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

Raphael Madzingaidzo[1], Louie van Schalkwyk[1] and Saul Nurick[1]

[1] Urban Real Estate Research Unit, Department of Construction Economics and Management, University of Cape Town; mdzrap001@myuct.ac.za; louie.vanschalkwyk@uct.ac.za; sd.nurick@uct.ac.za

Abstract

The construction industry has long been criticised for significantly contributing to global carbon emissions and a large energy consumer. 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. Green Building Features and Initiatives (GBFIs) have solved the construction industry's challenges. The Green Building Council of South Africa (GBCSA) manages and applies tools such as Green Star SA, EDGE, and Net-Zero to assist in incorporating and certifying GBFIs in buildings. A literature review was conducted to identify key drivers and barriers to adopting GBFIs to ensure that the research contributes to a better understanding of these factors in the context of South Africa. The study employed a qualitative research approach comprising multiple case study analyses, where semi-structured interviews were conducted with key stakeholders in the construction industry. The case studies involved five major residential developments in municipalities in the Western Cape and Gauteng Provinces. The study highlighted factors such as client awareness and developer initiative as the key drivers of adopting GBFIs, followed by increased international investment. However, the study yielded many barriers, including financial and government-related barriers in the form of legislation.

Keywords: Energy, Green Building Features and Initiatives (GBFIs), Residential property, South Africa.

1. Introduction

The energy sector has long been perceived to significantly influence the global environment (Pretorius *et al.*, 2015). A study by Coyle and Simmons (2014) identifies that the continued reliance on fossil fuels for energy production and transportation, coupled with the growth of the global population, are key factors contributing to the energy crisis currently being experienced worldwide. The widespread use of fossil fuels for energy generation has led to the depletion of natural resources, resulting in a gradual rise in carbon dioxide (CO_2) emissions, known as greenhouse gas (GHG) emissions (Coyle and Simmons, 2014).

The global energy crisis has led to nations across the globe grappling with energy deficiencies. Major emerging economies in Asia and Africa have faced severe energy deficits, with African nations such as South Africa (SA) being particularly affected. The electricity tariffs in SA saw a significant surge amidst the energy crisis. A study by Nguyen (2023) underscores the increased frequency of power outage periods in SA, which has had a considerable impact on the daily routines of individuals and economic operations.

In June 2019, the United Kingdom (UK) enacted legislation committing to achieving net-zero GHG emissions by 2050 (O'Beirne *et al.*, 2020). By enacting this law, the UK became the first developed economy globally to take a significant step towards tackling the Global Climate Change (GCC) crisis. The UK acknowledged the necessity of undertaking further measures to address CO_2 emission levels to meet their greenhouse gas removal (GGR) targets (O'Beirne *et al.*, 2020). GGR involves extracting greenhouse gases from the atmosphere and ensuring their long-term storage (O'Beirne *et al.*, 2020). The net-zero objective has since been recognised as a crucial component of the GCC mitigation strategy.

GCC mitigation necessitates the collaboration and ingenuity of all major stakeholders within the construction sector. Environmental Management Systems (EMS) emerged in response to the growing recognition of the adverse impacts that the construction industry exerts on the environment. Green buildings and sustainable practices were subsequently introduced as a mechanism to facilitate the advancement of energy-efficient buildings across the entire lifespan of a building (Howe, 2011). The adoption of green building (GB) practices has garnered significant traction in both developed and developing economies, with diverse certification criteria and methodologies utilised to assess the sustainability of a building. The Green Building Council of South Africa (GBCSA) is responsible for overseeing the certification of green buildings in South Africa. The GBCSA employs various tools such as Green Star SA, Net Zero, and EDGE rating systems to evaluate different categories of building adherence to sustainable practices and ultimately confer green certification upon them.

Developers in SA primarily employ the Green Star rating tool which is the standard used for commercial buildings. SA, however, is experiencing an increased rate of urbanisation with an expected 71 increase by 2030. The EDGE certification standard provides minimum requirements for a residential building's energy efficiency, water efficiency and embodied energy (GBCSA, 2017). The inconsistency with the country's electrical supply and the rising water scarcity issues are challenges that the EDGE certification system can address in the residential sector that is expanding.

The notion of GBs is distinguished by two elements, specifically the green building features and initiatives (GBFIs). A feature is described as "A building component that reduces resources consumption" (Michell and Nurick, 2014: 8) and an initiative is described 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) Consequently, GBFIs can be viewed as significant instruments to be integrated in the construction industry to tackle the ongoing energy crisis, and to improve other aspects of sustainable construction such as water saving and efficiency and the use of construction materials that contain less embodied carbon.

2. Literature Review

2.1 Overview of green buildings

GBs are perceived as a direct reaction to significant energy inefficiencies in buildings, which encompass the substantial amounts of waste generated during both construction and operation, along with the substantial volumes of pollutants and GHG emitted during construction (Howe, 2011). The building industry is acknowledged as the primary contributor to GHG emissions and environmental pollution (Dwaikat and Ali, 2016). It has been established that the construction sector ranks among the largest consumers of energy within economies and is among the foremost consumers of overall global resource utilisation (Dwaikat and Ali, 2016). Consequently, GBs aim to optimise land and energy usage, integrate renewable energy resources into building design and construction, enhance indoor and outdoor air quality, and preserve the efficient utilisation of water and other resources involved in the construction process (Howe, 2011).

Green building practices strive to establish environmentally sustainable and resource-efficient structures over the entire lifespan of a building, encompassing its design, construction, operation, maintenance, renovation, and eventual deconstruction. The level of energy utilised by the construction industry on a worldwide scale has consequently prompted nations across the world to establish strategies such as GB projects focused primarily on enhancing energy effectiveness throughout the lifespan of a building and reducing the consumption of limited resources. Emerging economies like South Africa have implemented the idea of GBs to contribute to GCC mitigation efforts and tackle the energy limitations resulting from the energy crisis within the nation.

2.2 GBFIs in SA

South Africa (SA) has the distinction of being the first African nation to become a member of the World Green Building Council (WGBC). Established in 2007, the Green Building Council of South Africa (GBCSA) has formulated GB rating tools that are specifically tailored to the local context. SA ranks among the top 30 largest countries globally in terms of land area, experiencing a notable urban growth rate estimated at around 67.4% (Agbajor and Mewomo, 2022). The construction industry in SA plays a significant role in the country's Gross Domestic Product (GDP) (Agbajor and Mewomo, 2022). As highlighted by Cowling (2024), the construction sector in SA has contributed an added value of approximately 109.5 billion rand to the GDP, underscoring its substantial economic impact.

The construction and real estate sector in SA exhibit a high reliance on energy, consuming a considerable portion of the nation's total energy output (Agbajor and Mewomo, 2022). Moreover, residential buildings are recognised as among the primary electricity consumers in SA following the industrial sector (Bohlmann and Inglesi-Lotz, 2018). Figure 1 indicates that the residential sector consumes approximately one fifth of SA's electricity. This confirms research conducted by Wang *et al.* (2011), Hache *et al.* (2017), and Doroudchi *et al.* (2018) highlighting the substantial energy demand exerted by this sector, suggesting its potential role in addressing the energy crisis and advancing clean energy production. SA, however, further implements the South African National Standards (SANS) building regulations, with SANS 10400-XA paying particular attention to energy usage in buildings and ways of promoting energy saving and efficiency (Gaum, 2021).

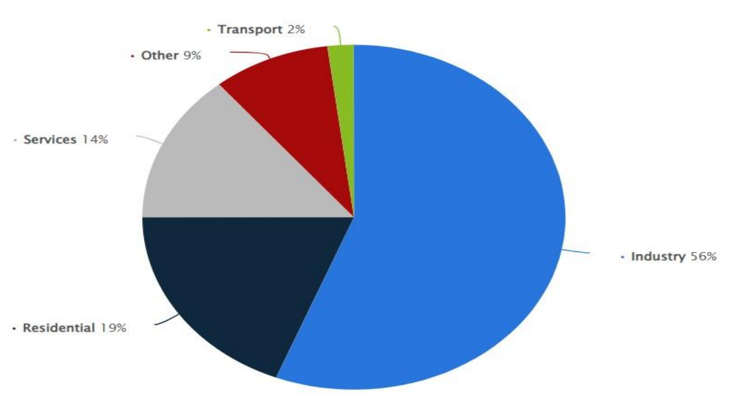

Figure 1: Sector-wise electricity consumption in SA (Source: Bohlmann and Inglesi-Lotz, 2018)

2.3 GBFIs in the private real estate sector

The effective integration of GBFIs within the construction industry is contingent upon governmental support through policy implementation and compliance with these guidelines by key stakeholders in the construction sector (Ho *et al.*, 2013). Numerous research studies have been carried out in both developed and developing nations to pinpoint obstacles to the adoption of sustainable building practices and propose remedies for these challenges (Nikyema and Blouin, 2020). The primary barriers identified in the United States encompass extended payback periods, expenses, a preference for conventional building methods over modern ones, high initial costs, and a lack of awareness among users regarding green practices and technologies (Nikyema and Blouin, 2020). Similarly, investigations in developed countries like Singapore and Australia have encountered comparable hurdles to those in the US, along with additional challenges such as insufficient research on barriers to green building practices, deficient team communication on green projects, inadequate governmental backing for green initiatives, among others (Hwang and Tan, 2012; Hwang and Ng, 2013; Nikyema and Blouin, 2020). Prior studies in developing countries like Malaysia, Turkey, China, and India have confirmed the barriers highlighted in research conducted in developed countries, while also introducing new obstacles like a lack of databases and information regarding green building practices and technologies (Bin Esa *et al.*, 2011; Zhang and Wang, 2013; Nikyema and Blouin, 2020).

The implementation of GBFIs has been notably more intricate in developing nations compared to their developed counterparts. In a study on facilitating the transition towards sustainable construction, Chang *et al.* (2016) underscores the challenges faced by developing countries in meeting certain green building standards due to limited resources. In the context of China, the difficulties stem from the inadequacy of crucial policies such as the Environmental Impact Assessment (EIA) Policy (Chang *et al.*, 2016). A study by Nikyema and Blouin (2020) in Burkina Faso, a developing nation in West Africa, revealed numerous barriers hindering the adoption of efficient GBFIs in the construction sector, including 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, thus impeding the country's alignment with global standards on GHG mitigation.

2.4 GBFIs and the private housing sector of SA

The drivers and barriers to adopting Green Building Financial Incentives (GBFIs) in the SA economy have predominantly been discussed in relation to the commercial aspect of the construction industry. The drivers for the acceptance of GBFIs compiled by Marsh *et al.* (2020) mainly pertain to the commercial sector of buildings, given that this was the primary focus during the initial implementation of GB practices. Conversely, the obstacles to adopting GBFIs were pinpointed in the research conducted by Nikyema and Blouin (2020), which specifically concentrated on emerging economies. The framework established by Nikyema and Blouin (2020) outlines the key barriers, which predominantly revolved around the commercial sector due to the significant economic impact that the commercial sector holds in a developing economy. Additional drivers and barriers, as 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), encompass the real estate sector holistically without distinguishing between residential and commercial aspects.

Nonetheless, the residential sector plays a crucial role as a major energy consumer in economies, emphasising the necessity of exploring drivers and barriers that directly influence this sector. Rating mechanisms have been devised to cater to the residential domain (GBCSA, 2017). Limited research exists on the drivers and barriers specifically associated with the private housing sector concerning adopting GBFIs. The detailed examination of drivers and barriers offers a potential framework for comprehending the factors likely pertinent to the private housing sector. Figure 2 illustrates the theoretical foundation supporting the adoption and implementation of GBFIs.

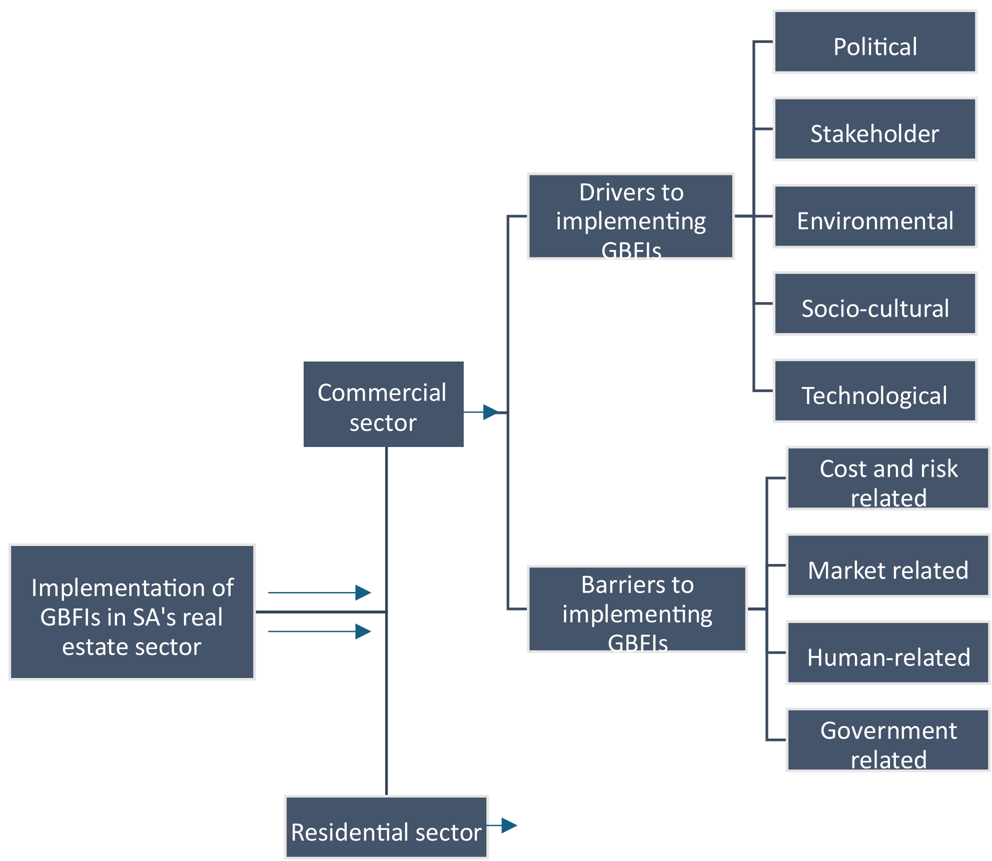

Figure 2: Theoretical framework depicting the drivers and barriers to implementing GBFIs.
Source: Authors construct (2024)

3. Methods

3.1 Research method

The research adopted a multiple case study approach. The multiple case study approach was suitable for this research, as it sought to explore the circumstances surrounding the implementation of GBFIs in the private residential sector, across some of 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. Convenience and purposive sampling were conducted, where available data with the same prominent residential developer was available in Cape Town, Johannesburg and Pretoria. Durban did not contain a significant number of EDGE certified residential buildings compared to Cape Town, Johannesburg and Pretoria. One key advantage of the multiple case study analysis is that it allows the researcher to analyse data within each case and across different cases Gustafsson (2017). Differences and similarities among the cases can be established and added to the literature with key influences (Gustafsson, 2017).

3.2 Unit of analysis

The research inquiry pertains to examining the factors influencing the implementation of GBFIs within SA's private housing sector. Emphasis is placed on identifying the factors driving or hindering the adoption of GBFIs in the private housing market, with a specific focus on the geographical locations of the developments serving as the primary case study. The unit of primary analysis consists of those selected for interviews. To ensure methodological consistency, individuals representing the various case study sites were interviewed to gather comprehensive data. Interviewees were selected based on their professional roles and involvement in the case study projects. The interviewees formed part of the respondents interviewed in a focus group setting.

3.3 Multiple case study design and sampling method

The individuals chosen to partake in this investigation were required to directly engage in the advancement and strategic planning of GBs within the SA private housing industry. Familiarity with GB methodologies and fundamentals was a prerequisite within the selection standards, which also involves the deliberate sampling methodology. The rationale behind selecting participants based on the aforementioned criteria was to ensure that the participants could furnish insights into GBFIs and, ultimately, the drivers and barriers to adopting GBFIs in the multiple case study projects.

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. The five case studies were situated in locations undergoing development by the same property developer. The developer is one of the largest sectional title developers in SA. The developer focuses on designing, constructing, and selling eco-friendly sectional title residential units across SA. Interviews were conducted in a focus-group format with respondents from the developer’s headquarters. Table 3 provides a description of their professional roles within the firm. The focus-group respondents offered valuable insights into each case study site. Additionally, interviews were carried out with respondents from the case studies, as outlined in Table 2; the case studies all belonged to the same developer detailed previously. The utilisation of purposive sampling greatly assisted in structuring the interview design coding system, as elaborated in Table 2. Table 1 delineates the coding framework for categorising the five distinct case studies.

Table 1: 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

Source: Authors construct (2024)

Table 2 consolidates the case studies previously outlined in Table 1 alongside the corresponding respondent associated with each case study. For example, the code "CS1" signifies Case study 1, while "R1" denotes Respondent 1, resulting in the combined code CS1R1 representing Case study 1 Respondent 1. The respondents from the case studies primarily comprised the on-site managers overseeing each development. One respondent was interviewed at each case study site.

Table 2: 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

Source: Authors construct (2024)

Table 3 showcases the focus group respondents, totalling five individuals, occupying managerial positions in the developing firm, actively engaged in developments across the various case studies, with high-level information regarding the research interest. The focus group is collectively coded as FG.

Table 3: Focus group respondents in managerial roles

Managing Director Energy
Head of Development Planning
Safety, Health, Environment and Quality Advisor
Green Accredited Professional
Environmental Head

Source: Authors construct (2024)

3.4 Case-study profiles

The five case-study profiles are as follows:

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 comprising one-, two- and three-bedroom apartments, with plans for further 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 further includes a lifestyle centre that acts as a communal space for residents. The lifestyle centre, as a commercial space, has achieved a Six-Star Green rating, certified by the GBCSA.

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 comprising one-, two- and three-bedroom apartments. The development has plans for further expansion and caters to both low-income and middle-income residents. 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 lifestyle centre is constructed to a Six-Star Green rating, certified by the GBCSA.

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 middle- to upper-income level residents. The development was one of the early developments undertaken by the developer and does not make use of RE energy sources of power supply.

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. There are plans to develop a green Eco bridge in the future that will act as a wildlife corridor. 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 lifestyle centre is constructed to a Six-Star Green rating, certified by the GBCSA.

Case study 5 is a residential development, located in Somerset West, City of Cape Town Metropolitan Municipality, Western Cape Province. The development comprises over 1000 units consisting of one-, two-, and three-bedroom apartments, with more under construction. The residential units are EDGE-certified. The lifestyle centre serving as a communal space for the residents has a Six-star green rating. The development makes use of water and energy-efficient fittings in the residential units. Furthermore, it makes use of construction material that has less embodied carbon.

3.5 Data analysis

The gathered data was structured and categorised based on the dominant concepts extracted from the participants' feedback. Data was obtained from the focus group participants who had the necessary high-level information regarding all the case-study developments. Data was further obtained from 1 respondent in each case study who provided further information relating to the particular case study as experienced on site. Data saturation was therefore reached as no new information could be obtained from interviewing more respondents from each case study development. This methodology facilitated the researcher in recognising patterns, hence discerning the commonalities and distinctions within each scenario. A thematic analysis was conducted to systematically examine and scrutinise the information, with the interpretation accomplished through the utilisation of NVIVO software for theme generation, culminating in a cross-case analysis to delve into the extent of similarities or disparities among the cases.

4. Findings

The data collected from the focus group and case study interviews was analysed and yielded themes and sub-themes highlighting the common factors that directly speak to the drivers and barriers to implementing GBFIs in the case study developments. The section below details the themes categorised into the primary and secondary drivers and barriers.

4.1 Primary drivers for GBFI implementation

4.1.1 Enhanced standard of living

FG respondents assert that integrating GBFIs into their developments elevates the quality of life for their clientele. They argue that integrated living, a key offering in their spaces, fosters social interaction among residents. This integrated living concept enables residents to explore different transportation options due to the developments' proximity to amenities and various public transit choices. Furthermore, the amenities provided support electric vehicle charging and cycling, promoting the use of clean-energy vehicles and encouraging a healthier lifestyle. Through these features, integrated living offers a broader perspective on the role of GBFIs in private residential developments.

Another element highlighted by FG respondents that enhances residents' quality of life is the distinction between an EDGE-certified home and an uncertified one, despite the higher cost. Certified homes with GBFIs offer improved air quality both indoors and outdoors, along with design elements that optimise natural light and air circulation, enhancing the overall aesthetic appeal. In contrast, CS1-CS5 respondents did not delve into the specifics of how quality of life is improved but emphasised that green technologies are implemented to meet clients' comfort requirements. These needs include consistent power supply, aesthetically pleasing green features that lead to water and energy savings, and good indoor and outdoor air quality within the development.

4.1.2 Awareness of GB principles and practices

The focus group highlighted increased awareness towards green building practices among stakeholders. Young property buyers prefer EDGE-certified homes over non-certified ones. Executive board members' passion drives sustainable construction initiatives. Some construction stakeholders resist transitioning to greener methods. The education of future stakeholders is crucial for the public's understanding of green buildings. CS1-CS5 respondents did not face the same challenges in their development.

4.1.3 Incentives by financial institutions

Bank incentives are significant in facilitating the adoption of GBFIs by both property developers and homeowners. Feedback from FG participants indicated that financial institutions have the potential to further support customers and motivate them to invest in properties incorporating GBFIs by reducing interest rates. Nonetheless, the factor highlighted by FG participants may act as a hindrance in the current economic context in South Africa, as the FG group did not emphasise the substantial impact of bank incentives thus far. On the other hand, respondents from CS1-CS5 did not elaborate further on bank incentives.

4.2 Secondary drivers to GBFI implementation

4.2.1 International investment

FG participants noted that global investment plays a pivotal role in facilitating the execution of extensive development initiatives carried out in each of the specified case studies. The utilisation of GBFIs was additionally characterised by FG participants as crucial for drawing external investments, aligning with contemporary investor priorities. Respondents affiliated with CS1-CS5 refrained from providing feedback regarding the financial investment dimension of the case study projects.

4.3 Primary barriers to GBFI implementation

4.3.1 Green building regulations

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

4.3.2 Environmental conditions

The FG, CS1, and CS2 each identified numerous environmental factors as obstacles encountered while implementing GBFIs within the developments. The FG participants emphasised the impact of seasonal cycles on solar energy output across all their projects. They elaborated on the varying weather conditions in different regions, resulting in diverse levels of solar radiation. Additionally, CS2 raises the issue of site topography as a significant environmental obstacle when attempting to deploy solar photovoltaics for energy production. The findings presented by Ibrahim et al. (2021) regarding the presence of renewable energy sources in the provinces of SA are corroborated by the participants, who specifically highlight solar energy as the primary renewable energy source in the case-study sites. CS1 highlights another environmental challenge, particularly focusing on water safety concerns related to rainwater harvesting and potential oil leaks from borehole drilling activities.

4.3.3 High financial costs relating to energy

Green technology implementation expenses are typically included in high energy-related financial charges. FG, CS1, CS3, and CS5 all described in detail how expensive the processes involved in producing energy from renewable sources are. According to FG, the main financial barrier is municipalities' failure to make it profitable for developers to return excess energy to the grid. This is one of the main challenges in attaining a net-zero development. FG also highlighted the developer's financial limitations when incorporating green technologies. Similarly, CS5 notes that one of the site's biggest challenges is the cost of energy wheeling. CS3 further emphasises the cost of implementing green technologies at the time as it was not a viable option in that period.

4.3.4 Municipal laws and involvement

Municipal laws and involvement pertain to the extent to which municipalities encourage or hinder the implementation of GBFIs through enacted legislation or financial assistance extended to developers or tenants. The case studies highlight that there are no specific differences in the municipal laws, but rather differing levels of municipal involvement with the current laws in place. FG claimed that since municipalities depend on the revenue generated from developments, they are not allowed to construct a whole off-grid development. CS2 provided more information about a green project involving a black waste-water treatment development that is pending clearance and funding from the municipality. CS4 indicated that their municipality mainly cares about the environmental aspect of SDG adherence, which restricts the municipality's participation in other GBFIs where support and approval are needed for the development.

4.4 Secondary barriers to GBFI implementation

4.4.1 Quality of green technology and maintenance

FG highlighted the calibre of green technology, particularly solar panels, as a significant obstacle in all five case studies. FG observed discrepancies in the quality standards of solar panels among the suppliers in different case study locations. This variance in quality further impacted the efficacy of the solar panels. CS1 and CS4 also noted the maintenance of the solar PV systems as problematic due to the challenging accessibility of the panels. CS3 further indicated that operational efficiencies were the primary hurdles encountered in relation to green technology and its maintenance.

4.4.2 State of infrastructure

The state of infrastructure pertains to the municipal infrastructure that supports communities and facilitates the development of CS1-CS5. Nonetheless, FG indicated that the existing municipal infrastructure is insufficient to meet the demands of new developments due to the absence of essential components such as new cables for transmitting energy generated through renewable sources from the developments to the municipalities.

4.5 Analysis of findings and development of empirical model

A summary of the cross-case analysis is provided in Table 4.

The respondents from the FG presented detailed insights into the factors driving and hindering the adoption of GBFIs in each of the case studies. However, respondents from CS1-CS5 offered less detailed responses concerning these factors. The analysis highlighted several significant obstacles, some of which have a greater impact than others, such as education on green-building principles and practices, the high financial costs associated with energy, municipal regulations, and green building codes. Conversely, the less significant barriers entail the quality of green technology and its maintenance, as well as the state of infrastructure.

Moreover, the analysis identified three main drivers for the adoption of GBFIs in the residential sector, namely, improving the standard of living, raising awareness of green buildings among construction stakeholders and the public, and providing incentives from financial institutions. Respondents from CS1-CS5 offered general information about the challenges faced on-site, lacking substantial details on the drivers, site experiences, and GBFI implementation. These respondents demonstrated a better understanding of the day-to-day challenges related to site activities rather than the drivers behind GBFI adoption. In contrast, FG respondents provided a comprehensive overview of the drivers and barriers encountered in implementing GBFIs across all case studies, offering more pertinent information due to their involvement in the developments from a higher managerial level perspective.

While most case study respondents highlighted barriers consistent with those identified by the FG participants, they commonly mentioned environmental conditions, high energy-related costs, municipal regulations, and issues related to green technology quality and maintenance. Figure 3 summarises the relationship between GBFIs in the residential sector and the drivers and barriers faced during their implementation.

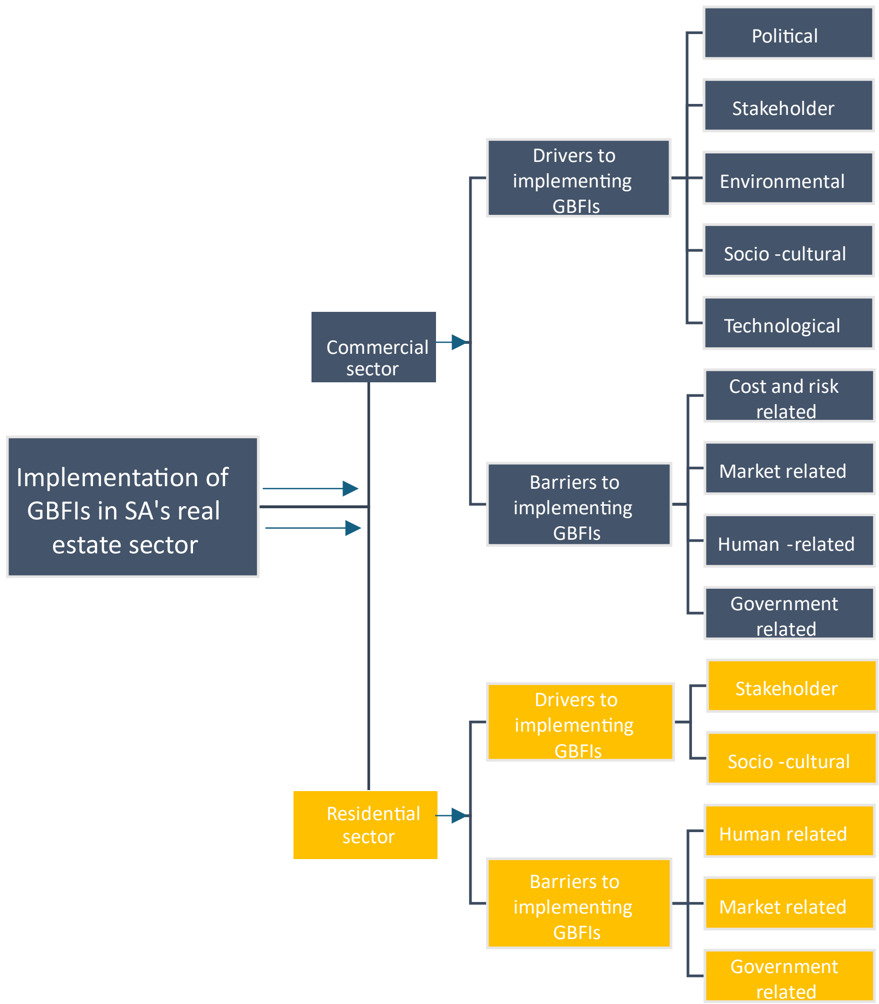

Figure 3: Empirical model depicting drivers and barriers to GBFI implementation

Source: Authors construct (2024)

Table 4: Cross-case analysis

		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 are lacking in clarity, leaving clauses open to interpretation.
CS1	Enhanced standard of living is not a dominant factor.	High market demand from first-time homeowners who are knowledgeable of green sustainable buildings.	Minor information on the impact of financial institutions.	Minor information regarding education levels of construction practitioners.	Cost to generate sufficient levels of power via RE means is considered high.	Municipal involvement levels not significantly addressed.	
CS2	Emphasis on aiming to provide regular power supply amidst the energy crisis.	Green building market demand not sufficiently addressed as being a factor.	Minor information provided on the impact of financial institutions.	General knowledge of green features implemented.	Cost of green technology is manageable	Acquiring the help of the municipality has been difficult regarding water treatment plants and infrastructure to accommodate energy wheeling.	
CS3	Greater emphasis on providing uninterrupted power supply.	Green-building market not addressed	No information was provided on impact of financial institutions.	Minor knowledge of GBFIs implemented.	Cost of incorporating green technologies at the time was too high		
CS4	Continuous relationship with community to find ways of enhancing living experience.	Green building housing market demand addressed as an important driver in the uptake of units.	Minor information provided on the impact of financial institutions.	Knowledgeable on concepts surrounding GBFIs 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	
CS5	Medium emphasis on regard for enhanced living standard as a driver.	High market demand for green sustainable buildings from the public.	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

Source: Authors construct (2024)

5. Conclusion

The drivers of the implementation of GBFIs consist of an enhanced living standard, a heightened awareness of GBs among the public and stakeholders in construction, and the incentives extended by financial institutions. The framework outlined by (Marsh *et al.*, 2020) delineates stakeholder drivers and socio-cultural drivers as pivotal factors in the adoption of GBFIs. The study underscores the significance of stakeholder drivers, emphasising the crucial role of stakeholder awareness in fostering demand for developments incorporating GBFIs. The driver of an enhanced standard of living is categorised under the broader spectrum of sociocultural drivers, as posited by Marsh *et al.* (2020). The socio-cultural dimension encompasses the creation of conditions that promote both the environmental and social aspects of sustainable GB design.

The primary obstacles identified in the research encompass the lack of education on green building principles and practices, the considerable costs associated with energy which still outweigh the limited incentives provided by financial institutions, municipal involvement, and green-building regulations pertaining to renewable energy implementation. Secondary barriers include the efficacy and upkeep of green technologies, as well as the state of existing infrastructure. These barriers are consistent with those highlighted in existing literature (Aktas and Ozorhon, 2015; Chan *et al.*, 2018; Nikyema and Blouin, 2020). The educational barrier aligns with human-related obstacles identified by Nikyema and Blouin (2020), followed by the high energy costs barrier, which corresponds to market-related challenges underscored by Chan *et al.* (2018). These market-related issues pertain to the availability and affordability of green technologies in developing nations. Subsequent barriers related to municipal involvement and inadequate green-building regulations for renewable energy align with government-related barriers outlined by Nikyema *et al.* (2020), shedding light on the need for more effective adaptation of policies and regulations conducive to local requirements. The lower-level barrier concerning infrastructure echoes government-related challenges delineated by Nikyema et al. (2020), emphasising the necessity for government frameworks facilitating efficient and cost-effective generation and distribution of renewable energy to drive the uptake of GBFIs in projects. The quality and maintenance of green technologies, the final barrier identified in the study, resonates with market-related challenges expounded by Aktas and Ozorhon (2015), emphasising the quality of green technologies available in developing contexts. Consequently, the drivers and barriers identified corroborate the argument and offer deeper insights into the most impactful factors impeding and propelling developers in the private residential sector.

The endeavour to adhere to international GB standards underscores the collaborative effort among developed and developing economies in supporting GCC mitigation measures. The current global energy crisis has further spurred actions by authorities to integrate RE sources in projects as energy stands as a crucial asset in the operation of any economic system (United Nations, 2023). Nonetheless, the feasibility of eco-friendly projects is influenced by various factors that can act as impediments or facilitators to the adoption of GBFIs, contingent upon the economic conditions.

Research indicates that the numerous obstacles mirror those encountered in developing nations, with primary barriers including insufficient knowledge of green construction principles and methods, substantial financial outlays associated with energy, inadequate building regulations related to RE integration, and a lack of local government backing for developers' environmentally conscious building projects.

Secondary barriers encompass the condition of infrastructure, the specific environmental characteristics of individual sites, and the quality of green technology provided by external vendors. These hindrances predominantly point towards the necessity for governmental intervention by establishing clearer guidelines for the incorporation of RE in green construction and aiding developers in their objectives of delivering EDGE-certified residences that concentrate on water, energy, and embodied carbon efficiencies.

Moreover, the analysis reveals that the motivating factors identified are fewer compared to the hindrances encountered. A heightened quality of life and familiarity with green-building principles and practices emerged as the primary stimulants for GBFI execution, while financial incentives from banks emerged as a secondary driver, underscoring the importance for financial institutions to enhance engagement with customers interested in acquiring eco-friendly properties. An escalation in awareness of GB principles and methods was recognised as a significant driver, emphasising the significance of establishing communication channels that inspire the public, particularly potential property owners, to invest in projects that encompass GBFIs. The existence of the EDGE residential certification system however proved to be a factor in accomplishing green construction practices, as achieving EDGE certification was a

goal for most of the case-study developments. The EDGE certification further ties in with the enhanced standard-of-living driver, as meeting the energy and water-saving requirements provides residents with increased energy and water security.

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Notes on Contributors

Raphael Madzingaidzo is a master's student in the Department of Construction Economics and Management at the University of Cape Town. He holds a BSc (Construction Studies), BSc (Hons) (Quantity Surveying), and PGDip (Business Communication) Cape Town.

Louie van Schalkwyk is a senior lecturer in property law in the Department of Construction Economics and Management at the University of Cape Town. She holds LLB and LLM degrees from the University of Stellenbosch and a PhD from the University of Cape Town.

Saul Nurick is a senior lecturer in property studies in the Department of Construction Economics and Management at the University of Cape Town. He holds a BCom, BSc (Hons) (Property Studies), MPhil Cape Town and PhD Witwatersrand. He is a professional member of the RICS (MRICS).

ORCID

Louie van Schalkwyk https://orcid.org/0000-0002-8724-6753
Saul Nurick https://orcid.org/0000-0002-9039-6170

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