a developing economy that is adopting GB principles and targets. Further drivers and barriers identified by Aktas and Ozorhon (2015), Darko et al. (2017), Chan *et al.* (2018), Anzagira *et al.* (2019), Oguntona *et al.* (2019), and Oke *et al.* (2019), relate to the real estate sector as a whole and do not differentiate between residential and commercial.

As discussed in Section 2.4, the residential sector however is a significant consumer of energy in economies, highlighting the importance of unpacking drivers and barriers that directly affect the residential sector. Rating tools have since been developed to relate to the housing space (GBCSA, 2017). There is minimal research on the drivers and barriers that directly relate to the private housing sector regarding the adoption of GBFIs. The detailed drivers and barriers provide a potential framework for understanding the drivers and barriers that may likely be relevant to the private housing sector. The private housing sector, as highlighted earlier in the literature review, plays a significant role in GCC mitigation and in addressing the energy crises that is currently faced by SA. Understanding the drivers and barriers to the adoption of GBFIs in the private housing sector will allow for a more holistic account of the state of adoption of GBFIs in the building sector of SA. Figure 2.3 provides the theoretical framework that underpins the research, by visually representing the key drivers and barriers to adoption of GBFIs in SA's real estate sector.

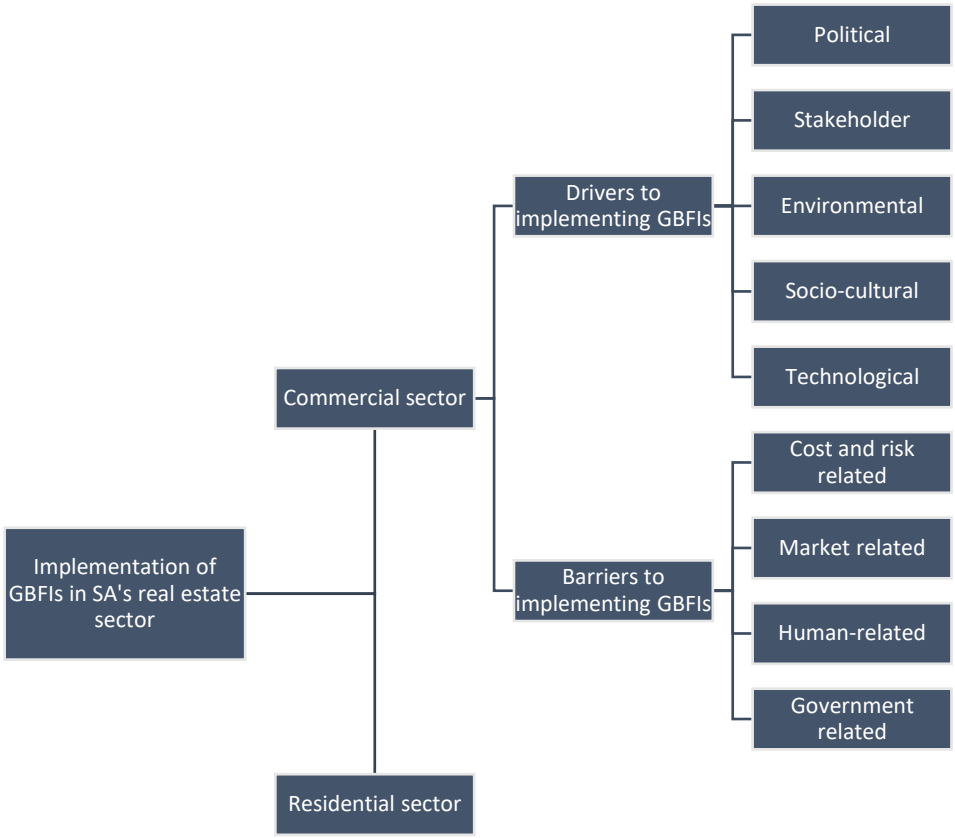

Figure 2.3 Theoretical framework. Source: Authors construct (2023)

2.10 Chapter Summary

The literature review provides a clearer picture of the origins of GBFIs from a global viewpoint down to the local SA context. The contribution of the construction sector to energy use and GCC is highlighted, which has led to economies adopting GB practices and rating tools in a drive to create more sustainable construction. There are various rating tools used to promote GB developments, with more tools becoming applicable in the residential sector of the building industry. The more notable views discussed in the literature review shine light on the drivers and barriers that developing and developed countries face when attempting to implement GBFIs in the building sector. In the case of SA, there exists drivers and barriers to adoption of GBFIs but mostly relating to the commercial side of the building industry. Figure 2.3 provides a summary of the key drivers and barriers to implementation of GBFIs in the commercial real estate sector. The literature on the drivers and barriers to the uptake of GBFIs is not sufficiently extensive and does not speak directly to the private housing sector. The drivers and barriers highlighted in the literature review however form the basic framework for understanding drivers and barriers faced in the private housing sector of SA as represented in the framework below.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The chapter details the development of the research method employed in collecting the data required to carry out the research, answer the research question and accomplish the research objectives. The research employed a qualitative approach using semi-structured interview questions. A case study design approach was used and justified after examining previous similar research studies that employed a case-study approach. The chapter further details the research design, data collection method and sampling method employed.

3.2 Research method

3.2.1 Previous research

A study conducted in the UK by Martiskainen and Kivimaa (2019), on the role of knowledge and policies as drivers for low-energy housing, made use of the qualitative research approach and employed the case-study method. Martiskainen and Kivimaa (2019) focused on 6 low-cost housing projects in the UK that made use of renewable energy technology. The 6 projects represented the 6 case studies that Martiskainen and Kivimaa (2019) used. The research method started with a review of the academic/policy literature related to renewable energy in the low-cost housing space followed by semi-structured interviews with experts such as local and national policy makers, housing associations, researchers and non-profit practitioners (Martiskainen and Kivimaa, 2019).

An earlier study by Barry *et al.* (2011) on the selection of renewable energy technologies for Africa employed the qualitative research approach using 8 case studies that were conducted in Rwanda, Malawi and Tanzania. The purpose of the research was to build on the previous research findings that highlighted the factors that contribute to the selection of appropriate renewable energy technologies (Barry *et al.*, 2011). The case studies mentioned by Barry *et al.* (2011) focused on collecting data related to the implementation of various forms of renewable energy in households, businesses and institutions across the mentioned African countries. The research method consisted of interviews with implementing agencies as well as end users of the various technologies (Barry *et al.*, 2011). The secondary data was gathered in the form of project reports and other documentation (Barry *et al.*, 2011).

3.2.2 Qualitative approach

Research approaches consist of plans and procedures that will guide the research in terms of providing detailed methods of data collection, analysis, and interpretation (Creswell, 2014). According to Creswell (2014), there are three approaches to research, namely: qualitative, quantitative and mixed method. Creswell (2014) further expresses that each of the methods are not as discrete as they appear, seeing as research can tend to be more qualitative than quantitative or vice versa. The mixed method approach however resides in the middle as it incorporates both qualitative and quantitative approaches (Creswell, 2014).

The research employed a qualitative approach. Qualitative research is an approach used in exploring and understanding the meaning that individuals or groups attribute to a particular human or social problem (Creswell, 2014). Qualitative research generates non-numerical data and has been recognized to add a new dimension to studies, that cannot be obtained through measurement of variables alone (Pathak *et al.*, 2013). The process of qualitative research consists of emerging questions and strategies, with data typically being collected in the participants setting, followed by data analysis building to form general themes, and the researcher interpreting the meaning of the data (Creswell, 2014). Qualitative research therefore uses an inductive style that allows the researcher to focus on rendering the complexity of a situation and the individual meaning (Creswell, 2014). The qualitative approach was therefore suitable for this research as it sought to investigate the drivers and barriers to implementing GBFIs in the private housing sector.

3.2.3 Limitations of case study

The case study approach is a qualitative method that serves to answer questions that the researcher does not have much control over (Quintão *et al.*, 2020). Case studies should further be viewed as a means to shed empirical light on theoretical concepts (Yin, 2018). Validity and reliability however have been dimensions that have been criticised in the case study approach (Quintão *et al.*, 2020). Validity and reliability speak to the trustworthiness of the findings obtained, which should be “credible, confirmable, transferable, and dependable” (McGloin, 2008: 265; Quintão *et al.*, 2020). The use of case studies in published scientific research has been numerous despite the difficulties that persist in design and operationalisation (Quintão *et al.*, 2020). To increase reliability and validity, Yin (2018) presents four criteria that must be ensured, namely:

- Construct validity to ensure that the researcher can correctly evaluate the studied concepts (Yin, 2018)

- Internal validity; to confirm that the conclusions are appropriate in light of the data obtained (Yin, 2018)
- External validity; which originates from the ability of the results to represent the studied phenomenon (Yin, 2018)
- Reliability; which relates to the ability of replication of the study by another researcher (Yin, 2018)

The replicability of the study becomes important in a multiple case studies where literal replication logic can be used to predict similar results, or where theoretical replication logic can be used to where contrasting results are required for predictable reasons (Quintão *et al.*, 2020). The study therefore makes use of the 4 step criteria presented by Yin (2018) to ensure a rigorous process that ensures reliability and validity of the case studies.

3.2.4 Unit of analysis

Case study research design is comprised of several components including, the research question(s), the propositions, the unit of analysis, the theory linking the data to the proposition and the data interpretation criteria (Yazan, 2015). The definition of the unit of analysis however, has been plagued with ambiguity as Grünbaum (2007) argues that there is no clear distinction between what defines a case study and a unit of analysis. Berg (2001: 188) however argues that a "unit of analysis defines what the case study is focusing on (what the case is), such as an individual, a group, an organisation, a city, and so forth." The unit of analysis can therefore be regarded as the individual or group of people being studied.

The study's research question is "what are the drivers and barriers to implementing Green Building Features and Initiatives (GBFIs) in SA's private housing sector?". The focus of the study is identifying the drivers and barriers to GBFI uptake in the private real estate market, therefore making the location of the developments the case study. The unit of analysis is thus comprised of the individual(s) being interviewed. To maintain a consistent approach, the general respondents responsible for all case study sites were interviewed to provide information on all the case studies. The interviewees were chosen based on their current professional position within the organisation in relation to the research topic and role in the case study developments. Subsequent interviews were conducted with one individual from each case study who was responsible for the daily site operations and could add to the information already provided by the general respondents.

3.2.5 Multiple case study design

Research designs, also referred to as strategies of inquiry, specify the types of study within the chosen research approaches detailed previously. Research designs are types of inquiries that provide specific direction to the research design (Creswell, 2014). The types of approaches employed in qualitative research design have increased over time and Creswell (2014) and makes mention of five types, namely: narrative research, phenomenological research, grounded theory, ethnography, and case studies. The research adopted the multiple case study approach to address the research question. According to Graue (2015: 15), a case study is "an empirical inquiry that describes a contemporary phenomenon in a real-world context under consideration, particularly if the boundary between the observed phenomenon and context is not clear". (Graue, 2015) A case study approach allows for an in-depth exploration of intricate phenomena within a given context (Graue, 2015). A case study gathers data using a variety of sources and using different methods such as interviews and observations. Case studies allow for research to be conducted in detail particularly when dealing with a large number of research participants and provides insight for further research (Graue, 2015)

The multiple case study approach however has multiple advantages compared to the single case study analysis. Gustafsson (2017) expresses that a multiple case study analysis allows the researcher to analyse data within each case and across different cases. The researcher is able to analyse various cases thereby establishing differences and similarities amongst the cases and in turn add to the literature with key influences of the differences and similarities (Gustafsson, 2017). The multiple case study analysis can therefore be seen to inherit the strengths of a case study approach whilst allowing for a broader more holistic exploration of the research phenomenon. The multiple case study approach was therefore suitable for this research, as it sought to explore the circumstances, detailed in the research problem, across the largest metropolitan areas in SA according to their population. The 3 chosen metropolitan areas for the case studies were Cape Town, Johannesburg, and Pretoria.

The qualitative multiple case study design, while valuable in providing in-depth insights, presents ethical risks related to participant privacy, informed consent, and researcher bias. For instance, researchers may unintentionally expose participants to harm by not fully disclosing the research's purpose or by misinterpreting sensitive data. Therefore, in line with ethical research standards, interviewees participated voluntarily after giving informed consent. The identity of interviewees is protected by using coding, thereby ensuring confidentiality. Furthermore, reliability and validity in qualitative research involves ensuring consistency and accuracy in data collection, analysis, and interpretation. Reliability can be enhanced through strategies like member checking, where participants review findings to confirm accuracy, and maintaining a detailed audit trail to document

research decisions (Nowell et al., 2017). Validity is strengthened through triangulation, which involves using multiple data sources or methods to cross-check findings (Patton, 2015). The research therefore achieved reliability and validity by interviewing respondents who meet the relevant criteria and by using interviews, observations, and literature findings as multiple data sources to cross-check the collected data.

3.2.6 Sampling method

The purposive sampling method was used, which is classified under non-probability sampling. According to Etikan *et al.* (2016), a sample refers to a portion of the population or known universe. Etikan *et al.* (2016) further states that the population itself does not strictly refer to a number of people but can refer to a total quantity of things or cases that are the subject of the research. There exists Probability sampling, which essentially means that each unit in the population has a non-zero chance of being included in the sample population (Etikan *et al.*, 2016). The opposite to probability sampling is the nonprobability sampling method. Nonprobability sampling does not require a random selection of participants from the population to create a sample, the selection is subjective and based on the specific elements that the researcher wishes to include in the sample (Etikan *et al.*, 2016). Purposive sampling is further described as a technique employed in the deliberate selection of participants owing to the specific qualities they possess, and the participants are selected via virtue of the knowledge and experience they possess (Etikan *et al.*, 2016).

The participants selected for this study needed to be directly involved in the development and planning aspect of GB in the SA private housing sector. Knowledge of GB technologies and principles was a requirement in the selection criteria which further encompasses the purposive sampling technique. The reason for selecting participants with the criteria detailed above was to ensure that respondents would be able to provide information surrounding GBFIs and ultimately the drivers and barriers to implementing GBFIs in the various case study developments.

3.3 Data collection

Face-to-face interviews were the primary data collection method, and the secondary method consisted of reviews of the national and municipal policies in conjunction with other relevant documents. Interviews provide a means for the participants to engage with the topic and provide their opinions. There are three main types of interviews, namely structured, semi-structured and unstructured interviews (Kajornboon, 2005).

3.3.1 Structured interviews

Structured interviews are a form of data collection method that control the data drawn out from the respondent tightly. Alsaawi (2014) describes structured interviews as pre planned interviews where the questions have been set out by the researcher, before conducting the interview, in a bid to maintain focus on the interview topic. The structured interview method however restricts the acquisition of in-depth data and further limits variations to the interview responses owing to the tight control (Alsaawi, 2014).

3.3.2 Unstructured interviews

Unstructured interviews are the opposite of the above-mentioned method owing to the unplanned nature of the questions. Alsaawi (2014) describes this method as one that promotes flexibility in the respondents' feedback and allows for greater elaboration which can result in the interview veering into unpredictable directions. Alsaawi (2014) further expresses that this form of interviewing allows for a more relaxed atmosphere characterised by less interference from the interviewer and is appropriate for researchers wanting to focus on a specific phenomenon in great depth as the data gathered may be significantly large.

3.3.3 Semi-structured interviews

Semi-structured interviews provide an outline for the topics to be covered and allow the interviewees more space to provide honest feedback (Kajornboon, 2005). Semi-structured interviews further allow for the collection of qualitative, open-ended data that are useful in addressing the research question (Kajornboon, 2005). Alsaawi (2014) further identifies semi-structured interviews as being a mixture of the structured and unstructured interview methods. The questions are structured in the sense that they are pre-planned, but unstructured owing to the open-ended nature of the questions which allows for follow up questions leading to more depth in the answers due to elaboration from the respondents (Alsaawi, 2014).

3.3.4 Advantages of interviews

Face-to-face (FtF) interviews are a common and popular form of qualitative data collection. FtF interviews are commonly characterised by synchronous communication in time and/or space. There further exists FtF interviews which are synchronous in time but asynchronous in space, such as interviews over platforms such as Zoom or Microsoft Teams. Opdenakker (2006) however states that there are pros and cons to the use of both synchronous and asynchronous FtF interviews. The pros of the chosen synchronous FtF method are that it takes advantage of the social cues present in FtF

interviews. The social cues such as body language, intonation and voice can be considered and added to the non-verbal transcription of the responses. A further advantage identified by Opdenakker (2006), is that synchronous communication allows for spontaneity on the part of the respondent without need for extended reflection.

Further pros identified by Opdenakker (2006) include:

- The ability of the interviewer to create a positive interview ambience.
- Termination of the interview is simpler, as compared to other methods, as clues can be provided that the interview is coming to an end, such as the shuffling of papers or turning off the tape recorder.

3.3.5 Disadvantages of interviews

FtF interviews however have certain drawbacks that have been identified in literature. Phellas *et al.* (2011) argue that despite the considerable advantages to FtF interviews, there exists a disadvantage in the form of bias, which is argued as one of the most important disadvantages to this method. Bias affects the reliability of the data and can manifest in the manner with which the interviewer presents the questions or in the respondent's answers if they wish to provide favourable answers only. The other challenges to FtF interviews presented by Opdenakker (2006) include:

- Travelling costs, particularly if the research covers a wide demographic area.
- The possibility of the device used to record the conversation malfunctioning, and the time associated with transcribing a recorded interview.
- Bias from the interviewer where certain visual behaviours can guide the respondent in a certain direction.

3.3.6 Interview Questions

Using the literature, the researcher created a semi-structured interview schedule outlined in Table 3.1. The interview schedule consists of 11 questions and the justification and source are included in the table.

Table 3.1 Interview questions

Question
1. What are your views on the introduction of Green Building Feature Initiatives in the building sector holistically?
Reason and source of question:
To determine if they have an understanding of GBFIs and implementation of them thereof.
Question

2. What is the importance of implementing Green Building Feature Initiatives in the private housing sector?
Reason and source of question:
To determine if they have an understanding of the role the housing sector has in GCC mitigation
Question
3. What are the benefits, for society and developers, of incorporating Green Building Feature Initiatives in the private housing sector?
Reason and source of question:
To determine stakeholder awareness (Oke *et al.*, 2019; Marsh *et al.*, 2020)
Question
4. What are the requirements for providing EDGE certification to a development?
Reason and source of question:
To determine awareness of GBCSA certification standards (Nikyema and Blouin, 2020)
Question
5. What are your views on the EDGE certification tool; any strengths or weaknesses you have observed?
Reason and source of question:
To determine level of attention paid to GBCSA rating tools (Nikyema and Blouin, 2020)
Question
6. What are your views on the net-zero aspect of green certification; is it achievable in the current private developments?
Reason and source of question:
To determine if the concept is viable in SA with the current RE energy technology and infrastructure available (Ahmed *et al.*, 2022)
Question
7. What are the strengths and weaknesses of the Green Star rating tool?
Reason and source of question:
To determine the extent to which the tool affects implementation of GBFIs (Chan *et al.*, 2018; Nikyema and Blouin, 2020)
Question
8. To what extent have green building regulations and principles aided in the implementation of renewable energy sources in private household developments?
Reason and source of question:
To determine the level of awareness to building regulations and the extent to which they have affected GBFI implementation (Marsh *et al.*, 2020; Nikyema and Blouin, 2020)
Question
9. What are the barriers you have faced in implementing Green Building Feature Initiatives in the private housing sector?
Reason and source of question:
To determine the key barriers to incorporating GBFIs in SAs private housing sector (Aktas and Ozorhon, 2015)
Question
10. What are the drivers to implementing GBFIs in your residential projects?
Reason and source of question:
To determine the key drivers to incorporating GBFIs in SA's private housing sector (Aktas and Ozorhon, 2015)
Question
11. What are the challenges or differences encountered in implementing Green Building Feature Initiatives in the different case study sites??
Reason and source of question:

To determine the variances between each location to provide a more accurate framework (Aktas and Ozorhon, 2015)

3.3.7 Respondent Labelling

The interviews conducted were carried out using a case study approach as detailed earlier in the chapter. The multiple case studies were based in locations that were being constructed by the same developer. Interviews were conducted with case study respondents, detailed in table 3.3. Further interviews were conducted with head office respondents who are, referred to as general respondents, but coded using their professional position in the firm as detailed in table 3.4. The general respondents provided insight into each case study location, via a focus group style interview, which was followed up by interviews with respondents at each case study site. Purposive sampling was employed which aided in the construction of the interview design coding system detailed in Tables 3.2, 3.3 and, 3.4.

Table 3.2 represents the coding system used to represent the 5 different case studies. The first 2 letters represent the term "Case study" followed by a numeric which represent the case study number. Each case study is assigned to the relevant city in the municipality under investigation in this research.

Table 3.3 is a combination of the case studies detailed in table 3.1 earlier, combined with the respondent for that case study. The code "CS1" represents case study 1, whilst the code "R1" represents Respondent 1 therefore making the combined code CS1R1 to represent Case study 1 Respondent 1. The case study respondents consisted of the site managers assigned to each development.

Table 3.4 represents the general respondents in a managerial role who undertook the interview and provided general feedback attributed to each case study. The code "MDE" for instance represents the Managing Director of Energy for the organisation. The respondents in table 3.4 represent key professionals directly involved in GB developments across the various case studies including a super script number, indicating the number of years they have been with the organisation responsible for the case study developments.

Table 3.2 Coding system for multiple case study approach

CS1	Case study 1
CS2	Case study 2
CS3	Case study 3
CS4	Case study 4

CS5	Case study 5

Table 3.3 Coding system for case study respondents

CS1R1	Case study 1 Respondent 1
CS2R1	Case study 2 Respondent 1
CS3R1	Case study 3 Respondent 1
CS4R1	Case study 4 Respondent 1
CS5R1	Case study 5 Respondent 1

Table 3.4 Coding system for general respondents in managerial role

MDE[3]	Managing Director Energy
HDP[19]	Head of Development Planning
SHEQ[1]	Safety, Health, Environment and Quality Advisor
GAP[6]	Green Accredited Professional
EH[1]	Environmental Head

3.4 Data Analysis Method

Data analysis is the next step that makes use of the responses provided by the participants detailed earlier in the chapter. The transcribed interviews are available in Appendix 1. The collected information was organized and grouped according to the prevalent ideas from the responses. The process allowed the researcher to identify themes thereby noting the similarities and differences in each case. Thematic analysis was conducted to analyse the data, analysis of which was achieved via the use of NVIVO software to generate themes and ending with a cross-case analysis to explore the depth of similarities or differences between the cases. The analysis of the results and the cross-case analysis are presented in chapter 4.

3.4.1 Thematic analysis

Thematic analysis (TA) is a common data analysis method used in qualitative research (Castleberry and Nolen, 2018). TA identifies, analyses, and presents trends popularly referred to as themes, from the data (Braun and Clarke, 2006; Castleberry and Nolen, 2018). TA allows for a wide range of topics and research questions to be addressed while permitting the researcher flexibility when analysing the data (Castleberry and Nolen, 2018). The TA method however has been criticised by researchers such as Nowell *et al.* (2017), who argue that the credibility of the research process end up being in question

owing to the lack of attention to the relevant TA process. Clarke and Braun (2013) further reiterate that guidance is required in the practical application of how to perform qualitative analysis using TA as a method to analyse the data.

Braun and Clarke (2006) however developed a framework for completing a comprehensive TA that can be applied to any form of qualitative research. The framework provides a six-step guide that was employed in this research. Table 3.5 presents the six steps framework developed by Braun and Clarke (2006) used to conduct a thorough TA of qualitative data. The six-step guide was employed by the researcher to achieve the themes presented in Chapter 4 of this research.

Table 3.5 Summary of Thematic Analysis six-step framework developed by Braune and Clarke (2006)

Steps	**Description**
Step 1. Data familiarity	This involves the researcher increasing their familiarity with the data by noting any initial analytical observations and re reading any transcribed data.
Step2. Generating initial codes	Systematically coding all the data across the data sets by noting interesting features and attributing them to the relevant codes
Step3. Search for themes	Grouping codes into preliminary themes based on their significance. The codes are then grouped into varying themes that speak to the research question.
Step4. Theme review	Preliminary themes are reviewed and modified to confirm whether the data supports the theme and whether the theme works in the context of the entire data set
Step 5. Define themes	Developing clear names and definitions for each theme.
Step 6. Producing the report	Relating the final analysis back to the research question and literature to produce a journal article or a dissertation or any form of scholarly article.

3.4.2 Cross-case analysis

A cross-case analysis is a method that enables a researcher to compare the similarities and differences in the data sets (Borman *et al.*, 2012). Implementing a cross-case analysis allows the researcher to investigate several cases thereby opening up various possibilities and alternatives to what may have been provided by analysing a single case (Borman *et al.*, 2012). The cross-case analysis further allows the researcher to seek explanations as to why one case may be different from the other.

The cross-case analysis is therefore implemented in step 5 of the TA six-step framework discussed earlier. The presentation of the cross-case analysis is detailed in Chapter 4, providing the major themes and subsequent similarities and differences between them.

3.5 Chapter Summary

The chapter focused on describing and justifying the research approach as well as the research design. The case study approach was explained leading into the justification of the use of the multiple case study approach which provides a more thorough in-depth analysis of the research subject. The purposive sampling method was discussed as well as the data collection method which involved the use of semi-structure interviews which are advantageous when proceeding with qualitative research. The various coding methods for the research participants were further explained leading into the explanation of the data analysis method which made use of a TA method to analyse the collected data.

CHAPTER 4: DATA PRESENTATION, ANALYSIS, AND FINDINGS

4.1 Introduction

Chapter 4 presents and discusses the findings from the data collected via the semi-structured interview process. The chapter begins with a brief overview of the multiple interviews and the five case studies, followed by a report of the research findings, relating to the common themes evident in each case study. The findings are subsequently analysed by comparing dominant themes with arguments presented in the literature. The chapter concludes with a presentation of the cross-case analysis to identify any differences or similarities between the five cases. This includes an overview of the respondents' perceptions relevant to the common themes. An empirical model of the results is further presented and discussed to compare and contrast with the theoretical model.

4.2 Data presentation and analysis

The following section provides an overview of the multiple interviews conducted at the developer's head office; primarily highlighting the general respondents' roles in the organisation. Multiple interviews were conducted initially at the developer's head office with selected respondents, and then at five separate housing development sites which formed the individual case studies. Each development site provides a unique case study owing to location, local government regulations, climate, and other relevant factors unique to each development The developer is one of the largest sectional title property developers in SA, listed on the Johannesburg Stock Exchange (JSE). The developer focuses on designing, constructing, and selling eco-friendly sectional title residential apartments in the provinces of Western Cape, Gauteng, and KwaZulu-Natal. The section further provides background to the five developments selected as the case studies. The multiple interviews and case studies are subsequently organised into the common themes and analysed by comparing these to the literature.

4.3 Focus Group

4.3.1 Overview

The focus group (FG) comprises the general respondents who are directly involved in the private residential developments across the five case studies. The respondents work at the head office of the developer and oversee different aspects of the residential projects. The respondents comprise: the Managing Director of Energy (MDE); the Head of Development Planning (HDP); the Safety, Health, Environment and Quality Advisor (SHEQ); the Green Accredited Professional (GAP); and the

Environmental Head (EH). The respondents are all directly involved in providing environmentally friendly residential developments that cater to the needs of the target market.

4.3.2 Drivers of implementation of GBFIs

Awareness of GB principles and practices

HDP reported that across all five cases, one of the key drivers has been the increased awareness amongst the younger generation purchasers as they are drawn more to the properties because of the green aspect.

*"We do believe that some of the younger generations are buying homes because of the greening you know we believe that that generational shift is coming through"- **HDP***

This supports the argument of Oke *et al.* (2019) that the client demand for GB's is crucial in the supply of adequate GBs and that client demand is made possible by client awareness. **MDE** further reported that the engagement of the board members in delivering green developments has managed to drive the implementation of GBFIs on a wide scale. This relates to the claim by Darko et al. (2017) that states that the increase in attention to sustainability matters, has driven stakeholders to commit more to green developments. **HDP** and **MDE** believe that client and developer awareness is a cornerstone of GBFI uptake.

Incentives by Financial Institutions

MDE spoke of the importance of bank incentives in helping the clients to purchase green-accredited properties.

*"…banks could jump on board and give them a reduction on their interest rates, yes the clients could pay a bit less"- **MDE**.*

MDE argues that the decreased interest rate offered by the financial institutions stimulates interest in GBFIs by encouraging clients to maintain green principles post-occupancy.

Enhancing standard of living

MDE responds that GBFIs provide spaces for integrated living thereby enhancing the community's style of living by centering the developments around green initiatives. **MDE** states that the bottom line is finding a way to promote better living for the clients. **MDE** further explains that there is an inherent perception of EDGE certified homes, or GBs in general, to have high upfront costs in terms of

acquiring the necessary building materials and technology, as well as the cost for specialist consultation with EDGE experts. **MDE** however suggests that this perception is not accurate as achieving EDGE certification does not create a loss for the developer but rather increases the value of the development and offers clients various benefits in terms of overall saving on water and electricity bills. The MDE states that the different EDGE certification levels, allow for the developers, and clients, to incorporate features that allow their building to achieve the required savings in energy, water, and embodied energy in materials.

GAP suggests that providing a home that is EDGE-certified increases the client's reception of the development, thereby driving the implementation of GBFIs. Client reception is increased via the strengths associated with EDGE-certified developments. **MDE** states that one of the major strengths of the rating tool comes with the design of an EDGE-certified development. EDGE-certified developments incorporate fittings and materials in the building design that save on water and power consumption. **MDE** states that the client's overall electricity bill to the municipality is significantly reduced as the EDGE-certified homes incorporate RE sources of power via solar PV. **MDE** further explains that water fittings incorporated in the EDGE-certified developments provide savings on water usage without compromising on efficiency for the clients. **MDE** further identified smart metering as a strength of the rating tool, which increases client reception of the developments. Smart metering allows the users to monitor where majority of their power usage is, and to make decisions to address high usage in the identified areas. The EDGE certification of the developments is not perceived as a barrier by the respondent but is rather viewed as a driver.

International investment

MDE reported that local and international investment in GB projects plays a crucial role in implementing GBFIs. **MDE** further stated that rentals for tenants are now much more affordable for their EDGE-certified buildings as compared to traditional uncertified dwellings. The local investment is considered to be an important driver as it shapes the perception and attitudes of individuals towards the uptake of GBs in an economy (Theunissen, 2015). Investment in GBs creates benefits in the form of rental premiums arising from reduced operational costs, reduced vacancy rates and higher tenant retention (Theunissen, 2015) **MDE** further stated that an individual's own private investment is now sensitive to how sustainable the project is as individuals have become more aware of the benefits of building green such as reduced interest rates on loans from financial institutions.

4.3.3 Barriers to implementation of GBFIs

Lack of knowledge in the construction industry and the general public

The general public and the construction industry are both important stakeholders in the uptake of GBFIs in the housing sector. **HDP** suggests that there is a significant lack of education and understanding when it comes to green construction. According to **HDP**, other countries are ahead of SA in terms of education around green principles and practices and that the population at large has not shifted their mindset towards green construction. HDP further suggests that increasing knowledge in the general public on principles surrounding GBs will encourage individuals to prioritise GBs.

*" …there's a lot of education that needs to happen in South Africa in terms of greening. I think other countries possibly its better received than in South Africa"-**HDP**.*

GAP reported that the construction industry is viewed as simple procedures of brickwork and plasterwork and installing some fittings. The associated savings on water and energy usage owing to the implementation of GBFIs however are what **GAP** associates with a lack of education and awareness from the general public. This is in line with the argument presented by Nikyema and Blouin (2020), that there are human-related barriers that come in the form of a lack of awareness by the general public in the benefits of GBs. The construction industry itself is responsible for delivering GBs and is therefore a key stakeholder in the implementation of GBFIs. **GAP** further reported serious resistance to change from stakeholders within the construction industry that is linked to the lack of education surrounding GBs.

Building regulations

HDP reported that the SANS 10400-XA building regulation is the only one that speaks to implementing RE sources in GBs, and that it does not specify the methodology of implementing certain GBFIs. SANS 10400-XA details the minimum requirements of the SA National Building Regulations on energy efficiency and environmental sustainability in building design. **HDP** implies that the SANS 10400-XA requires more detailing that will in turn aid developers in implementing GBFIs in the residential projects, but that it will not be an easy task.

*"SANS is very open-ended; they allow you to figure it out and then once you've figured it out yet to submit a lot of reporting to the cities proving our point"-**HDP**.*

EH reports that there is not enough engagement between key construction stakeholders and municipal authorities, in terms of creating legislation that aids developers in constructing GBs in the

residential sector. **EH** further suggests that the various municipalities in all the case studies are not hard-pressed "to do the right thing for developers as there is no legislation to monitor the activities". According to **EH**, a lack of pressure from the municipalities to address the concerns from their local developers and other construction stakeholders, will result in a lack of change of behaviour from the local level construction stakeholders and municipalities. This is in line with the argument by Nikyema and Blouin (2020) that government barriers can include a lack of adequate GB legislation that caters to the local needs of the community. **HDP** further suggested that significant change needs to come from a national level to address issues regarding the use of development rates paid by developers towards municipalities. The development charge is a payment made to the municipality by the developer, to cover the cost of municipal engineering services required owing to the type of land use. The municipal engineering services which form part of the development charge include infrastructure for transport, sewerage, stormwater, and solid waste outside the boundary walls of the development. **HDP** implies that the municipalities are not attending to the aforementioned infrastructure upgrades thereby slowing down development of the residential GBs.

Environmental conditions

HDP reported that weather conditions and seasonal cycles affect solar energy generation. For example, the energy output from solar installations done in Cape Town will be different from those installed in KwaZulu Natal or Gauteng, as output differs with levels of radiation in each location. **HDP** further stated that seasonal cycles must be factored into the calculation for each case study as they are different. HDP reiterated that the entire aim of the developments is to rely more on RE sources, with solar energy being the dominant source in the case studies, thereby decreasing the carbon footprint of the developments. An insufficient amount of solar panels for energy generation results in more dependence on municipal sources of electricity and a reliance on backup sources of power, such as the diesel-powered back-up generators available in each of the case study sites. A lack of sufficient solar panels can further lead to the case study developments being unable to meet some of the energy requirements of the EDGE rating tool and make it considerably more difficult to attain the Net-Zero rating standard.

High financial costs relating to energy

SHEQ reported that finances, in terms of the cost of energy and obtaining finances have been a barrier to implementing GBFIs in their developments. **HDP** further stated that there exists a financial constraint in SA, in terms of availability of green financing, that inhibits developers from incorporating high-level GBFIs and that it is related to the low levels of acceptance and awareness of greening in

buildings. This is in line with the argument presented by Aktas and Ozorhon (2015) that cost-related barriers may arise in developing countries as importing green technologies to meet GB standards may be high. According to **MDE**, the cost of selling back to the municipality however is not financially feasible as there are additional costs charged by the municipalities such as the high cost of the specialised meter that enables individuals to feed in power back to the grid.

*"…adding to that, there's the physical implementation of the cable in the ground has to be different cable obviously, has to be different remote metering kiosk. So, all of these costs add on"-**MDE.***

HDP added that there are extra costs, in terms of infrastructure, that the developer must pay to be able to sell excess power back to the municipality. The infrastructure required includes specific cables that are necessary to transport power to the grid and the groundwork required to install such cables and the advanced metering infrastructure meter.

Municipal laws and involvement

HDP reported that as developers, they are not permitted to develop large residential estates and be completely off-grid. According to **HDP**, being completely off-grid destabilises the manner in which the municipalities make money via the usage of municipal resources such as water and electricity. HDP proceeded to report on an example of a development in Tshwane, where households are expected to purchase a certain amount of power from the municipality, and that the municipality is not flexible with that law regardless of whether you produce power off-grid and do not require the minimum charged by the city authorities. This is similar to the argument by Nikyema and Blouin (2020) that government related barriers include the inefficient adaptation of GB policies to meet local needs.

Quality of green technology

HDP reported that the quality of solar PV systems installed by subcontractors poses a challenge as the systems do not end up performing as expected, and that the quality of the products differs from one region to the other. The difference in quality of the solar PV systems however is one that the developer is attempting to monitor closely but which remains difficult as one subcontractor is not available to provide the technology to all the developments. **HDP** suggests that the difference in quality of the products may be related to levels of education surrounding green technology, which speaks to manufacturing, testing, and maintenance of the products.

State of infrastructure

HDP stated that the municipalities make their money via the rates they collect from property owners and that the developments on which this study focuses pay development contributions because they are adding more load to the existing municipal infrastructure. **HDP,** however, suggested that the output from the contributions is not visible as the various municipalities have not upgraded infrastructure systems including roads, electricity and water to accommodate the new developments. **EH** added that a delay in the upgrade of infrastructure that services water and electricity inhibits the developments from being more water efficient and from consuming more energy generated via renewable sources.

*"…they are supposed to upgrade the systems, you know put in bigger piping for water, or go and buy more water and these things are not happening in SA"-**EH**.*

The electricity saving can be in the form of energy wheeling that requires the relevant electrical infrastructure to support the distribution of the RE to the developments. The lack of adequate electrical infrastructure further impedes the selling back of excess energy developed via RE means to the grid. **HDP** further implied that the electrical infrastructure plays a crucial role in implementing their GBFIs as one of the key aims of the developments is to make use of RE sources of power to sustain the developments and in turn lessen the burden on the grid, thereby addressing both the energy crisis and the climate change challenge. **EH** continued to add that the road infrastructure is pivotal in realising the green developments as there will be increased traffic in the area and that expansion of the green developments cannot occur without an upgrade of the existing road networks.

4.4 Case Study 1

4.4.1 Overview

Case study 1 is a residential development, located in Pretoria East, in the City of Tshwane Metropolitan Municipality, Gauteng province. The development consists of over 1900 units comprised of one-, two- and three-bedroom apartments, with plans for further development. The residential development's energy mix consists of solar PV, electricity from the municipal supply and a diesel-powered backup generator. The solar PV panels are located on the roof of the residential units. The completed residential units are EDGE-certified, making use of energy-efficient appliances, water-saving fixtures, and construction materials that use low-carbon embodied energy.

The development further makes use of rainwater harvesting systems and boreholes to address water costs and availability. The development includes a lifestyle centre that acts as a communal space for residents. The lifestyle centre's energy needs are met via the RE source of solar PV and makes use of the rainwater harvesting system. The lifestyle centre is further constructed to a Six-Star Green rating and has achieved a Net-Zero Carbon emission standard, certified by the GBCSA. The respondent for the case study shared key drivers and several barriers that they have experienced on site regarding the implementation of GBFIs on the development.

4.4.2 Drivers of implementation of GBFIs

Enhanced standard of living

CS1R reported that providing developments that offer a highly reduced experience of loadshedding periods has managed to create a demand for the residential units. The amenities available within the development and the surrounding area further offer ease of access for existing and potential residents which encourages a healthy lifestyle for individuals as they can walk or cycle to areas. CS1R further implied that the use of energy efficient appliances and water saving features provided the residents with a sense of helping the wider community to reduce resource consumption.

4.4.3 Barriers to implementation of GBFIs

Environmental alignment

CS1R highlighted that the major challenge faced on the site was regarding the use of harvested rainwater for consumption, flushing in the units and irrigation. CS1R stated that they have a water recycling system available but that it has been a difficult process to get the harvested recycled water approved for human consumption. The harvested water has therefore been directed towards

irrigation purposes with future plans to connect the system to each of the unit's toilet systems for flushing. CS1R further stated borehole drilling as being a challenge faced on the development due to potential oil leaks, identified during the hydrogeological study, which would contaminate the water. The water related challenges faced by CS1 have led to a continued overall dependence on municipal water supply. CS1 however have been able to retrofit the units with water efficient fixtures such as low-flow comfort aerators and dual flush toilets and toilet stops, to help meet EDGE certification standards.

High-cost implications

CS1R further stated that there are high-cost implications regarding providing water fit for consumption in terms of drinking purposes, which has therefore led to a dependence on municipal water supply towards the tenants. According to CS1R, there further exists high risks with supplying their own water to residents, be it recycled harvested rainwater or borehole water. The risk with harvested rainwater comes from the material used to store the water and the rigorous tests and treatment that the water needs to undergo to become suitable for drinking. Borehole water also needs to undergo testing to deem it suitable for drinking. CS1 have therefore opted to continue with municipal supply as they explore features that they can implement in their developments to decrease the cost of water usage in the development.

Quality and maintenance of green technologies

CS1R reported that maintenance of the solar PV panels is a challenge owing to the positioning of the panels. CS1R further stated that moving the panels to a lower level such as the carports is an option under consideration but may negatively affect solar energy output as the existing layout allows for more panels to be installed as opposed to the space available on the existing carports. CS1R further implied that maintenance of green technologies, such as solar panels, should be factored into the design stage of the development as this in turn affects expected energy output from the solar PV.

4.5 Case Study 2

4.5.1 Overview

Case study 2 is a residential development, located in Midrand, in the city of Johannesburg Metropolitan Municipality, Gauteng Province. The development consists of over 900 units comprised of one-, two- and three-bedroom apartments. The development has plans of further expansion and caters to both low-income and middle-income residents. The energy mix of the development consists of solar PV panels, electricity from the municipality, and a diesel-powered back-up generator. The solar PV panels are located on the roofs of the residential units and are north facing. The completed units in the developments are all EDGE certified, thereby providing 20% savings in energy, water, and embodied energy in the materials used.

The development includes a lifestyle centre that serves as a common space for residents. The lifestyle centre is equipped with energy saving appliances with half of the power requirements being provided for by the solar PV system. The lifestyle centre is further constructed to a Six-Star Green rating certified by the GBCSA. The respondent for CS2 shared two barriers that they have faced on site regarding GBFI implementation.

4.5.2 Drivers of implementation of GBFIs

Enhanced standard of living

CS2R reported that one of the primary goals of the development has been to provide a consistent electricity supply to residents amidst the energy crisis. CS2R further implied that the energy saving fixtures in the residential units coupled with the solar PV power supply allow for residents to experience energy security thereby increasing demand for the developments.

4.5.3 Barriers to implementation of GBFIs

Environmental conditions

CS2R reported that the topography of the site makes it challenging to install enough solar PV panels to meet their targeted RE output levels. The varying gradient of the site makes it difficult for the lower-level units to access enough sunlight to make the installation of solar PVs worthwhile in certain areas of the development.

Municipal laws and involvement

CS2R further detailed a blackwater treatment plant that is in the testing stage in the development. The aim of the blackwater treatment plant being the recycling of wastewater for use in the development including drinking, flushing and irrigation. According CS2R, getting the municipality to approve the blackwater treatment project has proved to be a barrier in achieving efficiency in the water aspect of the residential development. CS2R however stated that the development will continue testing the blackwater treatment plant and prove that they can provide recycled water that is safe for drinking and everyday use by tenants of the development. The development however continues its reliance on municipal water supply for use within the units whilst the harvested rainwater is used for irrigation purposes.

4.6 Case Study 3

4.6.1 Overview

Case study 3 is a residential development, located in Midrand, in the city of Johannesburg Metropolitan Municipality, Gauteng Province. The development consists of approximately 1030 completed residential units with more under construction. The units consist of 3-bedroom apartments that cater to the middle- to upper-income level residents of the area. The energy mix of the development consists of electricity supply from the municipality, gas supply, and a backup diesel-powered generator. The development was one of the early developments undertaken by the developer and does not make use of RE energy sources of power supply. The respondent for the case study however detailed one barrier faced in the implementation of GBFIs for the development.

4.6.2 Drivers of implementation of GBFIs

There were no recorded drivers for this case study development as CS3R detailed that the development does not GBFIs as it was one of the early developments in the portfolio, therefore the cost implication at the time of including RE sources of power were not feasible. CS3R however noted that owing to the energy mix, they are able to provide a more consistent power supply to residents thereby enhancing that particular aspect of their experience.

4.6.3 Barriers to implementation of GBFIs

High financial costs relating to energy

CS3R stated that at the time of development, in 2017, there existed a high cost to implementing green building technologies, which resulted in there being less GBFIs implemented in the development. This is in line with Chan *et al.* (2018) findings, that the cost of GBTs in developing countries continued to be a barrier in implementing GBFIs in developments. CS3R however further hinted at future plans to incorporate more RE sources in the form of solar PV, in a drive to move away from diesel-powered back-up generators as a form of alternative energy during times of loadshedding.

4.7 Case Study 4

4.7.1 Overview

Case study 4 is an eco-conscious residential development, located in the south of Johannesburg, in the city of Johannesburg Metropolitan Municipality, Gauteng Province. The development consists of one-, two-, and three-bedroom apartments. The development is built on a ridge, with future plans to develop a green eco-bridge that will act as a wildlife corridor. The energy mix of the development consists of power from the municipality, solar PV, and backup power from a diesel-powered generator that services the security features of the development. The completed residential units are EDGE-certified, making use of energy-efficient appliances, water-saving fixtures, and construction materials that use low-carbon embodied energy.

The development consists of a lifestyle centre with solar PV panels that supply half of the building's energy demand, and rainwater harvesting tanks to provide water for irrigation purposes. The lifestyle centre is further constructed to a Six-Star Green rating certified by the GBCSA. CS4R provided one key driver and one key barrier to the implementation of GBFIs which have been experienced on site.

4.7.2 Drivers of implementation of GBFIs

Enhancing standard of living of residents

CS4R reported that the particular development is nestled within an ecological area that hosts a variety of wildlife which the surrounding community enjoys. The development therefore makes use of integrated design that places amenities within walking distance of potential property owners thereby reducing the need to use vehicles that are dependent on sources of fossil fuel combustion. The integrative design further makes use of energy saving features in the form of solar panels for energy generation to reduce the impact of loadshedding cycles on residents. CS4R added that the development offers social activities in the form of guided walks and competitive activities that promote a healthy lifestyle which forms part of the design concept of the green development, thereby attracting more clients to the residential units.

4.7.3 Barriers to implementation of GBFIs

Maintenance of green technologies

CS4R reported that the placement of the solar PV panels has caused challenges in terms of maintenance of the technology. According to CS4R, alternative placements of the solar PV panels must

be considered. However, it will be difficult to find an ideal placement that will further provide sufficient levels of RE output to residents.

4.8 Case Study 5

4.8.1 Overview

Case study 5 is a residential development, located in Cape Town, City of Cape Town Metropolitan Municipality, Western Cape province. The development is comprised of over 1000 units consisting of one-, two-, and three-bedroom apartments, with more under construction. The energy mix of the development consists of power from the municipality, solar PV, and a backup diesel-powered generator. The development consists of units that are EDGE certified, as well as a lifestyle centre that serves as a communal space for residents. The development makes use of energy-efficient fittings in the residential units and communal spaces. Furthermore, it makes use of construction material that has less embodied carbon. The wastewater in the development is recycled and used for flushing toilets. The total energy generated via solar PV is fed back into the local grid of the development at a 10% discount to residents. CS5R provided one key driver and one major barrier to the implementation of GBFIs in the Cape Town development.

4.8.2 Drivers to implementation of GBFIs

Enhanced standard of living

CS5R reported that the loadshedding cycles have affected businesses and individuals alike on a large scale in the country as a whole. The use of RE sources of energy however has provided alleviation from the continuous loadshedding cycles that have affected the comfort of the individuals. The development further provides cleaner air quality inside and outside the units owing to the use of effective ventilation via building design and the use of natural and recycled materials that have reduced levels of toxicity.

4.8.3 Barriers to implementation of GBFIs

High financial costs relating to energy

CS5R reported that they would wish to enter into energy wheeling but that it is too expensive at the moment and would therefore not be financially viable. The high cost associated with energy wheeling has therefore hindered the development from incorporating higher levels of RE in their energy mix and in achieving a net-zero standard. CS1R further implied that the high cost of energy wheeling has resulted in a steady reliance on municipal power supply as less than 50% of the energy needs are met via the solar power generated on the development.

4.9 Cross-Case Analysis

The following section details the dominant themes and sub-themes that arose in the focus group interviews and in each of the case studies. The analysis highlights the common themes and the exclusive ones. The analysis is presented in a cross-case analysis in table 4.1.

4.9.1 Awareness of GB principles and practices

The focus group respondents highlighted a shift in the level of awareness by the general public and construction stakeholders towards GB principles and practices by various stakeholders associated with the developments. HDP respondent reported that the younger generation property buyers are buying more into the GB concept as demand for EDGE certified homes is more appealing to them compared to non-certified homes. The MDE respondent added that the drive and passion of the firm's executive board members towards GBFIs show awareness from the property developers regarding sustainable construction and acts as a driver in implementing GBFIs across all case study developments. FG respondent however stated that there is serious resistance from key construction stakeholders to change regarding moving from traditional methods of construction to greener methods of construction. FG respondents further mentioned that education of construction practitioners and future construction stakeholders currently in tertiary institutions, plays a pivotal role in making the general public understand the necessity of GBFIs in SA today. CS1-CS5 respondents however did not make mention of this challenge in their developments as they maintained that they were more able to speak on issues that directly affect day-to-day site operations.

4.9.2 Incentives by Financial Institutions

Bank incentives play a pivotal role in encouraging the implementation of GBFIs by both the developers and homeowners. FG respondents stated that banks could do more to help clients and incentivise them to own homes that implement GBFIs by lowering interest rates for clients. The driver mentioned by FG respondents however highlighted that the particular driver may lean more towards being a barrier in the current state of economic affairs in SA, as the FG respondents did not make mention of bank incentives playing a prominent role yet. CS1-CS5 respondents did not provide any more detail regarding bank incentives.

4.9.3 Enhanced standard of living

FG respondents believe that the inclusion of GBFIs into their developments enhances the standard of living for their clients. FG respondents stated that integrated living is one of the initiatives offered by their spaces and allows residents to benefit socially from each other. Integrated living allows for the

residents to explore alternative forms of transit as the developments offer close proximity to amenities and varying public transport options. The developments further offer amenities that support electric vehicle charging and support cycling, in order to promote a use of clean energy vehicles and to encourage a healthier lifestyle for residents. The features provided in the integrated living allow for a wider view of the extent of the role of GBFIs in private developments.

The difference between an EDGE-certified home and an uncertified home, at a higher cost, is another aspect mentioned by FG respondents that enhances the standard of living for residents. The residents get to enjoy the GBFIs present in certified homes that provide a different experience in terms of improved air quality both inside and outside the home and design features that allow for maximised natural light and air orientation offering an increased aesthetic feel as implied by the FG respondents. CS1-CS5 respondents however did not provide detailed information on the enhanced standard of living but rather mentioned that all green technologies implemented are to meet clients' comfort needs. The client's comfort needs in this case refer to meeting the client's requirements in terms of consistent power supply, aesthetics of the implemented green features that offer savings on water and energy, and the air quality both inside and outside the development.

4.9.4 International investment

FG respondents remarked that international investment aids in realising the large-scale development projects undertaken at each of the case studies. The implementation of GBFIs was further described by FG respondents as being important in attracting outside investment as that is what investors are concerned with today. CS1-CS5 respondents did not have comments on the financial investment aspect of the developments.

4.9.5 Green building regulations

The GB regulations determine standards that all developers/contractors must adhere to during construction of buildings today. FG respondent stated that the building regulation, SANS 10400XA, is the building regulation that speaks to implementation of RE sources in a building. FG further highlighted that the regulation is open ended and does not provide concise information relating to green technologies that should be implemented. CS1-CS5 however did not raise the building regulations as a barrier on site.

4.9.6 Environmental conditions

The FG and CS1 and CS2 all listed several environmental factors as being challenges they had faced in implementing GBFIs at the developments. FG respondents highlighted how the seasonal cycles affect

the solar output at all their developments. FG respondents further went to add that the weather conditions in each region vary, therefore providing differing levels of solar radiation. The data presented by Ibrahim *et al.* (2021) on the availability of RE sources in SA's provinces is further confirmed by the respondents who detail solar as being the primary RE source in the various case study developments. CS1 however proceeds to go into depth with the challenges detailing the challenges of water safety regarding the harvested rainwater and the potential oil leakages from the borehole drilling activities. CS2 further mentions site topography as being an environmental challenge when trying to implement solar PVs for energy generation.

4.9.7 High financial costs relating to energy

High financial costs relating to energy generally includes implementation cost of green technology. FG, CS1, CS3, and CS5 all detailed the high cost of activities related to generating energy via renewable means. FG1 highlighted that the major financial impediment arises from municipalities not making if financially viable for developers to sell back excess energy to the grid. FG further links the difficulty of selling back to the grid to one of the reasons why achieving a net-zero development will be difficult. Financial constraints from the developer's side of implementing green technology were further highlighted by FG. CS5 further mentions the cost of energy wheeling as being a major challenge at the site which is similar to the points raised by FG. CS3 highlights the cost of implementing GBFIs at the time of the development as green technology was not a financially viable option. CS1 in contrast speaks to the high-cost implications of supplying their own recycled water to residents in a state that makes it fit for consumption.

4.9.8 Municipal laws and involvement

Municipal laws and involvement relate to the levels that municipalities promote or deter GBFI implementation either through laws set in place or subsidies they provide to developers or their tenants. FG stated that they are not permitted to build an entire development that is off grid, as that is how the municipality/city makes its money. CS2 respondent offered more insight into a green project of a black waste-water treatment plant, that has been awaiting municipal support and approval. CS4 respondent further reported that their municipality only concerns themselves with the environmental side of SDG adherence, which therefore limits the municipalities involvement in other GBFIs where the development requires approval and support.

4.9.9 Quality of green technology and maintenance

The quality of green technology, primarily solar panels, was identified by FG1 as being a challenge across all 5 case studies. FG1 reported that the quality standards of the solar panels differed with the

suppliers from each case study location. The quality further compromised the performance of the solar panels. CS1 and CS4 however further mentioned the maintenance of the solar PV to be a challenge as the placement of the solar panels made it difficult to access them. CS3 reported that operational efficiencies were the major challenges faced pertaining to green technology and maintenance.

4.9.10 State of infrastructure

The state of infrastructure refers to the municipal infrastructure in place that services communities and in turn services the new developments in CS1-CS5. FG however stated that the current municipal infrastructure does not cater to the needs of the new developments as issues such as new cables, to transmit the energy generated via RE means, to transmit power from the developments to the municipalities are not in place. CS1-CS5 however did not provide further information on this challenge as it forms part of the information that they thought best highlighted by FG respondents.

4.10 Summary of discussion

The FG respondents provided high level detail of the drivers and barriers to implementation of GBFIs at each of the case study. CS1-CS5 respondents provided lower-level responses regarding the drivers and barriers. The analysis provided several key barriers, with some being more impactful than others. The key barriers include:

- Education of green building principles and practices
- High financial costs relating to energy
- Municipal laws and involvement
- Green building regulations

The less impactful barriers include:

- Quality of green technology and maintenance
- State of infrastructure

The analysis further provided three key drivers to the implementation of GBFIs in the residential sector which include:

- Enhanced standard of living
- Increased awareness of green buildings by construction stakeholders and the general public
- Incentives by financial institutions

CS1-CS5 respondents provided more general information regarding challenges faced on site and did not provide substantial information regarding the drivers, experience on site, and the implementation of GBFIs. CS1-CS5 respondents were more aware of the general challenges experienced on a day-to-day basis regarding site activities and not necessarily the drivers to implementing GBFIs. FG respondents provided a more holistic view on the drivers and barriers experienced with implementing GBFIs on all the case studies as they were more involved with the developments from a top-level perspective, thereby providing more relevant information. The majority of case study respondents however detailed barriers that were in line with those identified by the FG respondents. Environmental conditions, high financial costs relating to energy, municipal laws and involvement, and quality and maintenance of green technology were all mentioned in majority of case studies as being barriers experienced on site as was highlighted by the FG respondents. Table 4.1 provides a summary of the relationship between GBFIs in the private residential sector and the drivers and barriers that are faced in implementing the GBFIs.

Table 4.1 Cross-case analysis of the drivers and barriers to adoption of GBFIs on private residential developments

Relationship between private housing sector and the drivers & barriers to implementation of GBFIs							
	Drivers			**Barriers**			
	Enhanced standard of living	**Increased awareness**	**Incentives by financial institutions**	**Lack of education**	**High costs relating to energy**	**Municipal involvement**	**RE green building regulations**
FG	Enhanced standard of living for residents across all case study developments by applying integrated design and living.	Increased awareness of green buildings by younger generation, thereby increasing uptake of units by first time homeowners	Incentives by financial institutions have aided in the uptake of EDGE certified developments	Lack of education exhibited by construction practitioners regarding green building principles and practices	High financial costs relating to RE generation, impacting levels of energy and water efficiency on developments	Lack of adequate Municipal involvement hindering progress	GB regulations in terms of RE generation and use in private developments is lacking in clarity, leaving clauses open to interpretation.
CS1	Enhanced standard of living is not a dominant factor but one key aim is to cater to energy needs of clients thereby increasing satisfaction with the green developments.	High market demand from first time homeowners who are knowledgeable of green sustainable buildings	Minor information on the impact of financial institutions with uptake of residential units for prospective property owners	Minor information regarding education levels of construction practitioners with green building principles and practices	Cost to generate sufficient levels of power via RE means is considered high thereby limiting amount of energy that can be generated via RE means.	Municipal involvement levels not significantly addressed.	Impact of GB regulations not significantly addressed.

CS2	Emphasis on aiming to provide regular power supply amidst the energy crisis that has resulted in loadshedding cycles.	Green building market demand not sufficiently addressed as being a factor.	Minor information provided on the impact of financial institutions on uptake of units by prospective property buyers.	General knowledge on green features implemented.	Cost of green technology is manageable	Acquiring the help of the municipality has been difficult regarding water treatments plants and infrastructure to accommodate energy wheeling.	Impact of GB regulations not significantly addressed.
CS3		Green building market not addressed as a factor in implementing GBFIs	No information provided on impact of financial institutions on property demand for green residential homes.	Minor knowledge on green building features and initiatives implemented.	Cost of incorporating green technologies at the time was too high	Municipal involvement not mentioned.	Impact of GB regulation not addressed.
CS4	Continuous relationship with community to find ways of enhancing living experience by incorporating sustainable design and green solutions to living requirements	Green building housing market demand addressed as an important driver in the uptake of units by prospective property buyers.	Minor information provided on the impact of financial institutions on the uptake of units by prospective property buyers.	Knowledgeable on concepts surrounding green features and initiatives employed. Provided an analysis of energy saving features and various ways water efficiency has been achieved.	Cost of green technology is manageable but cannot reach the energy efficiencies required.	Municipality has been slow with approval of water recycling plants	Impact of GB regulations not significantly addressed.

CS5	Medium emphasis on regard for enhanced standard of living as a driver.	High market demand for green sustainable buildings from the general public, inclusive of younger generation property buyers and older generation property buyers.	Incentives by financial institutions evidenced as being accessible to prospective property owners.	Knowledgeable on concepts surrounding GBFIs employed in the development.	High costs regarding energy wheeling	Municipality has been slow with stimulating growth of infrastructure to service the development	SANS 10400XA is a guideline but does not provide clear guidelines

Table 4.1 depicts the findings of this research whereby the private residential developments employ GBFIs but face various drivers and barriers in implementing the GBFIs. The analysis indicates three key drivers that were primarily discussed in depth by the focus group respondents. Furthermore, the analysis highlights four key barriers to the implementation of GBFIs with both focus group and case study respondents providing views on the barriers. The analysis further highlights the low-level involvement of the case study respondents regarding knowledge on the drivers and barriers experienced on the developments, whereas the focus group respondents exhibit greater knowledge and appreciation of the drivers and challenges to implementing GBFIs on all the case study developments.

The findings of the research, depicted in table 4.1 highlight the key drivers and barriers experienced by the developer in the private real estate sector. The theoretical model presented at the end of chapter two provides a framework for understanding the key drivers and barriers to the adoption of GBFIs in the real estate sector of SA. Figure 4.1 provides the keys drivers and barriers as presented in the data analysis thereby forming an empirical model of the findings. The key drivers and barriers are in line with those presented in the theoretical model that primarily represented the commercial side of the real estate sector.

Figure 4.1 presents stakeholder drivers in the form of awareness of green building principles and practices by construction stakeholders, and an increased awareness by the general public as the results highlighted an increase in demand for the residential developments by potential homeowners. The stakeholder driver is in line with the major driver detailed in the theoretical model which highlights the importance of the construction industry stakeholders, from clients to construction consultants, in the uptake of GBFIs to provide more economically and environmentally friendly buildings. The socio-cultural driver detailed in figure 4.1 establishes it as a top driver as opposed to the theoretical model in figure 2.3. The socio-cultural driver in this study relates to an enhanced standard of living for homeowners of the case study developments.

The results express the importance of being able to provide GBFIs that increase the homeowners' satisfaction with the dwellings, by providing a more consistent source of power supply and water security through innovative use of GBFIs. Furthermore, the GBFIs offer a socially sustainable space for the case study residents thereby enhancing their experience of the residential developments and increasing demand for the private residential spaces. The socio-cultural driver depicted in figure 4.1 further highlights the difference between the commercial sector buildings and the private residential sector in terms of what primarily drives GBFI uptake in the two sectors. Figure 4.1 indicates several

human related barriers as being the most prominent followed by market and government related barriers. The barriers detailed in the empirical model are similar to those established in the theoretical model developed by authors such as Aktas and Ozorhon (2015), Darko *et al*. (2017), and Oke *et al.* (2019) with slight differences regarding the key barriers prominent in the private housing sector. The human related barriers which include education of green building principles and practices by construction stakeholders, proved to be a high-level barrier, followed by market related barriers in the form of high financial costs relating to RE generation. The government related barriers in the form of municipal laws and involvement, and GB regulations, formed part of the key barriers encountered in the private residential sector. The barriers detailed in figure 4.1 are more in line with the major barriers experienced in the commercial sector according to the theoretical framework developed in figure 2.3.

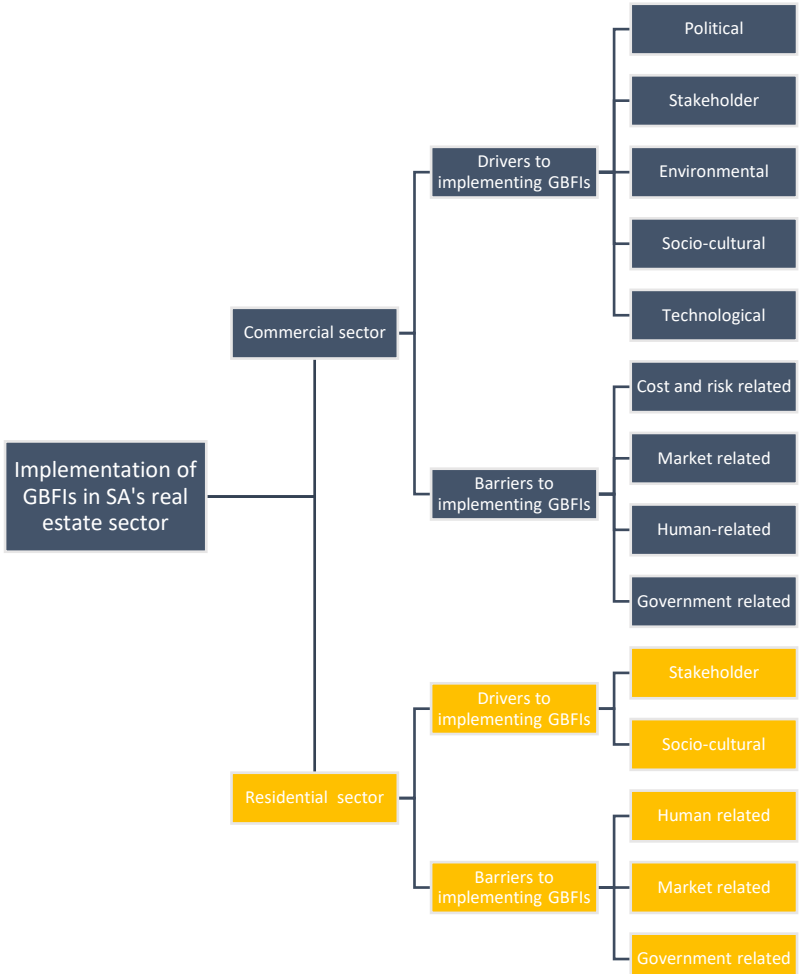

Figure 4.1 Empirical framework depicting the key drivers and barriers to adoption of GBFIs in SA's private residential real estate sector. Source: Author's construct (2024)

4.11 Chapter summary

The chapter presented the data collected from the semi-structured interviews with the focus group respondents and respondents from the five chosen case studies. Thematic analysis was further conducted to determine the common themes from the multiple interviews. A cross-case analysis was then undertaken to compare the findings from the focus group and from the case studies. The resultant analysis showed similarities and differences between the case studies and focus group interviews regarding the drivers and barriers faced in implementation of GBFIs in the developments. Arguments raised in the relevant literature were compared to the findings. The findings and discussions raised in the cross-case analysis are further employed in Chapter 5 to draw conclusions and provide recommendations for further research. The chapter concludes with a representation of the empirical model, that uses both the theoretical framework and the findings as the basis for the model.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The aim of this research was to investigate the drivers and barriers to implementing GBFIs in SA's private residential real estate sector. This chapter revisits the research objectives set out in Chapter 1, which are reviewed against the findings before supporting or refuting the research proposition. The chapter concludes by providing a set of research conclusions and outlining recommendations for future research in this area.

The problem statement, as outlined in Chapter 1, was as follows:

The housing sector is considered one of the largest consumers of energy and therein lies a possible solution to implement renewable energy generation in households, with the surplus to be sold back to the national energy power grid. GBFIs exist in a bid to increase the greenness of developments within the building sector. The implementation of GBFIs in the private housing sector could provide solutions to alleviating the effects of the energy crisis on households in an environmentally friendly manner. Literature however does not provide a framework to understand the drivers and barriers to implementation of GBFIs in the private housing sector of SA. There is a further lack of policy on adopting and investing in renewable energy in housing sectors, such as net-zero, carbon-neutral or net-positive.

5.2 Achievement of Research Objectives

The objectives of this study were to:

- Determine the role of GBFIs in the private housing estate sector
- Provide an overview of the role of private residential estate developers in the implementation of GBFIs in SA
- Identify the drivers and barriers to implementation of GBFIs in the private housing sector
- Identify Strengths and weaknesses of the Green Star, EDGE, and Net-Zero rating tools
- Provide a roadmap and framework of the drivers and barriers to GBFIs in SA's private residential sector

Objective (i), determining the role of GBFIs in the private housing sector. Role refers to the function that GBFIs play to address the challenges concerning energy and water scarcity, and GCC mitigation. Objective (i) was achieved through conducting semi-structured interviews with professionals responsible for implementing GBFIs in the residential developments, and relating this to the literature

on the role of GBs in the residential sector. Hache *et al.* (2017); Doroudchi *et al.* (2018) emphasise the role that the residential sector plays in energy consumption and how the sector may further address energy and GCC challenges by incorporating GBFIs to develop more environmentally friendly developments. The study was able to ascertain the roles of GBFIs from the developer's point of view, with the key role being able to provide clean energy that is able to meet the demands of the residential sector, as highlighted in the literature.

Objective (ii), providing an overview of the role of private real estate developers in implementing GBFIs, was achieved via reviewing the literature and conducting semi-structured interviews. The literature expressed a holistic view of what developers should focus on regarding implementation of GBFIs, paying closer attention to the commercial side of the building sector. The development of the EDGE rating tool however, highlighted by GBCSA (2017), focuses on residential building certification, putting further importance on stakeholders in the residential sector of the building industry. Private real estate developers further play a prominent role in today's society as there is an increase in the rate of urbanisation thus driving demand for living spaces. The study was able to draw out the respondents' views on what role they play as private real estate developers, which to them is to provide affordable dignified living spaces that incorporate GBFIs to help in the country's fight against GCC.

Objective (iii), identifying the drivers and barriers to implementation of GBFIs in the private housing sector, was partly achieved through semi-structure interviews. The data collected yielded more barriers than drivers with respondents focusing more on the challenges faced with implementing GBFIs. Once the respondents had demonstrated their knowledge on GBFIs and the need for them, the researcher could perform a thorough enquiry into the challenges faced in their green developments and any factors that have served as drivers to realising the green developments. Aktas and Ozorhon (2015) reiterate the need for countries to perform in-house studies to understand drivers and barriers to implementation of GBFIs, to provide local solutions to problems that may be unique to the country. Respondents provided more barriers than drivers to implementation of GBFIs with several of the drivers and barriers being similar to those presented in literature and in the theoretical framework.

Objective (iv), providing a framework of the drivers and barriers to GBFIs in SA's private housing sector, was achieved by analysing the results from objective (ii) and (iii). The need for objective (iv) rose from identifying the role that GBFIs play in addressing the challenges identified in objective (i). The respondents provided four main barriers, with two minor ones, and three main drivers. The drivers and barriers highlight the issues that require further investigation and unique local solutions.

5.3 Findings of the Research Question

The study aimed to address the following research question:

What are the drivers and barriers to implementing Green Building Features and Initiatives (GBFIs) in South Africa's private housing sector?

The uptake of GBs has been on the rise in economies around the world, spurred by the need to address the construction sector's negative environmental effects of depletion of natural resources and production of GHG emissions, and in turn, the energy crisis faced in the world today. GBFIs perform an important role in leading the construction sector in a cleaner more energy-efficient direction. Implementation of GBFIs however has its own set of challenges that may be unique to each country, whether developed or developing. Marsh *et al.* (2020) developed five main categories to describe the barriers faced in the implementation of GBFIs in SA. The categories highlighted in the study by Marsh *et al.* (2020) formed the theoretical framework for the study. Nikyema and Blouin (2020) further provided drivers of the uptake of GBFIs that were further used as a framework for the study.

The results from the study highlighted three major drivers of the implementation of GBFIs in the private residential sector, namely, enhanced standard of living, incentives by financial institutions, international investment, and awareness of GB principles and practices. The drivers from the study fall into the categories highlighted by Nikyema and Blouin (2020). The results from the study further highlighted several barriers to GBFI implementation, namely, awareness of GB principles and practices, building regulations, environmental conditions, high financial costs relating to energy, municipal laws and involvement, quality of green technology, and the state of infrastructure. The barriers derived from an analysis of the results provide detail that is specifically attributable to the private residential real estate sector of SA. The barriers from the study can be organised into the categories highlighted in the study by Nikyema and Blouin (2020), with an increased level of detail.

5.4 Support or Refute the Proposition

The research aimed to address the following proposition:

There are governmental, human, and market related barriers to the adoption of GBFIs in South Africa's private housing sector. There further exists, socio-cultural drivers, stakeholder drivers, and environmental factors, that serve as drivers to the adoption of GBFIs in the private housing sector.

Due to the findings, the proposition is supported, based on the drivers and barriers derived from the results of the study. The drivers include and enhanced standard of living, increased awareness of GBs by general public and construction stakeholders, and incentives offered by financial institutions. The

framework provided by Marsh *et al.* (2020: 31) mentions stakeholder drivers and socio-cultural drivers as being key drivers in implementation of GBFIs in developments. The research supports the stakeholder drivers as awareness of the stakeholders is key in stimulating the market demand of developments that utilise GBFIs. The enhanced standard of living driver falls under the umbrella driver of socio-cultural drivers as presented by (Marsh *et al.*, 2020: 31). The socio-cultural aspect includes providing a space that stimulates both the environmental and social aspect of sustainable GB design.

The key barriers presented in the study include, education of green building principles and practices, high costs relating to energy, municipal involvement and green building regulations relating to RE implementation. The identified lower-level barriers include the quality of green technology and maintenance, and the state of infrastructure. The barriers are further in line with the key barriers identified in the literature (Aktas and Ozorhon, 2015; Chan *et al.*, 2018; Nikyema and Blouin, 2020). The education barrier relates to the human related barriers presented by Nikyema and Blouin (2020), followed by the high energy costs barriers which is line with the market related barriers, highlighted by Chan *et al.* (2018), that speak to the availability and accessibility of green technology in developing countries and the associated high cost of implementing said technologies. The subsequent key barriers of municipal involvement and inadequate RE green building regulations relate to the government barriers presented by (Nikyema and Blouin, 2020).

The government related barriers highlight the inefficient adaptation of GB policies and regulations that are suitable for the needs of the location. The lower level barrier of the state of infrastructure further relates to the government barriers highlighted by Nikyema and Blouin (2020), whereby government bodies should have frameworks in place that allow the generation and distribution of RE to occur in an efficient and cost effective method that stimulates uptake of GBFIs in developments. The quality and maintenance of green technology, which forms the final identified barrier in the research, is line with the market related barriers presented by Aktas and Ozorhon (2015), which speaks to the quality of the available green technology in developing countries. The identified drivers and barriers therefore support the proposition and provide further insight into the more impactful drivers and barriers faced by developers in the private residential sector.

5.5 Conclusions

The drive to meet international GB standards highlights the collective effort by economies in developed and developing countries in meeting GCC mitigation efforts. The ongoing energy crisis in the world has further encouraged efforts by governments to implement RE sources in developments as energy is a pivotal resource in the functioning of any economy (United Nations, 2023). Feasibility of green developments however is dictated by several factors that in turn can serve as barriers or

drivers to the uptake of GBFIs, depending on the state of the economy. The study shows that the numerous barriers are similar to those faced in developing nations, with key barriers being; a lack of education of green building principles and practices, high financial costs relating to energy, inadequate building regulations relating to RE implementation, and lack of municipal support regarding developers' green initiatives. Lower-level barriers include the state of infrastructure, the unique environmental conditions of each site, and the quality of green technology from third party suppliers. The barriers primarily relate to a need for government intervention by providing clearer requirements in implementing RE in green buildings and by assisting developers in their goals of providing EDGE certified dwellings that target water, energy, and embodied carbon efficiencies.

The study further shows that the identified drivers are fewer compared to the number of barriers. Enhanced standard of living and awareness of green buildings proved to be the primary drivers to GBFI implementation with bank incentives forming a low-level driver highlighting the need for financial institutions to increase involvement with clients who wish to purchase green developments. Increase in awareness of GB principles and practices was identified as a key driver highlighting the importance of creating channels of communication that stimulate the general public, particularly potential property owners/buyers, to invest in developments that incorporate GBFIs.

5.6 Recommendations for Further Research

- Conduct further research with other private residential estate developers, of varying sizes, to obtain further details of the challenges faced as they may be different owing to the size of the development firm. This would allow the researcher to form a more detailed framework on understanding the driver and barriers to GBFI implementation in the SA private housing market
- Interview authorities in various municipalities to obtain further clarification on the municipal laws and by-laws that regulate development of residential estates, paying attention to the incorporation of RE sources. This would offer the researcher a more comprehensive understanding of the barrier presented by municipalities' involvement, or lack thereof, and provide possible solutions as to how municipalities can work more efficiently with private residential estate developers.
- Conduct further research into the building legislation that governs RE use, to determine which areas requires further detail and revision. A review of the legislation will stimulate a greater discussion on potential changes that need to happen from the highest level, that in turn will flow down to all levels of regulation.

- Train local construction professionals on sustainable building techniques and green certifications such as EDGE home to enhance their capacity to implement green building initiatives effectively and promote collaboration among construction development stakeholders, including architects, developers, local communities, etc to ensure a comprehensive approach to implementation of GBFIs.

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List of Appendices

Appendix 1: Consent Form

Research Project Information & Informed Consent Form

DEPARTMENT OF CONSTRUCTION ECONOMICS AND MANAGEMENT

Title of study: Investigating the Drivers and Barriers to Implementing Green Building Features and Initiatives (GBFIs) in South Africa's Private Housing Sector

Supervisors: Dr Louie van Schalkwyk. Email: louie.vanschalkwyk@uct.ac.za & Dr Saul Nurick Email sd.nurick@uct.ac.za

Dear Participant,

You are invited to participate in an academic research study conducted by Raphael Madzingaidzo, a Master of Philosophy student in the Construction Economics & Management (CEM) department at the University of Cape Town (UCT). This document serves as both a brief introduction to the research topic and the informed consent form, should you show interest in participating.

The purpose of the study is to investigate the drivers and barriers to implementation of GBFIs in South Africa's private housing sector. The determination of these drivers and barriers will aid in producing a framework for understanding the link between emerging GBFIs trends and their application in large-scale private residential developments. The investigation will provide insight regarding the effectiveness of current green certification methods employed in the residential sector and the role that GBFIs play in supporting renewable energy initiatives. The study will further provide understanding of the measures taken by developers to ensure the successful integration of GBFIs in private household developments, with the overall drive of creating a carbon neutral South Africa in the private housing sector.

Please note the following:

- Your participation in this study is entirely voluntary. You may choose not to participate in the study, and you may also stop participating at any time without any consequences.
- Your name will not be included in the Interview transcription or required to participate in the study. Therefore, your anonymity will be protected in the final research report. Furthermore, your answers will be strictly confidential and only used for the purpose of this study. Your data will not be shared with third parties.

- The findings of this study will be used for academic purposes only and may be published in an academic journal.
- No remuneration will be given for your participation in the study.
- The Interview should take no more than 40 minutes of your time.

Please indicate whether you consent to participate in the study by selecting one of the tick boxes. By consenting, you agree that:

- You have read and understood the information provided above.
- You give your consent to participate in the study on a voluntary basis.
- You give your consent to the audio recording of the interview for data transcription purposes only.

☐ **Yes, I consent** ☐ **No, I do not consent**

For any questions or comments regarding this study, please do not hesitate to contact Raphael Madzingaidzo at: mdzrap001@myuct.ac.za

Appendix 2: Interview Questions

South Africa's Green Building Feature Initiatives questions for Semi-structured interviews

1. What are your views on the introduction of Green Building Feature Initiatives in the building sector holistically?
2. What is the importance of implementing Green Building Feature Initiatives in the private housing sector?
3. What are the benefits, for society and developers, of incorporating Green Building Feature Initiatives in the private housing sector?
4. What are the requirements for providing EDGE certification to a development?
5. What are your views on the EDGE certification tool; any strengths or weaknesses you have observed?
6. What are your views on the net-zero aspect of green certification; is it achievable in the current private developments?
7. What are the strengths and weaknesses of the Green Star rating tool?
8. To what extent have green building regulations and principles aided in the implementation of renewable energy sources in private household developments?
9. What are the barriers you have faced in implementing Green Building Feature Initiatives in the private housing sector?
10. What are some of the ways you would suggest enabling a more efficient implementation of Green Building Feature Initiatives in the housing sector?
11. What are the challenges or differences encountered in implementing Green Building Feature Initiatives in Durban, Johannesburg, and Cape Town private residential projects?

Appendix 3: Interview Transcripts

Multiple Interview Managerial Positions

There are six speakers

Researcher

MDE

EH

SHEQ

HDP

GAP

Held on 10 October 2023 at the developer's head offices in Johannesburg.

Researcher: Thank you for meeting with me. My name is Raphael Madzingaidzo, MPhil student at the University of Cape Town. I circulated the interview questions earlier upon your request, so I am sure you are all familiar with the questions. We can get right into it with the first question. What are your views on the introduction of Green Building Feature Initiatives in the building sector from a holistic point of view?

MDE: The introduction of GBFIs is critical for the residential sector being in a both energy and water scarce country. This allows development to continue despite the surrounding infrastructure not being there. It also is the biggest contributor to emissions is the building sector. so, introducing this into buildings is the only way to long term continued development at the rate it needs to in a developing country. There's scarcity of resources, so you can't keep building a development that will need huge amounts of power when there isn't power available or huge amounts of water when there isn't water available. The only way to be able to continue doing large developments is to make them more efficient, make them use less resources, that's the only way to make the resources that are available work.

EH: Looking at a holistic view, we are a JSC listed company and with that listing comes a commitment to sustainable reporting as required by the JSC. But linked to that is our commitment as one of the largest residential developers in SA aligning to SA goals and SA's commitment to international bodies. That is where we as a developer from a very practical perspective of reduction of co2 emissions and water saving initiatives, from a practical implementation perspective, that is where we are bringing it

from the ground to a national commitment that leads to an international commitment. So it is important to understand the why we are doing what we are doing its twofold it's a country commitment internationally but also working from a local perspective working within from the constraints of SA context in terms of natural resources, how then do you still provide a necessity according to our constitution in terms of housing? But how do you deliver it in a sustainable manner? That's what we want to achieve with introducing GB withing our practices.

Researcher follow up question: So I reckon when you mentioned JSC listed company, that brings a commitment in and of itself?

EH: Correct, as a JSC listed company we a required to report sustainability matters. Looking at the investor trends and the market trends, there's a new concept of ESG metrics and principles that is required to be reported on. Investors then assess your company in terms of the risks related to ESG impacts both positive and negative and what is the risk to their investment. So we have started our journey in terms pf ESG reporting and its important that you understand the linkage from a SA commitment to an international commitment to our organisations commitment.

Researcher follow up question: So is it your view that property development companies that their commitment to the SA goals of low carbon emissions, is it something only related to the residential sector or do you think the commercial space aswell?

EH: I think uhm and again, talking without stats at hand, I think the fact that SA is linked to SDG's, its an aspiration for in a country to actually integrate those goals into whatever their mandate is of their company. For us, our mandate is building turnkey to suite all levels of society. Therefore, when my colleague talked earlier, we have different branding, we have green, classic and signature. The thinking behind those different levels of branding is from a social perspective. The social is linked very strongly to the SDG goals of how is our activity as an organization, what impact are we having on society and communities around us. So we are offering developments to different levels of is it economic levels of our communities. To come back to your question, I cannot answer in terms of other developers, but I do note that if those developers are JSC listed automatically there's a sustainability aspect that they will report on and they should integrate into their business

SHEQ: Just to add on my point of view as a senior citizen, we are doing the right thing. We want to leave the earth in a better way than it is currently. We just heard earlier on with shared resources, if we don't try to preserve what we have, the younger generation will suffer.

EH: And linked to that, its important to understand our vision, linked to that we need to understand that we are living in a very conscious society meaning that our buyers are more conscious of what they

are buying into. So, they are looking for developments that demonstrate green building principles. They are looking for developers of developments that they can invest in that their putting their hard saved earnings into that can demonstrate that they have appositive impact on society and environment. So it is very important to understand that it's a conscious market as compared to previously, I could say from my opinion there's an involvement of societies understanding of development now

HDP: from my perspective for I think other developers will jump onto the green building because there's a few things that are happening. In terms of the construction cost to develop, its going up, so if you can get your clients at the end of the day saving money in their pockets because we talk about this and the young people we are meeting today, yes they are on the social media, they know about green, they are reading about it all the time they are in a different environment, but the older generation guys are not that aware of it. What they are aware of is what does it mean for me financially. So GB brings across, and that's where we started, meaning the older generation guys when we started developing, is to see how we can make it better for our clients, how can we save them money so that the water consumption and electricity consumption with the cities can be reduced so that the cost they have to pay to cities is reduced firstly. That impact we then grew that a bit with our green bonds as well, where if they take out a loan, they get saving because they have a green building. So these are the kind of ideas and where it stemmed from originally. Its grown of course and we have evolved and the thing of making sure that the whole nice cuddly feeling thing that we want to give to be a good developer, because if we are standing at a braai, and I was to tell someone that I am a developer, they go like "oh, you are the guys that cut down the trees." That's what people think, that's the perception that is out there, however for every tree that we lose, we are adding six more. Those things are not said so our marketing is increasing and those type of things with colleagues coming on board with his team and explaining it better and putting it in perspective of cost and what we are doing for our people. Its massive. So for us starting this, we always believed that we are the starts, we think we are the best, so other developers will have to compete, will have to do something because our pricing will dictated and will be cheaper for someone to stay in our buildings than in our competitors homes, so they will automatically over time also start doing it.

Researcher: we have touched on the 2nd question already.

EH: I think we have talked to the 3rd question as well, benefits to societies and developers: we talked about the cost.

MDE: the various savings, the environmental and financial benefits. Financial benefits to developer and client at the end of the day and the altruistic benefits, making the world a better place by doing it.

Researcher: What your edge certification is all about, and some of the requirements you are aware of?

GAP: The edge education tool has got a preliminary certification which is basically a design rating on an apartment and it is followed by a post construction certification which is an as built certification which is basically proving what you built is in alignment with what you've designed so those are the two basic two certifications you get these a third one which is a -0 certification uh that certification is not targeted by us and the reason for that is it expires and would require a renewal and so basically just to explain to the preliminary certification also expires but then it is followed up by the post construction which doesn't so the post construction certification is a certification which will be held by that apartment however it goes in with the end of a pack that the client when they purchased their home they have that certification and they will have it and be able to sell their apartment as an edge efficient apartment um and obviously live in it. At our organisation we don't target the net zero because it expires and then it falls onto the client to have to renew. We do hope that the client would want to look at renewing the certification if they did want to look at renewing the certification if they did but you know and they so within edge you've got two ratings basically you've got an edge rating which is a 20% reduction on energy compared to the base case, 20% reduction on water against the base case and a 20% reduction on embodied carbon in materials used against the base case that's your edge certification. Then you have edge advanced certification this is the certification which we target in our developments. It is the highest certification you can get it is a 40% reduction on energy used against the base case 20% reduction on water against the base 20% reduction on embodied carbon and this is the certification we applied to all of our developments so our old developments prior to the edge advanced certification being developed it was only edge so our developments have an edge certification but the majority around 3/4 are edge certified and we would be willing to share those numbers with you. This goes to the strengths and weaknesses we have observed with the edge certification tool has been developed like all things start it off with the version 1 tool then we got a version 2 tool and we are currently working on a version 3 2 on one of our developments in Cape Town and there is a version 4 tool coming out in December 2025. So the tool is basically becoming more strict and stringent with regards to measures targeted. So the older tools had weaknesses that we could work around and you could target specific items within your unit to achieve a status which you may not actually sort of achieve where the YouTube and what we are finding in version 3 is becoming very strict and this is really taking oh bringing importance on aspects in the units or in the building that

are big energy consumers oh big water consumers and other aspects. Other strengths of the edge tool is location based. So you are comparing what if your bullet Janice book you are compared to the base case in Johannesburg any local materials so you're never you know you're never being evaluated unfairly I think that's obviously also become a lot more accurate as they developed a tool the data collected specialty boards to embody Corbin bricks and material until Africa very different to materials overseas but in in that aspect the age app does compare you to the local base cases so differently strengthen that yeah that's sort of a broad aspect if you put anything else that you want to so in the I don't know if we need to discuss there's just using the H2 strengths and weaknesses and there's nothing really yes equation 6 as we start discussing it technologies implemented

MDE: yeah so I mean I can add to that Think just keep it short the biggest strength I think the edge tool is to go into it put in information about your building and get guidance on how to make it more energy and water efficient so very easy very quick to do anyone can do it it's freely available you know it's localized information that that is great and this is strength of the edge tool however I'd say weakness of the edge tool is if you want to get the actual certification process to get the actual certification the amount of documentation and supporting documents that are required the whole process from a bureaucratic point of view is currently quite onerous and it's taking a long time and so with that you paying professionals and consultants to assist you with that certification starts making it become more costly as well so I'd say a weakness of the H2 is the process of actually getting the certification can be onerous in terms of professional time company time and then actual costs because All the supporting documentation that's needed I think that is a big problem because you got to this very easy to use very informative but then actually getting the certification to show that you have it up because the actual certificate is what is then used by a third party to say this is a green building that is the weakness of it is that actual the bureaucracy around certificate I think is the biggest weakness it's great OK.

Researcher follow up question: Leading on from that so like what are the implications for the clients if cost is one of your biggest things?

MDE: So, depends if you mean the client doesn't out client yeah there isn't really a complication for them because this is costed into the development and for us when you are developing at scale like we are that cost isn't that substantial on a per pocket basis. If you look at it on a development basis it is substantial but on per pocket basis it isn’t substantial. Where there is a significant implication for a client is if an individual wants to go and edge certified just their house or just their apartment you're looking at quite a big premium you know the order of 20,000 Rand to actually get the certificate which is not really going to be done so the weakness of the tool is while it's great in terms of practically

getting these things implemented it's not necessarily going to be accurate to get the certification which if you're trying to build incentives and things around that if they if it's impractical to get the actual certification on an individual level something to happen so on a massive scale for us it makes sense it's you know as a percentage of the whole project cost for us its not that's substantial as you get smaller it starts becoming very impractical.

HDP: for me at my own house, I will never do the edge, ever. yeah I mean even before we started with all of this I went to my house started working out the what is actually affecting my house income you know to the electricity, started working on what could I do to change it make it streamline changing the globes taking out the stove putting gas and overtime doing all these things at my house so that's fine and my bill to the cities coming down but I'm not going to fork out the money order spend it on changing my stove and buying a certificate that means nothing to me personally so just giving a personal viewpoint from our clients so they get it automatically because they're purchasing there's a great market believe it's the right thing to do we believe it builds for them yeah but for the public out there I don't see them doing it on an individual level.

MDE: and it's also individual doing it you have to go through that same paperwork process so like it's a lot of effort for at the moment the only benefit that you potentially could get is a reduced interest rates rate from your bank which has been that's great and it's worth it but if you having to spend a couple 100,000 of implementing the changes of our house which on a full house could be as well as in another 20,000 and six months without doing paperwork and paying a professional that's where it starts becoming very difficult so there if there was, if we wanted to encourage this, if there were incentives where the cost that the costs that they could be shown to be related to getting a green building certification you get a rebate or something related to maybe then it would start working

Researcher follow up question: and so then like OK so I understand now I'm like how from a client perspective it would not be as feasible so then how do you maintain the efficiency usages like which speak to your advanced age certification how do you maintain that in your properties?

MDE: so I think that's something that I can answer also a lot of it is just to the design of the apartment so it's inherent to the design a lot of the tell me all the energy related things have water you know we've installed fittings we can't stop people changing those out but if they do change it out they're going to stop getting those savings uh from an energy and water interview what we're now doing is we're implementing things on the developments which are not directly within an apartment to ensure that those efficiencies remain things like centralized solar PV systems to reduce the reduce the municipal energy consumption of the site you know making the common areas energy efficient things like that and that will all assist things like smart metering I think is a critical element of this because

the smart metering, if people make use of it and admittedly not everyone will, but on that you can see when you are using power and you can understand what you are doing that is causing you to use a lot of power and that encourages people to stop behaviours that are inefficient then on the water side we have put in low flow fittings throughout but now we're also implementing things like wastewater treatment plants or other water sources so that you've reducing your potable water consumption just by virtue of being in the building development where that watering plant is being maintained going forward by us to ensure keeps producing that that water So what we've tried to do is make it so that it will continue to be efficient even if the person decides to make changes inside their apartment they still going to get benefits on the wider design.

Researcher follow up question: on edge OK cool thank you I think that was actually quite a view on the edge rating tool. So you did mention that net zero is not something our organisation is into that but then I started to ask do you think the NetZero approach is something that should be looked into since the whole concept is basically trying to reach carbon neutral in you know in in developments you know so is that not something that that oh what are maybe some of the barriers in the private housing sector that's stop us from having I'm committing that too you know developments?

GAP: so just to let you know all one has signed a science based target commitment by we are committed to reducing our quality emissions 38% by 2030 and then to be net zero by 2050 you know this is a commitment and a lot of companies around the world have committed to and it's been aspect reducing our scope 1-2 and three missions to create the zero so your question was with regards to us going net zero in our developments so we are we speaking just specific to the apartment certification are we, I see you have later questions with regards to the lifestyle centres

Researcher: we can start with apartments.

GAP: regards to achieving a new serious certification on the building you need to have the annual carbon emission or carbon spent on a apartment must equal zero in terms of an offset so whatever you use must be offset by renewable and at the moment our PV systems which are our way off-setting carbon efficiency in a development aren't at that annual offset, reason being is in the winter months when the solar radiance isn't as high as in the summer months we are finding that solar obviously is less efficient so the consumption or usage through council electricity is a lot higher and the solar is a lot lower you know summer months vice versa we get really good efficiency from the solar installations Those solar installations are there to offset the geysers as a SANS XA requirement which we obviously comply with so right now, and x will confirm, is that the PV installed in our developments isn't sufficient to offset our consumption to a point where we become net zero we would need to install significantly more PV on the developments which is a capital aspect.

MDE: yes that that is correct the biggest problem with residential buildings and net zero is that load profiles in the residential sector are almost exactly out of balance with a solar load profile on a residential load profile all your power consumption is in the mornings and in the late afternoon evening which is when you're not getting solar energy, all your solar energy is being produced between 11:00 to 1:00 during the day so you can't just make a residential development net zero by throwing more solar at it and you need to do what we've already started as you make it as efficient as possible so that is an element of it gets you a lot closer and that is a lot of the reason why we didn't even get to the 40% reduction compared to a benchmark because a lot of that is reducing usage rather than just putting solar on the site to get to a true net zero from practical sense on residential you need to put energy storage on site which is extremely expensive and long term viability of it is debatable and so getting to a fully net zero residential development is very difficult and from a financial point here moment it's not really a viable option. There are things you can look at , wheeling of renewable energy into a development, things like that, but at the moment so that is not mature enough in South Africa for to make sense again residential large industrial scale mines things like that you can you can do that but on a residential scale going for a full net zero at the moment it's just not practical technical and from the financial

Researcher follow up question: so basically financially it's it's not as feasible in the current economic state of the economy ?

MDE: just from a from a technical perspective what you need to do to make it work makes it economically not feasible even if we're in a much better economic situation that's not going to change unless the technical side of it that allows you to get that changes several things that could happen that would allow it, then it becomes quite difficult that being said we do net zero buildings on our developments where we can take advantage of some elements that are some of the shortcomings of doing it on a development widescale. So on our lifestyle centres in developments we do build them as net zero carbon buildings where again the idea is you make them as energy efficient as possible you reduce how much energy they have and then you offset the entire consumption with solar PV the difference why you can do it there and you can't do that development level is because this is a building inside a development you can export from that building into the development for that energy to be used in this right that you don't lose that energy whereas if you're development level you can't currently in a feasible manner exporting to the municipal grid to offset the remainder of your energy and that is that is one of the key elements of when that changes then why stop becoming more feasible but right now it's not.

Researcher: I am sure we can move on to question number 7 now, your views on the green star rating tool, any strengths and weaknesses of the Green Star rating tool?

GAP: so the main I think the one of the most important aspects of the green star rating tool is it's giving a sort of verification to what we're doing and uh like we always the through the people of the council South Africa there are there are other certifiers but they are the main switch of fire and it's basically the right thing gives weight to what you're doing obviously our commitment to providing our clients with world class lifestyle sectors goes hand in hand with the highest rates you can get on a on a building on a lifetime season so we achieve 6 star ratings which are 75 points and upwards and there isn't anything higher than that. so we use we have applied the green star rating tool to 10 lifestyle centres at the moment that all holds six star ratings and we are busy with an 11th we also have a the rating tools also being used in the office sector in our offices that you're sitting in at the moment which is also a six star office rating but there's yeah there's there's a lot of aspects to that green story is sort of a new building certification and there's a net zero certification which relates to carbon, water, waste and ecology. we target the carbon and currently at the building that you're in the waste we currently busy with the net zero waste certification there as well. So there is many sort of tiers sort of ways to target things, we definitely are busy with multiple aspects. With regards to the tool, it is quite consultant or professional based in the aspect that you are paying quite a bit of money in professional fees, so that is something that could be a weakness for the tool, but it is a tool that is, if you come up to sort of a like a speed bump of sorts in the aspect that you this is what you have built and is dependent on the area that you are in and that if there is nothing you can do about it, you can approach the people in council and voice your concern and you can discuss it and go through it and add it as a series of location based. It is not stringent in the fact that this is the rule and sorry you didn't meet it you don't get the points. It is something that is dynamic and ever changing and being development continually and ever changing for each building.

Researcher: Thank you for that response. I think we can move onto the next question, to what extent have green building regulations and principles aided in the implementation of renewable energy sources in private household developments?

GAP: because to the commentary on the the PV it was in 2021 that's the that you SANS 10400 XA regulation came out and that's basically forced us to comply with the aspect that of geysers with this sort of electric resistive heating that we needed to offset so to just know no more than 50% supplied by means of resistance OK so obviously If geysers s are a have a COP of one very bad efficiency and that's why this this regulation was put in place and that's when we implement PV on the developments there are calculations done to ensure that we are compliant with that regulation.

Researcher follow up question: so the regulation itself does not go into detail regarding they use like that you need to use solar PV?

HDP: that you need to use solar PV So what it allows you to do and I mean at that stage when the regulation side I was probably the only one to the round started before that actually I know that was when it got implemented but cities so we looked you could do gas heating that many does there's also induction geezers or heating sources that you can use and then of course heat pumps and so many of the developers then went for that so we tested all of these different elements OK from the induction through to the gas and we found that all of them has got their shortcomings and the conventional geyser so being the most efficient way to give our clients and their constant heat source and with that said we had to because I mean the other ones you know we saw going to load shedding then the gas geyser and that night you know all the the the cost of gas is regulated through the fuel industry and that's also poor in terms of our environment environmental and our greening you know going to get and so there was a lot of consideration that took us months it took us like I think like two seasons to figure out which one of these elements is the best because also how do you actually physically do it influences when we did the heat pumps we got people in from porch university that we did this whole study for a year on heat pumps and if you do it individually or do you do it per building as a bigger structure and how do you store the water how do you get it how do you meet to the water what is the easiest way for body corporate stick to go to point So what we found as I developed by the way we develop is that the solar PV is the greatest way to go and offsetting it against the 50% resistant thing so we did start that calculations with net to prove all of that and then when we started implementing you know the cities got on board after that so they had a very they they they SANS is very open-ended they allow you to figure it out and then once you've figured it out yet to submit a lot of reporting to the cities proving our point and he shouldn't you know that this is how we want to approach it different way and they often got installed all the data that they've collected you can improve what your theory was yeah so we had to go through that originally

Researcher follow up question: basically the SANS10400 XA is the only one that speaks to you implementing RE sources

HDP: yeah so I'm hoping that things will change from you know as the like I say the cities are coming on board and you know they also adopting the screening but the wheels in the in the city works very slowly yes going to take you

Researcher follow up question: so basically in your different developments across the board you then implement you then implement your own your own methodology?

HDP: and so we thought like the black water treatment plants and things that we do, let me do we start working on what is the best solution how can we can see this is coming from a sustainability point of view in South Africa that there's not going to be sufficient water for instance or the load shedding is going to be a problem or this or that and pick up these things and we understand that the needs of our clients so we'll have to come up with a solution and it's not so much regulated only got this one regulation that they're talking about but we believe because we are doing this stuff with things that the city will come over like I said Joburg water for instance is looking at that munyaka seeing that as their test up seeing that this is quite good , it is probably the best wastewater treatment plant that they have seen, its better than their own. They are also learning from the new technology that x and x are bringing into the company and they really research it until they make a decision. And I think that will people become more aware of this the cities and inspectors and so forth they will start changing the regulations but I think it's going to take some time you're going to happen over night.

Researcher: Thank you for the details answer. We can continue with question 9, what are the barriers or challenges you have faced in implementing Green Building Feature Initiatives in the private housing sector**?**

HDP: okay so OK so I'm going to look at you but I mean for instance what we can see from the data is that like Cape Town is different weather wise, lets just talk solar for a minute you know so you have to figure out as the thing rolls through the season is it actually efficient is it the right thing to do if you ask these questions because the cycles of of the different seasons affect your solar PV for instance so what you've possibly done in Gauteng doesn't work as efficiently or the same within KZN or in Cape Town. so those kind of things pop up when we adjust and making sure that the the system that you install is actually delivering on what the calculations were so that's what x and x get up to all the time ****** and I'm making sure you have to constantly play policeman you know you get sold the system from external party gets installed but it doesn't always produce what you believe it's going to be so and that that we see in the different regions as well so and then we're left to adjust

Researcher follow up question: so quality basically of the materials use

HDP: OK that it's it's different between the different regions

Researcher follow up question: this mainly affects output then?

HDP: correct and seasonal.

Researcher follow up question: no other challenges you have faced in

SHEQ: Finances

HDP: this technologies I mean you must understand that as a developer you know we all do this it's quite nice and cuddly like always say but at the bottom line also trying to earn a living you know so if you uh going to implement all these systems which we're trying to do you know you have to have volume first you have to have it so your business model still works there's not real benefit from the city or cities in this case to pressurise us to do this but its all to our clients at this stage of the game so our clients are getting the benefit. The company per say financially is to take it from the bottom line something we're adding to development that wasn't there before you still buying the same house so our client still buys the house we do believe that some of the younger generations are buying homes because of the greening you know we believe that that generational shift is coming through but initially you know the people you know it's not there yet and in the future it will be very strong you know and but right now what we're finding is she still in between people you know they don't understand that there's a lot of education that needs to happen in South Africa in terms of greening. I think other countries possibly its better received than in South Africa. But there is also the financial constraint you have to balance out what can you afford to do so like you know trying to get the Rolls Royce so we would rather do the Toyota than doing the rolls Royce .

GAP: I think it's the education and the understanding is huge I think that the construction industry is quite simple and simple and basic aspect that is it's it's a it's some brickwork some plasterwork so we put some paint on paint but it's just painted and produce for some taps and and a toilet and it's all easy and that and you know there are people that are trying to sort of like other Portman is trying to influence the sort of industry positively and saying you know what instead of putting them to bed but then we know it is over five years it's going to save you 20% on the water so in the long run so and I know we always see more on this one of the barriers was obvious serious resistance to change and construction is is it prominent if it works why changes and we coming in and saying let's change it for the better and This is why so I think we're the people take a while to absorb get used to the idea because it's time to see something different you know resistance to changes as the area.

Researcher follow up question: so do the think the resistance could be linked to the average cost of moving into an apartment that has all these ratings in terms of edge ad all these technologies. So do you think that can cause resistance to people in terms of weighing up the cost with a normal apartment that maybe does not have all these ratings or technologies?

GAP: No I don't think it will be a barrier. Lets say a first time owner is presented with a home, uncertified green home then you have an edge certified home that's 40% of. You have all the numbers and comparing the two, I don't think it is a barrier, it is definitely an incentive.

Researcher follow up question: You spoke about costs in terms of finances that sometimes it is not feasible, how do you think that can be fixed in a sense for us to be able to implement those expensive features in our developments? Do you think it is something that can be fixed in terms of finances?

HDP: So there's a few things that can change. Firstly the cities, the city is just a big business at the end of the day. So the city makes their money with the rates they collect from the homes and they get a rate, that is the net income if you can see it that way. Upfront they have got these bar contribution offsets that you have to pay because you are adding so much more to the infrastructure load, you have to pay. What's supposed to happen in a perfect world is that once you pay this money, they are supposed to upgrade the systems, you know put in bigger piping for water, or go and buy more water and these things are not happening in SA. In terms of what needs to change, the city needs to see the benefit of green and help the developer to enforce the green on their developments . The way they need to do so is to understand the numbers of the change, if you do a blackwater treatment volume, solar etc you are actually reducing the purchase of this resource from them. On a development in Tshwane a household needs to buy from the city 5kv of worth of power, you have to, it's their law, they are not flexible, you have to pay that. So they go and calculate 5KVa of power per apartment. What we use on site is probably 1.8 to 1.2. We as a developer have to pay upfront the balance so the city can get the money but we do not know where that money goes. So that needs to change from their side and understand that if you are reducing this there's a benefit to the developer. So we tend to pay the city just to get our development going . then we install the system to make it cheaper for our clients and we have no benefit to that. That needs to change from a city perspective. We are not allowed to build a township or a development and be off the grid, we can't do that with the cities because that's their source of income, so its like a capture audience for them. They have to sell to keep on paying the salaries and do whatever they want. If they allow for instance lets talk about power again, us to like in an American system, I think its American systems, to feed back into the grid, all of a sudden it becomes cheaper because you can sell the power that you are generating to the cities, and it is cheaper for that entity that development to actually generate income to advance or to maintain the system. That needs to happen from them, that's the 2nd part of it. So upfront we start a development if you going to implement these things, we've proven it that you are doing it and give us a reduction when starting the development. When the development is completed give those people benefit to sell it back to the city.

Researcher follow up question: So selling back is not something that is happening currently in most of your developments?

HDP: It is not happening at this stage to the city.

MDE: Selling back of energy, there are a couple of municipalities that do have frameworks in place to allow it, but it is not financially viable. They charge additional admin fees, they require additional equipment but they do not pay you enough in energy in energy to make it viable

HDP: Adding to that, there's the physical implementation of the cable in the ground has to be different cable obviously, has to be different remote metering kiosk. So all of these costs add on. Plus selling back, if you are buying it at R10 and selling it back at R1 so that they can go sell it to someone else at R10, it doesn't make sense. SO a lot needs to change in South Africa and its not just a city level, it's a provincial level because those laws comes from a provincial level to the cities. All I am saying is that there is a lot of change that needs to come from the government point of view. At the moment what I see is that it's a profitable business the country is getting more income taxes and your rates and everything else, its mismanagement, a bit of corruption, that cycle, we have to go through the whole thing in South Africa, the legacies left from apartheid need to change. If there are leaders who are willing to change , and I can see those leaders, I can see them there , I speak to them often, then yes we can be able to move forward, but we are still a bit of a 3rd world country.

Researcher follow up question: How it worse with the Cape Town development, how does it work, you produce power using Solar PV and you get some electricity from municipality?

HDP: Physically how it works on the site, on our larger townships, there's one meter from the city, they meter, and they bill against. All the houses individually inside is like a mini city. There we have individual meters that we have to meter, not us per say but the body corporates and they have to read it and charge the clients. So yes within the estate we can manipulate the system to say the lifestyle centre is pushing back into the homes, the client is still getting the meter reading going, they don't know if its coming from Eskom or solar, theres a financial benefit there. We pass on that financial benefit to our clients, so they can get a guaranteed reduction in their bill. But the body corporate needs to collect that money and go pay the city their bill. What I am trying to say is if you drive down the road and the street light is the cities responsibility to light the streetlights, the developments can push that back and light the streetlights and get paid for that. There is a benefit there but we are being blocked off by our boundary wall, we cant push outside of our boundary wall, that's where it stops. The cities are saying that we can allow you to push it through to us now, we can generate, but the financial model doesn't work. They figured out that if they do that, they will lose from Eskom because eskom is not giving the city a rebate and the city is not giving the developer a rebate. It is a massive thing I am talking about. That needs to change if we can change that, that's when we can get sustainability through a country.

MDE: Just to add on to that, to put some numbers to that, the point in which feeding into the grid sort of starts making sense is 100MW. 100MW is 100 times what we would normally needing on a development. So its just not feasible based on the payment structures that they have because effectively what they do is that the city will pay 30% of the value, most municipalities not all, will give you about 30% of the value of what you would pay if you were buying energy from them for energy you need, But, then they will charge you an administrative fee for going at, keep doing all these rebates. SO the amount of energy you need to be exporting just to cover your admin fee and then to start getting some sort of benefit from it is substantial and if you are only getting a third of the value of the energy when exporting it, it makes the capital expenditure to that PV in to get paid for that energy, not viable, and maintenance. So that's your problem is mechanisms are in pace but what's been done is that city has looked at how this can maximise their benefits in getting a return from this and not what is it going to take to implement.

HDP: That's how the city is South Africa works. They are not at where are we to look after the planet, where are we looking after the people? They are not at that point and that is why I am saying it is emotional legacy problems In South Africa. To change that is not going to be our generation. All I am saying is that to get this done, we have to look past the numbers and actually just do it as if it's the right thing to do. We are not there as a country yet, it is a very difficult political question to answer. I am trying to put it as softly as possible. South Africa is all about the money, how much can I get into my pocket.

EH: The right thing to do is very subjective and the thought processes. In my opinion, the municipality is not going to do it because its is the right thing to do, they are only going to act if there is legislative requirements and that comes from a national perspective and I think that is where there is a gap in our country, there's not enough pressure coming from a national perspective on the municipalities. That's where legislation and policies comes into place because they are written at a national level and its then integrated into provincial policies and then municipal level. But we can have the discussions at a local level however if there is no pressure coming from a national level authorities, we are going to fail to see any change of behaviour in practice at a local level.

MDE: I do agree fully, I just do not know how you would do that. You know we are very practical people here, we do something and we go 100% and if it's the right or wrong decision , we figure it out as we go along, but yea its subjective.

EH: I want to bring it back to where there is a gap is the fact that South Africa at a national level is making these commitments but that needs to be underwritten by legislations. So if you say we need to reduce carbon in certain percentage it cant be a nice to do just because, and to give an example,

my level of nice to do and my behaviour and culture of the nice to do is very subjective for an example vs my colleague because we are coming from different levels of exposure, different levels of understanding, considering the South African context. Therefore that is what is required in the country for this to become the norm and become a traction in culture change. Unfortunately because you are dealing with people whon come from a different level of thinking and understanding and bringing in the education of the whole greening of South Africa, the reality is that legislation becomes a driver in a 3rd world country such as South Africa.

Researcher follow up question: basically in summary, we can have all these barriers and challenges but if there is no regulation or legislation that underpins how we implement these technologies, it will be difficult to address some of these challenges?

EH: but having said that you want legislation that enables developments you don't want legislation that's going to constrain development or constrain integrating green building principles into development and like the colleagues have said if it becomes too administrative too onerous to costly already that is your barrier so it's it's a it's a fine balance me having saying good legislation but it needs to enable development and green building principles integrated because again at the end of the day it's an economy that we run in South Africa it's what's your bottom line developers are going to shy away if it's going to become too costly.

Researcher: What are the drivers in the uptake of Green Building Feature Initiatives in the private housing sector?

MDE: our CO. he is very passionate is driven by what he does and so are the exco members of our board, even our MD is very strong about that. Their passion when they started this was to deliver a sustainable product and a quality product to people. They wanted to be the best at what they did. When I started out of garage so all I wanted to do is build the house make sure it's a great house make sure that it's something that people can be proud of, give title to people when I say title I mean title deeds give someone title to someone that couldn't afford it or have it they're very proud of that concept and how do you improve on that how do you make it better for that person what is this who's in everybody's live the house is probably the biggest investment you'll ever make in most people from talking about CEO's and so forth but I mean in the general well that's probably one of the biggest investments Steve and these guys they have always wanted to provide perfection you need to be able to feel like king in your place. Yes our buildings are smaller, they are not mansions, they are humble but they are well designed so we feel that you get some comfort. SO in that drive that they have, this is created , how do we make it better for our clients? That’s the bottom line And that’s how we got to the point of blackwater obviously, solar. That’s where it tarted from. The benefits of that came along

afterwards, it came along that yes well the banks could jump on board and give them a reduction on their interest rates, yes the clients could pay a bit less, but the original thinking was what makes it better for our clients. A direct impact on society and community. About 10 years ago there was speeches about integrated living, how do we change it in South Africa and the guys were speaking about all these different facets of staying together and we were like we are already doing it, our company is doing it, we have integrated living already. We got the different cutltures staying in a 1 development, integrating together. Its all about the societies, everyone living together, giving them a humble home, and this just came from that.

Researcher follow up question: do outside investments help pursuing these kind of developments which are sustainable and green

MDE: is doing sustainable developments attractive to investors is that what you're asking?

Researcher: Yes, we can put it like that

MDE: today I would say yes it is certainly and certainly any international investor is important we have done some some funding that is linked to that they get creasing just becoming more important that's that's from an investor point of view I would say your private investments and your your both your debt and your equity investment is becoming more and more sensitive to how sustainable project is that they are investing in certainly more so than I think the governmental side of things which was largely been discussed about being so far behind so yes I think being a sustainable development definitely helps with that and I just go further to say that it's becoming a requirement more and more

EH: So to add on to what you said and that's what I talked about in the beginning in terms of investors globally prior to investing in any organization and this is this but they look at our companies performance and it's linked to the whole concept of reporting on environmental and governance performance ESG and what's your risks to so investors are now from a financial perspective this is now being driven from a financial perspective not from an environment environmental or a green perspective investors are wanting to know if they invest in your company what are your risks related to ESG because obviously they don't want to invest in a company that's going to have a high level of risk in terms of the investment so as an organization we need to ensure those risks are managed we need to demonstrate it we need to quantify it we need to report on it and that is information that your investors use so that is also an attraction to investors towards organizations

Researcher: OK that's perfect I think we have tackled these questions. Is there anything you want to add from a planning point of view, any challenges you have faced at the different sites.

SHEQ: Not really much involved in the various developments just want to take you back in terms of barriers, when my colleague mentioned that sometimes the systems fail, don't you think that skills and education can be barriers there? I don't know how much this subject is involved at the varsity level, but we are fortunate here that we have employees who know about Green Buildings, just not sure from outside the organization, how much is known about this.

EH: That is very valid point raised. In my perspective, I have just joined the organization, in my environmental professional career, from a skills and education perspective, I think the traditional institutions are only coming on board, in the last couple of years, in terms of integrating sustainability modules into the different professions. I think we are a little bit too late, but on a positive note I think this is a start, but I think as a country we need to be educating and skilling the next generation, so that when they enter the professional field, there is already an understanding of sustainability in whichever field you delve into. So, yes, I think there is a bit of a challenge in terms of our institutions in changing and I remember at a time we had a workshop with x, they were looking at how do you look at all the tertiary institutions and how do start integrating sustainability aspects into whichever profession we are teaching.

Researcher: Anything else anyone would like to add?

EH: Maybe just from an environmental authority perspective, it is disappointing I must say that the process is following an environmental impact assessment in South Africa and that is a regulated process. There is opportunity and I see very slowly happening, in the conditions of the authorisations and I think it is coming in and alludes to what my colleague said in changing mindsets in governments, in terms of them doing things the way they traditionally did, and I am talking from the point of in terms of us wanting to implement black water waste treatment plants. We are seeing the benefit of it, the recycling opportunity. This is where I come to in terms of legislation and the onerous conditions put into authorization that then relay into costs towards the developer. Then you get to a point when you ask from a business perspective is this really worth our while going down a process of putting a black waste water treatment plant considering the conditions that authorities are putting in place. I am trying to be objective, and I understand the environmental impact of a black waste water treatment plant, however I think that authorities need to come to the party in terms of saying "here are your greening initiatives linked to a black water treatment plant. How can we perhaps work together perhaps take off the burdensome conditions." Let me give you a simple example of water quality testing and the frequency of it and who's responsibility Is that? Should that not be the department of water sanitation vs an applicant. So, what we are seeing currently in the country, it is still an authority vs a developer. That is where we need to move away from. There needs to be this let's work together

and let’s work together means how do we share the costs to make sustainable developments and that is not very forthcoming in South Africa.

Case Study Site 1: (CS1)

CS1 Interview

There are two speakers

Researcher

CS1R- Respondent

Held on 10 October 2023 at CS1 site in Pretoria

Researcher: Thank you for allowing me to be here and have a tour of your site. Please tell me about the number of units you currently have and your current energy mix in use?

CS1R: We currently have around 1992 completed residential units in the development. The particular development is targeted at low-income residents. The sale of the units has slowed down owing to the REPO rate that has affected the residential sales. We have a 650Kwh generator that can handle half of the energy requirements of the community. That way we can balance giving community what they want and what is available.

Researcher: Tell me about your solar PV, where it is located and how much of your energy requirements are fulfilled by it?

CS1R: Our solar is located on the roof of the units and the carports. Regarding power output, you may have to get specific figures from the office, but it is not enough to take the entire development off grid. We have a lifestyle Centre however that is completely reliant on RE from the Solar PV and serves as the only building in the residential development that can be considered to have achieved net-zero. The lifestyle Centre further makes use of rainwater harvesting system to use for flushing and such tasks. We are, however, hoping to have one for the entire development.

Researcher: What other green building features have you incorporated in this development?

CS1R: Water wise, we have 4 boreholes that try and aid tenants with their water bills. Regarding water fit for consumption, there are high-cost implications plus risks involved with trying to supply our own water for the residents.

Researcher: I see you have mentioned the cost implications regarding safe water supply. What are some of the challenges you have faced at this particular development regarding implementation of your green building features and initiatives?

CS1R: The challenges have stemmed from being more environmentally aligned regarding going into the ground with our construction, potential oil leakages from our alternative oil supply, plus water safety regarding the harvested water and recycling of it. Another major challenge is the maintenance of the Solar PV. Those are all the challenges we can speak to from an onsite perspective.

Researcher: Thank you so much for your time and the tour.

Case Study 2

Midrand

There are two speakers

Researcher

CS2R- Respondent

Held on 10 October at CS2 site in Midrand

Researcher: Thank you for allowing me to be here and have a tour of your site. Please tell me about the number of units you currently have and your current energy mix in use?

CS2R: The current site falls within the greater Sandton area. The development is a classic, meaning the target market was middle income residents. As you can see, the lifestyle centre is a bit different from other sites so that the aesthetic matches the development. There are north facing solar panels on the roofs of the residential units. LED has been incorporated into the lifestyle centre and into the residential units themselves as well as energy saving appliances.

Researcher: Thank you for the overview. In terms of water recycling and saving, what are some of the features in place?

CS2R: Currently we are at the testing stage for a black water treatment plant. The challenge there has been getting the municipality on board with the processes. More of that information is available at head office. We also have catchment dams for stormwater which we release slowly so as to slow down soil erosion.

Researcher: regarding your Solar PV, do you have output figures and exact coverage of solar on your site?

CS2R: Unfortunately, that information is available at head office. However, the topography of the site makes it difficult to utilize solar PV as efficiently as we would want to. That is the major challenge we face with Solar PV installation on this particular site.

Researcher: Thank you for your answers and time.

Case Study 3

CS3 InterviewThere are two speakers

Researcher

CS3R-Respondent

Held on 11 October 2023 at the CS3 site in Midrand

Researcher: Thank you for allowing me to be here and have a tour of your site. Please tell me about the number of units you currently have and your current energy mix in use?

CS3R: This is a signature development, meaning that target market is upper income residents. There are roughly 1050 units complete, with plans for more to be developed if demand picks up again. There is no solar in use for the residential units and energy is primarily reliant on electrical municipal supply, gas and backup diesel powered generator. There is some Solar PV however on the lifestyle centre, which is a building that serves as a social ambiance for the residents in the development. The design of the lifestyle centre is such that it consumes minimal power by making use of skylights for natural lighting and power saving LED fixtures.

Researcher: Thank you for the overview. In terms of water recycling and saving, what are some of the features in place?

CS3R: This is one of the earlier developments. There are storage tanks for rainwater capture but a lot more systems are still to be implemented at this development.

Researcher: Thank you. Lastly, are there any particular challenges faced with incorporating your green building features in this development?

CS3R: Cost of incorporating green building technologies at the time. The rest of the challenges are like those faced on any site such as operational efficiencies etc. For more particular challenges, head office may be able to address them more.

Researcher: Thank you for your answers and time.

Case Study 4

CS4 Interview

There are two speakers

Researcher

CS4R- Respondent

Held on 11 October 2023 at the CS4 site in Johannesburg South

Researcher: Thank you for allowing me to be here and have a tour of your site. Please tell me about the number of units you currently have and your current energy mix in use?

CS4R: The following development caters for various income level groups, located in the South of Johannesburg. The development is built on a ridge and there are various programmes, run by us, for the citizens so as to encourage healthy living in the form of marathons and other events. Regarding the energy mix, water is supplied by the municipality. We have applied for boreholes to use in our various water features and for irrigation purposes. Solar PV is installed in the lifestyle center and in the rooftops of the units. The solar PV provides half of the energy demand in the lifestyle centre. We further have rainwater harvesting, stored in the tanks on site. We further have a diesel-powered generator which services the gatehouse. There is no backup power yet for the residential units; we depend on municipal supply and Solar PV.

Researcher: Are there any challenges or barriers you have faced at this site when implementing your green building features or green oriented development?

CS4R: There are a couple of challenges we have faced here such as the need for community involvement in the construction project. Public participation is a requirement and a lot of groups wanted to be involved in terms of employment. The solar PV placement as well has been a challenge in terms of maintenance. It is better to move the Solar PV to the carports for ease of access. The municipality also only checks adherence to SDGs from the environmental perspective. Any other challenges are better addressed from the office side as these are the ones primarily faced on this site, which is similar to a lot of different construction sites.

Researcher: Thank you for your answers and time.

Case Study 5

CS5 Interview

There are two speakers

Researcher

CS5R- Respondent

Held on 29 August 2023 at the CS5 site in Cape Town

Researcher: Thank you for allowing me to be here and have a tour of your site. Please tell me about the number of units you currently have and your current energy mix in use?

CS5R: Welcome to the Cape Town development. Our units here are edge certified. We use a mixture of Solar PV and power from the municipality. Our PV feeds into the local grid.

Researcher: What are some of the ways you have managed to achieve your edge certification?

CS5R: We use energy efficient appliances, from LEDs to our hot water system and normal day to day appliances. We have energy saving via the insulation as well. We use flow-aerators in our water appliances and that saves our water usage drastically. Wastewater is recycled and used for flushing etc. Our materials used during construction have less embodied carbon, for example the tiles used, and the stock cement bricks, and we further use precast concrete elements.

Researcher: Are there any challenges you have faced in this particular site regarding the incorporation of these green building features and initiatives?

CS5R: We would definitely want to get into energy wheeling, but it is just too expensive at the moment. The relationship with banks is important for these large-scale developments to proceed.

Researcher: Thank you for the time and tour of the site.

Appendix 4: NVIVO theme development

	Drivers to implementing GBFIS				Barriers to implementing GBFIs							
	A : Awareness of GB practices and principles	B : Bank incentives	C : Enhancing standard of living	D : International investment	: Awareness of green principles and practice	F : Building regulations	G : Community involvement	H : Environmental conditions	I : High financial costs relating to energy	J : Municipal laws and involvement	Quality and maintenance of green technolog	L : State of infrastructure
1 : FG1	We do believe that some of the younger generations are buying homes because of the greening you know we believe that that generational shift is is coming through passionate is driven by what he does and so are the exco members of our board, even our MD is very strong about that. we do believe that some of the younger generations are buying homes because of the greening you know we believe that that generational shift is is coming through	banks could jump on board and give them a reduction on their interest rates, yes the clients could pay a bit less	Lets say a first time owner is presented with a home, uncertified green home then you have an edge certified home that's 40% of. You have all the numbers and comparing the two, I don't think it is a barrier, it is definitely an incentive. how do we make it better for our clients? integrated living already.	international investor international investor international investor	but initially you know the people you know it's not there yet there's a lot of education that needs to happen in South Africa in terms of greening. I think other countries possibly its better received than in South Africa the education and the understanding is is huge one of the barriers was obvious serious resistance to change culture change. skills and education can be barriers educating and skilling the next generation	SANS 10400 XA regulation came out and that's basically forced us to comply with the aspect that of geysers with this sort of electric resistive heating that we needed to offset so to just know no more than 50% supplied by means of resistance you could do gas heating that many does there's also induction geezers or heating sources that you can use and then of course heat pumps and so so many of the developers then went for that so we tested all of these different elements SANS is very open-ended they allow you to figure it out and then once you've figured it out yet to submit a lot of reporting to the cities proving our point SANS10400 XA is the only one that speaks to you implementing RE sources a lot of change that needs to come from the government point of view. At the moment what I see is that it's a profitable business the country is getting more income taxes and your rates and everything else, its mismanagement, a bit of corruption, that cycle, we have to go through the whole thing in South Africa, the legacies left from apartheid need to change. they are only going to act if there is legislative requirements and that comes from a national perspective and I think that is where there is a gap in our country, if there is no pressure coming from a national level authorities, we are going to fail to see any change of behaviour in practice at a local level.		cycles of the different seasons affect your solar PV for what you've possibly done in Gauteng doesn't work as efficiently or the same within KZN or in Cape Town.	Finances financial constraint Selling back of energy, there are a couple of municipalities that do have frameworks in place to allow it, but it is not financially viable. Adding to that, theres the physical implementation of the cable in the ground has to be different cable obviously, has to be different remote metering kiosk. So all of these costs add on. eskom is not giving the city a rebate and the city is not giving the developer a rebate. the amount of energy you need to be exporting just to cover your admin fee and then to start getting some sort of benefit from it is substantial and if you are only getting a third of the value of the energy when exporting it, it makes the capital expenditure to that PV in to get paid for that energy, not viable	On a development in Tshwane a household needs to buy from the city 5kv of worth of power, you have to, it's their law, they are not flexible, you have to pay that We are not allowed to build a township or a development and be off the grid, we can't do that with the cities because that's their source of income, so its like a capture audience for them.	get sold the system from external party gets installed but it doesn't always produce what you believe it's gonna it's different between the different regions	they are supposed to upgrade the systems, you know put in bigger piping for water, or go and buy nore water and these things are not happening in SA we do not know where that money goes.
2 : P1								The challenges have stemmed from being more environmentally aligned potential oil leakages plus water safety regarding the harvested water and recycling of it	there are high-cost implications		maintenance of the Solar PV.	
3 : P2								the topography of the site makes it difficult to utilize solar PV as efficiently as we would want to.		The challenge there has been getting the municipality on board with the processes		
4 : P3									Cost of incorporating green building technologies at the time		operational efficiencies	
5 : P4							the need for community involvement in the construction project			The municipality also only checks adherence to SDGs from the environmental perspective.	The solar PV placement as well has been a challenge in terms of maintenance	
6 : P5									We would definitely want to get into energy wheeling, but it is just too expensive at the moment			

Appendix 5: Ethics Approval Form

UNIVERSITY OF CAPE TOWN

2023/08/29

EBE/00374/2023

RE: Research Ethics Committee Project Approval Letter

Dear Raphael Madzingaidzo,

Your application for ethics review of your project titled

Investigating the Drivers and Barriers to Implementing Green Building Features and Initiatives (GBFIs) in South Africa's Private Housing Sector

has been reviewed and evaluated by the

Engineering & Built Environment Committee.

You may proceed with your research project titled:

Investigating the Drivers and Barriers to Implementing Green Building Features and Initiatives (GBFIs) in South Africa's Private Housing Sector

Please note that should:

(i) any serious or adverse effects to participants occur and/or,

(ii) aspect(s) of your current project change and/or

(iii) any unforeseen events that might affect continued ethical acceptability of the project occur then you should immediately report this to the approving REC. You may be required to submit an amendment to this application, in order to determine whether the changed aspects increase the ethical risks of your project.

Based on the information supplied your application has been successful and is approved.

Please note the following additional conditions associated with this approval:

(i) Approved. A section should be included in the dissertation that fully explains the ethical issues you anticipated and how these were handled. Also, noting that some of hte information gathered may be confidential, data should be safely stored, as per the dmp - thanks for including this!

Regards,

Engineering & Built Environment Committee.