Business Case: Green-Certified Buildings in South Africa's Residential Rental Market

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ABSTRACT

In this paper, the characteristics of the Excellence in Design for Greater Efficiencies (EDGE) green building certification system is explained, and the energy and water savings in a portfolio of residential units in the EDGE-certified residential building portfolio in South Africa was investigated. This research analysed the efficiency of energy and water usage, following certification, and the contribution to lowering building running costs and increasing property values was investigated.

The research revealed that the portfolio design of EDGE-certified buildings results is, on average, a 42% energy saving and a 54% water saving across the portfolio.

The research explores the overall reduction in building operating costs and the impact on property return by considering the payback period of the additional investment. The US Green Building Council indicate operating costs drop by 13%, with a drop of 10.5% in the first year and then an average of 16.9% over five years.

The research revealed that overall cost savings are significant, the cost of greening is recouped on average over 6 years and this means that property returns increase. The US Green Building Council indicate that property values increase by between 4%-6% for a study relating to LEED-certified buildings.

The research signifies the importance of bringing down energy and water costs to preserve and increase return and value, and this may be catalytic in increasing affordable housing investment and tenant standards of living. Where this activity is at scale within the right policy framework, an overall reduction in emissions may occur.

KEYWORDS

Green building certification; energy savings; water savings, Excellence in Design for Efficiencies “EDGE”; sustainability; resource saving; reduced operating costs; enhanced property values; shorter payback period on investment outlay; South Africa; energy efficiency; affordable housing

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ASAQS – Association of Quantity Surveyors

EDGE – Excellence in Design for Greater Efficiencies

ESG – Environmental, Social, and Governance

GBCSA – Green Building Council of South Africa

IFC – International Finance Corporation

IPCC – Intergovernmental Panel on Climate Change

KPIs – Key Performance Indicators

LCH – Life-Cycle Hypothesis

MSCI – Morgan Stanley Capital International

NDCs – Nationally Determined Contributions

NFGBSA – National Framework for Green Buildings South Africa

NHBRC – National Home Builders Registration Council

NOI – Net Operating Income

ROI – Return on Investment

SANS – South African National Standards

SDGs – Sustainable Development Goals

UNPRI – United Nations Principles for Responsible Investment

USAID – United States Agency for International Development

WGBC – World Green Building Council

WWR – Window-to-Wall Ratio

CHAPTER 1. INTRODUCTION

1.1 Statement of Purpose

As South Africa grapples with a dual crisis of energy insecurity and housing shortages, the building sector emerges as both a significant contributor to the problem and a critical part of the solution.

This study focuses on a portfolio of 18 residential developments certified under the EDGE green building standard, developed by a Gauteng-based firm with operations across Southern Africa. Each project is equipped with smart electricity and water meters, enabling the analysis of actual post-occupancy performance over time. By assessing energy and water consumption at the unit level, this research examines the extent to which EDGE-predicted savings are achieved in practice.

Green building certifications such as EDGE are intended to improve resource efficiency by ensuring that buildings are planned, constructed, and operated to minimise environmental impact. These certifications promote the use of fewer natural resources and support the broader sustainability goals of reducing the ecological footprint of residential development.

While green building certifications like EDGE promote resource-efficient design, limited research exists on whether the promised energy and water savings are realised in practice during the operational phase. This study addresses that critical gap.

The framework in Figure 1 is the author’s interpretation setting out the various concepts and connectors covered in the research report, indicated by arrows. The framework seeks to set out a visual representation of the context and boundaries of the research and includes key references.

FIGURE 1: Green Buildings Conceptual Framework Diagram

SUSTAINABLE DEVELOPMENT CONCEPTS

(Kahn, 1995 as cited by Basiago, A.D. 1999)

ENVIRONMENTAL SUSTAINABILITY – no degradation of source and sink function, and the rate of extraction should not exceed the rate of renewal.

The earth's source function is to produce soil, water, forests, and minerals, and to support human life and economic activity.

The earth's sink function is the mechanism to absorb pollution and waste, produce soil, water, forests, and minerals, and to support human life and economic activity.

SOCIAL SUSTAINABILITY – requires the cohesion of society and the ability to work toward a common goal. Individual needs such as health, shelter, nutrition, and well-being must be maintained.

ECONOMIC SUSTAINABILITY – is financially feasible environmental and social sustainability.

Sustainable buildings fall under sustainable development

SUSTAINABLE BUILDING AND CONSTRUCTION

BUILDING GREEN – refers to the building structure and construction process that is environmentally responsible and resource-efficient throughout the building life cycle, from inception, design, through operation, maintenance, and refurbishment. (Kats, 2009)

Building green forms part of sustainable buildings

GREEN BUILDINGS

The Green Building Council of South Africa (GBCSA), established in 2007 and a member of the World Green Building Council, explains that it has become critical to design, build, and operate buildings that are energy-efficient, resource-efficient, and environmentally responsible.

Building green saves energy, reduces carbon dioxide emissions, and improves water and air consumption. (GBCSA, 2023)

The South Africa Building Green Building Certification and training is guided by the GBCSA.

Types of Green Building Certifications in South Africa

Green Star SA	Assesses building environmental impact across nine categories, including management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, innovation, and socio-economic.
Net Zero	Buildings achieve net zero or net positive scores for carbon, water, waste, and ecology.
Energy Water Performance (EWP)	Operational performance tool for office buildings that compares energy and water building performance to a national average.
Excellence in Design for Greater Efficiency (EDGE)	Optimises performance of building design by requiring a minimum saving of 20% (EDGE-certified) in operational energy, water usage, and embodied energy through an online certification programme. *EDGE advanced 40% and EDGE Zero-Carbon

Note: From Green Building Council of South Africa [GBCSA 2023]

BUILDING AND CONSTRUCTION SECTOR

Components of the South Africa Building and Construction Sector

RESIDENTIAL, COMMERCIAL, INDUSTRIAL, INFRASTRUCTURE, ENERGY AND UTILITIES, INSTITUTIONAL

This research focuses on the residential multi-family rental housing market.

RESIDENTIAL BUILDINGS

The residential building sector comprises:

SINGLE-FAMILY RESIDENTIAL DWELLINGS AND

MULTI-FAMILY RESIDENTIAL DWELLINGS

MULTI-FAMILY RESIDENTIAL DWELLINGS – a housing classification where multiple separate housing units for residential are contained within one building or several buildings within one complex. The housing may be owned or rented.

The focus of this research is on multi-family residential dwellings where housing is rented and not owned.

BENEFITS AND COST SAVINGS – green building results in water and energy costs savings and these cost savings can be substantial. These cost savings when combined with lower building maintenance and other benefits can mean an increase in investment returns. (Kats, 2003).

Note: Author, *Conceptual Framework* 2024

1.2 Background of the Study

Buildings contribute approximately 30% of global energy consumption and CO_2 emissions (IEA, n.d.). In South Africa, these figures are magnified by coal-dependence and urban growth.

Awareness of the need to reduce water and energy consumption in South Africa's building and construction sector has grown substantially over the past two decades. Green building certification is now recognised internationally as a trusted benchmark for quality in the design, construction, and operation of buildings, interior fitouts, and precincts. Leading certification bodies include the United Kingdom-based Building Research Establishment, the United States Green Building Council, and the Green Building Council of Australia. These organisations are members of the World Green Building Council (WGBC), a global network responsible for developing and administering many of the world's leading building certifications, driving the adoption of sustainable and decarbonised built environments (World Green Building Council, n.d.).

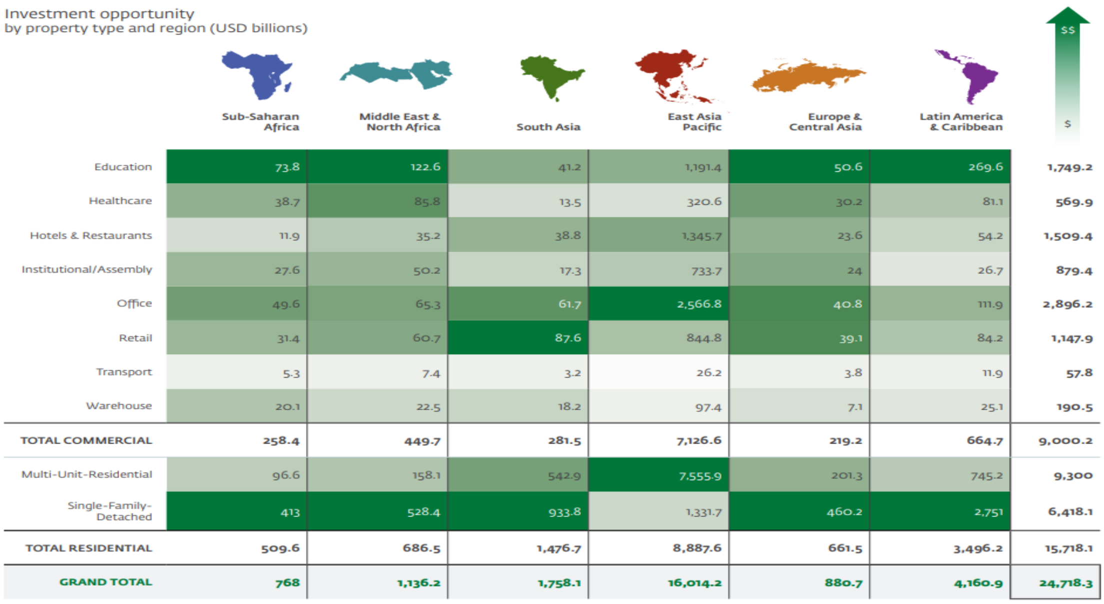
Globally, buildings are responsible for 30% of final energy use and 26% of greenhouse gas emissions (IEA, n.d.). Despite the benefits of green building, persistent barriers such as lack of awareness, limited understanding, market failures, and other obstacles continue to reinforce conventional construction approaches (Green Building Council of South Africa, 2022).

South Africa's green building market is moderately developed, with most certified green buildings found in the larger commercial and residential sectors. According to the Green Building Council of South Africa, the property industry should anticipate a cost premium of 1% to 10% when constructing green buildings. However, these initial costs are offset by significantly reduced operating expenses over time, leading to increased property rentals and higher returns on investment (Green Building Council of South Africa, 2022).

The establishment of the Green Building Council of South Africa (GBCSA) in 2007 significantly increased awareness and provided an objective framework for green building certification across South Africa and Africa, with only moderate investment required (Green Building Council of South Africa, n.d.).

Access to appropriate financing mechanisms is crucial for driving green building investment and achieving emission reduction targets. According to the World Bank, the global green building market is projected to reach US$24.7 trillion by 2030, with most investment occurring in Asia and residential buildings making up 60% of the market (IFC, 2019). The case for expanding green building markets is strong: initial capital costs are declining, leading to greater operating cost savings. These savings benefit building occupants directly, resulting in higher occupancy rates, increased rental income, and rising property values (IFC, 2019).

FIGURE 2: Green buildings – a financial and policy blueprint for emerging markets .



Investment opportunity
by property type and region (USD billions)

	Sub-Saharan Africa	Middle East & North Africa	South Asia	East Asia Pacific	Europe & Central Asia	Latin America & Caribbean	$ – $$
Education	73.8	122.6	41.2	1,191.4	50.6	269.6	1,749.2
Healthcare	38.7	85.8	13.5	320.6	30.2	81.1	569.9
Hotels & Restaurants	11.9	35.2	38.8	1,345.7	23.6	54.2	1,509.4
Institutional/Assembly	27.6	50.2	17.3	733.7	24	26.7	879.4
Office	49.6	65.3	61.7	2,566.8	40.8	111.9	2,896.2
Retail	31.4	60.7	87.6	844.8	39.1	84.2	1,147.9
Transport	5.3	7.4	3.2	26.2	3.8	11.9	57.8
Warehouse	20.1	22.5	18.2	97.4	7.1	25.1	190.5
TOTAL COMMERCIAL	258.4	449.7	281.5	7,126.6	219.2	664.7	9,000.2
Multi-Unit-Residential	96.6	158.1	542.9	7,555.9	201.3	745.2	9,300
Single-Family-Detached	413	528.4	933.8	1,331.7	460.2	2,751	6,418.1
TOTAL RESIDENTIAL	509.6	686.5	1,476.7	8,887.6	661.5	3,496.2	15,718.1
GRAND TOTAL	768	1,136.2	1,758.1	16,014.2	880.7	4,160.9	24,718.3

Note: From IFC, 2019 *Green Buildings Report*

As shown in Figure 2, Africa accounts for approximately 3% of the global green building market (IFC, 2019). Since 2014, the World Bank has supported the South African housing market through financing and the introduction of the EDGE certification tool. EDGE ensures that building designs are optimized from the outset to reduce energy use, water consumption, and embodied energy in materials. This certification can also be applied to existing buildings to improve their efficiency. The process involves establishing a baseline case and then projecting savings based on selected design and material choices. Actual consumption can subsequently be measured against the baseline and expected savings (EDGE, 2020).

South Africa – Country landscape

This research presents energy and water savings data from a leading residential developer active in South Africa, Namibia, and Botswana, with over 32,000 units completed. The following context outlines the South African landscape.

Energy: South Africa’s energy for industry, business, and residential use is heavily coal-dependent, with up to 90% generated from fossil fuels. As Africa’s largest carbon emitter, the country faces challenges in electricity supply and water scarcity.

Construction Market: Since 2010, residential growth has remained flat, driven mainly by private sector housing construction, delivering about 40,000 units annually. The major metropolitan areas—Johannesburg, Cape Town, Pretoria, and Durban—dominate development. Johannesburg leads in commercial and residential projects as the economic hub, while Durban and Cape Town focus on industrial, warehousing, and residential developments. Post-COVID-19 trends show increased remote work and rising interest from local and foreign buyers in the Western Cape (EDGE, 2023).

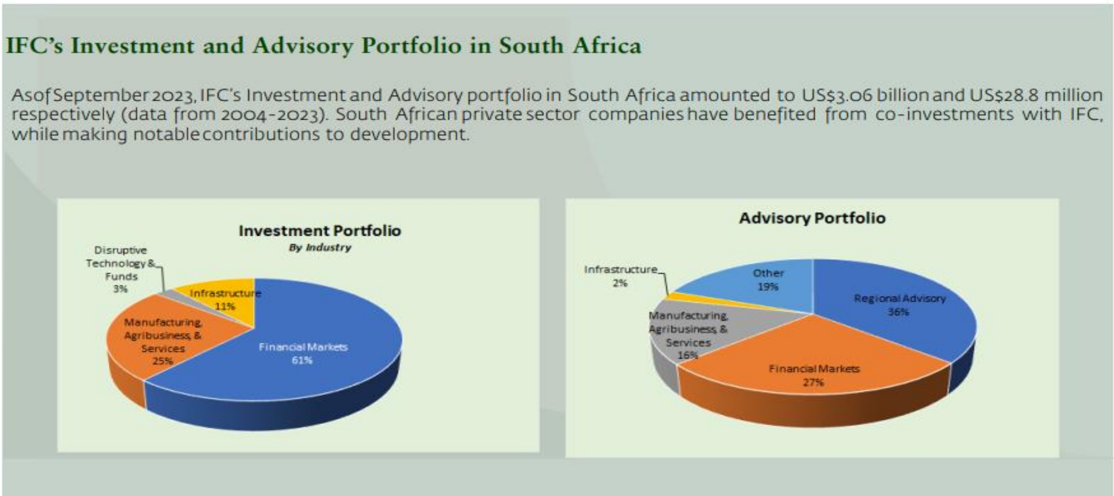
Developers: Small, micro, and medium enterprises constitute roughly 70% of the construction workforce, while larger firms generate about 50% of industry income.

Finance: South Africa’s financial sector is dominated by the “big five” banks, holding 90% of banking assets and loans. Climate-related loans accounted for only 2% of borrowings in 2020 (EDGE, 2023).

The IFC, part of the World Bank, is a major development finance institution supporting private sector growth in emerging markets. Total IFC investment in emerging markets is estimated at US$43 billion, with US$3.06 billion directed to South Africa and an advisory portfolio of US$28.8 million, as illustrated in Figure 3 (IFC, 2024).

Through this investment in private sector growth, the IFC facilitates development in private sector growth. It ultimately contributes to: 1) creating or strengthening markets; 2) promoting private sector and local capital market development; 3) scaling up advisory work to contribute to build capacity and skills development; and 4) partnering with the World Bank and other development finance organisations for sector-specific developments.

FIGURE 3: IFC Investment and Advisory Portfolio in South Africa



Note: From IFC, 2023 *IFC and South Africa Fact Sheet*

1.3 Research Problem

The next section outlines the green building certification systems in South Africa, followed by a focus on EDGE, the certification framework used in this research.

EDGE green building certification is granted before the building's use phase, with no ongoing assessment of actual energy and water savings post-occupancy. This raises the question of how real savings compare to the certification's promised targets.

This research examines a sample of EDGE-certified projects, comparing post-construction and operational data against initial certification claims to evaluate achieved energy and water savings.

Additionally, the study assesses these savings in relation to initial costs and payback periods, using established real estate valuation methods, supported by relevant examples.

Generally there is a lack of post occupancy EDGE evidence in South Africa.

1.4 Research Objectives

This research aims to:

1) Assess whether EDGE-certified residential buildings achieve their projected energy and water savings on a per building, per unit basis. Identify the cost savings associated with the projected savings and analyse the Net Operating Income impact;

2) Identify the developers' capital cost outlay for greening costs. Then evaluate the payback period for the total greening costs outlay per development by the developer based on utility savings and compare to other projects. Analyse and draw conclusions about how the payback period impacts return;

3) Determine the implications of these electricity and water savings on property returns, value and rental income. Calculate the payback period per development selected. If the payback is sooner, this typically that the capital is recovered faster and makes the investment more attractive.

1. **Sample Identification**

    - Identify an established property developer in Sout Africa with a track record of residential developments across Africa.
    - Identify a sample of residential buildings across South Africa with EDGE green building certification from the Green Building Council of South Africa.
    - Identify the base line energy and water usage associated with the EDGE certified building portfolio. (the base line measures the usage if no certification measures are added)
    - Identify the promised energy and water usage associated with the 20% energy and water savings for the certified building portfolio.
    - Identify the actual energy and water usage associated with the EDGE-certified buildings.
    - Quantify the cost savings that result from the energy and water savings on a per unit per months basis.
    - Then calculate the annual savings of electricity and water per unit and per annum.

2. **Data Collection**

    - Collect the energy and water usage data per building.
    - Identify the energy and water usage had no certification been applied (base case is NHBRC standard).
    - Identify the promised energy and water savings.
    - Identify the actual energy and water used per unit per month.

Summary

- Summarise the energy and water usage per building, per unit per month. Quantity the savings per year.

These objectives will be addressed through analysis of operational smart meter data from certified residential buildings, supported by contextual insights gathered from the developer's technical and financial team.

3. Performance and Cost Comparison

- Compare building performance data to the certification promise for EDGE-certified buildings.
- Compare building performance data to the expected use had no certification been applied (base).
- Identify the costs savings associated with energy and water use in the portfolio based on the actual consumption data.

4. Energy Savings and Analysis

- Evaluate actual energy savings to determine if the sampled buildings used more or less energy than designed.
- Analyse the energy consumption and costs to determine the achieved energy savings relative to the certification standard.
- Analyse the portfolio energy and water savings relative to the cost of greening.
- Draw conclusions from the analysis about what the payback period is of the cost outlay and initial investment in greening.
- Draw conclusions from the analysis in terms of building cost and the payback period and link the outcome to other research.

Operating costs for water and electricity in South Africa have risen faster than inflation over the past three decades, with particularly sharp increases since 2019

(Green Building Council of South Africa, 2022). Achieving savings in these costs increases building rental income and reduces tenant vacancies. Building value is often determined using methods such as the income capitalization approach, where the capital cost of greening is compared to annual cost savings—similar to a payback period or Return on Investment (ROI) calculation.

A shorter payback period means 1) faster recovery of green investment, 2) immediate net operating cost savings, 3) improved cash flows, and 4) when capitalized at a given rate, a higher property valuation (Kats, 2010). Net operating income (NOI) is calculated as rental income minus operating costs, while the capitalization rate represents the expected return on investment, derived by dividing NOI by property value and excluding financing costs (Wentzel, 2021).

The World Green Building Council states that energy savings converted into NOI can increase property values by 10% (World Green Building Council, 2013).

Commentary: Operating costs like water and electricity have increased more than inflation over the past three decades with significant increases since 2019. Achieving savings will increase building rental income and reduce tenant vacancies. Building value is determined through a number of methods including, using the income capitalisation approach. The cost of the capital outlay in greening can also be compared to the cost savings per annum. This is akin to a payback period or Return on Investment (ROI) calculation.

This is ROI can be evaluated through the payback period. A shorter payback period means 1) faster recovery of green investment, 2) immediate net operating cost savings, 3) enhanced cashflows 4) when capitalised at a given capitalisation rate, a higher property valuation. (Kats, 2010)

The net operating income is the building rental income less the building operating costs. The capitalisation rate is used to indicate the rate of return that is expected to be generated on a real estate investment property. It is derived by dividing the net operating income by the property value. The income capitalisation method excludes financing costs. (Wentzel, 2021)

The World Green Building Council asserts that energy savings converted into NOI can raise property values by 10%. (World Green Building Council, 2013)

1.5 Rationale

This research highlights the importance of sustainable buildings and advances knowledge on EDGE-certified residential projects and their energy savings during the operational phase. It enriches local understanding, identifies areas for further study, and offers recommendations to support green residential investment in South Africa.

The study underscores the critical role of financiers and stakeholders in emerging markets by clarifying market dynamics. South Africa presents significant green building opportunities, and this research provides factual data to dispel misconceptions, reduce barriers, and encourage greater investor participation.

1.6 Delimitations of the Study

The research applies to:

1.6.1 Green-certified EDGE residential buildings
1.6.2 Established property developer portfolio utility consumption data derived from physical meter readings, measured monthly
1.6.3 Residential buildings used for multi-family residential letting in South Africa
1.6.4 Residential buildings operating costs , actual versus savings per unit
1.6.5 Data available for the period 2019-2024

The research does not apply to office or commercial buildings.

The research also does not directly deal with tenant health or satisfaction but the research highlights this as a possible benefit.

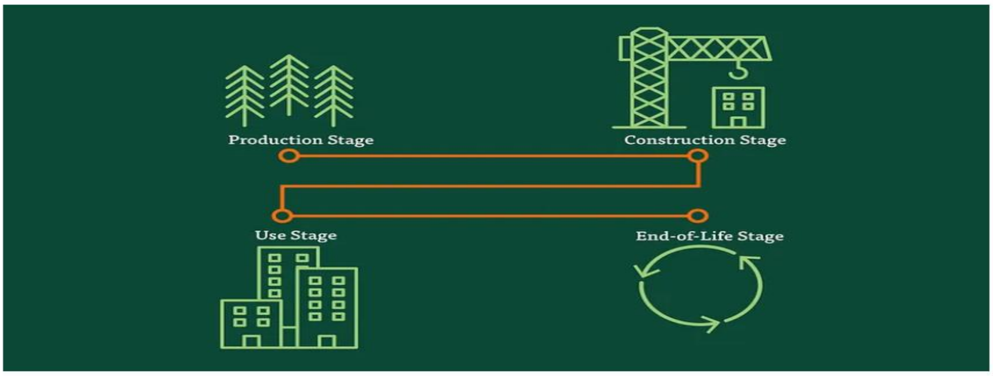
Definition of terms

Building green focuses on energy efficiency, resource conservation, and the use of sustainable, eco-friendly materials.. (Green Building Council of South Africa, n.d.)

Building life cycle: A building's life cycle includes stages from pre-construction through production, construction, occupancy, and end of life. (Sharma et al, 2011)

The diagrammatic representation of the building life cycle is shown in Figure 4.

FIGURE 4: Building Life Cycle Diagram



Note: From LPC 2024. *The Building Life Cycle: Definition, Stages and Assessment*

EDGE (Excellence in Design for Greater Efficiencies) is a green building certification system targeting at least 20% reductions in energy use, water use, and embodied carbon, with advanced certifications for 40% (EDGE Advanced) and 100% savings (Zero Carbon) (IFC, n.d.).

Building energy use typically comprises HVAC (39%), equipment (22%), lifts (9%), hot water (1%), and others (9%) (Martin, 2013). Water use mainly involves toilets, showers/baths, and taps (Beal et al., 2012).

Green building certification, including tools like Green Star, EDGE, Net Zero, and EWP, provides a universal, credible framework for assessing sustainable buildings, led locally by the Green Building Council of South Africa (GBCSA), a member-based organization focused on certification and training.

Property value is calculated by dividing annualized net operating income by the capitalization rate (Wentzel, 2021).

Energy use: The energy consumption of a building is typically HVAC [heating, ventilation, and air conditioning] (39%), equipment 22%, lifts 9%, hot water 1%, and other 9%. (Martin, 2013)

Water use: The water use of a building typically for toilets, showers/baths, and taps. (Beal et al, 2012)

1.7 Assumptions

The research assumes that the performance data for this asset class is available.

This is a reasonable assumption given that developers discuss the availability of data in public forums and that it is reported to investors and stakeholders.

The research does not assume what the outcome of the research will show.

1.8 Structure of the Study

Chapter 1 introduces the research context, problem statement, objectives, and rationale.

Chapter 2 presents a review of the relevant literature on green building certification, performance gaps, and value implications.

Chapter 3 outlines the research methodology, detailing the use of smart meter data to assess actual energy and water consumption, as well as informal expert insights that provide contextual understanding of the implementation and performance of EDGE-certified projects.

Chapter 4 presents and analyses the quantitative findings from the operational data.

Chapter 5 discusses the findings in relation to the literature and draws conclusions regarding the effectiveness and implications of EDGE certification.

1.9 Chapter Outline

The building industry is responsible for several environmental impacts. Building green prioritises energy efficiency and conservation of the earth's natural resources, promotes water and energy savings, and uses sustainable materials. Certification is a formal process that is facilitated in South Africa through the GBCSA. Certification applicable to residential buildings includes EDGE residential and Green Star residential. These are an independent and internationally recognised trusted mark of quality for the design, construction, and operation of buildings, interior fitouts, and green precincts.

Green Star SA certification requires that a building certification is measured every three years. EDGE certification does not currently require a measurement of the promised energy and/or water savings after construction, but is often monitored and reported to the financier. At the building design stage, material selected for construction is specified and evaluated by considering local conditions to determine the promised water and energy savings. A certified EDGE specialist assists the developer to design the building to meet the standard required. (Coville, 2023)

Certification and assessment occurs after the building construction is complete. The EDGE auditor reviews project documentation, verifies compliance with the EDGE design and construction requirements, provides a rigorous check of the project submission to GBCSA, and recommends the project to the GBCSA for assessment. The GBCSA then verifies the documentation and issues a final EDGE certificate per unit to the project owner.

The EDGE online tool incorporates local standards such as the SANS 10 400 standard and where there is no standard, as is the case for water, a global average of the standard is used. This measure for consumption is referred to as the base case. The addition of selected energy and water savings measures are explained below.

Energy Efficiency Measures:

Firstly high-performance building envelopes (walls, roofs, and windows) conserve energy, secondly; energy efficiency lighting systems such as LED lighting use less electricity compared to incandescent lighting, advanced HVAC (heating, ventilation, and air conditioning) systems are more efficient, use of renewable energy sources such as solar photovoltaic panels can meet a portion of the energy demand are important energy savers. The installation of energy-efficient appliances such as heat pumps, and the incorporation of energy management systems to monitor and control energy use such as pre-paid and smart meters will be valuable measures.

Water Efficiency Measures:

Low-flow fixtures and fittings to reduce water use in kitchens and bathrooms are common, secondly; efficient irrigation systems such as drip irrigation and rainwater harvesting are effective in reducing water consumption, recycling and treatment of greywater for non-potable uses such as flushing and irrigation can achieve high savings. Solar, insulation, shading, low-flow, aerated, and materials are added to achieve the minimum of 20% saving.

Materials Efficiency:

The use of locally-sourced sustainable or recycled materials to reduce embodied energy is optimal. Designing for durability and flexibility to extend the life of the building components and reduce the need for replacement is more efficient. Implementation of waste reduction strategies during construction and operation achieve efficiency. Lastly, modular construction or prefabricated components to reduce waste and improve construction efficiency.

Indoor and Other Practices:

1) Maximising natural light and reducing artificial light.
2) Implementing natural ventilation.

3) Using low-emission materials to improve indoor air quality.
4) Incorporating green roofs or reflective materials to reduce heat island effect.
5) Providing facilities that support alternative transportation e.g. electric vehicle charging and storage.
6) Using smart building technologies for efficient building operation and maintenance.

These measures contribute to the creation of sustainable, energy-efficient buildings that can achieve EDGE certification, showing a commitment to reducing environmental impact.

This research highlights the ongoing environmental impact of residential buildings through high energy consumption and materials used.

Reducing South Africa's emissions forms part of the Nationally Determined Contributions (NDCs), and South Africa has adopted a National Framework for Green Buildings in South Africa. (CSIR, 2011) A key strategy of the framework is to develop green building regulations and standards and the research also explores the status of the regulations.

Current public policy and standards explained by Watermeyer and Milford (2003) in The Use of Performance Based Building Codes to Attain Sustainable Housing Objectives: The South African Approach outlined at the Global Policy Summit on the Role of Performance Based Building Regulations in Addressing Societal Expectations, International Policy, and Local Needs.

South African National Standard (SANS) 204

A voluntary national standard for energy efficiency in buildings, published in 2008 and updated in 2010. The standard outlines the minimum requirements for a 3-star green building rating and is the energy efficiency regulation for all construction new build.

SANS 10400 PART XA The standard for energy usage in buildings, launched in 2011, considers hot water supply, building design, and use. This measure is compulsory for all buildings and homes.
SANS 10400 B The application of National Building Regulation and structural design elements.
SANS 10400 C The application of National Building Regulation dimension aspects.

Raising finance for South Africa through global climate funds (COP), multinational organisations (World Bank), development finance institutions (IFC, AFD Group, African Union), and financing (AMF, ACB, AIB) is enabled when the activities financed contribute to sustainability and reduced emissions.

The research examines the performance of energy-efficient certified green buildings and considers the reasons for variations in performance as well as the role of financiers and other stakeholders in building the emerging market for sustainable buildings.

The research further considers the impact that energy and water savings have on building costs and property values. In terms of the performance of green-certified assets, the research that the GBCSA has partnered with is the MSCI Green Annual Property Index for South Africa. It deals with Green Star – rather than EDGE – but the principle is illustrated here.

The MSCI Green Annual Property Index compares green-certified offices against similar uncertified ones, and tracks the difference in financial performance. It has been running since 2016, and has a relatively high level of academic rigour. A summary of the results from 2022 centres around the cost of green and cost of green per geographic area and per size of construction.

FIGURE 5: Cost of Green in SA Office Development

The total average green building cost premium achieved by the projects sampled (as expressed by the median*) has reduced from 5,95 % in the 2016 report to 3,63 % in this report.

The average green cost premium of office projects certified in the period 2019 – 2021 has positively decreased from 3,9 % for the previous period 2009 – 2018 to 3,15 %.

NOTE: The choice of indicator for the central tendency of the data (to describe the average green building cost premium) was the median. The median is the midpoint of a frequency distribution or the numerical centre of a set of data. Since the data sample was right skewed (0,942), the median was chosen as the preferred indicator over the arithmetic mean as it is less sensitive to skewed data.

Publication date- Green design penetration (%)	MIN	AVERAGE	MAX
TOTAL	**0,47%**	**3,63%**	**14,24%**
2009/14	1,14%	5,95%	14,24%
2015/18	1,14%	3,49%	12,01%
2019/21	0,47%	3,15%	10,83%

Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

Figure 5 shows that the average cost of green decreased to 3.15%.

FIGURE 6: Cost of Green per Geographic Area

The average green cost premium of 5,24 % for projects in KZN was about 50% higher when compared to the projects from other locations.

Location- Green cost premium (%)	MIN	AVERAGE	MAX
TOTAL	**0,47%**	**3,63%**	**14,24%**
GAUTENG	0,47%	3,53%	10,72%
WESTERN CAPE	0,49%	3,44%	14,24%
KWAZULU- NATAL	3,15%	5,24%	8,72%

Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

Figure 6 shows that the cost of green premium of 5.24% in KwaZulu-Natal was higher when compared to projects from other locations.

FIGURE 7: Cost of Green per Construction Area

Both Table 6 as well as Figure 11 confirm the strong negative correlation between green cost premium and construction size.

Construction area-Green cost premium (%)	MIN	AVERAGE	MAX
TOTAL	1.47%	3,63%	14,24%
<5,000m^2	0,49%	4,62%	12,24%
<10,000m^2	0,47%	3,55%	14,24%
<25,000m^2	2,70%	4,65%	12,01%
<50,000m^2	1,14%	3,22%	5,04%
>50,000m^2	2,03%	2,43%	2,50%

Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

*ignore the reference to Table 6 and Figure 11 as this is from the original material

Figure 7 investigates the cost of green and construction size. In simple terms, this indicates that as the size of the construction project increases, the additional cost associated with greening tends to decrease.

Conclusions of MSCI Research:

- Green building projects have matured from inception in 2009.
- Office buildings of all sizes have been certified green.
- Green Star-Certified buildings are located primarily in Gauteng, the Western Cape, and KwaZulu-Natal.
- The total average cost of green premium has reduced over time.
- Compared to small office buildings, large office buildings achieve Green Star-Certified Green Ratings with lower green cost premiums.

Figure 8 summarises the key findings by showing that green buildings have higher returns, lower vacancies, and lower operating costs.

FIGURE 8: Comparison Green and Non-Green Vacancy and Cost

The MSCI SA Green Annual Property Index is based on the market performance of Green Star certified buildings vs AAA grade non-green certified buildings in South Africa with the aim of understanding the comparative value of green building certification.

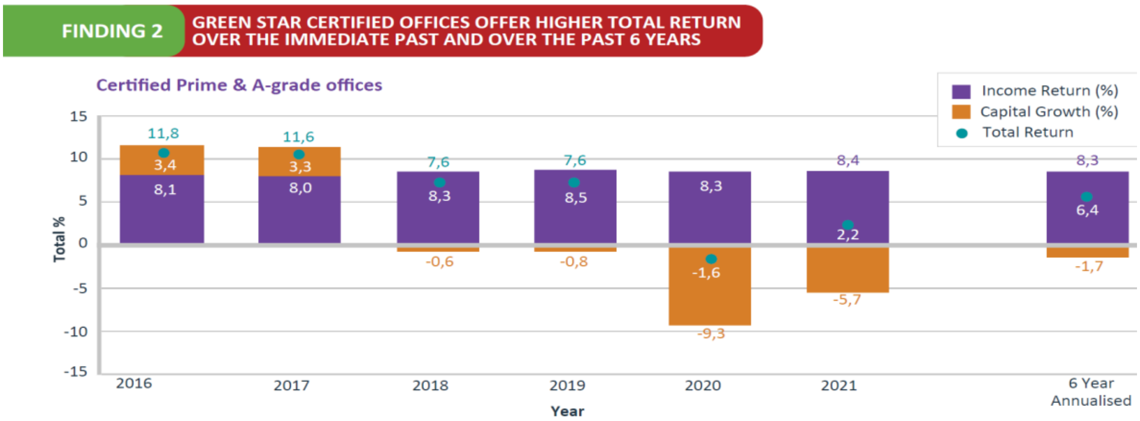
The MSCI index based on the financial performance of a building together with the GBCSA/ASAQS/UP data based on the green cost premium on the initial capital cost of a building, produces a convincing business case in support of Green Star certified buildings.

	Certified	Non-certified
Total Return (%)	2.2	0.5
Vacancy Rate (%)	15.6	16.3
Net Operating Income per square meter	144	111
Capital Value per square meter	20,998	16,226
Total Operating Cost % of Gross Income	35.6	39.8
Water Usage (m² per annum)	0.5	0.7
Electricity Usage (kWh per annum)	138	156

Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

Overall core findings for office buildings comparing certified and non-certified:

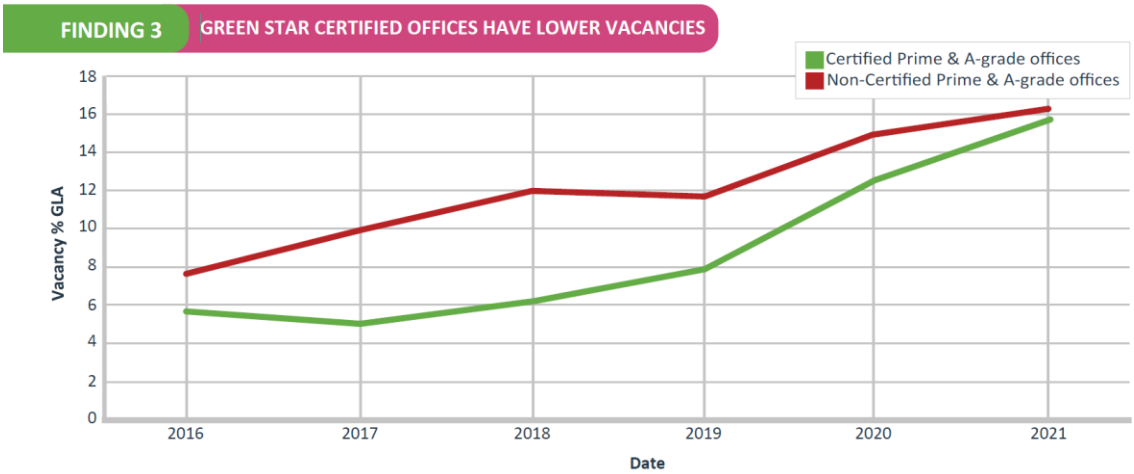
1. Green Star Buildings Offer a Higher Return (over time)



Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

The above graph shows higher returns over time for green office buildings.

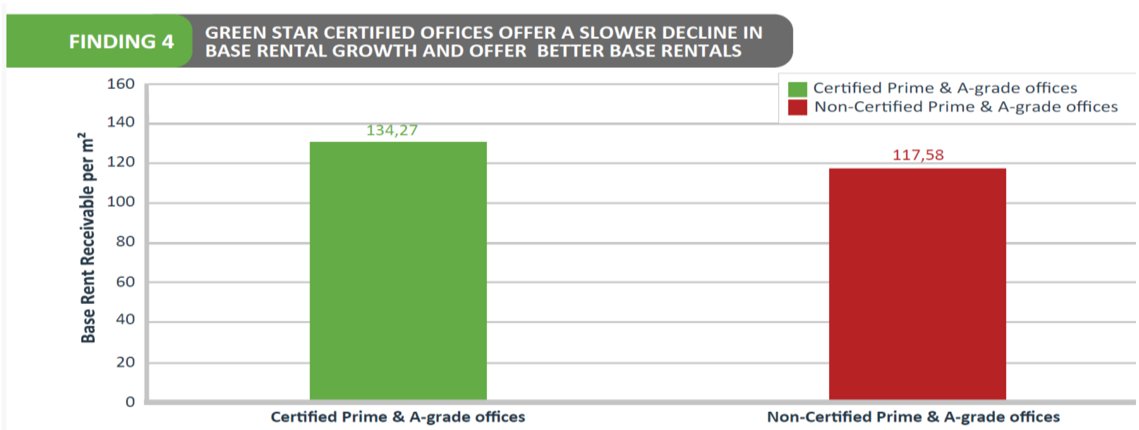
2. Green Star Buildings Have Lower Vacancies



Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

The above graph shows that green office buildings have lower vacancies over time.

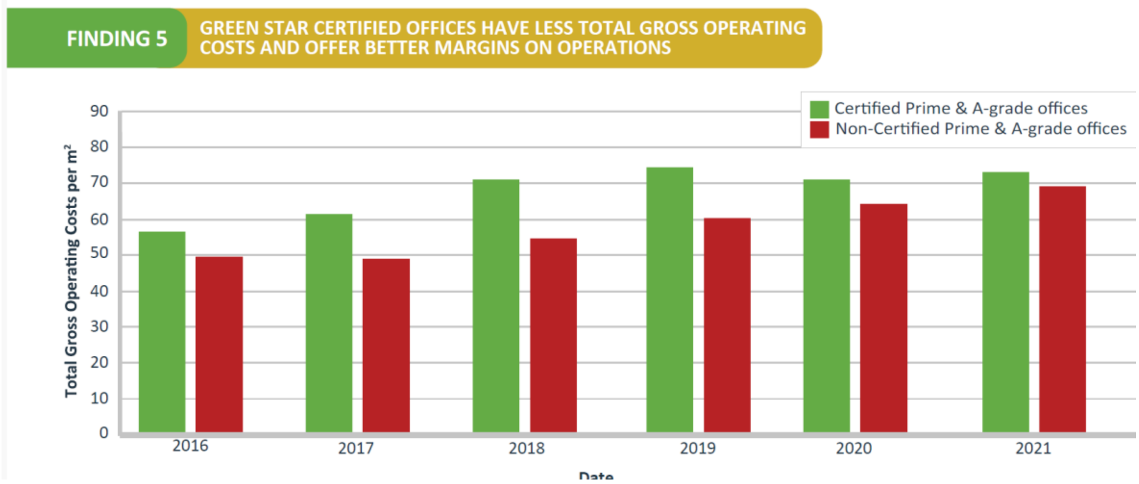
3. Green Star Buildings have Higher Rentals



Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

The above graph shows that green office buildings have higher rentals compared to non-certified office buildings.

4. Green Star Buildings Have Lower Operating Costs and Higher Margins



Note: From GBCSA, 2022 *MSCI South Africa Green Annual Property Index*

As shown above, Green Star Buildings deliver a 29% higher value per square metre and a 30% higher net operating income per square metre compared to non-certified green.

The index demonstrates higher earnings and reduced operational costs, which again magnify the earnings rate of green offices, and provides some solid numbers to contextualise that. (Green Building Council of South Africa, 2022)

As noted by Kats (2003), the value of green buildings lies not only in their environmental benefit but also in their superior financial performance over time.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The research discusses the environmental impact of the built environment, outlining key concepts of sustainability and highlighting the contribution from the building industry.

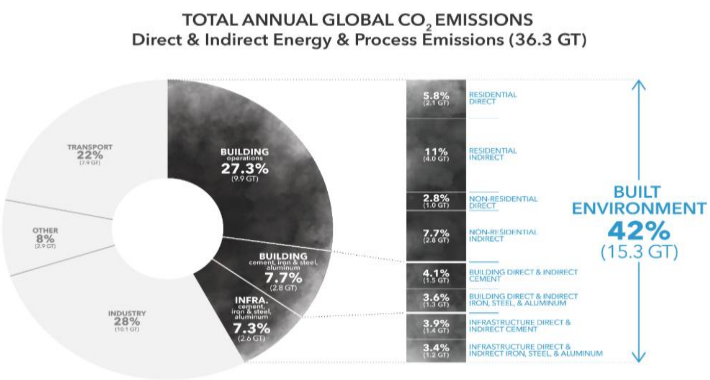
Building certification, particularly for residential buildings, is investigated and a comparison is drawn between the available certification tools in South Africa.

2.2 Background Discussion

2.2.1 The Built and the Natural Environment

The built environment contributes significantly to the degradation of the environment. Approximately 42% of global emissions are contributed by the built environment, with 27% contributed through building operations and infrastructure materials such as iron, steel, cement, and aluminium contributing an additional 15%. (Laxmipriyanka, 2009)

FIGURE 9: Total Annual Global CO_2 Emissions



Note: From Architecture 2030 *Why the Built Environment* using data from IEA and Statista (n.d.)

Figure 9 reflects the high relative value of emissions from the built environment and correlates to the reference earlier from IEA.

2.2.2 Development of Sustainability

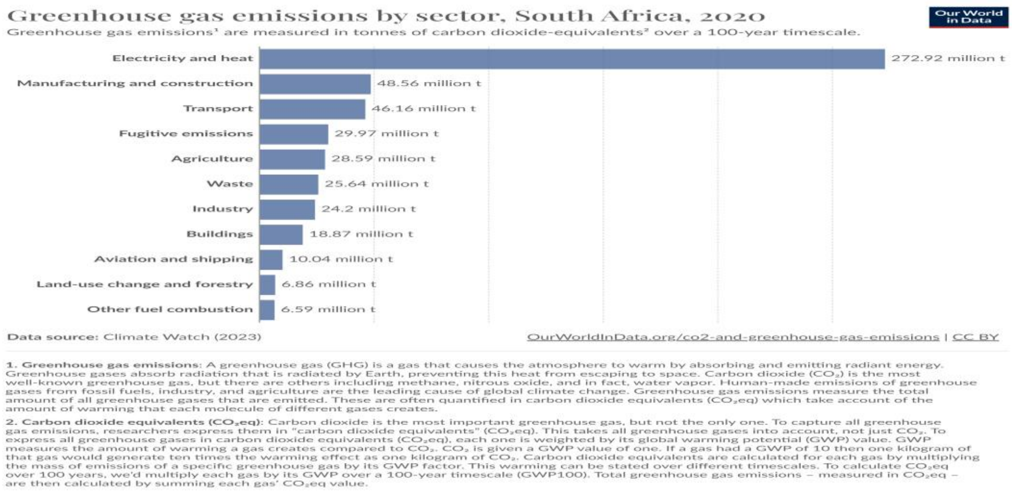
Long-term shifts in global temperatures and weather conditions have been impacted by human activities, and are the main driver of climate change. Greenhouse gas emissions contribute to rising temperatures and trap the heat from the sun. Carbon dioxide and methane are the main contributors to climate change, with buildings being a significant contributor of total emissions and a critical piece of a low carbon future. (IPCC, 2023)

In 1987, the World Commission on Environment and Development published a report titled “Our Common Future”. The document became known as the Brundtland Report after the commission’s chairwoman, Gro Harlem Brundtland, former Norwegian Prime Minister and Chair of the World Commission on Environment and Development. Sustainable development was defined in the report as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The three fundamentals of sustainability: environmental, social, and economic need to be in balance. (United Nations, n.d.)

The sustainable development debate has taken place alongside the United Nations Framework Convention on Climate Change, which was initiated at the Earth Summit in 1992. The United Nations 17 Sustainable Development Goals (SDGs) adopted in 2015 are a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. Broadly, the five pillars of the SDGs align to the International Monetary Fund five pillars of people, prosperity, planet, peace, and partnership. (United Nations. n.d.)

South Africa’s dependence on coal as a primary fuel source for electricity generation makes it one of the highest greenhouse gas emitters in the world. The energy sector contributes the highest proportion of emissions, but manufacturing and construction combined with building emissions contribute the second largest amount of emissions. Reducing these emissions can therefore play a vital part in reducing South Africa’s emissions and achieving lower emission targets.

FIGURE 10: Greenhouse Gas Emissions by Sector in South Africa, 2020



Note: From Our World in Data (n.d.) *South Africa CO_2 Country Profile*

Figure 10 shows the greenhouse emissions per sector in South Africa. If construction and manufacturing is considered, the relative contribution is significant.

Under Agenda 21, the Kyoto Protocol, and the Paris Agreement, South Africa has contractually committed to reducing carbon emissions to between 350 and 420 million tonnes by 2030 from a total of 442 million tonnes in 2020.

Climate change and South Africa’s inability to provide stable electricity supply poses a threat to the economy, and a key objective is to reduce emissions and broaden access to new energy technologies. (Department of Forestry, Fisheries and the Environment, n.d.)

On 9 November 2023, Reuters noted that it is unlikely that this target will be achieved due to delays in decommissioning eight coal-fired power stations. Six power stations were due to be decommissioned by 2030 and two by 2034. In addition, delays in switching to renewable energy policy has taken longer than planned. (Reuters. 2023)

Through policy action and focus on renewable energy in building and construction, emissions can be impacted and reduced by as much as 50%. (USAID, 2023)

Research conducted by the Council for Scientific and Industrial Research in 2009 for the Department of Environmental Affairs and Tourism discusses the emergence of green buildings in South Africa and their benefit on the environment. Building green can significantly impact energy consumption by as much as 50% and can result in lower water usage. (Laxmipriyanka, 2009)

2.2.3 Environmental impacts of the building industry

Environmental impacts of the building industry are dominated by the use phase, especially environmental impacts associated with energy and water usage. During the construction phase, there is the impact of materials and waste. (Heeren et al, 2015)

Housing units contribute positively to reducing shortages in the housing market and increasing employment opportunities, but also contribute negatively to the environment. According to the Construction Industry Development Board Deforestation, landslides, and soil erosion are some of the impacts. (CIBD, 2007) Non-residential and residential buildings account for 23% of total emissions, with 10% relating to non-residential, urban and rural residential contributing 8%, and manufacture of building materials 5%. (CIBD, 2009)

Urbanisation is expected to rise to 71% by 2030 with much of the population expected to reside in urban areas, which will increase the demand for housing.

2.2.4 Energy, Water, Materials, and Waste

Energy Efficiency – construction projects use significant amounts of fuel (petrol, diesel) for the transportation of materials and generators.

It is important to increase energy efficiency and reduce energy and water consumption. To contribute to sustainable development, construction and design allow for energy efficiency from the earliest stages of the project.

Pollution – Building and construction generates building rubble, plastic, and sometimes hazardous waste. Before construction commences, the design of a waste management plan will detail sources of waste and how they should be disposed of, and how waste can be reused or recycled. Noise pollution also impacts those close to the project.

2.2.5 Use of Sustainable Natural Resources

Construction projects use a significant number of natural resources, including soil, limestone, building sand, clay, metals (structured steel, electrical wiring), and water (potable and non-potable). The use of raw materials has a major impact on the environment, and before construction commences an analysis on how much material will be used and how it can be minimised is important.

2.2.6 Water

Construction cannot take place without water, and it is important to source water from non-potable sources to reduce environmental impact such as boreholes.

Other factors to consider include surface run-off which must be brought into the design, and this is usually done through a storm water management plan. Wastewater needs to be disposed of correctly and is considered hazardous waste due to the high levels of toxins.

More sustainable construction requires collaboration from a vast number of actors. Policy and legislation protects the environment and holds contractors accountable through building and safety requirements.

2.2.7 Green Building Cost Premium

A large amount of research exists regarding the cost premium associated with building green. Research conducted by Danie Hofman, lecturer at the University of Pretoria, demonstrated that the building premium in a sample of buildings was

5%, much lower than the perceived cost premium of 15%. Similar research by Greg Kats, a prominent figure in the green building industry, supports this outcome. (ASAQS, 2019)

In order to meet green building standards set by the GBCSA and National Building Regulations and Building Standards green building codes, buildings need to achieve a reduction in energy consumption as per EDGE or SANS 10400-XA guidelines.

The GBCSA was established in 2007 to lead the way for South Africa to achieve an environmentally sustainable built environment. The GBCSA's role is to deal with general green building advocacy, education, and resources, but its major role is the Green Star Rating System for Buildings. The rating system sets the benchmark for best practise green building and provides a framework to work with. The GBCSA also offers training for EDGE certification. EDGE is free software developed by the IFC, which is part of the World Bank. The EDGE standard sets a minimum of 20% reduction in energy and water consumption and embodied energy and a zero-carbon certification. (Green Building Council of South Africa, n.d.)

The Green Star and EDGE rating tools apply to office and residential buildings, and the rating tools provide certification once construction is completed with a rigorous audit and confirmation process by accredited specialists. Ongoing measurement of the energy and water savings and material use implications is not performed.

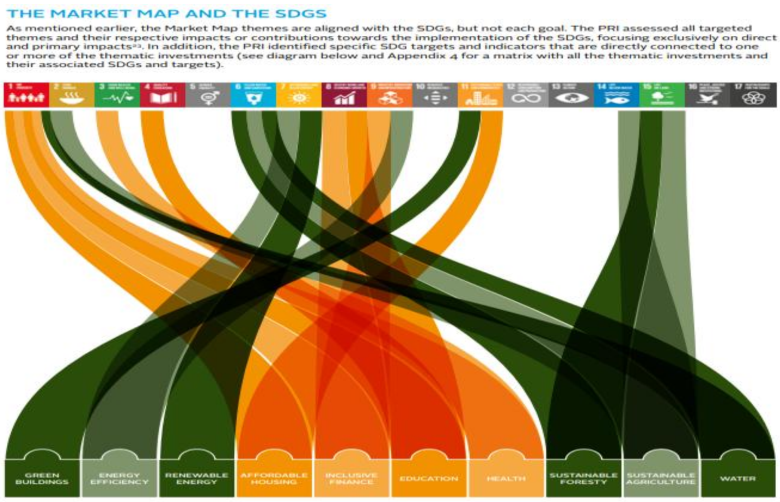
2.2.8 The Green Building Market and Evaluating Performance

The role of stakeholders such as the United Nations, World Bank, IFC, and other finance institutions enable local market activity so as to support green building construction, build knowledge so as to build an environment that supports government to develop policy, and set and raise the standard.

These actions can stimulate, strengthen, and build local markets. Certified green buildings can enable developers or financiers to raise funding through certified

ESG. (United Nations Principles for Responsible Investing, n.d.)

FIGURE 11: The Market Map and the UN SDGs



Note: From UNPRI (n.d.) *The Market Map and the UN SDGs*

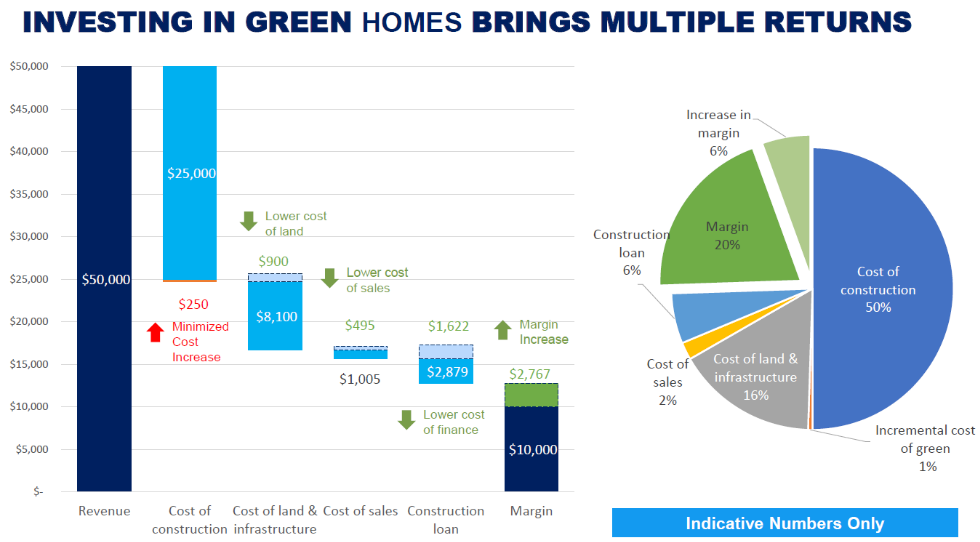
Figure 11 illustrates how different markets, regions, and sectors are all aligning with the principles of responsible investment as this is a growing market.

Research shows the benefits for property developers and includes: 1) having a competitive edge by acting first on new technology; 2) achieving higher property values for sales due to environmental appeal and lower running cost; 3) best practice: internationally recognised certification process and standard; 4) lower operating costs due to design specification efficiencies in energy, water, and material; and 5) improved reputation and brand strength.

Research also expands on the advantages for homeowners and tenants in green buildings despite the cost of greening such as: 1) utility bill savings; 2) better heating and lighting; 3) favourable environmental impact; 4) lower cost improves income; 5) improved disposable income improves repayment of rentals or loans, improving credit scores; and 6) higher property values.

Research further demonstrates that initial higher cost premiums are offset by cost savings and higher property values. (Kats, 2003)

FIGURE 12: Investing in Green Homes Brings Multiple Returns



Note: From IFC. (2023, 25 October). *Can Emerging Markets Afford Green and Resilient Housing?* [Video]. YouTube.

Figure 12 shows that for developers, investing in green means that overall running costs are reduced because of the saved water and energy costs. This means higher net income for property investors and property owners, and in the property industry electricity and water is recovered from tenants. If these costs are lower, these benefits can be passed directly on to tenants which improves affordability.

Despite higher income, consumers may make different choices as they manage what they spend their money on. This means that, theoretically, the risk of default may reduce if the consumer has a home loan, but practically the consumer may choose to spend the saving which may result in a different outcome.

The rebound effect in green buildings Gillingham, Kotchen, Rapson, and Wagner (2013) argue occurs when improvements in energy efficiency lead to lower operating costs, which in turn may cause tenants to consume more energy than anticipated, thereby offsetting some of the energy efficiency and environmental benefits. The tenant behaviour does not form part of this study but may be the subject of future studies.

Post-occupancy performance gap analysis refers to the evaluation of how a building actually performs after it is occupied, compared to the predicted or modelled performance. This performance gap focuses on identifying and understanding the difference between expected and actual outcomes. This can be important in ensuring that design intentions translate into actual environmental and financial performance. It supports continuous improvement, refines green building design and informs investment and valuation decisions. (de Wilde, P, 2014)

This research has identified the difference between actual and expected outcomes but a detailed analysis of the design or other improvements have not been considered in this research.

Some studies consistently note that buildings do not always perform as predicted, particularly once tenants occupy the space. These discrepancies between modelled and actual outcomes are referred to as “performance gaps,” and they can arise due to variations in user behaviour, maintenance, occupancy patterns, and climate responsiveness (Stevenson & Leaman, 2010).

Way and Bordass (2005) argue that such gaps are often exacerbated by the lack of routine feedback mechanisms in the built environment. They advocate for post-occupancy evaluation and continuous monitoring—such as the use of smart meters—as essential tools for understanding and improving building performance. Their work underscores the need to move beyond design-based projections and toward a culture of evidence-based performance validation, which aligns with this study’s use of actual utility data to assess EDGE-certified developments.

Post occupancy performance gap analysis *can* be conducted for EDGE certified buildings, but it is not mandatory or a formal requirement. Instead it is increasingly being encouraged as a best practise to validate the real-world benefits of green buildings beyond design-stage models.

Performance drift, may be part of the performance gap analysis, and refers to the gradual decline in building operational performance over time once it has been commissioned and occupied, even if it has been performing as expected. This decline can impact energy use and is impacted by maintenance, building system malfunction, hardware/software updates, and staff not following due process. (Crosbie & Baker, 2010)

Hedonic pricing studies measure the rental premium associated with green buildings, but the sustainability of that premium depends on how closely post-occupancy performance matches the original energy and comfort expectations. Performance gaps, rebound effects, and performance drift can all undermine the economic benefits of certification—making post-occupancy analysis essential to maintain long-term value. These studies use regression models to compare rental prices across similar properties, controlling for all other variables (e.g., size, location), to identify the price effect of the green features. (Fuerst & McAllister, 2011) This work is beyond the scope of this research.

Berardi (2013) highlights that sustainable buildings not only reduce resource consumption but also contribute to improved thermal comfort, air quality, and overall occupant well-being. In addition to environmental and financial outcomes, some studies also note potential co-benefits for occupants, including enhanced comfort and satisfaction.

In the Permanent Income Hypothesis, Friedman (2018) argues that consumption decisions are based on long-term income expectations rather than short-term fluctuations. Similarly, the Life-Cycle Hypothesis by Modigliani and Brumberg (1954) suggests that individuals smooth consumption over their lifetime, saving during high-income periods for future needs like retirement. Both models imply that temporary increases in income — such as monthly utility savings — may not translate directly into higher consumption, but rather into increased savings or financial resilience. Factors such as age, future expectations, and the perceived permanence of income changes influence how individuals adjust their spending behaviour.

2.3 EDGE Building Certification Applications

The source for this section of the research is the EDGE User Guide for all building types following training.

The application enables the user to select a specific building typology such as education, residential, or office and insert a specific location. Tabs for design, energy, water, and materials enable the user to select the default setting or enhance these elements by overwriting the default to select a higher specification in design that enables the efficiencies to be achieved.

The results of the building measures reflect in measurable key performance indicators (KPIs). To calculate these results, assumptions are made as to how the building will be used by occupants, and these provide the predicted energy and water usage. The KPIs include:

Final Energy Use	Energy consumption in kWh/month.
Final Water Use	Water consumption in m^3/month.
Final Operational CO_2 Emissions	The CO_2 emissions in tCO_2/month based on the final energy use multiplied by the CO_2 emission factor for the generation of grid electricity and other fuels in the project. The default value for the selected country's CO_2 emissions is shown in the design section, but can be overwritten if evidence can be provided to support it. The evidence must be from a reliable source such as a peer-reviewed publication from an international organisation or a specialised government approved study.
Final Embodied Energy	Automatically calculates the embodied energy in MJ/m^2 from the building dimensions and the materials selected in the materials section.
Final Utility Costs	Projects the monthly cost in US$/month or local currency per month for energy and water use.
Sub-project Floor Area	Displays the calculated Gross Internal Area for the sub-project multiplied by the sub-project multiplier.
Energy Savings	
Water Savings	
Operational CO_2 Savings	
Embodied Energy Savings	
Utility Cost Savings	Projects the annual savings in US$ and local currency in specific countries in utility bills.
Base Case Energy Performance Index	Energy use per unit area.

Improved Case Energy Performance Index	Energy use per unit area.
Total Building Construction	
Incremental Cost	Cost of implementing the selected efficiency measures in US$ or local currency in specific countries. Certain building measures may contribute to a lower overall cost compared to the baseline. Therefore, negative incremental costs are possible. EDGE cost data is based on average global data and is continuously refined. It is meant only as a guidance tool for comparison between measures. If specific local data is available, the use of it in a more specific financial model is encouraged for making financial decisions.
Increase in Cost	% increase in cost.
Payback in Years	Number of years to repay the incremental cost compared to the cost savings of utilities. The method used is simple payback based on the capital cost of the measure.
Number of People Impacted	
Base Case	Refrigerant Global Warming Potential.
Improved Case	Refrigerant Global Warming Potential (GWP). (Lower GWP compared to the base case with reduced greenhouse gas emissions.)
Detailed Results for Typologies	Residential typologies – shows when multiple typologies are present.

EDGE considers local environmental conditions and the implications to develop the base case. The base case is the energy and water use that applies meeting the minimum NHBRC building standard regulation.

The monthly atmospheric values have been included for the cities available in EDGE for each country. Default climate data is based on meteorological data from the city location. It is understood that the monthly values for the project site may vary from the average temperatures for the city due to variation in microclimates. Users can update these values in EDGE to reflect their project location. If the project site is not within a listed city, users may select a city close to it in geography and climate and manually enter the monthly climate values for the project location.

If any values are updated, the project team must submit evidence with a source for the values for EDGE certification compliance. (EDGEBUILDINGS, n.d.)

This part of the literature review considers specific research related to certification and certification data for the residential asset class previously published relating to green certification and building performance.

According to Boshoff and Mey, implementing building emission reduction strategies in South Africa can help the country meet its commitments to the Paris Agreement by reducing greenhouse gas emissions and improving energy efficiency in the residential building sector. (Boshoff & Mey, 2020) By encouraging minimum building standards to be more stringent, and certifications, South Africa can work towards lowering its carbon footprint and achieving its emission reduction targets.

Furthermore, the review emphasises the importance of setting more ambitious targets and implementing timeous mandatory regulations for new builds in order to align with the goals of the Paris Agreement. The authors highlight that by utilising building emission reduction strategies and tools, South Africa can play a significant role in mitigating climate change and meeting its international commitments under the Paris Agreement.

Patenaude and Plouffe conclude that certification programmes such as BOMA-BESt®, LEED®, and Living Building Challenge™ aim to reduce the environmental footprint of housing through various measures. (Patenaude & Plouffe, 2015) These measures are explained below:

1. BOMA-BESt

BOMA-BESt® focuses on regulating the environmental performance of existing buildings, including multi-unit residential buildings. It offers certification levels based on points collected, with a focus on energy, water, waste reduction, site emissions and effluents, indoor environment, and environmental management systems. Specific measures include energy assessment to analyse consumption, an Energy Management Plan for improvement, and consideration of factors such as emissions, effluents, and indoor environment.

2. LEED

LEED® (Leadership in Energy and Environmental Design) aims to support green building development by awarding certification levels based on points earned. LEED®-Homes, a programme under LEED®, covers categories such as innovation and design process, location and linkages, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and awareness and education. It focuses on optimising energy performance through building envelope effectiveness, insulation, air infiltration, and window quality.

3. Living Building Challenge

The Living Building Challenge™ certification programme emphasises post-occupancy measures to assess energy consumption, water consumption, and indoor air quality. It conducts evaluations of the level of energy consumption, water consumption, and indoor air quality to ensure that real performance of buildings is reflected. This programme aims to actively involve occupants in determining the performance of housing, thereby considering the impact of occupant behaviour on the environmental footprint.

The above three certification programmes integrate measures such as energy efficiency, water conservation, waste reduction, indoor air quality improvement, and sustainable material used to reduce the environmental footprint of housing during the construction and occupancy phases.

Global certification programmes such as BOMA-BESt®, LEED®, and Living Building Challenge™ fall short in adequately addressing the use phase of residential buildings in the following ways:

1) **Limited Post-Occupancy Evaluation**

Many certification programmes rely on simulations and estimates without real consideration of the use phase.

Certification processes often occur before occupancy, leading to discrepancies between anticipated and actual building performance.

Lack of post-occupancy evaluations may result in incomplete assessments of environmental performance, as actual building performance can differ significantly from design expectations.

2) **Insufficient Measurement of Energy Consumption**

Some programmes such as BOMA-BESt® may not require direct measurement of energy consumption but rely on visual inspections and billing data.

Energy assessments based on modelled scenarios at the design stage may not accurately reflect actual energy usage during occupancy.

3) **Limited Consideration of Occupant Behaviour**

Energy assessments based on modelled scenarios at the design stage may not accurately reflect actual energy usage during occupancy.

Certification programmes often focus on the building and its systems rather than considering the impact of occupant behaviour on energy consumption, water usage, and indoor air quality.

Lack of measures to validate performance after certification may overlook the influence of occupant actions on building sustainability.

4) **Outsourcing Building Impacts**

A disconnect between certification and actual use if there is no measurement of actual performance against expected performance.

5) **Monitoring and Evaluation**

Active measurement of energy consumption, water usage, and waste generation is important and by involving occupants, this can improve the environmental footprint.

The research shows that some certification programmes lack comprehensive post-occupancy evaluations, fail to measure actual energy consumption accurately, overlook occupant behaviour, and may not adequately validate performance after certification, highlighting the need for enhanced monitoring and evaluation strategies to address the use phase of residential buildings effectively. (Patenaude & Plouffe, 2015)

Isimbi and Park published research covering the analysis of the EDGE certification system on residential complexes to improve sustainability and affordability. (Isimbi & Park, 2022)

Isimbi and Park highlight that the key environmental and social strategies focused on in the EDGE certification system include:

1. Improving energy efficiency through technical solutions that reduce energy consumption, leading to lower utility fees for occupants.
2. Implementing strategies such as window-to-wall ratio (WWR), green roofs, air filtration systems, energy-efficient lighting, elevators, and air exchange systems to reduce indoor and outdoor temperature differences.
3. Water management strategies including various aspects such as general cleaning, washing, toilet flushing, rainwater collection, and water recycling to promote water conservation.
4. Utilising insulation materials, structural members of buildings (components that form the skeleton of the structure and support its weight and the load it carries), multi-pane glass, and low-E glass to enhance energy efficiency and reduce environmental impact.

These strategies aim to not only enhance the sustainability of buildings, but also to contribute to addressing housing shortages and promoting affordability in the context of South Africa.

This research analyses the efficiency of energy, water, embodied energy in materials, and annual CO_2 emissions in the context of housing issues through the following methods:

This study undertook a comprehensive analysis of **6,024 residential units** across **18 EDGE-certified developments** in South Africa. It involved:
(1) examining the actual electricity, water, and embodied energy in materials savings achieved through EDGE strategies and comparing these to a base case without certification;

(2) calculating the total annual CO_2 savings attributable to the adoption of green measures across the portfolio;

(3) assessing the broader environmental and social contribution of EDGE certification, particularly in reducing energy and water consumption and promoting sustainable housing in the face of growing demand; and

(4) evaluating the financial performance by comparing annual cost savings per unit — which rose from **R138 to R570** — against the additional “cost of green,” which ranged between **1% and 5%** of construction costs.

This comparison enabled the calculation of payback periods, offering insight into the timing and magnitude of return on investment. The findings demonstrate that EDGE certification is not only operationally and environmentally effective, but also financially viable, particularly in the affordable housing sector.

By focusing on these key metrics, the research provides insights into how the EDGE certification system positively influences the environmental performance of residential buildings and addresses critical housing issues in South Africa.

The implications of this study tie closely to the research presented and are important for the future of sustainable and affordable residential complexes.

Energy Efficiency – Prioritising energy savings and energy efficiency can lead to reduced utility costs and savings for landlords and residents, reduced demand, and better environmental impact.

Water Conservation – Water management strategies considered at design can reduce water consumption. This is crucial in regions facing water scarcity such as South Africa.

Embodied Energy in Materials – Reducing embodied energy in materials through sustainable construction practices can lead to lower environmental impact and promote eco-friendly building materials.

CO_2 Emissions Reduction – The Isimbi and Park study shows that EDGE certification results in significant annual CO_2 savings, indicating a positive contribution to mitigating climate change and reducing the carbon footprint of residential complexes.

Housing – EDGE can play a role in funding the housing shortage in South Africa. (Isimbi & Park, 2022)

In this study, the post-occupancy performance gap is assessed using actual energy and water consumption data obtained from smart meters installed across 18 EDGE-certified residential developments. This allows for a comparison between predicted EDGE savings and realised operational performance, offering an empirical basis for understanding the magnitude and drivers of performance deviation.

2.4 Conclusion of Literature Review

In conclusion, the literature review underscores the importance of the EDGE certification systems and their evaluation in driving sustainable practices in residential construction and its potential to address housing issues while promoting environmental stewardship and affordability.

Further research can be conducted on building pperformance gaps, rebound effects, and performance drift that can undermine the economic benefits of certification—making post-occupancy analysis essential to maintain long-term value.

Given the potential impact of tenant behaviour, maintenance practices, and contextual disruptions such as load-shedding on building performance, this study also draws on informal insights from the developer’s technical and operational teams. These perspectives help contextualise the causes of performance variation beyond what the quantitative data alone can reveal.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Research Design

A mixed methods approach was selected to combine the strengths of both quantitative and qualitative data. This design provides a more comprehensive view of the effectiveness of EDGE certification in delivering post-occupancy energy and water savings and their financial implications. (Creswell & Plano Clark, 2017)

The study selects one developer in sub Saharan Africa with 20 years experienced, based in 4 countries. The data for the 18 projects was obtained for 5363 units over the 5 year period.

The unit of measurement in this study is energy consumption (expressed in kilowatt-hours, kWh) and water consumption (expressed in kilolitres) per residential unit. These metrics were selected to quantify actual savings achieved in EDGE-certified developments and compare them to projected and baseline consumption value.

This design is suitable for understanding the actual post-certification savings associated with a residential development and what these savings mean for building rentals, operating costs, and value.

3.2 Participants

The property development firm based in Gauteng, with operations in four Sub-Saharan countries. The developer's selection was purposive, based on its established use of EDGE certification, data availability, and portfolio scale.

The data was collected from 18 developments over the period 2019 to 2024. The company applies EDGE certification to the developments, indicating adherence to specific environmental standards. The company was selected based on its history of working with EDGE certification, data availability, and track record. EDGE certification might influence building practices and sustainability outcomes and property values, and the company tracks this information internally and for investor reporting.

3.3 Research Approach

This study applies a case-based approach, combining quantitative analysis of metered performance data with informal expert insights. The primary quantitative component involves the analysis of smart meter data over a five-year period across 18 EDGE-certified developments. In addition, informal insights were obtained through unstructured discussions with the developer's project manager, energy engineer, and financial modelling staff. While these were not conducted through a formal qualitative protocol, the contextual input helped interpret observed performance patterns, clarify implementation decisions, and enrich the understanding of EDGE certification's practical implications (Yin, 2018).

Quantitative data: data sources:-

Time-stamped smart-meter downloads for every unit in each development (2019 – 2024).

Variables:

- kWh per unit per month (electricity)
- *kℓ per unit per month (water)*
- EDGE-predicted kWh/kℓ and baseline (NHBRC) kWh/kℓ

Key metrics computed:

Absolute savings (Rands) = Baseline – Actual (kWh or kℓ)

Percent savings (%)= (Baseline – Actual) ÷ Baseline × 100

Financial savings = Savings × Tariff (R/kWh or R/kℓ)

Analytical techniques:

- Statistics – 12 month moving average per month per building

The quantitative data will be gathered through analysis of company records and energy and water use reports provided, while qualitative data will be collected through semi-structured interviews with key stakeholders. The date and time stamped meter readings provide *objective evidence* of performance. Because the meters record what tenants actually consume, the numbers directly reveal whether the promised >20 % EDGE threshold is met or exceeded.

Qualitative data: data sources:-

In addition to quantitative analysis of operational data, informal insights were obtained through discussions with developers' project manager, energy engineer and financial modelling staff. While these insights were not gathered through a formal qualitative protocol, such as structured interviews or thematic coding, they provide valuable context for interpreting the qualitative findings. This informal input helped clarify implementation practises and deepen understanding of EDGE certification's real-world impact.

Although not conducted as formal interviews, the conversations were guided by key focus areas aligned with the study objectives. These include the rationale for selecting specific EDGE measures, where decisions to use solar photovoltaic (PV) systems were influenced by factors such as project location, cost and maintenance considerations. Operational challenges discussed included equipment failure such as faulty meters, user behaviour that compromised efficiency by manipulating or disabling energy-saving features, and contextual disruptions such as load shedding.

Insights were also obtained on the perceived financial and reputational value of EDGE certification, particularly in terms of its impact on financing terms, investor perception, rental levels, and the impact on the developers overall branding.

Finally, participants reflected on lessons learned and actions taken to drive continuous improvement, such as adjustments to design and operational practices, as well as enhanced tenant onboarding processes aimed at reducing performance variability over time.

3.4 Data Collection

Smart meter data from 18 residential developments were reviewed to assess actual energy (in kilowatt-hours) and water (in kilolitres) consumption per unit. This quantitative dataset spans the period 2019–2024 and includes monthly readings drawn from operational buildings across several provinces in South Africa. These data were used to evaluate the realised performance of EDGE-certified buildings against predicted and baseline consumption levels.

In addition, informal insights were obtained through unstructured discussions with the developer's project manager, energy engineer, and financial modelling staff. While not gathered through a formal qualitative research protocol, these discussions offered valuable contextual understanding of the design choices, operational challenges, and financial considerations associated with EDGE implementation. This informal input supported interpretation of the quantitative findings by offering plausible explanations for observed outcomes.

Secondary sources, including internal company reports, EDGE certification documents, and investor materials, were also reviewed to provide further insight into project characteristics and design decisions.

Instruments

No formal qualitative instruments such as interview guides or coding protocols were employed. Quantitative data were collected via smart meter records, and contextual insights were captured through note-taking during informal expert discussions and questions posed. Supporting documents were reviewed in their original format.

Data Analysis

Quantitative analysis involved descriptive statistics to compare actual versus predicted energy and water consumption and to quantify the cost savings achieved. Simple payback periods were calculated to assess the financial return on greening investments, using net operating income as a valuation basis where applicable.

Qualitative contextualisation was based on synthesised observations from informal discussions and document review. These insights were not subject to formal thematic coding, but were organised by topic area (e.g., design rationale, operational issues, financial impact) to support interpretation of quantitative trends and provide real-world perspective on EDGE performance.

3.5 Population and Sample

The population for this study consists of residential developments built by an established property developer based in Gauteng, South Africa, with operations across four Sub-Saharan countries. The developer has a strong track record in delivering EDGE-certified multi-family housing and maintains detailed operational data on its developments.

The sample includes 18 residential developments comprising a total of 5,363 units. These developments were selected using purposive sampling based on the availability of comprehensive utility consumption data and consistent application of EDGE certification standards. Each development was fitted with smart meters for water and electricity, generating consistent, timestamped consumption data.

Purposive sampling was used to ensure the selection of information-rich cases relevant to the research objectives (Patton, 2002). This allowed for detailed empirical evaluation of EDGE performance and financial implications in a real-world setting.

This purposive approach is appropriate for case-based research where rich, relevant data from a real-world setting is needed to evaluate post-occupancy building performance. The data allows for comparison between baseline consumption, predicted savings (as per EDGE design models), and actual energy and water usage. This empirical focus on measured outcomes is complemented by informal insights obtained from the developer’s technical and financial personnel, helping to contextualise observed performance patterns.

3.6 Quality Assurance

This section outlines the measures taken to ensure the reliability, credibility, and trustworthiness of the research findings, including the accuracy of quantitative data and the contextual validity of the qualitative insights.

3.6.1 Sources of Data

The primary data source consisted of smart meter readings for electricity and water usage, recorded monthly across 18 residential developments comprising 5,363 units. These readings were independently collected and compiled by the developer for operational monitoring and investor reporting. In addition, internal reports, EDGE certification documentation, and investor materials were reviewed to support analysis and contextual interpretation. Informal insights were gathered through unstructured discussions with key technical and financial personnel involved in project execution.

3.6.2 Data Collection

Quantitative data were extracted directly from digital records associated with smart meter infrastructure, reducing the risk of human error. Data integrity was supported through consistency in measurement units (kWh for electricity, kilolitres for water) and regular reporting intervals. Informal qualitative insights were recorded as field notes during discussions with the developer’s engineering and financial team. Document analysis involved triangulating reported EDGE projections with operational and financial outcomes.

3.6.3 Ethical Considerations

Ethical research conduct was upheld throughout the study. All informal participants were informed of the purpose of the research and consented to contribute contextual information voluntarily. No sensitive personal or company-identifying information is disclosed. The smart meter data were anonymised at the development level, and access to proprietary internal documentation was granted for academic purposes only. Data were stored securely and treated confidentially in compliance with research ethics protocols.

No personal tenant data was collected, and no ethical clearance was required for informal staff discussions.

3.6.4 External Validity / Transferability

The five-year data period, geographic diversity of developments, and consistent EDGE implementation enhance the external validity of the findings. While the study focuses on one developer, the patterns of consumption, savings, and performance are transferable to similar affordable, green-certified residential housing projects in similar urban contexts within South Africa or Sub-Saharan Africa.(Lincoln & Guba, 1985).

3.6.5 Internal Validity / Credibility

Credibility was strengthened through the use of objective, independently collected smart meter data over a continuous period. Informal discussions with technical experts served to clarify anomalies and contextual trends observed in the data, allowing for internal consistency in the interpretation of findings. Informal insights were triangulated with EDGE projections and operational documents to verify explanations for consumption outcomes (Shenton, 2004).

3.6.6 Reliability / Dependability

Reliability was ensured through the use of consistent measurement systems (smart meters) across all developments and standardised utility reporting by the developer. The longitudinal nature of the dataset supports dependability by capturing trends across multiple years. Observed consumption patterns were repeatable and consistent across developments, reinforcing the dependability of the findings (Miles, Huberman, & Saldaña, 2014).

CHAPTER 4. PRESENTATION OF RESULTS/FINDINGS

4.1 Introduction

This chapter presents and analyses the empirical findings of the study, based on post-occupancy data from smart meters installed in 18 EDGE-certified residential developments. The analysis aligns with the research objectives, focusing on the extent to which EDGE-predicted energy and water savings are achieved in practice, as well as the contextual factors that may influence these performance outcomes.

All 18 developments included in the study are newly constructed, sectional title residential projects. They are geographically distributed across five South African provinces: Gauteng, the Western Cape, KwaZulu-Natal, Mpumalanga, and the North West. The first development entered the portfolio in 2015 and holds the distinction of being the first EDGE-certified residential project in Africa.

The units primarily consist of two-bedroom, two-bathroom and two-bedroom, one-bathroom layouts, with a smaller proportion of one-bedroom and three-bedroom units. Unit sizes range from approximately 50 square metres for one-bedroom units to 70 square metres for two-bedroom, two-bathroom units. All units are fitted with individual smart meters for electricity and water, enabling monthly tracking of consumption at the unit level. Sale prices vary by geographic location, ranging from R700,000 to R1,200,000.

Three categories of consumption data are analysed in this chapter. The first is the base case, which refers to estimated water and electricity use calculated through the EDGE application using National Home Builders Registration Council (NHBRC) building standards and conventional construction practices. The second is EDGE-predicted consumption, which reflects anticipated resource use following the incorporation of certified energy- and water-saving design elements such as insulation, shading, ventilation, and solar energy systems. The third category is actual consumption, which represents the measured post-occupancy electricity and water use, recorded monthly through smart meters installed in each unit.

Electricity data are expressed in kilowatt-hours (kWh), and water consumption is measured in kilolitres (kL).

This chapter begins with a descriptive overview of the developments and their baseline characteristics, followed by a comparative analysis of predicted versus measured resource consumption. Where relevant, the findings are interpreted in conjunction with contextual insights from project stakeholders to explain any variances observed between design expectations and real-world outcomes.

FIGURE 13: The Data Format per Property Unit – Electricity Savings in KwH

Electricity Savings (KwH)	1
Base Case vs Edge	
Base Case Electricity Consumption (KwH)	214.00
EDGE assumption Electricity Consumption (KwH)	180.00
KwH Savings (Base Case minus Edge) Monthly	34.00
Unit Cost in R per KwH	R2.45
Average Unit Savings per Month (KwH)	**R83.30**
Edge vs Actual	
EDGE assumption Electricity (KwH)	180.00
Average Actual Electricity Consumption (KwH) Monthly	103.00
KwH Savings (Base Case minus Actual) Monthly	77.00
Unit Cost in R per KwH	R2.45
Average Unit Savings per Month (KwH)	**R188.65**
Base Case vs Actual	
Base Case elecricity Consumption (kwh)	214.00
Actual Electricity Consumption (KwH) reporting period	309.00
Average Actual Electricity Consumption (KwH) Monthly	103.00
KwH Savings (Base Case minus Actual) Monthly	111.00
Unit Cost in R per KwH	R2.45
Average Unit Savings per Month (KwH)	**R271.95**
	51.87%

The data is shown as follows: 1) comparing the base case (NHBRC standards) to actual; 2) comparing the energy use achieved through EDGE compared to actual; and 3) comparing the base case to actual.

FIGURE 14: The Data Format per Property Unit – Water Savings in kilolitres

Water Savings (Kl)	1
Base Case vs Edge	
Base Case Water Consumption (kl)	10.50
EDGE assumption water Consumption (kl)	8.10
Kl Savings (Base Case minus Edge) Monthly	2.40
Unit Cost in R per kl	R24.00
Average Unit Savings per Month (Kl)	**R57.60**
Edge vs Actual	
EDGE assumption water Consumption (kl)	8.10
Average Actual Water Consumption (Kl) Monthly	6.08
Kl Savings (Base Case minus Actual) Monthly	2.02
Unit Cost in R per Kl	R24.00
Average Unit Savings per Month (Kl)	**R48.48**
Base Case vs Actual	
Base Case Water Consumption (kl)	10.50
Actual Water Consumption (Kl) reporting period	18.24
Average Actual Water Consumption (Kl) Monthly	6.08
Kl Savings (Base Case minus Actual) Monthly	4.42
Unit Cost in R per Kl	R24.00
Average Unit Savings per Month (Kl)	**R106.08**
Overall Average Unit Savings per Month (KwH) + (Kl)	**R378.03**
Total Savings per Quarter (KwH) + (Kl)	**R1 134.09**

The data for the property portfolio is shown as follows: 1) comparing the base case (NHBRC standards) to actual; 2) comparing the energy use achieved through EDGE compared to actual; and 3) comparing the base case to actual.

The electricity and water savings are quantified in South African Rands and expressed as a saving in Rands per month per development.

FIGURE 15: Combined Water and Electricity Savings per Unit

Electricity: Ave. Consumption per Month		1
Base		214.00
Edge		180.00
Actual		103.00
% Ave. Saving (RHS)		42%
% Saving vs Base Case (RHS)		52%
Water: Ave. Unit Savings per Month		**1**
Base		10.50
Edge		8.10
Actual		6.08
% Ave. Saving (RHS)		54%
% Saving vs Base Case (RHS)		42%
Combined Savings per Month		**1**
Ave. Savings per Month	R	378.03
Ave. Portfolio Savings	R	570.80

The electricity and water savings for each development are combined in a monthly savings for all developments and is expressed in Rands and as a percentage. A running 12-month average of the savings is calculated for both water and electricity. An example of what this looks like is shown in Figure 15.

What this means is that the actual consumption is lower for electricity and water. For electricity actual consumption is 103 KwH per unit vs the promise of 180 and 214 base case. That amounts to a 42% saving in relation to the promise and a 52% saving compared to the base case.

For water actual consumption is 6.08 kilolitres per unit vs the promise of 8.10 and 10.50 base case. That amounts to a 54% saving in relation to the promise and a 42% saving compared to the base case.

4.2 Energy and Water Savings across the portfolio

This section presents the quantitative results related to the performance of the 18 EDGE-certified residential developments, focusing on post-occupancy energy and water savings as measured through smart meters. The analysis compares actual monthly consumption to projected EDGE targets, with savings expressed as a percentage of baseline consumption.

Figure 16 shows the electricity savings for the portfolio of 18 developments. This is the actual electricity used compared to the expected use, expressed as a % saving.

As the developments are completed, the data becomes available over the measurement period.

FIGURE 16: Electricity Saving – Portfolio 12-Month Average of 42%

	Quarterly Average % vs base																			
Electricity Savings (KwH)	1Q19	2Q19	3Q19	4Q19	1Q20	2Q20	3Q20	4Q20	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22	1Q23	2Q23	3Q23	4Q23
1	-	43%	43%	50%	49%	49%	26%	46%	48%	38%	38%	52%	52%	38%	41%	54%	51%	45%	36%	52%
2	-	34%	34%	49%	50%	50%	33%	44%	46%	32%	29%	50%	49%	29%	35%	53%	53%	40%	37%	52%
3	-	-	-	-	-	-	33%	58%	60%	49%	36%	57%	58%	35%	39%	60%	61%	44%	44%	44%
4	-	-	-	-	-	-	36%	54%	53%	43%	39%	54%	57%	42%	42%	59%	63%	53%	47%	59%
5	-	-	-	-	-	-	31%	50%	49%	39%	35%	48%	52%	42%	51%	51%	53%	45%	52%	53%
6	-	-	-	-	-	-	-	50%	43%	19%	25%	34%	34%	3%	27%	32%	28%	7%	-1%	23%
7	-	-	-	-	-	-	-	-	31%	12%	24%	27%	32%	20%	20%	53%	46%	27%	18%	46%
8	-	-	-	-	-	-	-	-	-	47%	38%	57%	54%	55%	52%	59%	59%	57%	53%	54%
9	-	-	-	-	-	-	-	-	-	26%	29%	27%	41%	24%	29%	40%	43%	22%	14%	43%
10	-	-	-	-	-	-	-	-	-	-	18%	26%	30%	7%	13%	25%	31%	8%	-1%	22%
11	-	-	-	-	-	-	-	-	-	-	44%	50%	49%	15%	28%	37%	43%	43%	5%	35%
12	-	-	-	-	-	-	-	-	-	-	36%	57%	58%	38%	43%	61%	64%	44%	42%	60%
13	-	-	-	-	-	-	-	-	-	-	-	-	-	17%	24%	41%	42%	15%	4%	35%
14	-	-	-	-	-	-	-	-	-	-	-	-	-	80%	12%	21%	20%	1%	-8%	28%
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55%	52%	46%	54%	55%	53%
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38%	46%	46%	46%	46%	48%
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8%	38%
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24%	0%	-12%	11%
Portfolio Average	-	**39%**	**39%**	**50%**	**50%**	**50%**	**32%**	**50%**	**47%**	**34%**	**33%**	**45%**	**31%**	**25%**	**30%**	**41%**	**43%**	**31%**	**24%**	**42%**

The results indicate a portfolio-wide average electricity saving of approximately 42% over a 12-month period ending in 2023. This means that, on average, actual electricity consumption was 42% lower than the EDGE base case projections. While some developments recorded little or no savings in isolated periods, the majority reported consistent electricity savings ranging between 24% and 50% across the monitoring period. Some variation can be attributable to seasonal changes in electricity demand, particularly higher consumption during winter months due to heating requirements.

Figure 17 shows the water savings for the portfolio of 18 developments. This is the actual water used compared to the expected use, expressed as a % saving.

As the developments are completed, the data becomes available over the measurement period.

FIGURE 17: Water Saving – Portfolio 12-Month Average of 54%

													Quarterly Average							
Water Savings (Kl)	1Q19	2Q19	3Q19	4Q19	1Q20	2Q20	3Q20	4Q20	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22	1Q23	2Q23	3Q23	4Q23
1	-	44%	44%	45%	60%	60%	36%	45%	45%	45%	45%	47%	52%	40%	40%	41%	43%	38%	47%	42%
2	-	58%	58%	56%	58%	58%	54%	58%	64%	58%	58%	58%	58%	58%	60%	57%	51%	51%	57%	57%
3	-	-	-	-	-	-	61%	62%	58%	58%	58%	62%	64%	58%	58%	58%	58%	58%	55%	58%
4	-	-	-	-	-	-	55%	58%	58%	58%	58%	58%	58%	58%	54%	62%	60%	58%	58%	58%
5	-	-	-	-	-	-	33%	33%	33%	33%	33%	36%	42%	39%	62%	66%	56%	52%	62%	72%
6	-	-	-	-	-	-	-	56%	56%	34%	45%	45%	34%	30%	41%	36%	36%	36%	41%	32%
7	-	-	-	-	-	-	-	-	48%	48%	48%	48%	48%	51%	68%	68%	56%	62%	62%	62%
8	-	-	-	-	-	-	-	-	-	64%	45%	33%	25%	37%	43%	51%	50%	45%	43%	45%
9	-	-	-	-	-	-	-	-	-	45%	45%	38%	38%	42%	61%	59%	64%	62%	62%	62%
10	-	-	-	-	-	-	-	-	-	-	41%	41%	41%	40%	62%	62%	62%	62%	62%	56%
11	-	-	-	-	-	-	-	-	-	-	29%	39%	32%	23%	50%	51%	43%	43%	49%	41%
12	-	-	-	-	-	-	-	-	-	-	61%	30%	9%	58%	61%	57%	57%	59%	59%	59%
13	-	-	-	-	-	-	-	-	-	-	-	-	-	32%	61%	62%	62%	62%	64%	60%
14	-	-	-	-	-	-	-	-	-	-	-	-	-	37%	56%	56%	75%	62%	54%	62%
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35%	35%	31%	33%	38%	33%
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56%	56%	56%	56%	56%	56%
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71%	65%
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58%	47%	52%	47%
Portfolio Average	-	**51%**	**51%**	**51%**	**59%**	**59%**	**48%**	**52%**	**52%**	**49%**	**47%**	**45%**	**28%**	**33%**	**48%**	**49%**	**51%**	**49%**	**55%**	**54%**

Similarly, water consumption data reveal strong performance relative to projected baselines. The portfolio achieved an average 12-month saving of 54% in water usage. As with electricity, while certain developments displayed periods of minimal savings, most developments consistently recorded water savings between 9% and 75%. These results suggest a robust outcome in terms of achieving EDGE targets for water conservation, despite some site-specific variability.

The fluctuations observed in water savings across the developments can be attributed to a combination of behavioural, technical, and contextual factors. Tenant usage patterns differ significantly between households; for example, shower duration, frequency of laundry, and the use of garden irrigation all vary, and these behaviours directly influence overall consumption. In many cases, water is not billed per unit, which weakens incentives for conservation. This behavioural variability has been widely documented as a key factor influencing post-occupancy performance (Stevenson & Leaman, 2010).

Occupancy rates also play a critical role. Developments that are not yet fully tenanted tend to show artificially low consumption, while fully occupied buildings reflect a more realistic, and often higher, usage profile. Early-stage occupancy and population ramp-up therefore skew efficiency figures. In addition, plumbing system inefficiencies—such as undetected leaks or the use of fittings that do not perform to specification—undermine intended savings, particularly if quality assurance during construction or early maintenance is weak.

Communal water use, such as irrigation for shared gardens or water drawn from common taps and laundry areas, are not be accounted for in unit-level meter readings. This unmetered consumption inflates overall development-level water use, even if individual units remain efficient. Similar issues have been noted in other studies of post-occupancy building performance, where disaggregated metering does not capture system-wide realities (Way & Bordass, 2005).

Furthermore, inconsistencies in smart meter installation, calibration, or data transmission—particularly in the early stages of occupancy—lead to measurement errors. Seasonal factors and regional climate variation also contributes to consumption patterns. For example, buildings located in warmer provinces often experience higher water use for hygiene and cooling, making seasonal fluctuations more pronounced.

Finally, baseline estimates used by EDGE are generated using standardised assumptions about occupant behaviour and building operation. If actual usage patterns deviate from these assumptions, realised performance may differ considerably from projected savings. These discrepancies highlight the broader challenge of translating design-stage models into reliable operational outcomes (Stevenson & Leaman, 2010).

Figure 18 shows the savings in Rands on a per development basis. The developments started in 2019 with most completed and measuring savings by 2023.

FIGURE 18: Combined Electricity and Water Saving Expressed in Rands per Unit

													Quarterly Average							
R Combined Savings per Month	1Q19	2Q19	3Q19	4Q19	1Q20	2Q20	3Q20	4Q20	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22	1Q23	2Q23	3Q23	4Q23
1	-	144.82	144.82	168.47	168.47	188.16	191.98	205.41	212.56	182.53	182.53	369.84	375.09	276.62	312.99	386.21	374.46	329.22	308.85	378.03
2	-	131.72	131.72	239.29	239.29	244.66	412.89	457.74	484.88	369.34	416.40	709.49	694.89	507.65	749.99	984.25	951.73	775.93	755.71	968.13
3	-	-	-	-	-	-	428.40	573.69	570.87	502.02	556.75	752.07	774.70	546.10	587.61	782.50	795.58	632.08	620.95	632.08
4	-	-	-	-	-	-	552.74	558.95	557.42	488.06	618.24	764.24	791.69	646.84	791.45	1 049.19	1 101.85	956.53	884.68	1 032.36
5	-	-	-	-	-	-	441.95	504.50	499.91	430.04	536.53	659.97	712.46	620.46	723.15	738.51	724.33	626.72	738.68	780.54
6	-	-	-	-	-	-	-	266.58	245.13	138.09	288.47	333.36	309.36	145.59	270.47	287.34	266.52	145.24	116.12	225.81
7	-	-	-	-	-	-	-	-	389.89	298.15	401.48	418.17	441.16	389.54	403.59	618.87	521.83	419.93	364.73	546.89
8	-	-	-	-	-	-	-	-	-	377.89	404.34	429.46	397.25	428.03	366.85	423.36	422.82	396.83	372.09	383.75
9	-	-	-	-	-	-	-	-	-	342.16	431.14	391.89	465.04	390.36	437.89	504.04	540.30	392.97	337.19	533.73
10	-	-	-	-	-	-	-	-	-	-	378.25	414.89	435.52	320.56	330.46	407.74	449.14	300.10	236.62	368.88
11	-	-	-	-	-	-	-	-	-	-	407.12	441.71	423.37	233.53	330.61	390.19	410.56	410.56	175.80	349.51
12	-	-	-	-	-	-	-	-	-	-	617.61	824.71	763.15	700.19	822.79	1 040.37	1 090.46	837.53	803.61	1 039.01
13	-	-	-	-	-	-	-	-	-	-	-	-	-	288.78	386.39	494.30	503.27	327.65	267.11	452.81
14	-	-	-	-	-	-	-	-	-	-	-	-	-	656.38	261.04	309.44	369.61	222.44	145.34	366.58
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	564.54	545.01	477.34	549.42	574.55	540.46
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	834.44	948.73	948.73	948.73	948.73	970.62
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	370.08	514.58
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	283.15	136.89	96.84	190.65
Portfolio Average	-	**138.27**	**138.27**	**203.88**	**203.88**	**216.41**	**405.59**	**427.81**	**422.95**	**347.59**	**436.57**	**542.48**	**365.76**	**341.70**	**454.13**	**550.56**	**568.43**	**467.15**	**450.98**	**570.80**

Figure 18 shows that the number of developments completed over the period is increasing and more data has become available for analysis. The average saving per unit starts at R138 per unit and increases to R570 per unit combined for electricity and water.

Analysis of the combined electricity and water savings, expressed in monetary terms, reveals a steady upward trend in per-unit cost savings over time. The developments in the portfolio commenced in 2019, with most reaching full completion and occupancy by 2023. Over this period, the number of operational developments increased annually, allowing for progressively more reliable measurement of actual utility savings.

The average combined monthly savings per residential unit—calculated from reduced electricity and water consumption—began at approximately R138 in the early years of the programme. By 2023, this figure had increased to R570 per unit, reflecting improved design integration, greater occupancy stability, and the cumulative impact of energy and water efficiency measures. These financial savings represent a tangible benefit of EDGE certification for end-users and may also influence the perceived value and marketability of the units.

4.3 Value Implications: Cost of Green, Payback Period, and Return Potential

Beyond the operational benefits of reduced utility consumption, the energy and water savings achieved across the portfolio also carry financial significance for both end-users and developers. This section draws on empirical data from 10 developments within the portfolio to quantify the annual utility cost savings and evaluate how these translate into broader value creation. These savings contribute directly to lower monthly household expenditures and, over time, may influence improved capital value and investment returns.

The additional construction cost associated with achieving EDGE certification—commonly referred to as the “cost of green”—varies across developments but remains modest in relation to total project expenditure. Based on actual cost data, the green premium in this portfolio ranges between 1% and 5% of total construction costs, depending on the scale and nature of the resource efficiency measures implemented. The primary drivers of this incremental investment include technologies such as solar photovoltaic systems, energy-efficient lighting, insulation improvements, and water-saving fittings.

FIGURE 19: Annual Water and Electricity Savings per annum

Number	Total Units	water usage pa	electricity usage pa	Electricity Savings pa	Water Savings pa	Total saving	Annual operating cost savings
1	188	R550 973.33	R2 057 697.14	R8 642.33	R2 975.26	R11 617.58	R2 184 105.79
2	318	R597 062.67	R1 462 468.57	R6 142.37	R3 224.14	R9 366.51	R2 978 549.04
3	180	R479 826.67	R1 189 034.29	R4 993.94	R2 591.06	R7 585.01	R1 365 301.44
4	162	R542 966.67	R864 432.00	R3 630.61	R2 932.02	R6 562.63	R1 063 146.77
5	97	R545 751.11	R823 268.57	R3 457.73	R2 947.06	R6 404.78	R621 264.05
6	424	R496 744.89	R655 066.29	R2 751.28	R2 682.42	R5 433.70	R2 303 889.14
7	290	R235 733.33	R777 000.00	R3 263.40	R1 272.96	R4 536.36	R1 315 544.40
8	269	R268 977.33	R652 779.43	R2 741.67	R1 452.48	R4 194.15	R1 128 226.67
9	312	R481 805.33	R427 902.86	R1 797.19	R2 601.75	R4 398.94	R1 372 469.53
10	156	R304 593.33	R153 088.00	R642.97	R1 644.80	R2 287.77	R356 892.68

Figures 19 above and 20 below present the measured annual utility savings and the associated green investment costs across a sample of ten developments. The data enables a simple payback period analysis to be shown, comparing the upfront cost of green features to the annual financial benefit derived from reduced utility bills.

The results show payback periods generally ranging from two to four years, depending on the development. For instance, in a development with a green premium of R15,000 per unit and annual savings of R6,000, the investment would be recovered within 30 months. These findings support broader studies indicating that EDGE-aligned residential buildings can recover their green investment within a relatively short time frame (World Bank Group, 2019).

FIGURE 20: Cost of Green and Payback Period

Number	Total Units	Date of Development	Total Development Cost	Cost of Green	Payback period through op cost savings	% cost of gtreen	Sq meters	Operating cost savings
1	188	2016	107 486 736	5 374 336.80	2.46	5%	10 180.0	R2 184 105.79
2	318	2019	233 131 354	11 656 567.71	3.91	5%	21 702.0	R2 978 549.04
3	180	2019	128 000 000	6 400 000.00	4.69	5%	10 332.0	R1 365 301.44
4	162	2019	90 275 000	4 513 750.00	4.25	5%	7 290.0	R1 063 146.77
5	97	2020	60 817 319.32	3 040 865.97	4.89	5%	4 703.0	R621 264.05
6	424	2018	273 505 648	13 675 282.40	5.94	5%	26 096.0	R2 303 889.14
7	290	2019	205 000 000.00	10 250 000.00	7.79	5%	17 382.0	R1 315 544.40
8	269	2018	151 929 517	7 596 475.85	6.73	5%	14 472.0	R1 128 226.67
9	312	2020	227 220 889	11 361 044.45	8.28	5%	18 380.8	R1 372 469.53
10	156	2019	74 421 502	3 721 075.10	10.43	5%	8 847.0	R356 892.68

As illustrated in Figure 20, developments with higher green premiums also tend to show proportionally higher savings, indicating a scalable relationship between investment and return.

The value implications of EDGE certification extend beyond direct financial savings. Lower operating costs improve the net operating income (NOI) of a development, which in turn supports higher valuations under income capitalisation methodologies commonly used in residential investment analysis. In addition, certified green buildings may command stronger demand in the market due to growing awareness of environmental and cost-of-living benefits. For developers, EDGE certification can contribute to reputational gains, potentially improving access to green financing instruments or concessional capital linked to sustainability performance.

The relatively modest capital outlay required to achieve EDGE standards—coupled with demonstrable utility savings, short payback periods, and reputational advantages—positions green residential buildings as an increasingly attractive asset class. These findings reinforce the commercial case for incorporating resource efficiency into residential development models, particularly in emerging markets where utility costs and environmental risks are significant.

4.4 Summary of the Results/Findings

The findings presented in this chapter demonstrate that EDGE-certified residential developments across the portfolio achieved meaningful reductions in both electricity and water consumption during the post-occupancy phase. On average, electricity usage was reduced by 42% and water consumption by 54% relative to the EDGE base case assumptions. These results suggest that, in most cases, the design-phase efficiency assumptions of EDGE were met or exceeded in actual operation.

However, the findings also reveal variability across developments, particularly in water savings. These fluctuations were influenced by behavioural, contextual, and operational factors, including tenant usage patterns, occupancy rates, plumbing inefficiencies, and the presence of unmetered communal water use. Such variation aligns with literature that highlights the post-occupancy performance gap and underscores the importance of continuous monitoring.

From a financial perspective, the combined monthly savings in electricity and water costs ranged from R138 to R570 per unit over time. When compared to the incremental cost of green construction—estimated between 1% and 5% of total development cost—these savings translate into simple payback periods of between two and four years. This supports the commercial viability of EDGE certification and suggests that green residential buildings can yield attractive returns for both end-users and developers.

The findings also confirm the added reputational and operational value of certification, which enhance tenant appeal, support favourable financing conditions, and contribute to asset value. These insights form the basis for the discussion in Chapter 5, which reflects on the broader implications for green residential development in the South African context.

Beyond measurable resource savings, the data and contextual feedback suggest that improvements in building envelope design and water efficiency may also support improved tenant living conditions. Although not directly measured in this study, this is consistent with global findings that associate green buildings with better indoor comfort and reduced exposure to energy insecurity (Berardi, 2013; World Bank Group, 2019).

4.5 Comparison of Literature Review and Own Findings

Table 1 is a consistency table to compare the answers obtained from the research questions to findings with the answers obtained from the literature.

TABLE 1: Comparison of literature review and findings

	State Research Question or Objective		Literature Review Response and Reference	Empirical findings from this study
	EDGE-certified projects entail the incorporation of elements during the design phase of a building to achieve electricity and water savings.		Green certifications like EDGE aim to reduce energy and water consumption by at least 20% compared to conventional buildings (IFC, 2021).	The developments achieved an average of 42% electricity savings and 54% water savings across the portfolio.
	Confirms the existence of a post-occupancy gap, reinforcing prior literature on		The “performance gap” often arises between design-stage projections and actual post-occupancy outcomes due to	While most developments performed well, some showed wide variations, particularly in water savings.

	State Research Question or Objective		Literature Review Response and Reference	Empirical findings from this study
	performance drift and real-world complexity.		behavioural and operational variances (Stevenson & Leaman, 2010; Way & Bordass, 2005).	Factors included tenant behaviour, leaks, occupancy rates, and seasonal effects.
	Contributes local empirical evidence of smart meter effectiveness in South African residential green buildings.		Smart meters are increasingly used for monitoring post-occupancy performance and validating sustainability outcomes (Way & Bordass, 2005).	All units in the sample were fitted with smart electricity and water meters, enabling monthly measurement at the unit level.
	Confirms cost-effectiveness of green investments and supports a short to medium-term ROI, extending existing global findings to a local portfolio context.		Green building investments are often perceived as more expensive, but can deliver positive returns through lower operating costs and improved asset value (World Bank Group, 2019).	The “cost of green” ranged from 1% to 5% of construction costs. Payback periods were estimated at 2–4 years, with monthly savings of R138–R570 per unit.
	Adds qualitative evidence from		Certification may enhance reputation,	The developer reported improved

	State Research Question or Objective		Literature Review Response and Reference	Empirical findings from this study
	practitioner insight to support the broader reputational value of certification.		tenant appeal, and access to concessional finance (Dwaikat & Ali, 2018).	marketability and reputational value, and potential benefits for financing and investor confidence.
	Fills an empirical gap in regional research and adds new data to the sparse body of literature on EDGE performance in emerging markets.		Limited data exists on EDGE post-occupancy performance in Sub-Saharan Africa (IFC, 2021).	This study provides rare measured post-occupancy data from 18 EDGE-certified developments in South Africa.
	Building design and certification can enhance energy and water savings. achieved.		Patenaude, M. & Plouffe, S. (2015) conclude that certification programmes such as BOMA-BESt®, LEED®, and Living Building Challenge™ aim to reduce the environmental footprint of housing through various measures.	Post-occupancy evaluations, enhance the understanding of energy savings by evaluating the performance achieved and determining reasons for variations and how design or other measures can improve performance.

	State Research Question or Objective		Literature Review Response and Reference	Empirical findings from this study
			EDGE certification also achieves this objective.	
	The EDGE measures during design are generally not measured during the use of the building but if they were further improvements could result in energy efficiency.		Isimbi, D. and Park, J. (2022) published research covering the analysis of the EDGE certification system on residential complexes to improve sustainability and affordability.	Water management strategies such as general cleaning, washing, toilet flushing, rainwater collection, and water recycling to promote water conservation. Utilising insulation materials, low-E glass enhance energy efficiency and reduce environmental impact. Lower costs improve affordability as they are usually savings in the hands of owners and tenants.
	Payback period and value.		Green certification increases building value and is supported by extensive research.	The data findings support the research with the cumulative annual cost savings

	State Research Question or Objective		**Literature Review Response and Reference**	**Empirical findings from this study**
			Kats demonstrated that green buildings, while costing slightly more upfront (around 2%), provide substantial long-term financial benefits. Kats, 2003 Kats, 2010 Cost premium – green buildings do carry an initial cost outlay of between 1%-5% but the payback period is a measure of return on investment and on average was between 2-5 years.	exceeding the cost of greening. The data revealed that in the certified green residential portfolio reviewed, the operating costs are lower due to the electricity and water savings. In the data reviewed, the cost of greening was estimated at 5% and the cost savings made up for this investment over a three to four-year period in nominal terms.
	Green buildings may enhance investor brand and market share.		There is evidence that green buildings may improve developers brand impact. Dwaikat & Ali (2018)	Qualitative insights revealed reputational and financing advantages from EDGE adoption.

	State Research Question or Objective		Literature Review Response and Reference	Empirical findings from this study
	Green buildings may provide tenants with better living conditions resulting in health benefits.		Although not directly measured in this study, this was mentioned by the developer and is mentioned in the introduction. This is also consistent with global findings that associate green buildings with better indoor comfort and reduced exposure to energy insecurity (Berardi, 2013; World Bank Group, 2019).	There is growing evidence that green buildings can result in improved living conditions for tenants, particularly in terms of: *Thermal comfort, *Indoor air quality, *Utility affordability, *Occupant satisfaction and well-being.

CHAPTER 5. DISCUSSION OF THE RESULTS OR FINDINGS

This chapter discusses the data and findings of the research and highlights the broader industry implications.

These issues are particularly relevant for South Africa, given the housing shortage, the need to ensure ongoing access to affordable electricity and water, and the broader economic implications. In this chapter, these arguments will be linked to current research.

5.1 Introduction

This chapter presents a deeper interpretation of the findings within the South African context. It considers the broader economic and industry implications of the results and is supported by relevant literature and a practical case example.

5.2 Presentation of Findings

Resource Savings

The results confirm that EDGE-certified developments deliver measurable benefits. On average, electricity and water savings of 42% and 54% were achieved, exceeding the 20% EDGE baseline across all projects.

Performance Variability

Performance varied between developments, underscoring the role of tenant behaviour, maintenance issues, and contextual disruptions such as load-shedding. These findings support the presence of post-occupancy performance drift.

Value

The cost of green features ranged from 1–5% of development costs. These modest investments produced meaningful utility savings, improved Net Operating Income, and supported higher property values and short payback periods. Although EDGE savings rose from R138 to R570 per unit monthly, this may not translate into higher discretionary consumption. According to the Permanent Income Hypothesis (Friedman, 2018) and the Life-Cycle Hypothesis (Modigliani & Brumberg, 1954), spending behaviour depends on long-term income expectations. As such, EDGE-related savings may support consumption smoothing or long-term financial stability, especially in low- to middle-income households.

Beyond operational savings and improved NOI, EDGE certification may also enhance a developer’s brand reputation. Demonstrating measurable sustainability outcomes on a consistent basis can strengthen relationships with financiers, attract impact investors, and support alignment with environmental, social, and governance (ESG) criteria. This reputational benefit may translate into competitive advantage in future funding or development partnerships.

Other Green Benefits

While resident well-being was not directly measured in this study, informal staff insights and supporting literature (Berardi, 2013) suggest that EDGE-certified buildings offer co-benefits such as improved thermal comfort, healthier indoor environments, and reduced exposure to energy and water stress. These factors may improve residents' quality of life and support more resilient, affordable housing models — particularly relevant in urban South African contexts.

5.3 Broader implications of the study

The relevance of the study is considered in the context of environmental impact, affordability, and housing in the context of South Africa.

South Africa’s housing crisis is a multifaceted issue rooted in historical inequalities, and is exacerbated by ongoing challenges such as urbanisation, income inequality, unemployment, insufficient government resources, inadequate maintenance, and poor service delivery. The nation faces a significant shortage of affordable housing, leading to the proliferation of informal settlements and townships that perpetuate the legacies of apartheid-era spatial planning. (Moolla, Kotze, & Block, 2011)

Moolla, Kotze, and Block's (2011) research into Reconstruction and Development Programme (RDP) housing is contextualised within the broader socio-historical and spatial challenges that define South Africa's housing landscape:

1. Historical Context

The study's exploration of housing satisfaction in Braamfischerville sheds light on the broader historical context of housing in South Africa. Under apartheid, policies of racial segregation relegated non-white populations to underdeveloped and peripheral areas, known as townships, characterised by poor infrastructure and limited access to economic opportunities. The RDP programme emerged as a post-apartheid initiative to redress these inequalities. Despite its intentions, the demand for affordable housing continues to exceed supply, with more than 2.4 million households registered on the National Housing Needs Register as of 2023. The study's findings on inadequate housing quality and infrastructure resonate with this ongoing housing deficit and the complexities of addressing historical inequities.

2. Informal Settlements and Townships

The study highlights how RDP housing, while an improvement over informal settlements, does not fully resolve the challenges of spatial and socio-economic inequalities. Many South Africans still reside in informal settlements that lack basic services such as water, sanitation, and electricity. These settlements, often located on the peripheries of urban centres, perpetuate the spatial inequalities entrenched during apartheid. The research underscores that while RDP housing provides a step forward, significant disparities in living conditions and access to opportunities persist, reflecting broader systemic issues within the housing sector.

3. Legacy Issues

The persistent challenges identified in RDP housing, such as construction quality and inadequate infrastructure, highlight the enduring impact of apartheid-era spatial planning. As noted in the study, the socio-economic disparities and spatial segregation created during apartheid continue to manifest in modern housing initiatives. Efforts to upgrade informal settlements and provide better-quality housing have been met with bureaucratic, financial, and logistical challenges, a theme echoed in the limitations of RDP housing projects explored in the research.

5.4 Concluding Remarks

Moolla, Kotze, and Block’s (2011) study underscores the complexity of addressing South Africa’s housing crisis. Their findings align with the need for a multifaceted approach that goes beyond simply increasing the supply of affordable housing. Solutions must encompass improvements in the quality of housing construction, the upgrading of informal settlements, and the provision of essential services and infrastructure. Moreover, addressing these challenges requires policies that bridge socio-economic gaps and promote integrated, sustainable development. The research highlights that while progress has been made, significant work remains to overcome the legacy of apartheid and meet the housing needs of all South Africans.

5.5 Case Study

Varghese argues that there is much to learn from the development of the green building sector in South Africa. This research provides guidelines for sustainable housing and shows that green technology can play an important part in housing and sustainability, and that a comprehensive approach to consider these aspects is needed. (Varghese, 2022)

This study contributes new empirical evidence to the evolving literature on green building performance in emerging markets. While much of the existing research focuses on modelled savings or developed-market case studies, this work is among the first to assess post-occupancy energy and water performance using smart meter data across a portfolio of EDGE-certified residential developments in South Africa.

The findings validate that EDGE performance targets are not only achievable but can be exceeded in real-world conditions when supported by appropriate technologies and design features. This extends the discourse on the performance gap by showing that high performance is possible — but not guaranteed — and is influenced by behavioural, technical, and contextual factors.

By incorporating insights on financial payback, cost of green features, and branding advantages, the research integrates environmental and economic dimensions of sustainability. It also adds a behavioural perspective through the lens of the Permanent Income and Life-Cycle Hypotheses, helping to interpret the household-level financial impact of resource efficiency.

Finally, the study contributes to South African and broader Sub-Saharan African knowledge by offering a replicable methodological approach and highlighting the role of green certification in delivering affordability, utility savings, and reputational value in the affordable housing sector.

Linking environment, housing, and affordability in the case study:

1. Environmental Impact

The built environment, including housing, contributes significantly to greenhouse gas emissions, with approximately 30%-40% attributed to this sector. (Lamb et al, 2021)

According to Berkebile and McLennan, sustainable design and planning can drastically reduce energy demand and consumption, potentially lowering energy use by a factor of five. (Berkebile & McLennan, 1999)

Varghese emphasises the importance of integrating sustainability into housing practices to mitigate environmental degradation and address climate change effectively.

The research paper demonstrates the savings in electricity and water through sustainable design. These savings have a positive impact on the environment.

2. Housing in South Africa

The housing sector faces immense challenges, including high demand, limited delivery options, and historical issues such as spatial inequality and community segregation. These stem from the apartheid era and has resulted in informal settlements being a long distance from formal places of employment. (Ziblim, 2013)

Ziblim examines South Africa's efforts to improve informal settlements in the Upgrading of Informal Settlements Programme and highlights several challenges such as: 1) inconsistent implementation among municipalities, 2) limited community engagement and involvement, 3) unclear selection criteria where upgrades occur, 4) limited land availability, and 5) limited and dysfunctional municipal resources. Despite the housing policy, there is an inability to meet immediate housing demands and address systemic issues such as race and income inequalities, achieve community resilience, and address spatial justice.

As evidenced through this research, the green building sector, initiated by the GBCSA, has made strides in promoting sustainable practices in the housing industry, providing valuable lessons for future housing guidelines.

3. Affordability

McDonald performed research in Canada in 2005 which suggested that sustainable aspects of housing projects are often viewed as additional costs, particularly when targeting middle to low income groups (McDonald, 2005).

The average cost for green buildings is 5% less than conventional construction, challenging the perception that it is more expensive.

The case for green buildings is not solely about incorporating advanced technologies. Instead, it involves changing the mindset of building owners and design teams, establishing clear environmental goals from the outset, and utilising an integrated design process.

5.6 Conclusion

This chapter has explored the research findings through multiple lenses — environmental, economic, and social — to assess the effectiveness and value of EDGE-certified residential developments in South Africa.

The empirical results demonstrate that real-world electricity and water savings significantly exceed the EDGE baseline, confirming the environmental benefits of green building design when supported by smart metering and efficient systems. The variability in performance across developments highlights the importance of contextual and behavioural factors, underscoring the value of post-occupancy monitoring and adaptive management.

Financially, the analysis confirms that modest upfront investments in green measures can yield short payback periods, increased Net Operating Income, and meaningful monthly savings for residents. These findings reinforce the case for integrating sustainability into housing as a long-term value strategy — not only for developers but also for occupants. When viewed through the lens of consumption theory, the utility savings may support greater financial stability for low- to middle-income households, even if not immediately visible in increased spending.

Furthermore, the research highlights important co-benefits — from enhanced thermal comfort to reputational gains for developers — that extend the impact of EDGE certification beyond technical performance. These findings make a valuable contribution to both the literature and practice of green housing in Sub-Saharan Africa, offering a replicable model for future projects aiming to balance environmental targets with affordability and long-term value creation.

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The study also suggests that current national building standards — which serve as the baseline for EDGE calculations — may be too lenient to drive transformative environmental outcomes. If regulatory requirements were more stringent, the potential for greater energy and water savings would increase, thereby amplifying both household benefits and environmental impact. This raises an opportunity for policymakers to revisit the baseline assumptions embedded in building codes and incentive schemes, aligning them more closely with sustainability targets.

In closing, this chapter underscores the role of empirical performance measurement in validating green design claims and advancing sustainable housing at scale. The next chapter reflects on these findings in relation to the broader research aim and presents final conclusions and recommendations.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This study investigated the post-occupancy performance and value implications of EDGE-certified residential developments in South Africa. Focusing on a portfolio of 18 projects developed by a single firm across five provinces, the research analysed actual electricity and water consumption at unit level using smart meter data. All developments incorporated energy- and water-efficiency features in line with EDGE certification.

A mixed methods approach was used, combining quantitative analysis of consumption data with qualitative insights from informal discussions with project stakeholders. The study aimed to determine whether projected utility savings were realised in practice, identify sources of performance variability across developments, and evaluate the financial impact on both residents and the developer.

The analysis was structured around three themes: (1) actual resource savings, benchmarked against EDGE projections; (2) variability in performance, highlighting operational and behavioural factors; and (3) financial outcomes such as savings per unit, cost of green, payback periods, and property value implications. By aligning empirical results with theoretical frameworks and operational realities, the research contributes to a deeper understanding of EDGE effectiveness in the affordable housing sector and informs South Africa’s broader green building agenda.

6.2 Key Conclusions

The findings of this study provide several key conclusions that speak directly to the original research objectives.

1. EDGE certification delivers significant post-occupancy savings.

Smart meter data confirmed that electricity and water savings across the portfolio consistently exceeded the 20% baseline required by EDGE certification. On average, electricity use was reduced by 42%, and water use by 54%, validating the operational effectiveness of green design elements such as solar PV, low-flow fittings, and insulation. These results confirm that green buildings can deliver measurable environmental performance beyond theoretical models.

2. Performance varies due to contextual and behavioural factors.

Despite strong aggregate performance, variability was evident across developments and timeframes. Contributing factors included equipment failure, tenant interference with efficiency settings, and external issues such as load-shedding. These findings support the concept of post-occupancy performance drift and emphasise the need for ongoing monitoring, user engagement, and maintenance.

3. Financial value is created for both end-users and developers.

The additional cost of green measures ranged between 1% and 5% of total development cost, yet savings per unit increased from R138 to R570 per month. These outcomes led to short payback periods, enhanced NOI, and improved asset value. Furthermore, developers benefitted from ESG alignment, access to green finance, and strengthened brand reputation — underscoring value beyond cost savings.

4. Regulatory baselines may be too low to drive optimal outcomes.

Because EDGE performance is benchmarked against national building standards, findings suggest that South Africa’s regulatory baselines may be too lenient to incentivise optimal outcomes. Stricter standards could drive higher minimum efficiency and amplify the environmental and financial gains of green construction.

5. Green buildings offer broader co-benefits.

While not directly measured, qualitative insights and supporting literature indicate improved thermal comfort, affordability, and energy stability for residents. These co-benefits enhance tenant wellbeing and support the case for integrating green design into mainstream housing policy, especially in low- to middle-income markets.

6.3 Contributions of the Study

6.3.1 Theoretical Contributions

This study extends the literature on post-occupancy building performance, particularly within the under-researched context of Sub-Saharan Africa. Whereas much of the existing research centres on projected or modelled savings, this study provides empirical evidence that actual electricity and water savings in EDGE-certified residential developments can exceed expectations. In doing so, it reinforces the importance of post-occupancy verification as a critical element in green building assessment.

The study also contributes to the discourse on the “performance gap,” supporting prior findings by Bordass and Leaman (2005) and Stevenson and Leaman (2010), while offering new evidence from residential buildings in emerging markets. Variability in operational outcomes across developments is shown to be influenced by behavioural, technical, and contextual factors, further validating the multidimensional nature of performance drift.

In addition, the research introduces a behavioural economics perspective to the field. By applying the Permanent Income Hypothesis (Friedman, 2018) and Life-Cycle Hypothesis (Modigliani & Brumberg, 1954), it offers an original interpretation of how monthly utility savings may contribute to household financial stability, rather than directly fuelling increased consumption. This expands the notion of “value” in green housing to include economic resilience for end-users.

6.3.2 Methodological Contributions

The study demonstrates the value of smart meter data for assessing real-world performance at scale. By analysing monthly electricity and water consumption across 18 developments, it presents a replicable approach to measuring the impact of green building features in the residential sector.

The use of a mixed-methods design — combining operational data with informal expert insights from energy engineers, project managers, and financial modelling professionals — reflects a pragmatic approach to applied research. This balance of quantitative rigor and practical context allows for deeper interpretation of performance trends, offering a methodology that can be adopted by both researchers and practitioners in future post-occupancy evaluations.

6.3.3 Practical and Policy Contributions

The findings offer practical insights for property developers, investors, and housing policymakers. The study demonstrates that modest green premiums (1%–5% of development cost) can generate meaningful financial returns through short payback periods, enhanced NOI, and long-term asset value. EDGE certification is shown to deliver operational benefits while supporting reputational advantages, ESG alignment, and potentially improved access to sustainability-linked finance.

For policymakers, the study presents a strong case for revisiting current building codes. Because EDGE benchmarks performance against national standards, relatively low baselines may limit the full impact of green certification. Stricter regulatory standards could raise the bar for minimum efficiency, leading to broader resource savings and improved outcomes for residents. These findings contribute to national and regional policy discussions on scaling green housing without compromising affordability.

Table 2 consolidates the alignment between the study's original research questions, key conclusions, and contributions to knowledge, highlighting how each component of the investigation addressed the core objectives.

TABLE 2: Consistency table – research questions, conclusions, and contribution to knowledge

RQ #	State research question or objective	State literature-based proposition or hypothesis	State conclusion or answer based on own research	Highlight key differences between your initial propositions / hypotheses and your findings – this is your contribution to knowledge
RQ1	Do EDGE-certified residential developments deliver measurable post-occupancy energy and water savings, and how do these compare with projected performance levels?	EDGE certification is expected to achieve at least 20% reductions in electricity and water use compared to national baseline standards (IFC, 2021). However, most studies report projected rather than measured outcomes, especially in Sub-Saharan Africa.	Smart meter data showed average savings of 42% in electricity and 54% in water consumption, exceeding EDGE minimum thresholds. This demonstrates that real-world performance can surpass expectations under appropriate implementation conditions.	While literature generally assumes minimum 20% savings, this study empirically confirms that EDGE-certified developments in South Africa can exceed these benchmarks. It provides one of the first post-occupancy validations using operational data in the region.
RQ2	What is the degree of variability in energy and water	Studies highlight performance gaps between design and	Significant variation in savings across developments was observed, linked to	The study not only confirms the performance gap but adds detailed insight into its behavioral and operational drivers

RQ #	State research question or objective	State literature-based proposition or hypothesis	State conclusion or answer based on own research	Highlight key differences between your initial propositions / hypotheses and your findings – this is your contribution to knowledge
	performance across developments, and what behavioural or operational factors contribute to this?	actual outcomes, attributed to behaviour, system faults, and operational challenges (Stevenson & Leaman, 2010; Way & Bordass, 2005).	tenant behaviour, faulty systems, unmetered common areas, and load-shedding. These insights emerged through integrated analysis of consumption data and practitioner feedback.	in multi-unit green housing. It also suggests, based on literature and informal feedback, that energy efficiency may influence tenant comfort and affordability, warranting further research.
3	What are the financial and strategic value implications of EDGE certification for developers and residents, including cost of green, payback periods, and reputational or ESG benefits?	Green certification can reduce long-term costs and improve value perception, despite moderate upfront costs (World Bank Group, 2019; Dwaikat & Ali, 2018). These benefits are rarely quantified in the South African residential context.	Green premiums ranged from 1–5%. Monthly savings increased from R138 to R570 per unit, with 2–4 year payback. Additional benefits included improved branding, marketability, and access to ESG-aligned finance. Literature and informal insights suggest added tenant value in comfort and utility predictability.	The study confirms value creation for developers and residents and introduces a behavioural-economic lens (PIH and LCH) to explain how savings support financial resilience. It also extends value theory by highlighting likely tenant-level co-benefits and strategic brand advantages in a regional context.

6.4 Recommendations

6.4.1 For Developers and Design Professionals

Developers and architects should integrate green measures early in the design phase. This study confirms that modest increases in upfront capital expenditure (1%–5%) deliver short payback periods and significant long-term savings. Features such as solar PV, insulation, shading, and low-flow water fittings consistently improved outcomes.

Design teams are encouraged to adopt simulation tools and energy-conscious design training to optimise performance. Tenant onboarding is equally critical — basic orientation, signage, or mobile feedback systems can reduce performance drift and promote efficient use of installed technologies.

6.4.2 For Policymakers and Regulators

Current building codes may be insufficient to drive optimal environmental outcomes. EDGE certification benchmarks performance against these standards, and lenient baselines limit the overall impact. More stringent regulations could elevate sector-wide performance.

Policymakers should also introduce incentives (e.g., tax benefits, expedited permitting) to encourage uptake of green certification and establish mechanisms to prevent greenwashing. Strong third-party verification and clearer enforcement frameworks would support credibility and compliance.

6.4.3 For Financiers and Investors

Financial institutions should integrate green metrics into their credit assessments. EDGE-certified buildings offer higher net operating income, reduced utility risks, and reputational advantages — aligning well with ESG-linked finance criteria. These merits could justify preferential terms such as sustainability-linked loans or lower credit spreads. Green housing should be recognised as a viable asset class for resilient, long-term investment.

6.4.4 For Researchers and Industry Bodies

Further post-occupancy research is needed to fully understand drivers of performance variability. Standardised frameworks and data sharing could improve benchmarking, policy development, and knowledge transfer. Cross-sector collaboration between academia, developers, utilities, and residents will help bridge the gap between design intent and lived experience.

6.5 Suggestions for Further Research

6.5.1 Post-Occupancy Performance and Behaviour

Although this study found strong average savings, variation across developments suggests the need for deeper investigation into operational performance. Future research could explore the role of tenant education, maintenance practices, and contextual disruptions — such as load-shedding — in shaping outcomes.

6.5.2 Tenant Experience and Living Conditions

Broader social benefits — like improved thermal comfort and affordability — were supported by qualitative insights and literature but not formally measured. Research tracking tenant satisfaction, behaviour change, and financial resilience over time would add important depth. Future studies might also examine links between green housing and health, retention, or financial inclusion.

6.5.3 Building Materials and Emerging Technologies

As technologies evolve, it is important to understand how new materials and systems (e.g., insulation, solar integration, rainwater harvesting) affect cost and performance. Research can identify optimal paths to exceed EDGE requirements and support climate-resilient housing design.

6.5.4 Regulatory Evolution and Standards

There is a need to evaluate and update certification frameworks to remain effective. Future studies might propose stricter minimum codes, examine incentive structures, or assess how regulatory shifts influence developer and market behaviour. Effective policy must keep pace with technological change to maximise sector-wide impact.

6.6 Conclusion

This study assessed the post-occupancy performance of EDGE-certified residential developments in South Africa, using smart meter data to evaluate actual electricity and water consumption. In the context of growing concerns around energy security, housing affordability, and climate resilience, the findings provide robust evidence that green certification, when thoughtfully applied, delivers measurable value for both end-users and developers.

Across 18 developments, electricity and water savings averaged 42% and 54% respectively—well above EDGE's 20% baseline. These savings translated into real monthly cost reductions for residents, enhanced financial returns for developers, and stronger investment cases for financiers. Green buildings thus emerge not only as environmentally sound, but as financially and strategically advantageous assets in a transitioning economy.

The study also highlighted key complexities. Variability in performance—due to tenant behaviour, technical issues, and contextual factors—underscores the importance of integrated design, effective management, and occupant engagement. By framing these savings through the lens of behavioural economics, the study links operational efficiency to household financial resilience, particularly for low-to-middle income groups.

Crucially, the research points to a regulatory gap. EDGE performance is benchmarked against national standards, which remain too lenient to drive optimal outcomes. More ambitious building codes, paired with enforcement and targeted incentives, could elevate sector-wide impact and accelerate the green transition.

The relationship between the research questions, core findings, and knowledge contributions is summarised in Table 2, offering a clear overview of the study's impact across theoretical, methodological, and practical domains.

In sum, this study offers a practical, data-driven roadmap for positioning green housing as a mainstream solution. It urges developers, policymakers, investors, and researchers to treat sustainability not as a luxury, but as the foundation for housing that is affordable, resilient, and future-ready. The challenges are real—but the evidence is clear: smart, efficient, and inclusive design is no longer optional. It is essential.

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