PERSPECTIVES ON THE EFFECTIVENESS OF GREEN BUILDINGS IN CLIMATE CHANGE MITIGATION: A STUDY OF THE CITY OF JOHANNESBURG.

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A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science

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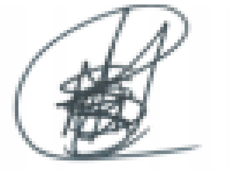
Signed on…4 March 2021………………in Johannesburg, South Africa.

DECLARATION

I, Malesotse Makgalemele declare that this Dissertation entitled "Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg." is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



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ABSTRACT

It has been proved that anthropogenic activities globally have resulted in accelerated climate change and global warming, beginning with the industrial revolution, through the release of greenhouse gases of which Carbon Dioxide is the most prevalent. Estimations indicate that up to 40% of greenhouse gases are emitted from the construction and building sector hence the urgency for climate change mitigation. The aim of this study was to determine the effectiveness of retrofitted certified green buildings of office use in the City of Johannesburg in terms of climate change mitigation during their operational lifecycle. The study utilized semi-structured interviews which were conducted with various stakeholders as well as existing literature. Their purpose was to gather the information needed to examine the various perspectives on green buildings in terms of climate change mitigation. Parallel to the human perceptions, energy consumption data was also collected from the property companies and meteorological data was collected from the South African Weather Services. These two data sets as well as calculated Carbon emission data were analysed against each other to examine whether climate, particularly temperature, impacted how buildings consume energy and emit Carbon emissions.

The empirical evidence suggests that despite factors contributing to increased energy consumption and Carbon emissions in buildings existing, retrofitting and certifying existing office buildings in the City of Johannesburg generally mitigates this. The process of certification, like the majority of the legislation and institutional frameworks in existence countrywide governing green buildings, is voluntary and act more as a guide. Challenges in governance and implementation of legislation present an obstacle to realising the full potential of green buildings. Generally, the building sector in the country has been positively impacted by the green building phenomena with incentives from various economic sectors playing a significant role and other potential ones identified.

Key words: Climate change mitigation, energy consumption, Carbon emissions, green buildings, certification, legislation, incentives.

DEDICATION

To my family, my father Tebogo Makgalemele, my mother Mpho Makgalemele, my sisters Ntebaleng, Makotsene, Barati, Tebogo, my brother Tebogo Jr and my niece Onkgopoleng. Your constant love, support and prayers have seen me through the most difficult and challenging periods of my life and helped guide me to the highest echelons of my life as well. Thank you for being the best support system in the world. Everyday I praise and thank God that I have you all in my life. I love all of you dearly.

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CHAPTER ONE

FRAMES OF REFERENCE

1.1 Introduction

It is now a scientifically proven fact that changes in climatic conditions have been exacerbated by increased anthropogenic activities which have significantly contributed to global warming (Johnston and Gibson 2008). Evidence shows that Carbon Dioxide is the most prevalent greenhouse gas (GHG) contributor and its emissions have soared from 280 ppm prior to 1800 to 396 ppm since 2013 (Australian Academy of Science 2018).

Recent reports of the IPCC indicate that rising global temperatures this century are expected to have far reaching consequences on the climate resulting in impacts such as increased droughts and flooding (Yurivilca and Minoja 2019). This is expected to have negative impacts on buildings (Yurivilca and Minoja 2019). To cope with these, it is imperative that GHG emissions from the construction sector, specifically buildings, be mitigated whilst also increasing the sectors adaptative capacity and resilience to future climate change (Yurivilca and Minoja 2019). One of the most effective manners in which to achieve this is developing strategies, policies etc. which include the promotion of energy efficiency, the use of renewable energy and proper utilization of waste (Yurivilca and Minoja 2019). This is to promote sustainable development which defined in 1987 by the Bruntland Commission as ‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Cotgrave and Riley 2013:3). Compared to all the other continents on the planet, Africa faces the highest risk to climate change because of stressors such as its population’s high reliance on non-irrigated agriculture, weak adaptive capacity and extreme poverty despite being the continent with the lowest GHG emissions (African Union 2014).

As the fastest growing continent on the planet the construction industry in Africa has been positively impacted with top global construction companies channelling their focus on the African construction industry (CRO 2020). Caterpillar Inc, a top American company dealing with construction, is one example whereby in 2016 the company posted strong quarterly earning reports from construction projects on the continent (CRO 2020). In contrast, South Africa which is one of the most advanced economies on the continent, has seen a steady down turn in its construction sector post the 2010 soccer world cup which previously was booming due to infrastructure projects in preparation for the 2010 soccer world cup (Bulbulia 2018). However, challenges still confront the construction industry on the continent including South Africa such as lack of skills development and skills migration particularly in the case of South Africa due to divestments (Bulbulia 2018). In addition to this, the continent in general and especially South Africa are struggling with corruption as construction companies will at times bribe top government officials for tenders and in South Africa the past administration was also characterised by state capture (Bulbulia 2018) (CRO 2020). This resulted in political uncertainty in the country which caused the loss of investor confidence (Bulbulia 2018). Policy uncertainty as well as lack of proper policy implementation, for example the National Development Plan 2030 (NDP 2030) in South Africa has also impeded the development of the construction industry (Bulbulia 2018) (CRO 2020).

The emergence of the global green building movement in the early 1990's came about as one of the solutions that the construction industry can apply to reduce its impact on the climate (Kibert 2008). Although the first tool for rating green buildings named the Building Research Establishment Environmental Assessment Method (BREEAM) was developed in the United Kingdom (UK), the global green building movement commenced with the establishment of the first green building council in the United States of America in 1993 which sought to promote sustainability practices in buildings and the construction industry as a whole (Zhang et al 2019)(WGBC 2021). A green building is defined as a structure created using environmentally resourceful and conscientious procedures throughout the duration of its life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction (Kukreja 2016). These include implementing methods of building which substantially reduce harm to the environment such as selecting sustainable and environmentally friendly building materials and construction methods with lower embodied energy (in the case of materials embodied energy is energy used for their extraction, processing, manufacture and transportation whilst in the case of buildings it is the direct energy used to construct the building and indirectly, the energy from the manufacture and transportation of the building material), insulating the building envelope to conserve energy, insuring that throughout the lifecycle of the building energy efficiency specifications have been implemented such as energy efficiency technologies (eg. LED lights) and incorporating passive energy design such as natural ventilation in the form of landscaping with natural vegetation or use of water bodies for evaporation and cooling (Akadiri et al 2012). The green building industry is now a rapidly growing global phenomenon and the inputs that buildings make to pollution is being addressed at local and national levels in countries globally (Gottfried and Malik 2009). Challenges which inhibit the green building industry include poor promotion of the development of green infrastructure, lack of access to financial resources to construct green buildings and lack of service and public transport structures needed to aid the establishment of a sustainable built environment, especially in developing nations [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2009]. Green infrastructure in the urban environment in South African cities is defined as 'the interconnected set of natural and man-made ecological systems, green spaces and other landscape features' (Pasquini and Enqvist 2019:5) It is inclusive of trees which are both planted and indigenous, wetlands, parks, green open spaces and original grassland and woodlands, together with building and street-level design interventions (if present) that incorporate vegetation (Pasquini and Enqvist 2019). In the developed world, the implementation of green buildings is generally at an advanced stage as the GBC's in those countries such as the US, UK and Japan are at a mature stage of implementation having developed and improved green building laws and regulation systems which are integrated i.e the US has developed mandate and incentive based policies which considerably enhances green building implementation (Zhang et al 2019). In contrast, in the developing world such as sub-Saharan Africa where green building is still largely emerging, challenges include sourcing materials locally, lack of financial and technical capacity to implement green buildings, higher initial cost of construction, lack of proper awareness and knowledge, unsustainable building practices being locked in the construction industry and lack of political will (Koko and Bello 2020). The dearth of knowledge and training on the subject of sustainable construction and green buildings makes the implementation of green buildings and their effectiveness in places like the region of Sub-Saharan Africa, which is mainly comprised of developing nations, very difficult (GBCSA 2007)

Owing to its reliance on fossil-fuels to power its energy intensive economy South Africa (SA) is considered a noteworthy emitter of GHG in Africa (DEA 2012). South Africa is the 14th highest emitter of GHGs worldwide due to its heavy reliance on coal to fuel its economy (McSweeney and Timperley 2018). The draft electricity plan which has been put forward for consideration recommends a significant shift away from fossil fuels towards gas and renewable energy with coal gradually being phased out after 2030 with no new coal plants being developed and four fifths of capacity being closed (McSweeney and Timperley 2018). Although the electricity provided by coal results in GHG emissions, it will still play a substantial role as it will remain in the energy mix therefore impacting the supply chain when considering green buildings as a stable electricity supply is needed for production of goods, including renewable technologies and components used in green buildings such as LED lights, solar panels and bricks etc. (McSweeney and Timperley 2018). South Africa is an exception on the continent as it possesses strong legislative and institutional frameworks as well as policies, plans and strategies such as the internationally acclaimed Constitution of the Republic of South Africa and all laws emanating from it. These laws include the Building Standards Act No. 103 of 1977 and the National Building Regulations, SA National Building Standards (SANS) and the National Environmental Management Act No. 107 of 1998 (NEMA) which aims to promote sustainable development and enhance and preserve the environment (The Constitution 1996). The country also has a range of policies and frameworks which, although not compulsory for implementation as yet, act as a guide in the development and implementation of green buildings. These include the National Department of Public Works Green Building Framework (2011), National Green Building Policy (2018) (DPW), South African Local Government Association Green Building Booklet (2017) and municipal focused plans such as the Design Guidelines for Energy Efficient Buildings in Johannesburg. South Africa is also one of Africa's most industrious countries with a large economy which is second only to Nigeria (McSweeney and Timperley 2018). Despite the country participating in the global movement against adverse climate change through being a signatory to and ratifying major climate change agreements like the Paris Agreement, efforts have been undermined by poor governance and lack of political will especially during the administration of former president Jacob Zuma which lasted for 9 years (McSweeney and Timperley 2018). Although former president Jacob Zuma's administration advocated climate change vocally it was undermined due to corruption and accusations of delaying development of policies to reduce emissions (McSweeney and Timperley 2018). This resulted in skepticism of South Africa's climate efforts however the current cabinet under President Ramaphosa has announced plans for a significant shift from coal to renewable energy (McSweeney and Timperley 2018). South Africa is also home to institutions such as the non-profit company the Green Building Council of South Africa (GBCSA) formed in 2007 to initiate environmentally sustainable building solutions which are market-oriented to transform the country's property industry (GBCSA 2017). Through institutions such as the GBCSA, South Africa and particularly the City of Johannesburg which is the economic epicentre of the country, has pioneered the evolution of the green building industry on the continent.

1.2 Problem Statement

The Constitution of the Republic of South Africa assures a sound and healthy environment which is beneficial for human health under Section 24 (The Constitution 1996). In line with this, the National Development Plan 2030 (2011) emphasises building sustainably as a step for the country towards responding effectively in terms of climate change mitigation. Gauteng province is arguably the economic centre of the country with it having the impressive distinction of containing the wealthiest square mile on the continent located in Sandton (GDARD 2011 and SA-venues 2018). The City of Johannesburg is also considered the financial capital of the country as the Johannesburg Stock Exchange and hundreds of commercial businesses and headquarters of multinational corporations are located there (SA-venues 2018). Adverse climate change poses a major risk to the city and therefore threatens the economy of the country seriously. Scientifically modelled projected climate change scenarios for the City of Johannesburg suggest that temperatures may rise by around 2.3 °C in the imminent future (2056 – 2065) and around 4.4 °C in the distant future (2081 – 2100) (CoJ Climate Change Adaptation Plan 2009).Temperature statistics and data would be the most reflective of the status and potential impacts of climate change as temperature increases have been driven by increases in Carbon emissions and this data is important to determine which interventions to implement, per sector, to enhance energy efficiency. Overall, the average temperature in South Africa is increasing more rapidly than the global average temperature with projections estimating that by the end of the century if the status quo continues the national temperature would have increased by 6°C (Pasquini and Enqvist 2019). Cities such as the City of Johannesburg are likely to become climate change disaster areas due in part to the increase in the Urban Heat Island effect which will result in temperature extremes between the cities and their surrounding rural areas resulting in extreme weather events such as flooding, erosion and drought (Pasquini and Enqvist 2019). For informal settlements adverse climate change impacts will be worsened by the fact that there is limited green infrastructure i.e lack of green vegetation, unsustainable building types built with unsustainable materials such as zinc and high levels of density (Pasquini and Enqvist 2019). The informal settlements along the Jukskei River are an example. In townships, e.g Soweto, there is limited green infrastructure such as trees and other vegetation (Pasquini and Enqvist 2019). In the formal areas densification is expected to result in positive impacts such as promotion of energy efficiency and reducing Carbon emissions however continuing densification often results in encroachment of existing urban green infrastructure undermining ecological processes and threatening urban green infrastructure i.e the City of Johannesburg Central Business District has very little green infrastructure (Pasquini and Enqvist 2019). Further exacerbating the situation is phenomena such as rural to urban migration from the outskirts of the province to the inner city which is ongoing and rapidly increasing, which has exposed people to the high risks of living in informal settlements and overcrowded conditions characterised by inadequate infrastructure (Serdeczny et al 2016).

It is necessary for mitigating interventions to be put in place urgently to halt and reverse the situation. Urban planning and property are key sectors of the city which are at risk of climate change and its effects (CoJ Climate Change Adaptation Plan 2009). However, the argument is that despite the well-intentioned approach of the City to green their buildings, their strategies primarily focus on energy efficiency and zero carbon emissions in publicly owned buildings and will be voluntary and not mandatory for implementation. The other aspects and benefits of green buildings are reduced consumption of energy and water (30%-60%), lower maintenance and operational costs, improved indoor air quality resulting in improved health and productivity for occupants, reduction in waste production and more efficient waste management as well as financial benefits such as increased marketability (Oguntona et al 2019).

Therefore, the growth in green buildings in the country has largely been spearheaded by the private sector. According to the GBCSA (2018) so far 461 projects in the country have been certified as green using building certification tools such as the Green Star South Africa rating tools. The tools was developed by the GBCSA to provide a common standard of quantification for green buildings in South Africa and consists of the following eight environmental categories; indoor environmental quality, energy, transport, water, ecology, emissions, materials and management (Botes 2012). A large proportion of certified green buildings are of commercial use and are existing buildings which were retrofitted to be green (GBCSA 2018). Due to the city's importance as the financial hub of the country, its dedication to climate change mitigation, the necessity of adequate infrastructure for country's economy and the location of many of the retrofitted certified green buildings of business and commercial use there, it is the view point of the researcher that it is thus highly important to investigate whether these buildings are more energy efficient and also more efficient in reducing their Carbon footprint over time, as they have been classified as an option that the construction industry can utilise to mitigate climate change.

In view of the above observations, **this study sought to investigate the performance of certified green buildings of office and commercial use in the City of Johannesburg in terms of energy efficiency and emissions reduction by monitoring their ability to maintain or improve their energy consumption from the time that they received certification. Specifically, buildings certified between 2008 and 2017 were investigated in the study. They were also assessed against their performance as nominal buildings before certification. The energy efficiency benchmark which was used is that described in SANS 10400-XA which states that the annual consumption of an office in Gauteng shall not exceed 200 kWh/(m²·a). The investigation focused on the operational phase[1] of the buildings' lifecycle**. This study is anchored on two policy assumptions. Firstly, to have a comprehensive understanding of whether greening a building does contribute to increasing its energy efficiency and in so doing reduce its carbon emissions and environmental footprint. Secondly, to determine

[1] The duration of time that an authorised building development is in operation following the completion of construction and commissioning beginning on a date which has been specified in the operational phase notice (Law Insider 2020).

the efficacy of the building performance rating tools on green buildings currently implemented in South Africa.

1.3 Research Questions

In view of the above observations, the following questions guided the research process:

i. What are the main factors which increase energy consumption and emissions in buildings?
ii. To what extent does the existing legislation and institutional frameworks in South Africa promote the development and implementation of green buildings?
iii. Has the application of building rating performance tools and achieving certification continued to influence the performance of green buildings causing them to be more energy efficient and to maintain or decrease their energy consumption and Carbon emissions.
iv. What influence has the green building phenomenon had on the building industry in South Africa?

1.4 Research Aims and Objectives

The aim of this study was to investigate the effectiveness of certified green buildings in energy efficiency and reduction of Carbon emissions vis-a-vis climate change mitigation.

In light of the above aim the objectives are:

i. To measure the energy efficiency and emissions of green buildings
ii. To assess whether there are gaps in the existing legislation and institutional frameworks which affect the implementation of green buildings
iii. To discover challenges in building performance rating tools in South Africa and how they are applied which affect how green buildings monitor and maintain their energy efficiency
iv. To explore how energy efficiency in infrastructure and the construction of green buildings in the construction industry in South Africa can be incentivised

1.5 Theoretical Considerations and Literature review

A global milestone in understanding climate change and climate variability was achieved when the World Meteorological Organisation and the United Nations Environment Programme established the Inter-governmental Panel on Climate Change (IPCC) (Tobias et al 2009). Since 1990, the IPCC has released four assessment reports whereby scientific data has been analysed and assessed to ascertain the risk and likely impact of anthropogenic climate change (Tobias et al 2009). Furthermore, in support of that argument, other results of assessments have found that global warming has emanated from increased greenhouse gas emissions in the atmosphere emanating from increased anthropogenic activities (Sagheb et al 2011). Thus, the argument for climate change mitigation was brought forward as an effective mechanism to halt and reverse adverse climate change.

The critical urgency of the global climatic conditions hence, led to the establishment of a number of global legislative frameworks and agreements which aimed to mitigate global temperature increases to a set amount. The first breakthrough of these was the Kyoto Protocol Treaty, a legally binding treaty, which was signed and adopted in 1997 by 55 countries in Kyoto Japan who committed to reducing Green House Gas (GHG) emissions (UNFCCC 2011). Once the Kyoto Protocol expired, in response to this a new agreement was ratified known as the Paris Agreement in 2015 which required countries to commit legislatively at a domestic level nationally determined contributions (NDCs) in keeping with the Agreement and to implement and increase their ambitions over time to inhibit the rise in global mean temperature so that it remains well below the agreed maximum target of 2°C (Rogelj et al 2016).

According to Steenkamp and Naude (2018) South Africa's commitment to decreasing GHG's, as the country which emits the most GHG's in Africa who ratified the agreement, was the establishment of climate change legislative frameworks which included the National Climate Change Response Strategy for South Africa to Address Climate Change (NCCRS) (DEA 2004), the National Climate Change Response White Paper (NCCRP) (DEA 2011) and Chapter 5 'Environmental Sustainability and Resilience' of the National Development Plan (NDP) (National Planning Commission 2011). In addition to this regarding infrastructure and the built environment, the country has been at the forefront of adapting legislation to the current climatic context by incorporating two new energy standards (Mustapha 2016). The new energy standards are SANS204 which is Green Building in South Africa and SANS 10400-XA which regulates energy consumption in buildings (Mustapha 2016).

Conceptually green buildings first emerged in the early 1990's to transform the construction industry, which was identified in recent years as one of the industries which are big GHG emitters, and evolve it to become increasingly sustainable and to reduce its negative effects on the environment, with particular emphasis on reducing emissions of greenhouse gases (Kibert 2004). Since then, the industry around the construction of green buildings has experienced rapid growth and the movement has also spread globally as more and more countries face the realities of climate change and discover possible socio-economic benefits attached to going green (Greene et al 2006). However, green buildings and the concept of sustainable construction is not without its critics and there has been much debate around the effectiveness of green buildings in energy and resource efficiency and exactly how they are instrumental in climate change mitigation and adaptation.

Proponents for green buildings argue that given the current global situation with regards to adverse climate change, green construction ought to be implemented as a fundamental change in how humans live and build, to decrease their detrimental impacts on the environment (Johnston and Gibson 2008). Furthermore, Shamout (2016) argues that the development of green buildings is of absolute necessity and is one of the most effective strategies to tackle the energy problem specifically. The South African Local Government Association (SALGA) summit report found that these buildings can substantially reduce energy utilisation and production of GHG's which is favourable for climate change mitigation especially since 30% of the greenhouse gases emitted in the atmosphere are attributed to buildings (Green Economy Summit Report 2010). Opponents to green buildings however disagree. The main arguments against green buildings include the conflict that they cause in the industry as the aim of their development is to balance socio-economic and environmental issues to accomplish sustainable development (Baloi 2003). This is especially difficult in developing nations which are constrained in terms of financial, legislative and infrastructural support.

In South Africa, however, existing literature suggests that the growth and evolution of the green building industry has thus mostly centred around the private sector in important metropolitan areas such as the City of Johannesburg. As the focal point of this study and as one of the most important and crucial municipalities in the country due in great part to its socio-economic importance as the financial hub of the country and the location of many of the country's businesses and companies, the City of Johannesburg has identified Climate change and climate variability as negatively affecting its growth and development in multiple ways (CoJ Climate Change Adaptation Framework 2017). These include manifesting itself in the form of droughts and floods, for example, which impact important infrastructure such as buildings hence the need for certified green buildings (CoJ Climate Change Adaptation Framework 2017). Certification is handled by the GBCSA which lobbies for all structures to be designed, built and operated sustainably and awards this through certification (GBCSA 2017).

1.6 Research methodology

This section gives a brief description of the research methodology used for this study. The key data collection tools which were used in this study were interview guides, a data collection template and the GBCSA's website. Data was collected from certified green buildings located in the City of Johannesburg. For this study the researcher sampled individual certified green buildings which are of office and commercial use which were as similar as possible in terms of size. This approach was chosen to limit the margins of error which could occur as much as possible. Furthermore, the

Existing Building Performance V1 Tool (EBP V1 Tool) of the GBCSA was analysed as part of this study to determine its effectiveness in assisting green buildings to enhance their energy efficiency and reduce their Carbon footprint. This tool was the one identified as being relevant for the study as the buildings being researched are existing buildings. Existing literature was also analysed using rapid appraisal. Stakeholders interviewed for the study were the City of Johannesburg and its entity City Power, academic experts, the banking institution, the Gauteng Department of Agriculture and Rural Development (GDARD), the Gauteng Department of Infrastructure Development (GDID), the Council for Scientific and Industrial Research (CSIR), the GBCSA, private sector companies such as the company which specialises in measuring Carbon for buildings, an environmental green building consultant and three Property companies; Property Company 1, Property Company 2 and Property Company 3. Based on the data collection and different data collection tools it was decided that a mixed method approach would be best for this study.

This study used both qualitative and quantitative research methods. The qualitative research method was selected for this study as it allowed the researcher an opportunity to receive a multitude of responses which allowed the researcher to answer the research questions from multiple angles as well as to obtain numerous information for this study. The quantitative research method was used for analysation, comparison and support of the qualitative data. The detailed research methodology utilized in this study is comprehensively discussed under Chapter three of this dissertation.

1.7 Scope of the study

This study covered the effectiveness of certified green buildings as tools in climate change mitigation. In order to determine this, the researcher selected certified retrofitted green buildings of office use for this investigation. It was decided that only buildings which achieved certification between 2008 and 2017 will be assessed due to the assumption that post certification data exists for those buildings certified in that time range. Furthermore, the investigation only analysed the operational phase of the buildings' lifecycle. Due to time constraints and ease of access for the researcher the study was limited to South Africa, with the area of focus being the City of Johannesburg. As the study is looking at green buildings as tools for climate change mitigation, it was decided that the study would focus on the energy consumption and Carbon emissions of the buildings. This was to determine whether certifying and retrofitting the buildings had any impact in terms of enhancing their energy efficiency and therefore reducing their Carbon footprint. Any modifications done to make the building more energy efficient is accounted for in the energy consumption data which is provided.

1.8 Ethical Consideration

Ethical considerations are defined as one of the most critical parts of the research (Dudovskiy 2018). The main ethical issues which may have arisen from this study was the disclosure of the names of the Property Companies' who provided energy consumption data as well as the leakage of the full EBP V1 Tool technical manual of the GBCSA. This information is private and confidential and could have been unintentionally exposed to untrusted sources. This would have resulted in data breach which would have jeopardised the study. Therefore, for this study full consent was obtained from the property companies who own and manage the buildings prior to the investigation as well as the GBCSA. Adequate levels of confidentiality of the research data was ensured with Non-Disclosure Agreements being signed with the property companies who provided data and a letter of permission being received from the GBCSA. This also applied to the government departments, CSIR and the private sector stakeholders. Following the fulfilment of all the requirements of the Human Research ethics committee, ethical clearance was obtained for the study. The ethical clearance certificate is attached as Appendix A under Appendices. Other ethical considerations for this study included but were not limited to prioritising the dignity of research participants, honest and transparent communication in relation to the research and protection of the privacy of the participants (Dudovskiy 2018).

The following ethical considerations were observed to conduct the study:

(i) Ethical clearance was granted by the University of the Witwatersrand.

(ii) Informed consent was obtained from the participants.

(iii) The right to confidentiality, anonymity and withdrawal from the study was observed.

(iv) The respondents were also given an opportunity to ask questions and request clarification whenever they needed to.

1.9 Structure of the Dissertation

This section illustrates how the chapters were systematically sequenced and constructed to reflect the organization of the dissertation as well as how the study was organized and conducted. The dissertation consists of six chapters. **Chapter one** is comprised of the Frames of References, which includes the problem statement, research questions, research aims and objectives, literature review, research methodology, the scope of the study and ethical considerations. **Chapter two**, is comprised of a comprehensive literature review on climate change, climate change mitigation, climate change and associated legislation and agreements from the global to the local scale, literature on the construction industry, provincial and local government in South Africa, green buildings, certification tools and methods as well as energy consumption and Carbon emissions. The methodological considerations are discussed in **Chapter three** which are inclusive of the Research philosophy, Research Design, Study Population and Sampling Procedure, Data Collection Tools, Data analysis and the Methodological Considerations. The empirical evidence of the study is reported in **Chapter four**. A detailed analysis, discussion and the ultimate implications of the findings of this study in a broader context are presented in **Chapter five**. Finally, **Chapter six** consists of the conclusion, recommendations, and limitations of the study.

CHAPTER TWO

THEORETICAL CONSIDERATIONS AND LITERATURE REVIEW

2.1 Introduction

This Chapter is dedicated to discussing the existing body of knowledge of the impacts of certified green buildings as tools in climate change mitigation. The focus areas of this body of knowledge looks specifically at the certified green buildings with regards to their energy consumption and Carbon emissions. Of particular interest, is whether certification has enabled them to become more energy efficient and reduce their carbon footprint therefore being effective tools in terms of climate change mitigation. It is a globally accepted and scientifically proven fact that changes in the earth's climatic conditions have been aggravated by increased anthropogenic activities which have significantly contributed to global warming (Johnston and Gibson 2008). Research literature provides strong confirmation of climate (Fussel, 2009; Smith et al., 2009).

In light of the above, this Chapter is divided into three subsections. The first subsection is dedicated to defining the key concepts used in this chapter. This is crucial to provide a common comprehension of the words which are referred to in this chapter. Secondly, the literature is contextualized and various perspectives and synergies are discussed. The third subsection is dedicated to discussing the gaps in the existing literature. It is important to engage with some of the views of various academics in order to establish the existing gaps in knowledge.

2.2 Definition of Key Concepts

This subsection is dedicated to defining some key concepts which have been repeatedly used in this study which form the analytical framework for the research.

(i) **Anthropogenic activities**: Trenberth (2018) refers to anthropogenic activities as human activities which lead to the release of Carbon Dioxide as well as other heat-absorbing GHGs in quantities that are abundant enough to alter the composition of the atmosphere, giving rise to an accumulation of heat in the earth's atmosphere, often referred to as global warming. The IPPC in 1996 stated that anthropogenic activities are human activities which have already caused a noticeable change in global climate.

(ii) **Buildings performance rating tools**-The World Green Building Council (WGBC) defines buildings performance rating tools as elements used to evaluate and acknowledge buildings which meet specific standards (WGBC 2020). These tools are often voluntary, acknowledging and rewarding corporations and organisations who construct and operate environmentally sustainable buildings, motivating them and incentivising them to enhance their sustainability further (WGBC 2020). The usage of terms such as "method" and "tool" are often used interchangeably as well as the terms "certification", "rating" or "labelling" to show extended outputs from the process of assessment (Gobbi et al 2016). Rating tools vary in their approach and are applicable to all cycles in the lifecycle of a green building (WGBC 2020). They can also differ in the type of buildings which they are applied to for example residential buildings or industrial buildings (WGBC 2020).

For the purpose of this study, we refer to building performance rating tools as building certification tools as defined by the WGBC. Specifically, in this study the building certification tool which will be referred to is the EBP V1 Tool developed by the GBCSA as the study is focusing on existing buildings of office use in the City of Johannesburg.

(iii) **Building Retrofits**-Retrofitting refers to the process of altering something after it has been manufactured (City of Melbourne 2020). Retrofitting a building is the process of altering its systems or structure following inception of construction and occupation (City of Melbourne 2020). This has the potential to enhance amenities for the occupants of the building as well as enhance the performance of the building significantly in terms of reducing energy and water consumption (City of Melbourne 2020). Green Heart Enterprises (2019) adds that retrofitting is the process of adding new components to the original building or structure with the aim of improving the functionality of the building by adding new technology, building systems, or equipment.

For the purpose of this study, building retrofits will refer to those which alter systems or structure of buildings after their initial erection and use which results in the improvement of the building's performance in terms of reducing energy consumption and therefore improving on its Carbon emissions with the specific focus on retrofitted certified green buildings of office and commercial use.

(iv) **Climate Change Adaptation**-Climate Change Adaptation is defined by Shaftel et al (2019) as responding to climate change which is already occurring and expected future climate change. The aim of adaptation is two-fold: to lower the risk of hazardous impacts of climate change as well as to reap any potential benefits that may arise from climate change.

(v) **Climate Change Mitigation**-Shaftel et al (2019) defines climate change mitigation as the reduction of emissions of heat-trapping GHGs as well as their stabilization in the atmosphere either by decreasing their sources (such as the combustion of fossil fuels for electricity, heat or transport) or augmenting the "sinks" that amass and accumulate these gases (such as the oceans, forests and soil). The objective of mitigation is to circumvent serious anthropogenic interference with the climatic system, and to stabilize the levels of GHGs, particularly Carbon Dioxide. (from the 2014 report on Mitigation of Climate Change from the United Nations Intergovernmental Panel on Climate Change, page 4).

(vi) **Green Buildings**- a Green Building, also known as a sustainable building, is defined as a building that reduces or eliminates negative impacts on the climate and natural environment (WGBC 2019). The building also has the potential to create positive impacts on both their inhabitants, the climate and environment (WGBC 2019). Green buildings can be residential, office, commercial, retail etc. buildings. The following features which characterise green buildings are listed below as obtained from the WGBC (WGBC 2019).

1. The utilisation of energy and water in an efficient manner.
2. The utilisation of renewable energies.
3. The minimisation of pollution and waste and promoting re-use and recycling.
4. Environmental air quality of a high standard.
5. The use of materials that are not hazardous and are both ethical and sustainable.
6. The factoring in of the environment in the full lifecycle of the building from the design cycle to the operational cycle of the building.
7. The consideration of the quality of life of tenants in the lifecycle of the building from the design to the operational phase.
8. Is incorporated of a design which allows for adaptation to a transforming environment.

(vii) **Global Warming**-Nunez (2019) describes global warming as climate change that leads to an increase in the average temperature of the atmosphere and therefore earth. Additionally, global warming is described as having multiple different causes, but it is usually associated with anthropogenic interference, especially the release of extreme amounts of greenhouse gases (EPA 2006).

(viii) **Green House Gas (GHG)**- A GHG is defined as any gas that has the ability to absorb infrared radiation emitted from the surface of the earth and reradiate it back to the earth's surface thus contributing to the greenhouse effect (Mann 2020). Carbon dioxide, methane, and water vapour are the GHGs (Mann 2020).

(ix) **Institutional and Legislative Framework**-This refers to a country's parliament's institutional and legal framework which is inclusive of the Constitution of the country, other laws which must be adopted such as those which govern the electoral system, the role of parliament in the budget process, access to information etc.(agora-parl 2020). Furthermore, legal and institutional frameworks are also critical to found and determine the various duties and authorities of different stakeholders involved in designing, administering, delivering, and enforcing systems therefore, it is crucial for them to function effectively and to avoid overlaps, duplications, multiplications or gaps (Social Protection & Human Rights 2015).

For the purpose of this study the legislation and institutional frameworks referred to will be those which govern environment, climate change and buildings. These are inclusive of the SANS Building Standards which are SANS 10400-XA and SANS 204, the Constitution of South Africa, the Carbon Tax Act of 2019 and the National Energy Act 34 of 2008.

(x) **Incentives**-According to Macmillan Dictionary (2020) an incentive can be described as a motivation to work harder as there will be benefits for doing this. Incentives can be short-term and/or long-term which can be tied up with the performance of an entities' productivity and efficiency (Rupali 2020). Performance through incentives may be specified as cost saving, quantity produced, standards met or quality improved, revenue generated, return on investment or increased profit (Rupali 2020).

(xi) **Opponents**-Longman Dictionary (2020) defines an opponent as one who disagrees with a plan, idea or a system and wishes to try to halt or change it. Macmillan Dictionary (2020) furthermore supports this by stating that an opponent is someone who disagrees with an idea or plan etc. and tries to change or stop it. Collins Dictionary (2020) further goes to explain that in terms of ideas or policies, an opponent does not agree with them and does not want them to be carried out.

(xii) **Proponents**- Merriam-Webster (2020) defines a proponent as one who argues in favour of something. A proponent can also be defined as an advocate (Merriam-Webster 2020). Cambridge Dictionary (2020) further defines a proponent as an individual who openly states their support of a specific idea or programme. A proponent also advocates a theory, proposal, or course of action (Lexico 2020).

(xiii) **Sustainable Development** –The most cited definition of sustainable development is referred to as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations General Assembly 1987:43). This was adapted by the Bruntland Commissions in 1987.

2.3 Contextualizing the Literature on Climate Change Mitigation and the Emergence of Green Buildings: A Global Perspective

The World Meteorological Organisation and the United Nations Environment Programme formed the United Nation's Inter - governmental Panel on Climate Change (IPCC) with the aim of providing the world with the most relevant and extensive scientific, technological and socio-economic data regarding climate change (IPPC 2007). The assessment reports it has released suggest a high risk and potential impact of anthropogenic climate change (Tobias et al 2009). In response to the growing crisis of climate change, it was decided globally that concrete action had to be taken. The first serious discussions and analyses of climate change and sustainable development emerged during the 1980s whereby the World Conservation Union originated the term 'sustainable development' in 1981. It was the focus of the Bruntland Commission report titled Our Common Future published in 1987 (Halliday 2008). However, many argue that the phrase sustainable development itself is hard to convey (Halliday 2008). Sustainability in and of itself revolves around significant problems and the complex manner in which they interact such as the division of wealth and opportunity between the most affluent populations and the poorest ones, health, welfare, security, safety and basic needs of communities and individuals (Halliday 2008). Central to the arguments around sustainable development is how it is implemented in developing vs developed countries as this will contrast depending on the countries' needs. Since then, Yudelson (2018) argues that many countries around the world started to take action.

Heightened media and political attention exacerbated by new scientific evidence showing the scope of negative climate change started the negotiations for a multi-lateral climate change treaty(Van Calster et al 2015). At the United Nations Conference on the Environment and Development in Rio de Janeiro in 1992, the United Nations Framework on Climate Change Convention (UNFCCC) was adopted and served as a significant starting block for developing international climate change law (Van Calster et al 2015). According to Van Calster et al (2015) the convention's main objective was the stabilisation of GHG concentrations in the atmosphere to avoid dangerous anthropogenic interference within the climate system. To put it more technically, its goal was to avoid temperature increases more than 2°C above pre-industrial levels (Van Calster et al 2015). Furthermore, at the first Conference of the Parties (COP) in 1995, it was agreed that a protocol or a more binding legal instrument, should come into play leading to the establishment of the Kyoto Protocol (Van Calster et al 2015). The protocol aimed to put in place emission targets for industrialised countries and market-based flexibility mechanisms to help nations attain feasible emission reductions (Van Calster et al 2015).

Although there continues to be debate from advocates against climate change on the state of global warming such as whether it is slowing down or even occurring, generally most corporate, government and academic discussion now revolves around how best to counter it (Van Culster et al 2015). The response which has widely been chosen to counter adverse climate change is mitigation which aims to address the root causes of increased GHG emissions by decreasing their concentrations in the atmosphere (Van Culster et al 2015). Of all the GHGs, Carbon Dioxide is arguably the most significant contributor. Of the Carbon Dioxide emissions produced globally by human beings, Gunawansa and Kua (2009) are of the view that three quarters stem from the energy sector. In the early 2000's there was a global paradigm shift from economic growth being a good thing despite the environmental consequences, to accepting that buildings contributed to Carbon Dioxide emissions and therefore to global climate change, mostly through the consumption of energy. Although the Kyoto protocol was widely ratified by most countries including the major emitters such as the United States of America, Van Calster et al (2015) argues that it lacked significant clout due to its broad principles and commitments, and there was no real specific and time-binding emission limitations or reduction targets. Despite this, the protocol was entered into force with the Ratification of Russia in 2005 even though the United States of America withdrew (Van Calster et al 2015). Years of disagreement between parties coupled with the impending expiry of the Kyoto Protocol's targets in 2012 resulted in a new agreement ultimately being adopted on the 12 December 2015 which was titled The Paris Agreement (Van Calster et al 2015). Streck et al (2016) argue that although its similarity with the Kyoto Protocol is that it is a universal legally-binding framework which aims for the global warming goal of below 2°C on pre-industrial averages, it is different in the sense that it presents a more strengthened and internationally harmonised global response to the imminent threat of adverse climate change. However, Van Calster et al (2015) argue that it did not come without challenges which include to balance the bottom-up to top-down approach to international climate policy, its ability to be flexible and dynamic enough to accommodate changes in scientific knowledge, social, economic and political conditions as well as being stable enough that the ultimate objective is not lost. Van Culster et al (2015) are also of the observation that countries such as China, which overtook the USA as the biggest emitter of Carbon Dioxide in 2013, often defend their form of implementation-or lack of sustainable development-on their needs as countries undergoing the process of shifting to market economies and achieving economic development hence their ever- increasing emission levels. Therefore Halliday (2008) argues with expectations and increasing industrialisation predicted for the future, evidence suggests that life quality all over the world can be improved whilst also improving efficiency in how natural resources are used.

The construction industry is amongst the industries which have been recognised as the highest emitters of Carbon Dioxide, however it also bears the distinction of being one of the sectors whereby the quickest, most cost-effective and easily attainable cuts in Carbon dioxide emissions can be achieved (Green Economy Summit Report 2010) (Sagheb et al 2011). According to Booth et al (2012), they observe that in Organisation for Economic Co-operation Development (OECD) countries alone, buildings account for 25-40% of total energy use and 30% of all GHG emissions. This is further supported by Van Calster et al (2015) who are of the view that worldwide buildings consume large amounts of energy and contribute high volumes of Carbon Dioxide therefore reductions in emissions by the sector will have very positive overall environmental benefits. Van Calster et al (2015) argue that in the United States of America (USA) alone, consumption of all energy from the building stock mostly comprising of residential and commercial buildings, is 41% with 73% of electricity produced being used by these buildings. Thus, since there can be no economic growth without development, a more inclusive and sustainable approach to construction and buildings had to emerge which would take into account socio-economic and environmental factors. Furthermore, Kuzwayo (2017) argues that it is clearer that a sustainable and resilient built environment allows for human wellbeing through supporting and allowing positive socio-economic integration. This resulted in the emergence of green buildings (CSIR 2011).

Proponents for green buildings argue that with the current context that the world finds itself in, specifically in terms of climate change which is in large part due to the impact of the energy intensive construction industry, green construction should be implemented as a fundamental change in how humans live and build, to decrease their negative impact on the environment (Johnston and Gibson 2008). How this can be achieved, according to the proponents for green buildings, is through what Yudelson (2018) calls a "circular economy," whereby the need for unlimited growth is replaced by reducing the demands on the earth, using only renewable energy and recycling waste outputs. However, on the other side of the discourse, opponents of green buildings put forward the argument that green buildings cause conflict in the construction industry as the aim of development to balance socio-economic and integrated environmental issues for the achievement of the mandate of sustainable development is difficult (Baloi 2003). With specific regards to the energy problem, it is argued that green buildings are more favourable as they utilise resources such as energy efficiently resulting in savings thereby decreasing the adverse impacts of buildings on the environment (Shamout 2016). However, materials and building methods for green buildings have often been cited as a disadvantage for green building due to the labour intensive nature of using natural or sustainable materials, difficulty in maintaining the building and some of the engineering methods not being widely accepted (Precision Structural Engineering 2018). An example of this is constructing via the rammed earth method which comprises of ramming and compressing earth into a framework that has been built in order to create a wall; although it is easy to work with and the construction costs are low, the labour costs, soil selection and design make it an incredibly restrictive form of construction (Precision Structural Engineering 2018). Given the scientific data of high GHG emissions from buildings however, it is still important to integrate principles of green building into current construction practices and for future planning for developments so as to enhance sustainable development in developing nations and to prevent bad industry practices from being locked in.

A critical aspect in the green building industry is that of building assessment performance rating tools and their effect on green buildings. There are multiple ways to track the energy performance and emissions reductions of buildings once they go green. These are called appraisal tools and techniques (Halliday 2008). The appraisal tools and techniques as identified by Halliday (2008) are:

1. Policy which sets implementable targets, actions and timescales.
2. Regulation which are part of legislation.
3. Awards which aim to promote and incentivise best practice.
4. Checklists which highlight important and actionable issues.

5. Labels and certification which are useful for clients such as building owners and design teams wishing to go beyond regulatory standards and ensure development of better practice.

6. Benchmarking which establishes and measures performance related to agreed indicators which allows for projects, products and processes to be compared.

The diagram and table below illustrates the numerous building assessment performance rating tools which currently exist across the globe in various countries such as the United Kingdom European nations, both North and South America, South Africa and South East Asia.

<u>Figure 1: Diagram showing the various building performance rating tools in use currently around the world</u>

Exhibit 2 | Main Rating Tools

U.K. and Europe	Americas	Rest of the World
BREEAM (inc Eco-homes)	LEED (U.S. & Canada)	Green Star (Australia)
The Green Guide to Specification	U.S. DOE (U.S. Department of Energy) Design Guide (U.S.)	BEAM (Hong Kong)
Office Scorer	WBDG (Whole Building Design Guide) (U.S.)	LEED (China and India)
ENVEST	HOK Sustainable Design Guide (U.S.)	Greenmark (Singapore)
Sustainability Checklists (e.g. SEEDA; BRE)	BREEAM Canada (Canada)	GBTool (South Africa)
Environmental Impact Assessment (EIA)	Green Globes (U.S. & Canada)	
Strategic Environmental Assessment (SEA)		

Note: The sources are RICS (2007) and Green Globes (2009).

Source: Reed et al (2009).

Certification and labelling is important to green building owners as they provide objective evaluation of a building's impact on the environment (Halliday 2008).

In many developed cities in the world, such as London, it is anticipated that the stock of existing buildings will still be present in 2050 (Brittlebank 2015). The challenge faced by these cities, is that close to 80% of the greenhouse gas emissions in these cities emanates from these buildings as these buildings were built to prioritise vehicles over people, with poor insulation and materials now determined to be hazardous which did not take into account the health and wellbeing of their inhabitants (Brittlebank 2015). Thus Brittlebank (2015) argues to drastically decrease emissions of greenhouse gases retrofitting and renovation of these buildings has been identified as necessary to limit global warming within the 2 degrees Celsius limit. It is the observation of Abdulla and Alibaba (2017) that due to the considerable size of glazed façades which constitute part of the building envelope of office buildings as well as the nature of office activities, they utilise a greater amount of energy than other types of commercial buildings. This is due to the fact that the glazed envelopes of existing office buildings result in glare, increased heat in summer, reduced heat in winter, and increasing cooling and heating loads, specifically in hot and arid climates (Abdulla and Alibaba 2017).

Concerns surrounding sustainability and technological evolution can be allayed through the creation of energy-efficient buildings and retrofit strategies of various requirements of buildings which can be attained through technological advances such as the integration of shading devices with PV, promoting of natural light and reduction of glare for example (Abdulla and Alibaba 2017). This is further supported by Dubois et al (2016) who is of the view that an estimated 19 % (~3000 TWh) of the global electric energy consumption is for lighting. Furthermore, Dubois et al (2016) argue that in the absence of the necessary amendments in policies, markets and practical implementations usage of electrical energy will continue to rise in spite of the important and advancing technical improvements such as light management techniques. Across the globe numerous countries are confronted by the same situation; that most of their lighting installations are technically out of date with some falling into the range of 25 years and older (Dubois et al 2016). Dubois et al (2016) argue that in comparison to installations which already exist, modern technological inventions increase efficiency and frequently accompany good payback times. However, refurbishments of lighting are lagging in comparison to what is possible economically, technically possible and feasible resulting in the realisation of major lighting energy savings mainly through retrofitting of existing buildings (Dubois et al 2016).

2.4 Contextualizing the Literature on Sustainable Development and the Emergence of Green Buildings: A Sub-Saharan Africa Perspective

Sub-Saharan Africa is one of the most rapidly growing regions globally, growing at 4.5% each year resulting in this region of the world representing one of the areas with the potential for rapid economic growth (Brittlebank 2015). However, recent studies also suggest that the continent of Africa is the most susceptible to the negative impacts of climate changes in large part due to a variety of stressors and its low adaptive capacity (IPCC 2007). It is the observation of Hyman (2016) that Africa's urban population growth has been rapid and unprecedented with estimations forecasting that over the next three decades 22 million people will have shifted from rural to urban settlements exerting pressure on already overburdened and dilapidated infrastructure systems. It is expected that there will be a high rise in infrastructure projects across Africa, with $325,828 million worth of construction projects happening in 2014, an increase of 50% compared to 2013 (Brittlebank 2015). This supports the findings of Hyman (2016) that according to estimations, an annual US$93 billion will be needed over the next decade to resolve infrastructure backlogs on the continent, to ensure the development of the continent and to enhance the socio-economic conditions of the population [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)]. African governments have pinpointed this and resolving the infrastructure backlog is a key priority for the New Partnership for Africa's Development (NEPAD 2001).

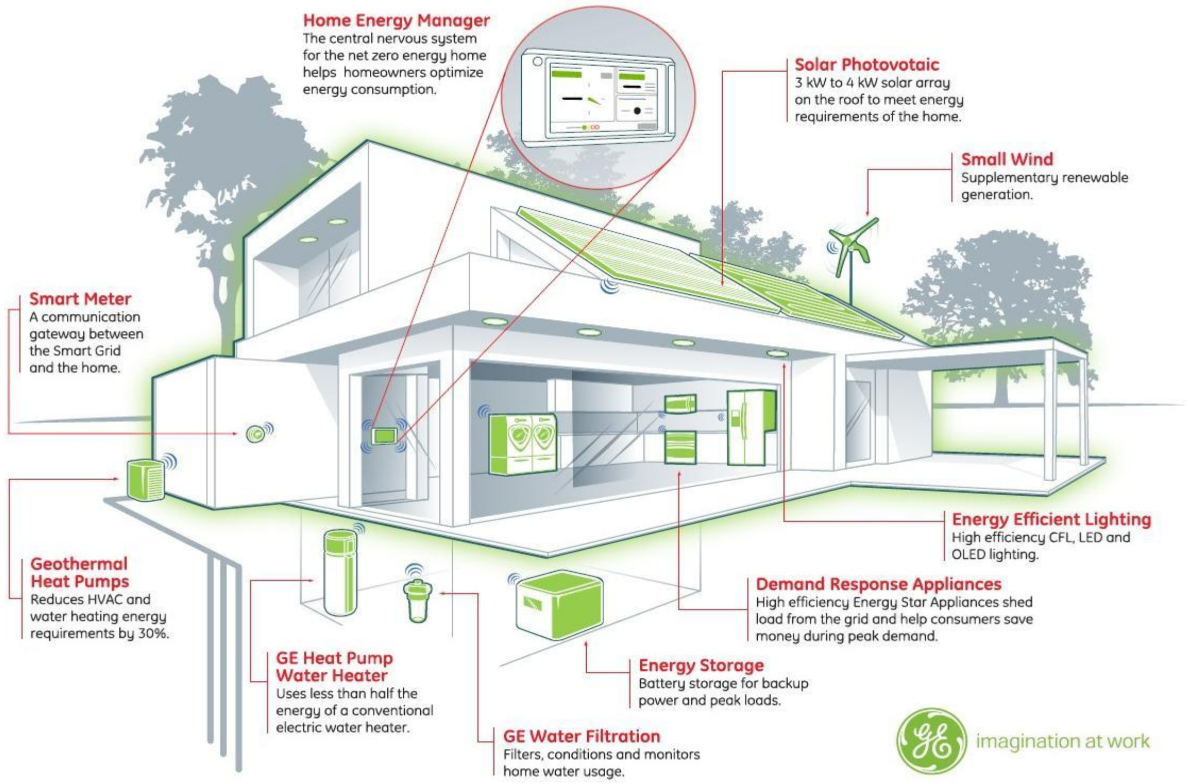
Furthermore, Du Plessis et al (2002) argue that one of the initial steps should be to formulate an action plan or outline a programme which will steer the sector onto a financially sustainable pathway which is also focused on implementing the principles of sustainable development. However, although billions of dollars are expected to flow into the continent for infrastructure projects and interventions in the construction industry, critics have argued that over half a century of investment in construction in Africa has fallen short of producing the swift and accelerated social justice, economic growth and transition to democratic government systems and has instead resulted in rampant environmental and social problems (Serageldin 1992). Furthermore Brittlebank (2015) argues that despite the amount of foreign investment bringing much required funds, materials and practices of construction that also come with foreign investment lack the appropriateness to deal with the unique challenges of sub-Saharan African countries. However, proponents of sustainable development argue that if basic rules are followed in the procurement processes of attaining sustainable construction materials and building elements which are simple to maintain or replace, the challenges can be mitigated [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) 2009]. Furthermore, challenges can be mitigated if it is ensured that processes of production meet the requirements of an adequate working environment [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)2009].

The topic of sustainable construction and development, in and of itself, in Sub-Saharan Africa has come with its own set of challenges. In contrast to first world nations such as the United States of America, many developing countries continue to implement styles and scales of development which have been identified as inappropriate and wholly unsustainable (Halliday 2008). Another challenge for sustainable development is the region's construction industry (Umar and Khamidi 2014). Overall, Umar and Khamidi (2014) argue that there is insufficient enforceable energy efficiency specifications for buildings and coupled with the absence of financial incentives and the lack of adequate sustainable design awareness among building experts, the industry is unwilling to adopt sustainable construction. This is supported further by Brittlebank (2015) who observes that this is exacerbated by challenges such as informal settlements that are poorly designed which pose economic, social and environmental risks as well as rural to urban migration which places a strain on already existing infrastructure. Proponents of sustainable development, however, warn of the ever-increasing demands on the earth's limited resources, ever increasing levels of pollution and that as we grow more aware of our moral responsibility, equity between developed and developing nations is more favourable (Halliday 2008). In the African context specifically, the construction industry is confronted by a number of crucial challenges which necessitate solutions which will guarantee enhanced sustainable buildings and construction processes [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) 2009]. Booth et al (2012) argue that in many African countries construction is a major economic activity contributing to the majority of their gross fixed capital. This creates a situation through which climate change impacts concerning the construction industry conflict with its socio-economic importance. However, experts argue that a more sustained and equitable growth in the building industry will be achieved only if sub-Saharan Africa's urbanisation specifications and infrastructure requirements are interpreted in the context of global environmental change, decreasing finite natural resources and increasing climate change (Hyman 2016). Furthermore, instead of manifesting into an environmental crisis, it can be used as a unique opportunity for the region to let go of outdated and obsolete technology and have a competitive advantage on the global stage in creating low-carbon, resource-efficient and productive urban spaces and ultimately green buildings.

In response to the extreme challenges faced in sub-Saharan Africa regarding the construction industry and climate change-but also the potential of the region for rapid economic growth-a very strong movement arose for green building in the region (Brittlebank 2015). The first Green Building Council (GBC), the GBCSA, was established in 2007 followed by fledgling GBCs being developed in Tanzania, Kenya, Ghana, Namibia as well as Mauritius (Brittlebank 2015). Furthermore, leaders of green building in countries such as Botswana, Nigeria, Mozambique, Zambia, Zimbabwe, Ethiopia and Uganda are also following suit by having discussions with the WGBC about adapting the GBC model in their countries (Brittlebank 2015). The aim of these GBCs is to bring together all spheres such as architects, developers, government, business leaders and communities to come up with inclusive solutions for the future development of Africa. However, Baloi (2003) argues that 'the conflict between environmental protection and economic competitiveness is described as a false dichotomy'. Furthermore, Baloi (2003) argues that the attainability of green building is still considerably difficult in developing countries where, despite heightened interest of the movement, constraints such as lack of capacity, training and knowledge of the sector makes it hard to implement. This is further supported by Naidoo (2009) who argues that there is a dearth of region-specific green building information, awareness and limited government support. Adding to this, high levels of poverty also pose a significant threat to the green building market in sub-Saharan Africa (Naidoo 2009). The problem of implementing sustainable green buildings in Africa is further complicated by the increased perceived risk of Africa as an investment destination due to price volatility in African markets, sluggish economic growth, governance and security concerns as well as humanitarian crises (Hyman 2016). In addition to this Czerwinska (2017) also argues that shortages of skilled professionals and scarce local products have also been cited as impediments in delivering green buildings. Furthermore, there is debate around whether actual building performance of green buildings actually lives up to expectations (Vinnitskaya 2011). However, Hyman (2016) argues that sustainable development and green buildings remain crucial for sub-Saharan Africa as cities in the region are increasingly emerging as engines of growth. This is supported by Kuzwayo (2017) who observes that this is essential as a built environment which is both sustainable and resilient is necessary for the well-being of humans and supports and enables positive human interaction and social integration. According to Kuzwayo (2017) green building in the region could be used as a powerful lever in meeting the development agenda and it is vital for various industry stakeholders across the continent to understand this in the context of the Sustainable Development Goals. City governments in various developing countries in sub-Saharan Africa, otherwise known as local government, are tasked with the delivery of basic services and addressing environmental challenges, two core responsibilities which are interdependent (Kuzwayo 2017). Therefore, Czerwinska (2017) argues that their mandate should also include the transformation of the built environment in sub-Saharan Africa to become green. Across the region countries are taking action in terms of long-term and large scale transformation in how buildings and cities are constructed (Czerwinska 2017). For example, Rwanda has developed an Economic Development and Poverty Reduction Strategy (2nd edition) which outlines the country's aspiration to a green approach to economic transformation (Czerwinska 2017). Green building remains crucial for creating better African cities however, it is dependent on a variety of key role players. It is the observation of Kuzwayo (2017) that government can provide excellent leadership in green building and facilitate the development and implementation of adequate policy and legislation promoting green building. Government entities, business, labour, the civil society also play a role in the training and awareness campaigns as well as creating financial incentives for green building (Kuzwayo 2017). GBCs are therefore critical players as well as they provide the knowledge, tools and create the platforms for collaboration and co-creation (Kuzwayo 2017). In sub-Saharan Africa the GBCs form part of the Africa Region Network of GBCs (Kuzwayo 2017). The four key strategies they focus on are:

1. To support robust regulatory and voluntary legislative and institutional frameworks.
2. To recognise and scale local construction materials and operations.
3. To train the green building professionals of the present and the future.
4. To direct foreign and domestic investment to green building

Figure 2: Illustration of a green house and methods of how a green building can save energy and reduce its emissions



Source: Killough (2014).

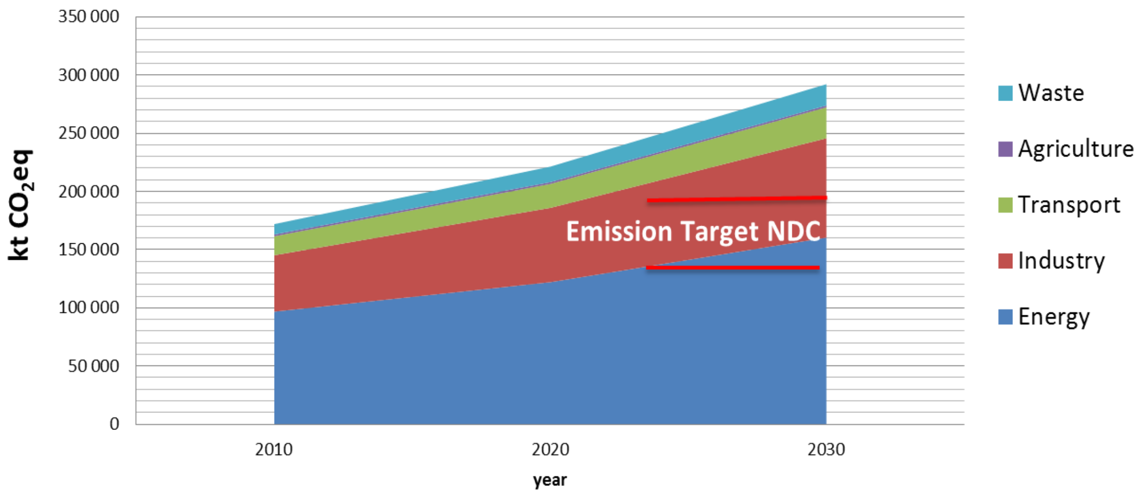
However, Naidoo (2009) argues that green building professionals still face a number of obstacles, particularly in continued market growth. The most significant of these are inclusive of increased costs of construction of green buildings at the inception phase as well as insufficient public awareness and education on green buildings (Naidoo 2009). This argument is further supported by Umar and Khamidi (2014) that there is a high cost to corporations to achieve the skills expected to increase market usage of green buildings. Furthermore, research shows that the critical life-cycle financial advantages of green design do not necessarily make up for the excess original value of the green building (Umar and Khamidi 2014). Umar and Khamidi (2014) also argue that more often than not, because of policy, ownership, and business structures, the advantages of green building do not accumulate for those who have invested in them.

Buildings in hot and arid climates consume a lot of energy (Oguntona et al 2019). Furthermore, Orguntona et al (2019) argue that the procedures leading to the production, generation and distribution of energy have been recognised as having adverse environmental impacts as well as impacting humans negatively. A large amount of the existing buildings were built during a period when provisions for energy efficiency in buildings were deficient within the applicable building codes (Oguntona et al 2019). Therefore, Okorafor (2019) argues that it is crucial to reduce consumption and decrease the cost of heating, cooling and lighting in existing buildings through energy retrofits as one of the methods of addressing the issue of energy consumption in buildings (Oguntona et al 2019).

2.5 Contextualizing the Literature on Sustainable Development and Green Buildings: A South African Perspective

The topic of climate change adaptation has gained momentum in recent years however much environmental legislation still evolves around climate change mitigation when it comes to achieving sustainable development (Van Culster et al 2015). The building industry in South Africa comprises of both the built (both residential and non-residential) and civil engineering sectors which are significant contributors to the economy of South Africa contributing up to 35% to Gross Domestic Fixed Investment (CSIR 2011). The vast majority of GHG emissions in the country are attributed to the energy sector, which contributed 78% of the country's total GHG emissions in 1994, and over 90% of Carbon Dioxide emissions (Mwakasonda 2007). Therefore, Mwakasonda (2007) argues that this pattern is due to the economy's heavy reliance on coal as a primary energy source. According to DEA (2014) Gauteng province, as the economic epicentre of the country and the financial capital of Africa is therefore a significant contributor of Carbon Dioxide emissions as most of these emissions come from energy consumption. This is also supported by Ateba et al (2019) who further observe that the province of Gauteng has significant economic strength and is critical as it provides stamina to the economy of the country. Ateba et al (2019) is of the view that the City of Johannesburg is recognised as the economic capital of Gauteng. With the City of Johannesburg being host to the Johannesburg Stock Exchange, hundreds of commercial businesses and headquarters for multinational corporations, DEA (2014) argues that the adverse effects of climate change on its building infrastructure poses a major risk as it will threaten the economy of the country seriously. Therefore, to mitigate this a large proportion of certified green buildings have been built provincially (GBCSA 2018).

Figure 3: Gauteng 2030 Emission Target with prioritised interventions in place



Source: DEA (2014)

The diagram above shows the projected emissions per industry for Gauteng province between 2010 and 2030. Scientifically modelled projected climate change scenarios for the City of Johannesburg indicate that temperatures have the potential to rise by around 2.3 °C in the imminent future (2056 – 2065) and by around 4.4 °C in the distant future (2081 – 2100) (CoJ Climate Change Adaptation Plan 2009). The mitigation potential which has been selected for commercial and institutional buildings in the country is estimated at 7.5 Mt-CO2e in 2020 (DEA 2014). In buildings, these interventions include installation of heating, ventilation and air conditioning (HVAC) systems with heat recovery, lighting which is efficient, appliances which are energy efficient and HVAC equipment with variable speed drives (VSDs) (Mahuma et al 2009). However, Mahuma et al (2009) argues that there are challenges in terms of implementing these interventions which are mainly market related such as the lack of local manufacturing capacity in the country which means that local businesses need to import costly components, the price sensitivity of the South African market and investor risk aversion caused by the economic downturn globally. In contrast, DEA (2014) has a differing view to Mahuma et al (2019) arguing that the danger is that without interventions the building sector's emissions, which forms part of the industry sector, will rise from 63% of all emissions in 2010 to 76% by 2050. In consideration of this, it is the view of Mahuma et al (2009) that if the economy could improve, the positive impact would be an increase in investor confidence in investing in renewable energy products and projects as well as the establishment of local assembly facilities. Thus, the situation can be rescued (Mahuma et al 2009).

According to Mahuma et al (2009) the challenge of reconciling development with climate change objectives is very real and crucial. The country is a signatory to the UNFCCC and reaffirmed its commitments to fighting climate change and global warming by putting an over-arching framework of legislation in place which feeds directly from the overarching international framework (Mahuma et al 2009). South African legislation regarding climate change is mostly national legislation with first and foremost the Constitution of the country, specifically section 24 which enshrines the right to a healthy environment for all citizens (The Constitution 1996). In line with the Constitution, the National Development Plan 2030 (2011) emphasises building sustainably as a step for the country towards responding effectively in terms of climate change mitigation. Recently South Africa enacted new legislation to encourage green infrastructure in the country. The new energy standards are SANS204 which is Green Building in South Africa and SANS 10400-XA which is for more sustainable and efficient energy use in buildings (Mustapha

2016). However, it is critical to emphasise that good governance is the key to implementation of policy and legislation.

The built environment and urban planning is one of the City of Johannesburg's key sectors which is threatened by climate change and its effects (CoJ Climate Change Adaptation Plan 2009). Thus, infrastructure in the City of Johannesburg is also important and needs to be strengthened to enhance its resilience and adaptive capacity towards climate change. It is thus not surprising that the evolution and growth in green buildings boomed in the city particularly the areas of Sandton and the Broader Sandton Node.

The GBCSA was established in 2007 offering an opportunity for South African businesses and real estate entities to understand how to benefit from green building investment and the potential drawbacks associated with it (Theunissen 2016). Furthermore, the knowledge on how to operate, manage and make financial returns on green buildings is knowledge that is also dispensed by the council (Theunissen 2016). Therefore, Halliday (2008) observes that the GBCSA is often at the forefront of change advancing past even governments to address issues surrounding unsustainable development. Furthermore, Halliday (2008) argues that clients, conventional businesses, designers and developers are also key players as they take advantage of the increasing awareness of consumers in global warming matters and consumer power. Therefore, it is important for them to ensure that their impacts on the environment stemming from their business activities are positive to attract consumers and investment. Contractors, developers, suppliers and constructors are changing their operational habits as well to make sure they fall under the sustainability ambit as expectations of responsible behaviour, rising cost of doing business and legal precautions have impacted behaviour (Halliday 2008).

In South Africa, the argument is that despite the perception that green building cost a lot to implement and operate compared to non-green or nominal buildings, no data exists to support this (GBCSA 2016). Proponents of green buildings argue that the following benefits for green buildings exist as identified by the GBCSA (GBCSA 2018).

1. Decreased operating costs, especially in terms of energy and water usage. A study conducted by the GBCSA in 2018 found that Green Star South Africa buildings profiled had saved between 25% to 50% of energy compared to conventional buildings.
2. Higher returns on assets.
3. Enhanced marketability with the positive features of green buildings being linked to the company brand and image.
4. Ability to attract and retain public sector tenants as the Department of Public Works' planned 'Green Building Framework' will include distinct green building specifications for government and multi-national tenant accommodation.
5. Elevated productivity.

The argument against green buildings revolves around a very critical issue: implementation. Furthermore, some of the important reasons as to why there are such varying views on green buildings and sustainable construction also falls down to the advantages and barriers to their implementation, whether real or perceived. Green buildings in South Africa face the same advantages and barriers as compared to other parts of the world, with proponents undertaking a range of studies on the topic. These independent studies carried out by the GBCSA show that on average the savings that certified buildings can make in terms of reduced energy consumption is up to 85% less energy, 65% less potable water and reduction of the amount of waste generated by 65% that is to be taken to landfills than non-certified buildings (Green Economy Summit Report 2010). However, Mustapha (2016) argues that they are impeded by the slow implementation of green buildings and this is blamed mainly on the inability or lack of will to implement relevant legislation such as green building legislation and standards as well as energy standards which govern energy efficiency in buildings such as SANS 10400-XA.

There are a number of other barriers that opponents to green buildings have cited which include the upfront cost of building green due to the expense of some of their building components, training people in new techniques of construction, the perceived unattractiveness of green buildings due to their alternative designs and materials used as well as the belief that in the long run they don't work (Johnston and Gibson 2008). However, these arguments have widely been disproved as green buildings are said to actually decrease operating costs in the long run due to their energy and resource efficiency, and their increased durability and decreased cost of maintenance (Johnston and Gibson 2008). Furthermore, Johnston and Gibson (2008) argue that materials which are increasingly being used to construct green buildings are becoming more and more reliable as competition in the manufacturing industry rises due to market forces. Given the challenges in the implementation of green buildings in South Africa, particularly pertaining to implementation of legislation and seemingly financial constraints, the private sector has largely been behind green building industry's growth.

The Green Star SA rating tools were developed by the GBCSA and consists of the following eight environmental categories: indoor environmental quality, energy, transport, water, ecology, emissions, materials and management (Botes 2012). Based on the Australian system and evolved to fit the South African context, Green Star South Africa separately evaluates the environmental initiatives of projects and/or buildings based on the mentioned criteria including others (Existing Building Performance V1 Tool Technical Manual 2014).

The Existing Building Performance V1 Tool Technical Manual (2014: vii) illustrates that the purpose of Green Star SA toolkits is to:

1. Establish a universal language and standard of measurement applicable to green buildings.
2. Encourage integration of design and operation of buildings as a whole.
3. Locate the impacts of building lifecycle.
4. Increase awareness of the benefits of green building.

5. Acknowledge leadership in the environmental sphere.
6. Assist in facilitating the transition of the built environment to decrease environmental impacts.

There are two ways a building can be certified green: through retrofitting or 'as built' (new) (Halliday 2008). An 'as built' green building is one that is built from the ground up and did not pre-exist prior to being certified green (Goosen 2009). A retrofitted green building is one that pre-existed prior to certification and often retrofitting entails the alteration of the building in a manner which may enhance their energy efficiency or reduce their demand for energy (US Department of Energy 2019).

Although both retrofitted green buildings and as built green buildings are expected to maintain and improve in terms of the sustainability factors which have to be adhered to within the tool, there are critical differences in the manner of certification of the two in the country. The first difference is the rating tool used to certify the buildings. Retrofitted buildings are certified utilising the EBP V1 Tool and new buildings are certified utilising the Green Star South Africa-Design or As Built Performance Tool V1 (Existing Building Performance V1 Tool Technical Manual 2014). These tools are Green Star SA toolkits developed by the GBCSA. The main difference between them is that with the As Built rating tool, Green Star South Africa only acknowledges and awards leaders in the market (only certifies 4 Star or above) whereas with the EBP V1 Tool the GBCSA recognises that the move to becoming a 4-6 star rated building may be a lengthy journey therefore those who are doing significant work in reaching this point should be acknowledged (Existing Building Performance V1 Tool Technical Manual 2014). This ensures that they are maintaining their positive environmental performance but it also gives them the chance to improve it and attain higher certification. The focus of this study is the performance of certified retrofitted green buildings of office use during their operational life cycle therefore the EBP V1 Tool is applicable to this study.

There are a variety of benefits which comes with Green Star South Africa certification (Goosen 2009). Furthermore, Goosen (2009) is of the view that Green Star SA rating tools give credit to projects which exhibit environmental leadership in the design, construction and building itself. It is also the observation of Goosen (2009) that achieving a rating of 4, 5 or 6 star enables a project to:

1. Achieve recognition in the market in terms of innovation in the green building industry.
2. Gain a competitive advantage through the promotion of the building as both environmentally friendly as well as suitable for work occupation.
3. Achieve validation through the process of objective third party assessment.
4. Warrant the promotion of a Green Star SA rating and utilise its certification logo.

According to Tobias et al (2009) building rating systems and codes are important to apply as they set minimum standards for construction, renovation and operation for green buildings. Tobias et al (2009) argue that in terms of looking at energy efficiency in green buildings, green buildings which have been retrofitted can also improve their energy efficiency just as substantially as new green buildings, and require critical attention as in many countries, including South Africa, the existing building stock is far greater than new buildings. Retrofitting is regularly associated with buildings since the life expectancy of the structure and the materials which constitute the building envelope is lengthier than the components which have been fitted in the building (Oguntona et al 2019). Furthermore, Oguntona et al (2019) also argue that studies have demonstrated that the retrofitting of buildings which already exist is amongst the key ways of dramatically reducing GHG emissions and energy consumption. Although at the beginning when a building qualifies for green certification it is likely operating and performing at its optimum in terms of energy and resource efficiency, it is critical to continually assess its performance over time to determine whether it is indeed energy efficient. The City of Johannesburg is home to a great number of buildings which have been certified green of business and commercial use, thus investigating their energy consumption and emissions is very important when looking at their contribution in climate change mitigation.

The first building to be certified in South Africa is the Nedbank Phase II in October 2009 (GBCSA 2017). It is owned by Nedbank and is their head office in Sandton. The building is estimated at 65 000m² in size (GBCSA 2017).

Figure 4: Nedbank Phase II

Source: Asakheni Consulting Engineers (2020).

2.6 Gaps in the Existing Knowledge

Research has shown that gaps which exist betwixt green building practice and legislation in countries have been widely investigated with the general consensus being that they are due mainly to a lack of knowledge as well as awareness of legislation surrounding green buildings or practices by stakeholders in the construction industry (Windapo and Goulding 2015). However, Zhou et al (2018) dispute this, arguing that there has been extensive research on the hurdles and benefits of building green and the way countries around the world have embraced the green building phenomenon. The motivation for stakeholders to implement green construction principles has become a focal point of scholars in recent times. However, Windapo and Goulding (2015) argue that such studies are usually very generalised and look broadly at the industry, thus a more specific and detailed analysis is needed. Furthermore, Zhou et al (2018) argue that the notion of green building is limited in developing countries and this is evidenced by the unsustainable construction methods which are employed as well as a dearth of conscious of construction teams with regards to the environment particularly when the building is being erected.

In terms of the developing world, literature is limited in large part as a result of a scarcity in knowledge of sustainable construction practices as well as building practices, and a lack of focus on the specific area of study. In further support of this statement, Luken and Clarence-Smith (2019) argue that this is extremely difficult particularly in countries in sub-Saharan Africa as few reliable statistics exist on the industry's input and aggregated data for the release of pollutants such as Carbon emissions is virtually non-existent in the literature (Luken and Clarence-Smith 2019). Therefore, amongst others, international data sources have to be relied on. This is further supported by Naidoo (2009) who argues that significant scarcity of region-specific information on green buildings is due to high levels of poverty, limited government support, lack of public awareness and a need of education of the sector. Gaps in the literature are particularly evident in legislative and institutional frameworks governing green buildings as well as funding initiatives to incentivise green buildings. Around the world, it has been demonstrated that it is necessary for certification, which is a process which largely remains voluntary, to accompany and be implemented alongside solid environmental legislation in order to provide direction which is critical to emerging markets which are focused on green building (Brittlebank 2015). Furthermore, it is highly recommended that stakeholders in the construction industry are furnished with frameworks or guidelines which will assist them in constructing in an environmentally friendly manner (Zhou et al 2018). However, Brittlebank (2015) argues that most states in Africa are devoid of standards which outline minimum specifications for buildings and construction. In addition to this, there are those who have building standards in existence however they are extremely outdated (Brittlebank 2015). Although South Africa comparably has a strong legislative and institutional framework governing green buildings including energy efficiency in buildings-as well as leading the green building market on the continent-legislative institutional frameworks in the country have to be tested to determine gaps which affect the implementation of green buildings and their effectiveness (Windapo and Goulding 2015).

CHAPTER THREE

METHODOLOGICAL CONSIDERATION

3.1 Introduction

This chapter discusses the methodological principles used in this study. Kothari (2004:21) defines research methodology as a 'systematic way to solve the research problem'. It can further be explained as the scientific manner through which research is conducted and the particular process and logic followed by the researcher to study the research problem (Kothari 2004). Furthermore, Kumar (2008) states that theoretical knowledge that constitutes research methodology is therefore, organised around the operational steps that form this research process for both quantitative and qualitative research. This includes the processes utilised by researchers to gain knowledge, and to undertake the work of describing, explaining and predicting phenomena (Rajasekar et al 2013) For this study, we interpret methodology as the ways in which the sample size was set; the sampling methods that were utilised to determine the sample size; the tools which were used to collect data as well as how the data was organized and analysed.

In view of this, the chapter is divided into five subsections. The first sub-section is a recap of the research aims and objectives of the study. The research aims stipulates what the research was investigating. The research objectives describe concisely what the research is trying to achieve. Secondly, the research philosophy used in the study is discussed. The research philosophy constitutes the belief of the researcher in how the study should be approached and the way data about the study should be collected, analysed and utilised. The description of the research site is indicated in the third section. The research design used is indicated in the fourth section. The research design refers to the comprehensive approach which is used by the researcher to combine various elements of the study in a rational manner which will ensure that the research problem is successfully addressed. The fifth and sixth subsections are dedicated to data analysis and methodological reflections respectively. Data analysis describes the process used to analyse the data. The methodological reflections describe the researcher's experience in the field. They give an account of the challenges and the opportunities experienced by the researcher in conducting and completing the research at the various stages of the study and how these issues were approached and resolved to complete the study. The methodological reflections also cover recommendations for future research.

3.2 Recapping the Research Aims and Objectives

As discussed in section 1.4 of this dissertation, the aim of this study was to investigate the effectiveness of certified green buildings in energy efficiency and reduction of Carbon emissions vis-a-vis climate change mitigation. This involved assessing the performance of certified green buildings in terms of energy consumption and the reduction of Carbon emissions of office use in the City of Johannesburg over a period of at least 18 months. To achieve these aims four research objectives were conceived. It is essential to observe that the aims and objectives used in this research informed the research methodology which was adopted and applied in this study.

3.3 Research philosophy

The system which is comprised of the researcher's thoughts is also known as the research philosophy (Žukauskas et al 2018). This is established by the researcher subsequent to new knowledge about the research study being obtained (Žukauskas et al 2018). This knowledge is scientifically accurate and reliable (Žukauskas et al 2018). Žukauskas et al (2018) is of the view that research philosophy forms the foundation of the research and involves the selection of the strategy to be used for the research, the establishment of the problem as well as collecting, processing, and analysing data. Rajasekar et al (2013) argues for every specific field, research is performed in accordance with a paradigm, which is expected to have met the overall approval of the scientists operating in the particular field.

According to Holden and Lynch (2004) knowledge depends on the formation of a perspective which is philosophical and requires the researcher to come to several primary assumptions which are normally two-dimensional: the first which looks at society and its nature as well as the nature of science. Žukauskas et al (2018) further argues that individual researchers are directed by their individuated approach to their research and this influences the assumptions of the research. According to Rajasekar et al (2013), once these assumptions have been determined an academic statement of the problem can be formulated and be solved in a sequential manner with different stages starting at the selection of a research topic to the stage of the final report. In Goles and Hirschheim (2000) it is argued that paradigms are important in a research philosophy as they offer scientific achievements which are widely acknowledged and offer ideal problems and answers for a period of time. Chilisa and Kawulich (2015) further supports this statement by saying that every researcher has his or her own view of what constitutes factual knowledge and these guide our thinking, our beliefs, and our assumptions about science and ourselves and they frame how we view the world around us which defines a paradigm. Kothari (2004) argues that research usually alludes to the exploration for knowledge and can also be defined as a scientific and organised search for important facts on a particular topic. Redman and Mory (1923) supports and adds to this by defining research as an organised effort to attain contemporary knowledge.

According to Chilisa and Kawulich (2015) the paradigm belief chosen by the researcher assists in guiding the investigation in terms of methodology and design as well as in describing various world views such as ontology (which describes the nature of reality and being) and epistemology (which looks at nature and the scope of knowledge). Žukauskas et al (2018) states that the researcher must possess a distinct understanding of their chosen paradigm which will provide the researcher with the philosophical, hypothetical, instrumental, and methodological basis necessary to conduct the research. Žukauskas et al (2018) further argues that the scientific research paradigm and philosophy of the researcher is dependent on multiple factors including the researcher's mental model, perspective of the world, individual perception, numerous beliefs and attitudes in relation to what they perceive about reality. Thus, the researchers' beliefs and value sets are critical in order to put forward convincing arguments and terminology in order to acquire reliable results and in some instances can have a pronounced impact on the research outcome.

Epistemology is defined as knowledge, particularly how knowledge is constructed, interpreted and presented (Tennis 2008). The epistematic stance of the observer or researcher will dictate what that knowledge is (Tennis 2008). There are a myriad of epistematic stances such as pragmatism, positivism, operationalism, referentialism, instrumentalism, empiricism, rationalism and realism (Tennis 2008). Depending on the researcher's epistemological standpoint, the appropriate theoretical perspective can be chosen for the study which will then inform the methodological approach (Tennis 2008). It was decided that the best method to adopt for this investigation was a mixed-method approach of both quantitative and qualitative analysis.

The epistemological standpoint of this study was positivism. Positivism follows the view that only 'factual' knowledge obtained through observation, which includes measurement is reliable (Dudovskiy 2018). In a Positivistic study, the findings of the research are observable, quantifiable, interpretable and can be statistically analysed (Dudovskiy 2018). Another important feature of Positivism is that the researcher has to conduct the research in an objective manner (Dudovskiy 2018). Therefore, for this study the Positivistic approach was the most appropriate methodological approach, especially where the quantitative approach was employed, as the research is focused on certified green buildings whose performance relies on data collection and interpretation. In order to do this as accurately as possible, the researcher has to be objective in terms of data collection and interpretation. Data from the South African Weather Services was also sourced.

In terms of the qualitative aspect of the research, Viswambharan and Priya (2015) highlight the importance of utilizing documentary analysis as a qualitative methodology. For this research, qualitative methods offer an effective way of analysing existing literature and legislation, particularly building, energy and environmental legislation as well as policies, plans and strategies. This documentation was received from the various institutions identified as important and relevant for the study such as the University of the Witwatersrand, the GBCSA, provincial authorities such as GDARD and GDID, the City of Johannesburg, research and government institutions such as the CSIR, the National Department of Energy (NDoE) which is the national authority governing and regulating energy in all sectors and academic experts. Private stakeholders and property companies who are owners and managers of certified green buildings, an environmental consultant, and a company which calculates carbon emissions for buildings were also engaged in the research.

The importance of these institutions is that they work closely together and contribute to the development of legislative and institutional frameworks which govern the built, energy and environmental legislation in the country. The study uses qualitative analysis in order to gain insights into these legislative and institutional frameworks. The institutions have also conducted studies which are related to this investigation. They collect, manage and archive data and information which was important and useful for this investigation. The GBCSA's building performance rating tool was also reviewed to investigate any other phenomena in the research.

3.4 Description of the Research Site

The information on which this dissertation is based was collected from the City of Johannesburg. This study site was chosen as it is a central part of the country from a social and economic viewpoint. The city is the epicentre of the economy of Gauteng, which is the economic capital of the country. The city is predominantly built up and cosmopolitan, and is home to approximately more than 10 000 business including multinational corporations, the banking sector, the

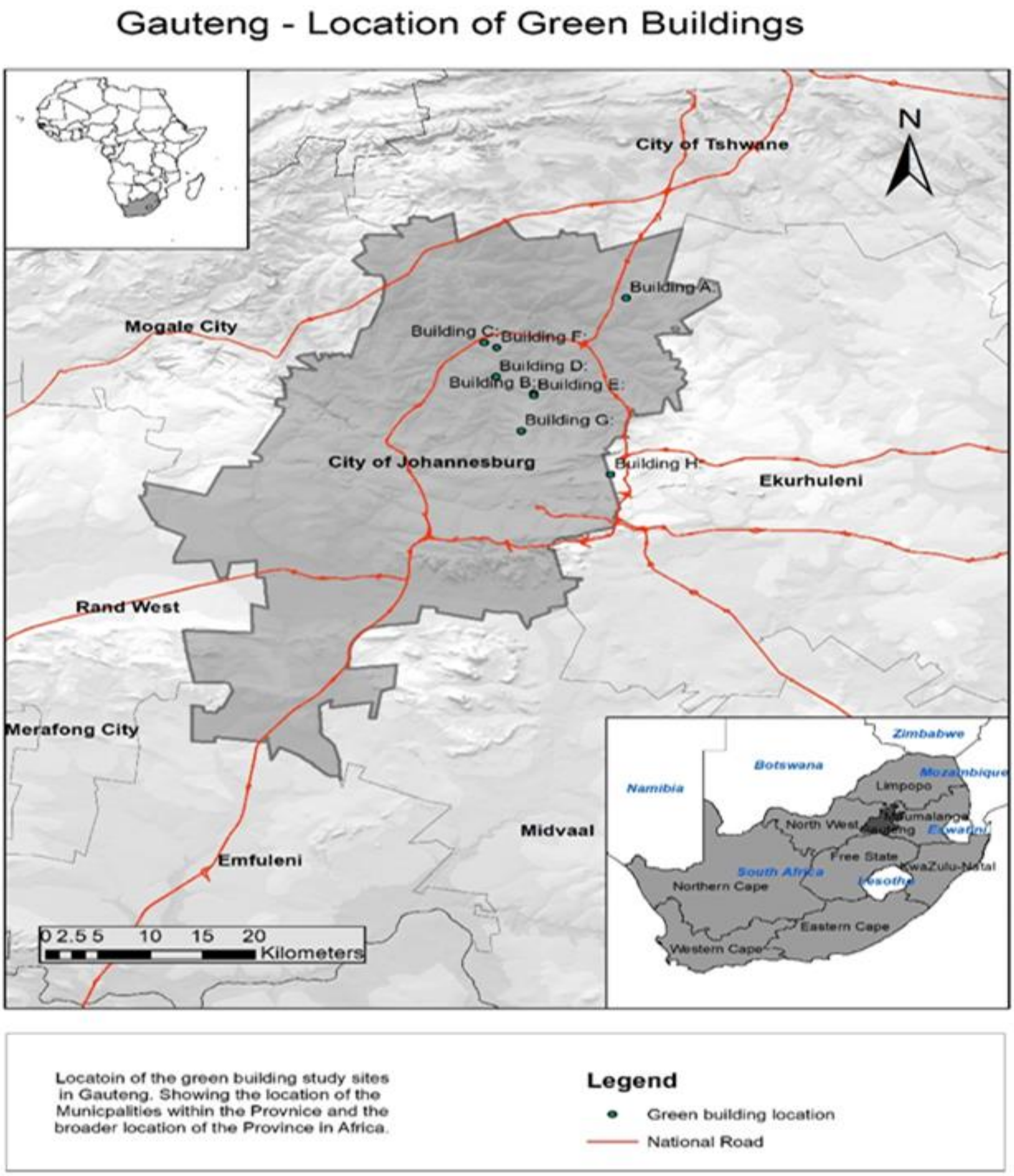
Johannesburg Stock Exchange. Mega human developments like Waterfall Estate, Cosmo City and mega malls such as Sandton Mega Mall which are integral to the financial and commercial facets of the country (GDARD 2011 and SA-venues 2018). Furthermore, the city is the country's most populous metropolitan as well as the city with the largest and most diverse economy which contributed roughly 15% of national Gross Domestic Product (GDP) in 2016 and provides the highest number of jobs with an estimate of 2.04 million people employed (CoJ Draft Integrated Development Plan 2018/19).

According to the city's Draft Integrated Development Plan (2018/19), the city contributes approximately 5.05 million people to the entire provincial population, despite Gauteng comprising only 1.4% of the land surface of the country (Gauteng Annual Compliance Report 2018/19). This thus requires proper plans for the city to handle the difficulties which accompany the increase of the population of the city and to establish a sustainable and resilient built environment.

Private companies in the city have embraced going green and areas such as Sandton central and the broader Sandton node have emerged as the epicentre for green buildings in South Africa (Engineering News SA 2016). The private sector is also particularly keen on greening buildings and constructing green buildings as certification of buildings increases their appeal and marketability as well as increases their independence from Eskom as the main energy supplier (GBCSA 2018). Commercial properties who also aim to be certified as green are also attracted to the City of Johannesburg, particularly in areas such as Sandton, because of the sustainable public transport and eco-friendly mobility forms such as the Gautrain and the Rea Vaya Bus Transit System which runs through the area and are beneficial for buildings targeting green building certification (Engineering News SA 2016). This is important to them because points are awarded for their proximity to sustainable public transport in order to qualify for certification (Engineering News SA 2016). Therefore, due to the high concentration of companies, specifically private companies, economic activity, the high concentration of certified green buildings and the dynamics which climate change presents to these, the City of Johannesburg is the best site in the country to study the effect that certified green buildings have in terms of climate change mitigation.

For this research, 8 certified green buildings were selected and data received for them. The data received was from Property Group 1 and Property Group 2. The stakeholders who were interviewed provided the information. This was the head of facilities at Property Group 2 and the sustainability manager at Property Group 1. The sites of the data collection were the head offices of both Property Group 1 and Property Group 2 where they keep all the data of their buildings which belong to them. Property Group 1 is located in Sandhurst, Sandton and Property Group 2 in Rosebank, Johannesburg respectively. Only 3 Building C, Building D and Building G of Property Group 1 were utilised as they had complete datasets. The buildings of Property Group 2 were not used as their datasets were not complete therefore the researcher determined that they were not of use to the study. These are Building F and Building H. In addition to this, Building H fell out of the study site of the City of Johannesburg as it was just in the border of the City of Ekhuruleni. Building A, Building B and Building E of Property Group 1 were also not utilised as they had incomplete datasets. The buildings are presented in the maps below.

<u>Figure 5: Location of Certified Green Buildings to be researched for study in the City of Johannesburg</u>



Source: Leroy (2020)

Figure 5 above gives the location of the buildings within the City of Johannesburg as surrounded by the other municipalities in Gauteng. The image in the bottom right-hand corner shows Gauteng's location in South Africa. Gauteng is shaded darker than all the other provinces. The image in the top left-hand corner shows South Africa's location in Africa. The country is shaded in grey. The significance of this image is to give perspective to the fact that such a small area on the continent is such a driving force in the green building industry and is home to a significant amount of certified green buildings on the continent.

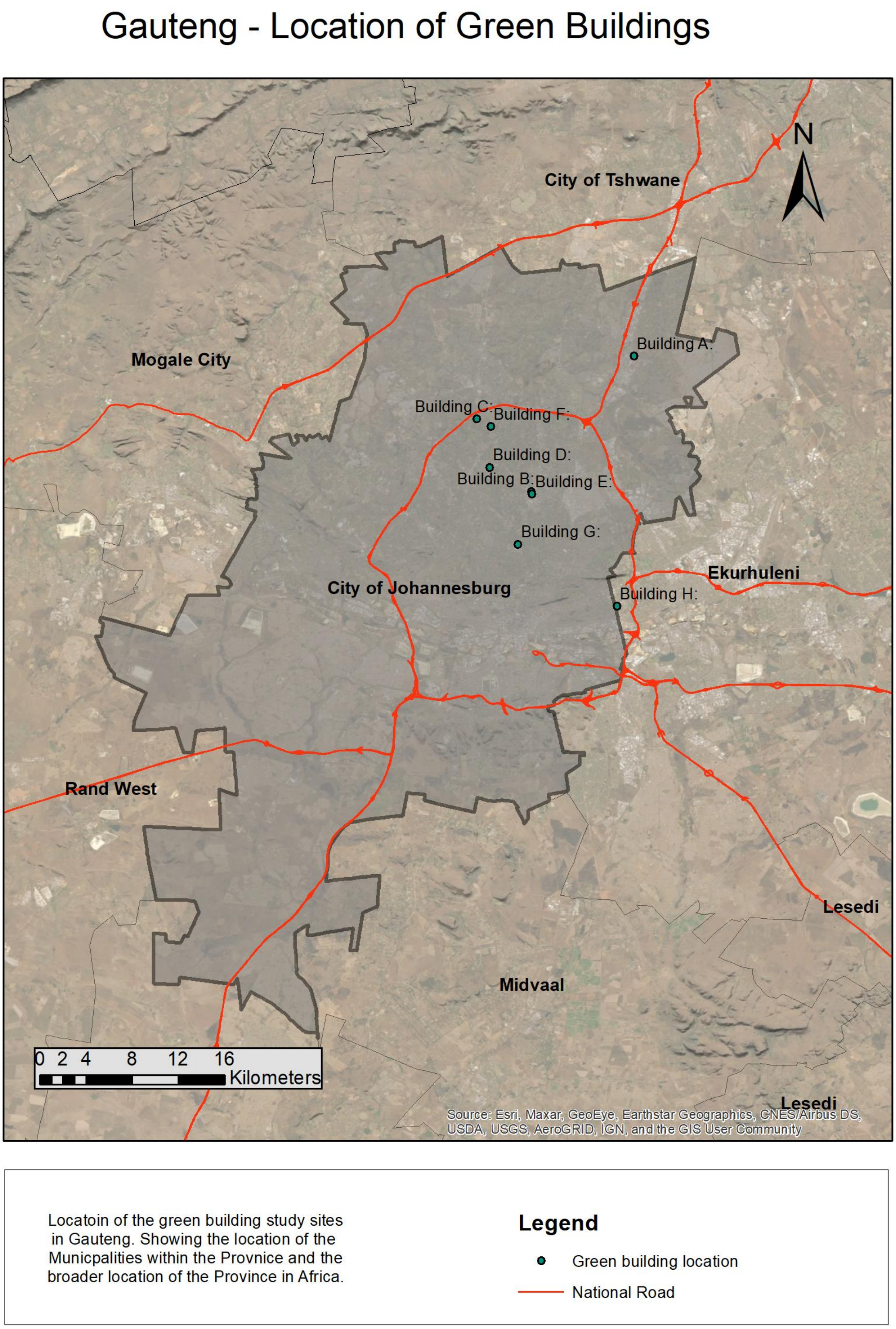


Figure 6: Terrain surrounding the Green Buildings in the City of Johannesburg

Source: Leroy (2021)

The map above shows the actual sites of the buildings, the geographical terrain surrounding them as well as the other municipalities in Gauteng which surround them. This map supports the map above it and is important as the geographic location of the buildings, in the context of their surroundings, can impact their performance. The City of Johannesburg falls under one temporal zone however other factors such as the location of buildings may have an impact on their performance i.e cooler, shaded and more suburban areas versus hotter, busier central business districts. Both Figure 5 and Figure 6 were created using the ArcMap 10.7 GIS Tool.

3.5 Research Design

Kothari (2004) describes the research design as the conceptual framework for conducting the research and its purpose is to facilitate the efficiency of the research resulting in it yielding the maximum amount of information. Rajasekar et al (2013) further adds to this by arguing that a research design should stipulate the variety of approaches to be employed in finding a solution to the research problem, sources and information connected to the problem as well as timeframes and the expense of the research. Rajasekar et al (2013) also argues that the research design lays the groundwork for the research work in its entirety and assists in performing the chosen task in a simple and systematic way.

This section explains the study population, sampling procedure and the data collection tools used in detail.

3.5.1 Study Population and Sampling Procedure

The study population represents a complete set of items that share commonality from which inferences can be drawn (Dawson 2013). According to Alvi (2016) an investigation to assess each and every element of a population is impossible so a group of the study population is selected for assessment. This is known as sampling. According to Alvi (2016) sampling is a process whereby a sample is taken out of a given population. Sample inferences for the population are then drawn based on the information gathered from the sample (Alvi 2016). A sample is defined as a group, items or individuals selected from a research population for investigative purposes to test or develop a hypothesis (Alvi 2016 and Dawson 2013). There are two classifications of sampling categories: probability sampling whereby the sample has a known probability of being selected and non-probability sampling whereby there is no known probability of the sample being selected therefore samples are chosen on the basis of convenience or through voluntary response surveys (Pennsylvania State University 2018). The choice of which type of sampling procedure to use during research is dependent on the research question and the population which is to be researched (Leedy and Ormrod 2005). For research where there is an inability to draw out inferences about the entire population then non-probability sampling, also known as purposive sampling is the best suited sampling method (O' Leary, 2004). For research whereby inferences can be drawn about the population, probability sampling or representative sampling is the most accurate (Alvi 2016).

For this research, probability sampling was used as the probability of the sample being selected is known and inferences can be drawn about the population, about whether they are effective in reducing their energy consumption and Carbon footprint gradually and are thus successful as tools in terms of mitigating climate change. Also, it is possible to assign probabilities to members of the population objectively. To identify which buildings were sampled, the criteria of usage was used. Only buildings of office use were selected by means of a desktop analysis of the GBCSA's case studies of all the buildings certified in the City of Johannesburg. For this study probability sampling is also the best suited method as the population group, the retrofitted certified green buildings of office use, could be very precisely defined and there was a high probability of each and every one of them being included in the sample.

In this study the population was comprised of retrofitted green certified buildings of office use which meet expected minimum energy-efficiency levels according to the South African building standards. They must also observe the rating requirements of the EBP V1 Tool for meeting their energy efficiency levels to remain certified. The table below was provided by the GBCSA who maintain a database of all certified green buildings in South Africa. According to the GBCSA (2018), there are 461 buildings which have been certified green. Of these, 173 certified green buildings were certified using the EBP V1 Tool. The table below illustrates the number of buildings and the various tools used to certify them:

Table 1: Total figures of buildings certified green according to the various certification tools used by the GBCSA

Certification Tool	Description	Count	Percentage
New Buildings and Major Refurbishments	This tool is applied when rating new buildings across South Africa and Africa.	216	47
Existing Building Performance-V1 (EBP-V1)	This tool assesses the environmental performance and operation of already operational existing buildings of all typologies.	173	38
Energy Water Performance4-V1 (EWP-V1)	This tool is an operational performance management tool which is currently applied for office buildings only. It rates the entire building's performance in terms of energy consumption against the national average benchmark.	25	5
Interiors Fit Outs	This tool is applied in the independent benchmarking of the environmental design initiatives which the tenant(s) of the building have implemented.	28	6
Net Zero	This tool is applied to award buildings of all typologies with a net zero/positive rating which have strived to completely reduce or positively redress their environmental impacts.	11	2
Excellence in Design for Greater Efficiencies (EDGE)E Post construction	This rating tool combines design and as built rating into one official certification for any sector of property development. The achievement of the EDGE standard is dependant on the accomplishment of minimum savings	8	2

	of 20% in energy, water and embodied energy in materials.		
Total Certification Count: (all tools)		**461**	**100**

Source: GBCSA (2018)

From the table above, a simple percentage calculation gave the various percentage amounts of buildings rated per certification tool in the country. This was done by dividing the number of buildings rated per certification tool which was then divided by the total certification count and multiplied by 100 to give a percentage:

$$P = (n/N) \times 100$$

Where:

P is the percentage of buildings per certification tool

n is the count of buildings per certification tool

N is the total certification count of buildings in the country

The answers were then rounded off to give the percentage which would represent whole buildings.

Thus, the following calculations for each of the categories was executed:

1. For New Buildings and Major Refurbishments:

$$P = (n/N) \times 100$$

$$P = (216/461) \times 100 = 46.85\%$$

Rounded off to 47%

2. For Existing Building Performance-V1 (EBP-V1) certified buildings:

$$P = (n/N) \times 100$$

$$P = (173/461) \times 100 = 37.53\%$$

Rounded off to 38%

3. For Energy Water Performance4-V1 (EWP-V1) certified buildings:

$$P = (n/N) \times 100$$

$$P = (25/461) \times 100 = 5.42\%$$

Rounded off to 5%

4. For Interiors Fit Outs certified buildings:

$$P = (n/N) \times 100$$

$$P = (28/461) \times 100 = 6.07\%$$

Rounded off to 6%

5. For Net Zero certified buildings:

$$P = (n/N) \times 100$$

$$P = (11/461) \times 100 = 2.39\%$$

Rounded off to 2%

6. For EDGE Post construction certified buildings:

$$P = (n/N) \times 100$$

$$P = (8/461) \times 100 = 1.74\%$$

Rounded off to 2%

The researcher decided to convert them into percentages for perspective in terms of how prolific the use of each tool is. From the results above, of the green buildings certified the highest percentage were certified using the New Buildings and Major Refurbishments certification tool. The second highest percentage of certified green buildings were certified using the EBP-V1 Tool.

The lowest percentage were certified using the EDGE Post construction certification tool. Only about 2% of certified buildings in the city are certified using the Net Zero/Positive Rating Tool. This indicates that many buildings in the city are not ecologically and emissions friendly. In the future, it is envisioned that the city will aim to develop or retrofit more buildings with the aim of making them net zero Carbon emitters thus resulting in the highest percentage of buildings being certified using the Net Zero/Positive Rating tool.

The researcher made use of provincial intergovernmental platforms, telephonic requests and email requests to access key stakeholders who were of critical importance to the research and eventually contributed to the study. The intergovernmental platform which was used was the Gauteng Climate Change Indaba 2018 which was hosted by GDARD. On this platform the researcher was able to access the first key stakeholder for the study, a major banking institution, who were present at the Indaba. The banking institution was a critical stakeholder for the research as they own the first building certified green in South Africa in 2009. The snowball technique was utilised throughout this study whereby the initial respondents of the study, assisted the researcher to access future respondents from their acquaintances in the field. This was done via email as well as telephonically. In the first instance, the banking institution was able to bring the researcher into contact with the manager of the Sandton central improvement district who brought the researcher into contact with the prominent property groups which own and manage certified green buildings located in the City of Johannesburg. Other property companies were identified using the internet website search engine Google whereby all the property companies who own or manage green buildings in the City of Johannesburg were selected. Letters of permission requesting the property companies to take part in the study were compiled and emailed to them. Although some property companies initially responded upon further investigation, utilising the GBCSA's Annual Integrated Report which lists all certified buildings according to type (office, residential), rating tool used to certify them (EDGE, EBP V1), rating achieved, owner of building and project team that worked on them as well the year that the project was certified, it was found that the green buildings owned and managed by some of them were not the relevant buildings needed for the study, which are existing buildings of office use, and were not rated using the tool which was relevant for the study, the EBP V1 Tool. Therefore, ultimately Property Company 1, Property Company 2, which was the property company which initially responded, and Property Company 3 took part in the study. Of the property companies contacted, these 3 responded positively. In terms of operations and size of the property companies, both Property Company 1 and 2 are large with both having their headquarters nationally and being listed on the Johannesburg Stock Exchange (JSE) with Property Company 1 also having international investments. The snowball technique was further utilised to access the relevant employees in these property companies who provided the researcher with permission to utilise their buildings in the study. Property Company 1 and 2 provided energy consumption data for their buildings and Property Company 1 provided the Carbon coefficient used to calculate Carbon emissions from their buildings to the researcher which was used in the study.

Qualitative Interviews

All the stakeholders except SAWS and the National Department of Energy took part in the initial round of interviews. SAWS only had to provide temperature data and interviewees could not be secured from the National Department of Energy due to their delayed screening processes. For the second round of interviews SAWS, Property Company 2, the National Department of Energy and the company which specialises in calculating Carbon did not take part. Property Company 2 did not respond and the company which specialises in calculating Carbon explained that they do not specialise in green buildings therefore it was determined by the researcher that there input would not be of much value. The table below shows the stakeholders secured for the interviews.

Table 2: Stakeholders Interviewed for the Study

Informant	Organisation	Position
A B C D	Property Company 1	Sustainability Manager Sustainability Manager Sustainabiltiy Specialist (Project Implementation and Management) Sustainabiltiy Specialist (Project Implementation and Management)
E	Property Company 2	Head of Facilities
F	Property Company 3	Managing Director
G	Academic Expert at tertiary institution	Senior Lecturer: Department of Architecture
H I	GBCSA	Sustainability Advocate and Educator Business Development and Key Accounts Specialist
J K	GDARD	Deputy Director: Climate Change and Research Development Chief Mechanical Engineer

L	GDID	Mechanical Engineer: Green Technology
M	CSIR	Professional Architect; MA Smart Places Cluster
N O P	Environmental Consultant	Owner and Director Sustainability Consultant Sustainability Consultant
Q	Banking Institution	Property Portfolio Manager
R	City of Johannesburg	Programme Advisor, New Building Efficiency for City of Johannesburg
S	City Power	Chief Engineer for renewable energy
T	Company which specialises in Carbon measurements	Co-founder

Source: Field based surveys

It is important to note that throughout the course of the study some interviewees left the organisations they were working for and others stopped responding as well. Therefore, only the responses of the interviewees who continued to take part in the study could be captured.

Purposive sampling was applied to select the buildings to be used in the study. It was deemed suitable as characteristics, as well as ease of access to the buildings and the objectives of the study were the main concerns of the research. Furthermore, purposive sampling is useful in a mixed-method study as the research required that the target sample be reached quickly (Crossman 2020).

The targeted sample was 6 buildings. They were acquired using the buildings' characteristics in their case studies on the GBCSA's web site. The characteristics of the buildings used for the research are their rating, which was 4-star rating, and size. The rating tool selected was the EBP-V1 Tool as the GBCSA indicated to the researcher that the sample of buildings that the researcher was investigating were certified according to the EBP-V1 Tool as they are existing, retrofitted office buildings. The researcher was eventually provided with data for 8 buildings. Property Group 1 provided data for 6 of their buildings and Property Group 2 provided data for 2 of their buildings. Eventually, only 3 of the 8 buildings were utilised for the research as the other 5 buildings had incomplete datasets. These buildings all belonged to Property Group 1. Thus only 3 buildings were investigated.

The characteristics of interest and importance of these buildings are as follows: all three buildings are certified retrofitted buildings of office use however Building G also has a gym and eateries. They are all between 8500m² and 9110m². Building G increased in size. Buildings C and D are both 2 floors high with external and basement parking and multiple tenants. Building G has 8 floors of lettable office area which are fully air-conditioned with multiple tenants. Similar to Buildings C and D, it also has open and closed parking. In contrast to Buildings C and D which are located in more suburban areas, Building G is located in the middle of the Rosebank CBD. The size of a building gives the overall environmental footprint of the building however the number of floors gives an indication of how many tenants the building can accommodate. Thus, it is important to compare and contrast these distinguishing characteristics of the buildings as they are important in determining the performance of the buildings when considering their consumption of energy and emissions of Carbon. Two buildings may be the same size however their energy consumption may differ due to the different amounts of floor levels and occupants. The more floors a building has the more tenants a building will have. Therefore, Building G's energy consumption and Carbon emissions may be very different to Building C and Building D. Furthermore, the geographic location of the building can also play a part in the energy consumption of buildings. Buildings C and D which are located in cooler and more suburban areas may absorb less heat than Building G which is located in the Rosebank CBD. Therefore, Building G may consume more energy. Furthermore, the use of the buildings is important. Although all three are primarily of office use Building G also has a gym and eateries. This distinguishes it from Building C and D and may contribute to its energy consumption.

In addition, the snowball technique was employed. This kind of sampling relies on the referral from one informant to another creating the opportunity to add additional respondents who are knowledgeable about the research, but may not be easily accessible (Dawson 2013 and O'Leary, 2004). This technique was particularly useful for getting hold of officials in the institutions identified for this study who may be rare to find or difficult to approach but are knowledgeable and thus crucial for the research (Alvi 2016).

3.5.2 Data Collection Tools

According to Creswell (2009a) a data collection instrument can be described as an instrument used in research to calculate, examine or report data. Data collection is a crucial part of any research study therefore it was important that for this research appropriate data collection tools were used for data collection.

This section discusses the data collection tools that were utilized for this study. The tools that are selected for the purpose of this study are the GBCSA's EBP V1 Tool, data collection template, GBCSA's website, interview guides and relevant literature and legislation.

3.5.2.1 Green Building Council of South Africa's Existing Building Performance Rating Tool V1

The rating tool used to rate retrofitted certified green buildings of office use is the EBP V1 Tool (Existing Building Performance V1 Tool Technical Manual 2014). Its intention is to objectively measure and rate the continuous environmental performance of existing buildings ((Existing Building Performance V1 Tool Technical Manual 2014).

Table 3: Green Star South Africa – Existing Building Performance Rating Bands

Overall Score	Rating	Represents
10-19	One Star	Approaching a Better, Greener Building
20-29	Two Star	Approaching a Better, Greener Building
30-44	Three Star	Good in terms of Practice
45-59	Four Star	Best in terms of Practice
60-74	Five Star	Excellence in terms of South African Standards
75+	Six Star	Excellence in terms of World Leadership

Source: Existing Building Performance V1 Tool Technical Manual (2014)

The EBP V1 Tool was used to identify the buildings to be used for this study. The GBCSA referred the researcher to the tool as it is the one which is used to certify buildings which were being studied for this research which are retrofitted certified green buildings of office use. According to the EBP V1 Tool, before a building can get certification after retrofitting or modification it must show that any changes made have resulted in improved energy performance and emissions reduction which will qualify it for green certification ((Existing Building Performance V1 Tool Technical Manual 2014). Thus, this tool is applicable to the study. The researcher conducted a manual count of all the office buildings which were certified in the City of Johannesburg utilising the GBCSA's Integrated Annual Report of 2018 and next to these buildings it was listed which tool was used to rate these buildings. Thus, it was simple to identify the buildings to be sampled for the study as next to them in the report it was stated that the EBP V1 Tool was used to certify them. When these buildings were identified their case studies further revealed their rating. Therefore, using table 3 above, which is in the tool, it was determined that 4 star rated buildings will be studied.

A full and detailed description of the EBP V1 Tool's technical manual is accessible on request from the GBCSA or can be purchased from them.

3.5.2.2 Data Collection Template

Three sets of energy consumption data was needed and a data collection template was drawn to collect them. The data collection template is attached as appendix P. The first set of data requested was 12 months benchmark data to give a benchmark of the consumption of energy of the building prior to application for certification. This is known as the benchmark energy data. The second set of data requested was 12 months performance cycle data to show how the building performed in terms of energy consumption during its application to the GBCSA for certification. This is called the certification data and during this cycle the building has to demonstrate lower energy consumption levels. The third is 12 months post certification energy consumption data to assess whether the building has maintained and/or improved on its energy consumption and emissions after achieving its certification. The occupancy rate of the building as well as the total floor area of the building was also requested as to qualify for certification the building must demonstrate that it has been in operation for at least 12 months and be 70% occupied.

3.5.2.3 Green Building Council of South Africa Website

The GBCSA has uploaded all the information on Green Star certified buildings on to their website. The website serves as a very useful and informative tool as it provides very detailed and valuable information pertinent to the study such as the project profiles of each certified green building. These are accessed via a link to the project directory which is a database which gives information and insight into the rated projects (GBCSA 2020). When the project directory link is opened it gives three further links; the rating tool used for certification of the building, the status of the building (whether it is certified/registered) and the province it can be found. These can be used to access the case studies of the buildings which have further important information such as the address of the buildings, how many points and stars they achieved, how much each credit contributed, a brief description of the buildings and the area surrounding them, sustainable building features, project team (owner of the building, accredited professional who worked on getting the building certified, sustainable building consultant who worked on getting the building certified and the project manager) as well as the floor areas [total gross floor area (GFA), total gross lettable area (GLA) and car parking area]. This information is important to the research as it was used to select the certified green buildings researched for this study.

3.5.2.4 Note Books

Interviews involve the researcher orally asking questions to individuals who then respond orally to the questions asked (Thomas 2003). Wisker (2008) states that interviews allow a researcher to personally interact with the subjects of the research and to acquire a thorough understanding of the perceptions, attitudes and contextual information that exists.

Structured interviews are composed of a clear set of pre-determined questions asked in a particular order with the aim of the interviews being standardization sans improvisation (O'Leary, 2004). Initially although only structured interviews were intended to be used for this study, semi-structured interviews were also carried out with all stakeholders to encourage open discussion and sharing of information otherwise not covered in the interview questions. There were specific data, energy usage and emissions data required from these interviews, therefore questions asked included specific ones for each respondent. Note books were used to take notes and write the responses of the interviewees to the questions posed in the interview guides throughout the study. As two rounds of interviews were conducted for the study, two sets of interview guides were drawn up. The first interview guide presented different questions to different stakeholders. The function of this first interview was to capture the specific and unique characteristics of their organisation, what their role is in terms of the green building industry in South Africa and their unique perception of green buildings and the future of the green building industry in the country. The second interview guide had uniform questions for all the stakeholders. They were mainly structured around the research questions of the study to and the various perspectives and information from the stakeholders captured.

3.5.2.5 Documentary review of existing data

The use of documentary methods refers to the analysis of existing documents that contain information about the phenomenon which are to be studied (Mogalakwe 2006). Mogalakwe (2006) further argues that the review of documents is just as effective and can be even more affordable than social and scientific surveys, face to face interviews or participant observation. In support of this, (Andrews et al 2012) state that with the present trend of researchers globally collecting vast amounts of data and archiving them becoming more prevalent, it is only practical to utilise existing data for research. Two types of documents are used in documentary study: primary documents and secondary documents (Mogalakwe 2006). Primary documents are compiled by referring to first-hand accounts produced by people who experienced the specific event or behaviour which is to be studied (Mogalakwe 2006). Secondary documents are documents produced by individuals who were not at the scene but who received first-hand accounts to put together the documents (Bailey 1994).

The investigation used existing literature, building performance rating tools and existing legislation and institutional frameworks to develop an inference at the end of the research. The approach to this qualitative aspect of the research is rapid appraisal. According to Beebe (1995:42) 'rapid appraisal is an approach for developing a preliminary, qualitative understanding of a situation'. The method is chosen due to the time constraints of the study as well as the fact that it is flexible but rigorous (Beebe 1995). The approach of rapid appraisal which was used for this investigation was iterative qualitative data collection and analysis (Beebe 1995). This study utilised and reviewed secondary documents to develop a hypothesis at the end of the research. Existing data such as government policies, plans, programmes and strategies around climate change and climate change mitigation, climate variability, energy consumption, Carbon emissions, the construction industry, green buildings and certification as well as global, national and local overarching legislative frameworks and agreements related to this were reviewed. The EBP V1 building rating tool was also reviewed. It also looked at the existing academic literature and peer reviewed articles about the above listed topics to further understand the phenomenon under investigation. This was done mainly through desktop research using internet search engines such as google, and academic search *engines such as Ebscohost and Jstor as well as the legislative and institutional frameworks given or referred by the stakeholders who were involved in the study to the researcher.

A convergent parallel mixed methods study approach was used to collect, analyse and interpret the quantitative and qualitative data. Whilst qualitative data was being sourced via interviews, quantitative data was also being sourced from property companies and SAWS. In addition to this documentary collection and review of existing literature, legislation, building performance tools etc was done via rapid appraisal. In the end, once all the data was received, the qualitative and quantitative databases were integrated for data analysis.

3.6 Data analysis

Data analysis is the central step in both qualitative and quantitative research (Flik 2014). Regardless of what type of data is collected, the decisive analysis of that data is what forms the outcome of the research (Flik 2014). Furthermore, Shamoo and Resnik (2003) define data analysis as the procedure of applying statistical techniques to delineate and demonstrate, condense and recap, and assess data. According to Shamoo and Resnik (2003), analytic procedures offer a way of drawing inductive interpretations from data and differentiating the phenomenon of interest from the statistical fluctuations present in the data. This study is a mixed methods research. Data analysis in mixed methods research is comprised of the separate analysis of both quantitative data using quantitative methods and the qualitative data using qualitative methods (Creswell and Clark 2018). Furthermore, Creswell and Clark (2018) further explain that mixed methods analysis involves the combination of both quantitative and qualitative databases which integrate quantitative and qualitative data analysis.

A combination of quantitative and qualitative approaches was used in the data analysis. The method of qualitative analysis used was rapid appraisal. The data obtained from the interview guides from the stakeholders which comprised of both closed and open-ended questions were coded and the researcher searched for similar themes in the responses received. Coding was carried out utilising the Microsoft Excel spreadsheet package. This information was used to determine the outcome of the first question which was to determine the main factors which increase energy consumption and emissions in buildings as well as the fourth question which was to determine how the green building phenomenon can influence and incentivise the construction industry in South Africa. The stakeholders' responses were tabulated and percentages worked out to determine the most common factors increasing energy consumption and emissions in buildings as well as the incentives and influence on the construction industry which was used to answer question 4.

Rapid appraisal was also used to analyse the legislation and institutional frameworks. The existing legislation was analysed and the relevant items of legislation for the study were extracted and critiqued. The researcher considered if the existing legislative and institutional frameworks covered all aspects of climate change, green buildings, energy efficiency and Carbon emissions. The legislation analysed which was relevant for the study was the Constitution of the country, the Carbon Tax Act 2019, the building codes and standards which deal with energy efficiency and green building which are the building standards SANS 10400-XA standard and SANS 204. SANS 10400-XA is enforceable in terms of the National Building Regulations and Building Standards

Act whilst the SANS 204 building standard is still voluntary. Other legislative frameworks was the National Energy Act 34 of 2008, the City of Johannesburg's Green Building Policy and Green Building by-laws as well as the EBP V1 Tool.

The method of quantitative analysis of the data analysis used was a descriptive method. This method was used to analyse the tool and the energy consumption and Carbon emissions of green buildings. The first part involved the analysis of the EBP V1 Tool. The purpose of analysing this tool is to determine whether its application and achieving certification through it continues to influence the performance of green buildings increasing their energy efficiency and to maintain or reduce their Carbon footprint. Several factors were considered; whether the tool enhances performance, the ease of applying the tool, the expense of applying the tool, the quality of the tool, how easy it is to understand and the preference of the tool over other tools. This was done to determine the efficacy of the tool.

The second (quantitative) part of the third question of the research was to look at the actual performance of the buildings with regards to energy efficiency and Carbon emissions. For this, data of energy consumption of each green building over a 36-month period was analysed. The data represented the pre-certified 12 months benchmark data, the 12-month certification cycle and the 12 month post-certification cycle. The data was stored in an excel spreadsheet. Other data provided in the spreadsheet was the occupation of the buildings in percentage and the source of power which was electricity. First the energy consumption data was converted into MWh from kWh using the following formula: $M=K/1000$

Where:

M is the energy consumption in MWh

K is the energy consumption in kWh

1000 is the conversion factor

It was necessary to convert the energy consumption to MWh in order to calculate the Carbon emissions. Property Company 1 which provided the data for the 3 buildings also provided their Carbon emission factor used to calculate the amount of Carbon emissions from their buildings. It is a standard figure of 0.95tCO_2e/ MWh. The equation used to calculate the Carbon emissions is:

tCO_2e=CE x EC

Where:

tCO_2 is the amount of Carbon Emissions in tonnes

CE is the Carbon Emission Factor/Megawatt hour

EC is the energy consumption for the metering period

All the data, including total figures for the energy consumption and Carbon emissions were tabulated. The figures for the energy consumption were provided to the researcher via an excel spreadsheet and the data collection template. The researcher constructed a table in excel which included all information for all three buildings utilised for this study. Five main columns were created: first for the period in months (from 1-12), the second for the data period (benchmark, certification, post certification) and the remaining three for Buildings C, D and G respectively. Under the columns for the buildings, 5 further sub-columns were created for the metering period (exact monthly date), energy consumption for each metering period converted into MWh, calculated Carbon emissions for each metering period expressed as tCO2e, occupational percentage for each metering period and temperature provided by SAWS for each metering period in °C. The metering period for each building is linked to the periods column. Forty-one rows were created for the table. The first two rows accommodated the headings of the columns. For each data period, 12 rows were created to accommodate the 12 consecutive month periods and the final 3 rows were for the totals of the sub-columns under each building. Three sets of graphs were then produced. The first was for energy consumption against temperature for all three periods;

benchmark, certification and post-certification. This was done to see any trends and relationship to determine if energy consumption of buildings are affected by temperature. The second set of graphs analysed energy consumption against Carbon emissions for all three periods. And the last set of graphs analysed Carbon emissions against temperature. Furthermore, the buildings were compared to each other to see if there are any notable differences or similarities in their energy consumption and Carbon emissions and how they react to temperature. Another calculation done in the study was for annual energy consumption for the buildings during their benchmark period. This was calculated to determine whether the buildings were performing within the maximum threshold of their energy consumption as stipulated in SANS 10400-XA. Therefore, in order to calculate this, the following equation was used:

$kWh/m^2/a = kWh/GLA$

Where:

$kWh/m^2/a$ = the annual energy consumption per m^2 for the buildings

GLA = the Gross Lettable Area in m^2

kWh = the energy consumption of the buildings in kWh

The equation is a calculation of the total energy consumption per annum of the buildings divided by the gross lettable area in m^2. This provides the energy consumption of the buildings in m^2/a. To calculate the category scores in the Green Star SA Scoring System illustrated by figure 12 under Chapter 4 the following equation was used: Category Score=(Points achieved /Total points achievable for the category) x 100

Where:

The Category Score=the score for an environmental category expressed as a percentage

The Points Achieved=the points which have been achieved for an environmental category during assessment for certification

The Total Points Achievable for the Category=the maximum allocated points which can be achieved for the category as illustrated in the tool

This was significant for the study as the calculation of the category scores is one of the key steps which lead to the final rating of the building.

The information received from the interviews was then transcribed for coding and Microsoft Excel was used. Despite the high number of stakeholders who initially took part in the study, as mentioned before, throughout the study some left their organisations, some stopped responding and only some responded to questions. All these were factors which were out of the control of the researcher. In order to present the results in the most logical and accurate manner it was decided that graphs would be used for the responses received. It must be noted that all the calculations, graphs and tables were done in Microsoft excel. The calculations for percentages were done using the Microsoft excel equation for working out percentages.

To answer the first research question, the main factors which increase energy consumption and emissions in buildings, the factors were separated into four main factors: general, specific, internal and external. Respondents gave sub-factors for each main factor which contribute as identified in the graphs in Chapter 4 under section 4.2. As this was an open ended question, respondents could give multiple responses per factor i.e a respondent could give multiple sub-factors under the main factor general. All the most similar responses were collected and then tallied. In Microsoft excel, a spreadsheet was opened to capture the information. For each different research question, a different page was created. For each main factor, 3 columns were allocated and a total row at the bottom. The 3 columns were for name of sub-factor, the second column was for how many times it was mentioned and the third column converted this into a percentage. The total row at the bottom added up both the second column, which was for the total number of responses received, and the third column being 100%. To get the percentages for each sub-factor, the amount of times a sub-factor was mentioned was divided by the total responses and multiplied by a 100 i.e under the general factors, building use type was mentioned four times as a sub-factor which increases energy consumption and Carbon emissions in buildings. For this research question, 12 responses were received so the number 4 was divided by 12, and then multiplied by a 100 which gave the percentage of 33.333…….%. The calculations were all done in excel and rounded off to the 2nd denominator. Bar graphs were then drawn. This was repeated for all the main factors.

For the third research question, under the first section which looks at the Building performance Rating tools and their impact on the performance of green buildings, in order to work out the values in table 9 which looked at factors which influence the efficacy of the tool the type of factors were listed and presented to the respondents and all they had to do was answer yes (Y), no (N), no response (NR) or not applicable (N/A). The number of respondents who took part were 12 therefore it was decided that the sample size would be 12. A spreadsheet was opened in excel and 11 columns were created. The first column created was for the number of factors, the second was for the type of factors, the third was for the sample size and the last 8 were for the responses yes (Y), no (N), no response (NR) or not applicable (N/A). Furthermore, under each response there were 2 columns: one for the manual count of the response and the second column converting this into a percentage. The percentage was derived from dividing the number of counts under the specific response and dividing it by the sample size and multiplying by a 100. For example, under the first factor 'enhances performance' the manual count of the responses under 'Y' was 6. This was divided by the sample size and then multiplied by a 100 to get the percentage of 50%. The calculations were done in Microsoft excel and rounded off to the 2nd denominator. The researcher decided to also use percentages for accuracy. The results were then tabulated in excel.

Under the second section of the third research question, in terms of analysing the impact of certification on the performance of the buildings, the energy consumption data for the buildings utilised in the study was provided by Property Company 1 in Microsoft excel. Separate sheets were created for the table, and to create the 3 sets of graphs which looks at energy consumption against temperature, energy consumption against Carbon emissions and Carbon emissions against temperature in the benchmark, certification and post-certification periods. The only figures to calculate were the Carbon emissions and this was done using Property Company 1's emission factor which they use for all their buildings. All the data was then tabulated and for each period a total row was added to add up the energy consumption and Carbon emissions. The other columns in the table were a number column, column for months, metering period, data period, occupation rate and temperature for each building C, D and G. For each set of data, combination graphs were constructed in excel with two axes showing the two sets of data in relation to each other so trends could be observed.

For the 4th research question, on the influence of the green building phenomenon on the construction industry, like research question 1 this was also an open-ended question so respondents could answer multiple times. The respondents were asked if it was positively, negatively or neutrally impacted. Some answered both positive and negative and gave reasons why so the same process was used like question 1 to code the data. A spreadsheet was created in excel to calculate the percentages of the manual counts. In order to do this for each response option, positive, negative or neutral the number of responses from the respondents who took part were added. The manual count per response option was then divided by the total number of responses and multiplied by a 100 to get the perentages of each response option. The data was then graphed. All The calculations were done in excel.

For the graphs which were constructed which show the incentives for construction green buildings in South Africa per sector it was also an open-ended question and the respondents were given the opportunity to list the incentives given by government, private sector and NGO's respectively. The most common incentives were noted and again a manual count was done to determine the total number of responses received. A table was created where all the data was input. The number of the individual incentives received was then divided by the total number of responses and then multiplied by a 100 to get a percentage. The results were then expressed as pie charts. The percentages which were worked out in the table which illustrated further incentives which could be implemented to enhance green building in the country were worked out with the researcher deciding to tabulate the results due to the long list of incentives provided. Since only 11 respondents responded to this question the sample size was 11. The respondents were given the opportunity to answer Y(yes), NR (no response) and N/A (not applicable). They were then given the opportunity to mention the type of incentives. The most common ones where identified and then tabulated with the manual count of the responses. Using the Microsoft excel calculation function the percentages were then calculated per response per incentive. Interestingly, the figures for each response Y, N, N/A was the same for each respondent.

3.7 Methodological Reflections

The researcher is a fulltime employee at GDARD which is also funding her studies. Therefore, the researcher embarked on her studies on a part-time basis. The researcher was expected to excel in doing her job and to succeed in her studies. The researcher had to self-finance the data collection process in terms of travelling costs to the various stakeholders to conduct interviews for the research. The researcher conducted the data collection process individually as the sample size was not large. Fortunately for the researcher the stakeholders involved in the study had expertise in the field of the research being conducted.

The first step that the researcher undertook before engaging with the stakeholders was to telephone them directly having gleaned their information from a desktop research. The telephonic information given led the researcher to the relevant person/people necessary for the study and the researcher either spoke to them directly or was given their emails to contact them. The researcher also contacted the Sandton Central City Improvement District manager when the research was still only based within the Sandton CBD and the Wider Sandton Node. The manager contacted the heads of utilities of various certified green buildings on behalf of the researcher and provided crucial information of heads of utilities of 3 companies who were owners of certified green buildings who were contacted. Of these three, 2 participated in the research. The researcher found that the process which worked very well in getting stakeholders to take part was to draft 'request for permission to take part in study' letters which were emailed to prospective stakeholders. The letters detailed what the study was about and what would be expected from the stakeholders. Furthermore, the letters also detailed how the prospective stakeholders would benefit from this study. This strategy worked very well in terms of getting all the stakeholders on board with the study as they saw how partaking in the study would add value to this particular field of research and be beneficial to them as well. In response, the stakeholders issued letters of confirmation.

The stakeholders which took part in the research included sector departments GDARD, the GDID, as well as other institutions such as a company which specialises in calculating Carbon from buildings, the bank, academic experts, the GBCSA, environmental consultants, the CSIR, the City of Johannnesburg, City Power, SAWS as well as the 3 property companies, known as Property Company 1, Property Company 2 and Property Company 3. All the stakeholders except the bank and the company which specialises in calculating Carbon from buildings issued formal letters of permission agreeing to form a part of the research as they did not provide energy consumption data. SAWS, as a public entity also gave the researcher data without requesting a permission letter as they deemed it an academic study. Although 3 property companies eventually took part in the study, the first biggest challenge was to get property companies on board. The GBCSA and environmental consultant revealed to the researcher that companies which own certified green buildings are the custodians of energy consumption data therefore that information could only be supplied by them. Initially some companies agreed to be part of the study but then declined to respond to correspondences. A big part of the challenge was that the study was researching retrofitted existing buildings of office use certified using the EBP V1 Tool, and not all the property companies own and manage these types of buildings certified using this tool. Therefore, the researcher resolved this by further communicating with the GBCSA who advised the researcher to refer to their annual report which lists all the certified buildings on the continent by usage type, certification tool used, certification date, whether it is new or existing and most importantly, ownership of the building. From here, the researcher was eventually able to identify the property companies who could take part in the study and after communicating with them via email and sending them permissions letters, eventually secured participation by Property Company 1, 2 and 3. As Property Company 1 and 2 gave the researcher data, the researcher was obliged to sign non-disclosure agreements. This was due to the sensitivity and confidentiality of the information of their buildings as they needed to protect it. The next aspect of the challenge faced by the study was to retrieve energy consumption data from the participating property companies. The challenge faced was twofold: the first challenge was getting hold of the facilities managers and their teams as they are very busy and as the companies manage a large portfolio of buildings they were often on site and out of the office. The second problem was the retrieval of the actual data itself because according to the facilities managers; it takes quite some time to retrieve the energy consumption data itself as part of it is historical data. As there were multiple buildings involved, this would also require a coordinated process. To overcome this, the researcher exercised patience and continued to communicate with the property companies and their teams about getting data until they were available and able to.

Data collection and information collection in the form of face-to-face interviews was mainly conducted. It was decided that an interview with City Power in Johannesburg will be conducted as opposed with the National Department of Energy as the researcher was finding difficulties with being vetted by the department which is compulsory for all external clients according to that department's law. The reason given to the researcher for this was that the State Security Agency in charge of vetting of individuals was experiencing technical constraints thereby delaying the process. Therefore, the issue was resolved when the department agreed that the researcher be allowed to use information they have published publicly. Although the researcher had pre-selected the green buildings for which data would be requested, Property Group 1 informed the researcher that they would decide which buildings of theirs would be utilised in the research. This was to avoid bias in the study. Therefore, the researcher then requested the property company to ensure that the buildings for which they would provide energy consumption data were as similar as possible in order to make an accurate analysis and comparison in the study. The interviews were highly successful as the stakeholders are particularly knowledgeable about their respective fields of study and their expertise in the role they fulfil in the green building process. Follow up interviews were conducted to conclude the data collection process.

The researcher made one amendment to the research. The researcher expanded the geographical area of the research to the City of Johannesburg as the initial lottery to draw which green buildings to approach for the study and a subsequent desktop analysis of them showed that a significant number of them in the area of Sandton City and the Broader Sandton Node are new builds. Furthermore, the researcher found that there are many other buildings which are retrofitted certified green buildings relevant to the study located in other parts of the City of Johannesburg. The researcher found out, through consultation with the City of Johannesburg and the GBCSA that this will not change the scope of the study as the City of Johannesburg falls under one climatic temporal zone and energy consumption of buildings is something which also emanates internally. Therefore, the title of the research was changed from *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of Sandton and the broader Sandton Node* to *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg* .The researcher is optimistic that the chosen methodology will answer the question of the research and has found that all facets of the green building industry (private, government, non-profit organisations, research councils etc.) are highly professional, expert and driven, and is pleased with the willingness of stakeholders to help. The industry continues to develop in South Africa, however much ground has been gained in the country especially in mega city centres such as the City of Johannesburg which makes it part of the global leaders in green building. Furthermore, the researcher has learned the importance not just of self-educating and research, but also the skill of building human interpersonal-relationships, patience, being professional and respecting meeting commitments and time as the stakeholders involved are all professionals in their field who are very busy and have generously contributed to the research. The researcher continues to learn the social skills of making people feel comfortable around oneself, valuing their input into the study and gratitude.

CHAPTER FOUR

EMPIRICAL EVIDENCE

4.1 Introduction

This chapter is dedicated to presenting the findings of this study, which were obtained from the data collection phase. It is important to present and discuss the views obtained from the research participants. Each section speaks to the findings of the data collection. The first section is dedicated to presenting the main factors which increase energy consumption and emissions in buildings. The purpose of this is to provide precise knowledge of the factors which drive energy consumption and emissions of buildings and the extent to which these factors play a role in doing this. The second section is dedicated to presenting the existing legislation and institutional frameworks in South Africa which promote the development and implementation of green buildings. The purpose of this is to provide further understanding of the importance of the application of legislative and institutional frameworks in the implementation of green buildings. Thereafter, the influence of applying building rating performance tools and receiving certification on the performance of green buildings in terms of energy efficiency and Carbon reductions is presented. The purpose of this is to determine whether rating tools are effective in making buildings more environmentally efficient. Lastly, reflection is done on the influence that the green building phenomenon has had on the construction industry in the country. The importance of this is firstly to determine how pervasive green building currently is in the country and how the building industry has been impacted. In view of the above, this chapter is structured around the research questions, which were asked in *section 1.3* of this dissertation.

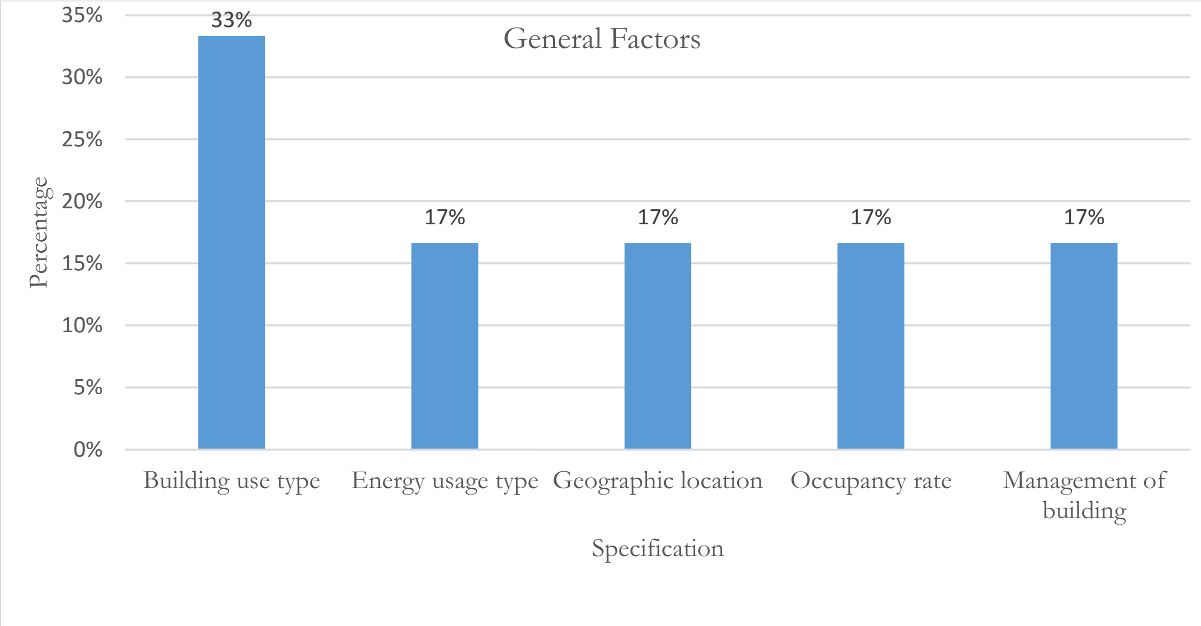
4.2 Factors Contributing to Increased Energy Consumption and Carbon Emissions in Buildings in the Research Sites.

This section was interested in identifying which factors contribute to increased energy consumption and Carbon emissions in buildings. For this part of the study, the researcher used open ended questions and used thematic analysis to derive the most important factors and sub-factors concerning energy consumption and Carbon emissions in buildings. The question posed to the stakeholders was 'what are the main factors which increase energy consumption and emissions in buildings?' The question was further subdivided into general, specific, internal and external. The main factors were categorised into general, specific, internal and external. The results below indicate the responses of the stakeholders proving that there are a range of sub factors, which fall under each main factor, which contribute to increased consumption of energy in buildings and emissions of Carbon. In this section, multiple participants identified the same sub-factors for each category of main factors. Therefore, it was decided that the sub-factors would be graphed. In view of this, the participants were asked which factors contribute to enhanced energy consumption and Carbon emissions in buildings. The figures below outline their responses.

4.2.1 The General Factors Contributing to Increased Energy Consumption and Carbon Emissions in Buildings in the Research Sites.

The first aspect of this section of the study focused on the general factors which increase energy consumption and Carbon emissions in buildings as identified by the participants. This was important to establish the overall main reasons why buildings consume more energy and emit more Carbon. Furthermore, the specific, internal and external factors could also be linked to the general factors.

Figure 7: A Graph illustrating the General Factors which Increase Energy Consumption and Carbon Emissions in Buildings in the Research Sites.



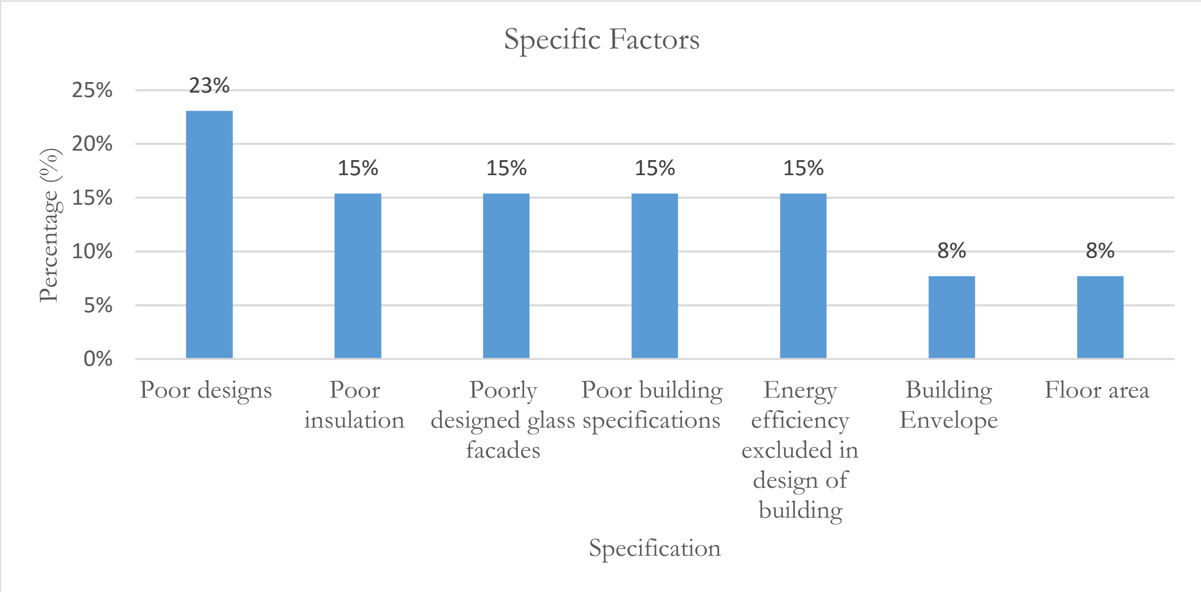
Source: Based on fieldbased surveys (2019, 2020)

The first question was interested in identifying the main factors and associated subfactors which are the most responsible for increasing energy consumption and Carbon emissions in buildings. This subsection explores the general factors. Based on the data presented in Figure 7 it is suggestive that the sub-factor identified by the research participants as the most responsible for increasing energy consumption and Carbon emissions in buildings was building use type at 33%. Followed by this, the sub-factors energy usage type, management of the building, occupancy rate and geographic location contributed equally at 17%.each.

4.2.2 The Specific Factors Contributing to Increased Energy Consumption and Carbon Emissions in Buildings in the Research Sites.

This section focused on the specific factors which contribute to increased energy consumption and Carbon emissions in buildings. This section was critical to the study as the responses received from the participants focused on technical aspects of the building. As the study is focused on certified retrofitted existing office buildings, the impact of the specific factors would be particularly interesting as efficiency measures in this case would be done mainly through building modifications. As all 3 buildings utilised in this study underwent retrofits it would be interesting to uncover to what extent these impacted the energy consumption and Carbon emissions of the buildings and whether they were part of the factors identified by the participants.

Figure 8: A Graph illustrating the Specific Factors which Increase Energy Consumption and Carbon Emissions in Buildings in the Research Sites.



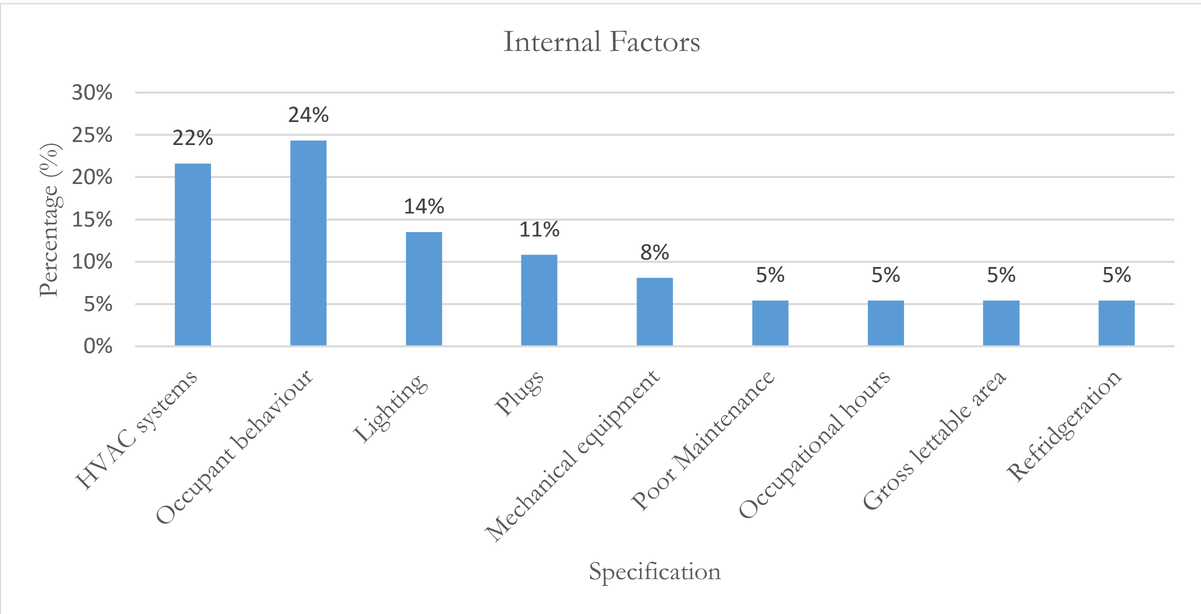
Source: Based on fieldbased surveys (2019, 2020)

This subsection illustrates the specific factors which contribute to increased energy consumption and Carbon emissions in buildings. It is interesting to note that there are more sub-factors in the specific category as compared to the general category. As presented in Figure 8, the participants identified the sub-factors as contributing almost equally to each other in terms of increased energy consumption and Carbon emissions in buildings. In contrast to the general factors, the specific factors allude more to the technical aspects of the building. Based on the data presented it is suggestive that the sub-factor identified by the participants as contributing the most in this category is the poor design of the building at 23%. Followed by this, the sub-factors poor insulation, poorly designed glass facades, poor building specifications and 'energy efficiency being excluded in design of the building' were identified as being equal to each other in terms of contributing to increased energy consumption and Carbon emissions in buildings at 15% each. The final two specific sub-factors which were identified by the participants as contributing the least to the increase of energy consumption and Carbon emissions were building envelope and floor area at 8% each.

4.2.3 The Internal Factors Contributing to Increased Energy Consumption and Carbon Emissions in Buildings in the Research Sites.

The graph below illustrates the internal factors which were identified by all the participants as increasing energy consumption and Carbon emissions in buildings. It was important to discover these as they are greatly linked to the usage of the building, which has been identified as one of the general factors which drive up consumption and emissions in buildings. Furthermore, in order to discover how buildings consume energy and emit Carbon, it is important to identify how they are utilised internally as the study is focused on the operational lifecycle of the building.

Figure 9: A Graph illustrating the Internal Factors which Increase Energy Consumption and Carbon Emissions in Buildings in the Research Sites.



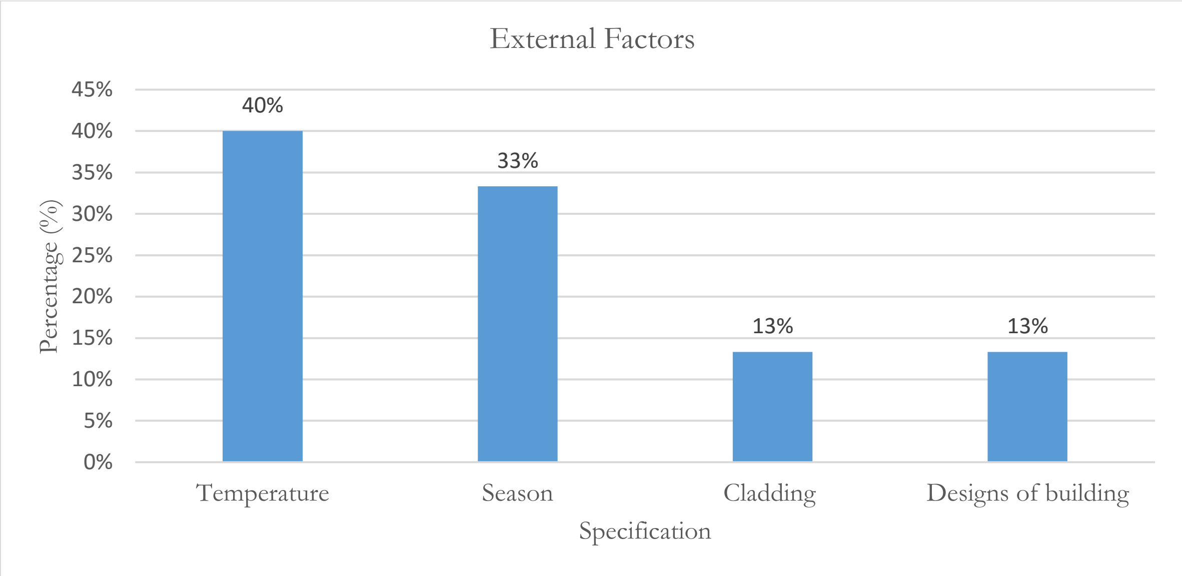
Source: Based on fieldbased surveys (2019, 2020)

This subsection illustrates the internal factors which contribute to increased energy consumption and Carbon emissions in buildings. Based on the data presented in Figure 9, there are many internal sub-factors which the participants identified as contributing to increased energy consumption and Carbon emissions. Internally occupant behaviour is most responsible at 24%. Followed by this, the sub-factor HVAC systems was identified as the second highest in terms of contributing to increased energy consumption and Carbon emissions in buildings internally at 22%. Lighting and plugs were the 3rd and 4th sub-factors identified by the participants as contributing to increased energy consumption and Carbon emissions in buildings internally at 14% and 11% respectively. Mechanical equipment was the next identified internal factor at 8% and includes elevators, escalators and plumbing equipment. The final four internal sub-factors which were identified by the participants as contributing the least to the increase of energy consumption and Carbon emissions were poor maintenance, occupational hours, gross lettable area and refrigeration at 5% each respectively.

4.2.4 The External Factors Contributing to Increased Energy Consumption and Carbon Emissions in Buildings in the Research Sites.

The graph below illustrates the external factors which were identified by all the participants as increasing energy consumption and Carbon emissions in buildings. It was important to discover these as there could be a link with the internal factors. The premise of this is that how the building is used by the occupants, including equipment like HVAC systems and lighting, may be influenced by external factors. Therefore, in order to make the building functional, occupants may adjust their usage internally to cope with external factors which they may not be able to control.

Figure 10: A Graph illustrating the External Factors which Increase Energy Consumption and Carbon Emissions in Buildings in the Research Sites.



Source: Based on fieldbased surveys (2019, 2020)

This section illustrates the external factors which contribute to increased energy consumption and Carbon emissions in buildings. Based on the data presented in Figure 10, there are four main sub-factors which the participants identified as contributing to increased energy consumption and Carbon emissions. It is suggestive that the sub-factor identified by the participants as contributing to increased energy consumption and Carbon emissions in buildings the most is temperature at 40%. The second sub-factor which was identified by the research participants as contributing highest externally to the energy consumption of the building and Carbon emissions was seasons at 33%. The last two specific sub-factors which were identified by the participants as contributing the least to the increase of energy consumption and Carbon emissions were cladding and building design at 13% each.

Therefore, it can be surmised from the results obtained above, that the energy consumption and Carbon emissions of buildings are affected from all angles. The most numerous factors are specific and internal factors. There seems to be a correlation between external factors, particularly temperature, and internal factors as the internal use of the building is affected by the temperature outside. Apart from occupancy rate and management of the building, the general factors are quite fixed. This is the same in the case of all the specific factors. This finding has important implications on the energy consumption and Carbon emissions of existing buildings as it suggests that the best measures that can be put in place to make these buildings more efficient is through retrofits.

4.3 Perspectives of Environmental and Building Legislation and Institutional Frameworks in Green Buildings in RSA.

This section was interested in identifying the existing legislation and institutional frameworks which govern energy consumption and Carbon emissions in buildings in South Africa and for the City of Johannesburg. Knowledge of the existing legislation and institutional frameworks was important in order to establish to what extent the various sectors of the country were accountable for ensuring that climate change mitigation efforts, greening of buildings (including certification) as well as reduction in energy consumption and Carbon emissions were being realised. The question posed here was 'whose mandate is it to develop green building legislation, strategies, policies and guidelines?' It was further broken down into government (national, provincial, local), private sector, civil society and NGO's. Furthermore, the follow up question 'is there existing legislation and institutional frameworks in South Africa which have helped promote the development and implementation of green buildings? (Y/N)' was asked for both government and other sectors. The stakeholders were given the opportunity to give the function of the legislation and institutional frameworks if they existed. Finally, the researcher also posed the question 'do other policies, guidelines, strategies exist in South Africa to promote the development and implementation of green buildings? (Y/N)'. The stakeholders were given the opportunity to give the function of the legislation and institutional frameworks if they existed.

Participants from the various sectors in the industry who took part in the study gave legislation and institutional frameworks which were relevant to their professional field so the researcher decided to include all of the responses which were relevant to the study as opposed to compiling graphical responses or numerical counts. The number of participants who took part in this section was 11. One of the participants did not respond to the questions forwarded to them. The main sectors identified were government, private sector and Non-Profit organisations (NPOs). The government sector was further divided into the national, provincial and local sphere. A description of each relevant item of legislation and institutional framework was also provided. The legislation was analysed using the rapid appraisal method.

4.3.1 National Legislation and Institutional Frameworks

The national legislation identified by the participants as relevant to this study is the Constitution of the Republic of South Africa, Act 108 of 1996 (section 24), the Carbon Tax Act 2019, the SANS 10400-XA Building Standard, the SANS 204-1 (2008) Building Standard and the National Energy Act 34 of 2008. All the above are mandatory laws which have to be implemented. Below is a description of the sections of the legislation which were further identified as being relevant to this study:

Perspectives on the Environment in the South African Environmental Legislation

4.3.1.1 The Constitution

In April of 1994 between the 26th and 29th South Africa's first general democratic elections were held (Facing History and Ourselves 2020). Subsequently, the major political parties assembled to draft a new constitution (Facing History and Ourselves 2020). Prior to this, South Africa did not have a democratic constitution and it had no constitutional environmental right (du Plessis 2018). The new Constitution of the Republic of South Africa was approved by the Constitutional Court in 1996 and came into effect in 1997 (Government of South Africa 2020). In order to reverse the negative effects of the country's apartheid past, which included the misuse of natural resources and the environment as well as to solve the current challenge of sustainable development, Section

24 was included in the Constitution (Warnich 2018). It describes the environmental rights in South Africa (Warnich 2018). The environmental rights of the country serve two purposes: firstly they assure a healthy environment to every citizen and secondly they instruct the state to ensure compliance with this (Warnich 2018).

Below is the exact interpretation of Section 24 of the Constitution of South Africa (No 108 of 1996) as contained in the Bill of Rights (The Constitution 1996:9)

Everyone has the right:

(a) to an environment that is not harmful to their health or well-being

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that -

(i) prevent pollution and ecological degradation

(ii) promote conservation

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Section 24 of the Constitution also has International Environmental Law integrated into it which includes the duty of care which states that any individual who has caused considerable damage and pollution to the environment, is causing considerable damage and pollution to the environment or will potentially cause considerable damage and pollution to the environment is obligated to take action to ensure that such pollution and degradation is averted (The Constitution 1996). It also incorporates the polluter must pay principle which states that those who pollute the environment must pay for rectifying the damage to the environment and any health issues which came with the degradation of the environment (The Constitution 1996). It also provides for the cost of future prevention, control and limitation of pollution to the environment to be carried by those who cause harm to the environment (The Constitution 1996).

This section of the Constitution is significant for this study as it is the basis of the acts which are developed to protect the environment as well as develop regulations for implementation. These acts also govern energy and climate change. They are described below. Section 24 of the Constitution further makes provision for a mandate on the government to guarantee environmental protection and ecologically sustainable development (Warnich 2018). This has implications for all economic sectors including the construction sector as its energy intensive operations, Carbon emissions as well as physical footprint makes it one of the most significant polluters. Therefore, in order to fulfil the provisions of a clean environment and just socio-economic development for the citizens of South Africa while also preventing pollution and enhancing sustainable use of natural resources and ecological sustainable development, interventions in the construction industry had to be implemented to make it greener. These interventions include the mandating of the SANS Building Standard SANS 10400-XA (2011) and the creation of the SANS 204-1 (2008) Building Standard, the enaction of the Carbon Tax Act of 2019 and the National Energy Act 34 of 2008. They are discussed in more detail below. The courts and the judiciary fulfil the role of ensuring the enforcement of all these environmental rights, laws and regulations (Warnich 2018).

4.3.1.2 Carbon Tax Act 2019

Emanating from the development of the Constitution of 1996, South Africa has goals to take critical action to counter global warming and its impacts (Warnich 2018). This is being achieved in line with the UNFCCC as South Africa is part of the countries who have ratified international Climate laws such as the Paris Agreement on Climate Change of 2015 (Warnich 2018). As part of its contribution to stabilise and reduce GHG emissions in the atmosphere, taking into account the country's Nationally Determined Contribution commitments under the Paris Agreement of 2015 as well as its goal to transition the country to a sustainable low Carbon economy, the government enacted the Carbon Tax Act of 2019 (Zireva 2020). Through the Carbon Tax Act, South Africa's National Treasury is imposing taxes on activities which release large amounts of GHGs (Zireva 2020). The foundation of the Carbon Tax Act is built on the "polluter pays" principle in the Constitution of South Africa as described above where those who damage the environment are held liable for the cost of remedying it (Zireva 2020). The Carbon Tax Act applies to industries that perform activities above a given threshold as stipulated in Schedule 2 of the Act whereby these activities release large quantities of GHGs (Zireva 2020). In terms of the Act, the monies levied and collected are directed to the National Revenue Fund (Carbon Tax Act 2019).

The participants identified the act as being significant to this study as office buildings which form the basis of this research fall under the commercial/institutional sector which is one of the industries who apply to pay Carbon Tax in the country. Schedule 2 of the Carbon Tax Act is comprised of a table which illustrates the emissions thresholds of the various sectors as shown below: For the sake of this study only the information for the Commercial/Institutional sector is illustrated as it applies to office buildings.

Schedule 2

IPPC Code	Activity/Sector	Threshold	Basic tax-free allowance for fossil fuel combustion emissions %	Basic tax-free allowance for process emissions %	Fugitive emissions allowance %	Trade exposure allowance %	Performance allowance %	Carbon budget allowance %	Offsets allowance %	Maximum total allowances %
1A4a	Commercial/Institutional	10 MW(th)	60%	0	0	10	5	5	10	90

Source: Carbon Tax Act (2019)

The particular section of the table the study is interested in is the threshold column which states that per annum a commercial/institutional building has a threshold of 10MW(th) meaning that should energy combustion exceed that figure, it will be liable to pay Caron Tax (Carbon Tax Act 2019). Furthermore, tax free allowance given for activities which result in energy combustion and emissions is 60% (Carbon Tax Act 2019). This means that for all activities which occur on site which result in energy combustion and consumption as well as emissions, 60% of them are tax free (Carbon Tax Act 2019). Additionally, 10% is allowed for trade exposed activities (Carbon Tax Act 2019). These activities are those conducted by the commercial/institutional building which are vulnerable to competition with other international institutions (Carbon Tax Act 2019). Institutions who are vulnerable are often exporting or importing institutions, of which none of the buildings being researched for this study fall under. The performance allowance for this sector is 5%. The performance allowance refers to the amount of allowance which will be given to institutions etc. which decrease the emissions intensity of their activities (Carbon Tax Act 2019). Similarly, a 5% Carbon budget allowance will also be given (Carbon Tax Act 2019). The Carbon budget allowance will only apply to commercial/institutional buildings etc. which comply with the annual reporting requirements (Carbon Tax Act 2019). A 10% Carbon offset allowance is also given (Carbon Tax Act 2019). A Carbon offset refers to a reduction in Carbon Dioxide emissions from a commercial/ institutional building etc. which is made to compensate for emissions made elsewhere to reduce their tax liability (Carbon Tax Act 2019). All in all, when all the allowances are added up, the maximum total allowance as described in the last column of the table is 90% for companies, institutions, buildings etc. which fall under this sector.

4.3.1.3 SANS 10400-XA:2011

As mentioned before in the study, the built environment is amongst the largest contributors to GHG emissions. Rising concerns about climate change and the cost of energy have resulted in energy becoming a critical aspect to incorporate in building design (City Energy 2020). A large proportion of South Africa's buildings were designed and built when electric power was very affordable, but the increase in the cost of electricity has resulted in buildings becoming less cost-effective to operate (City Energy 2020).

The Constitution of South Africa makes provisions for the environment to be protected and the government has implemented legislation which promotes sustainability (City Energy 2020).

Having observed trends in other countries, South Africa is focusing on enhancing the energy efficiency of existing buildings through retrofitting measures which enhance their energy efficiency as well as ensuring that new buildings are designed in such a way that they maximise energy efficiency (City Energy 2020). This resulted in the mandating of the SANS 10400–XA Building Standard which refers to Energy Usage in Buildings in 2011 (City Energy 2020).

Below is the extracts taken from the building standard which is relevant to this study which addresses building envelope and maximum annual energy consumption. It must be noted that SANS 204-1 which refers to Green Building in South Africa is already built into this standard however one of the participants informed the researcher that it is currently being phased out as the stipulations of SANS 10400-XA have been found to be adequate enough to address those which SANS 204-1 covers (see SANS 10400-XA: 6):

4.2 Energy usage and building envelope

4.2.1 In terms of the building envelope, the functional regulations contained in part XA of the National Building Regulations shall be deemed to be satisfied where,

b) in any building of occupancy classified in terms of Regulation A20 as A1, A2, A3, A4, C1, C2, E1, E2, E3, E4, F1, F2, F3, G1, H1, H2, H3, H4, and H5, the orientation and shading are in accordance with the requirements of SANS 204. The external walls of the buildings must be in accordance with the requirements of 4.4.3. Section 4.4.3 requires that fenestration is in accordance with the requirements of 4.4.4, roof assembly construction is in accordance with the requirements of 4.4.5, if in-slab heating is installed, it is in accordance with the requirements of 4.4.2, and services that use energy or control the use of energy, including heating, air conditioning and mechanical ventilation in accordance with SANS 204, and hot water systems in accordance with the requirements of 4.1 (services exclude cooking facilities and portable appliances).

Regulation A20 refers to the classification and designation of the occupancies of buildings. As the study is focused on office buildings, according to regulation A20 the classification of office buildings is G1. Furthermore, according to table 4 below, the climatic zone which is relevant for the offices being researched in this study is number 1 as it is the climatic zone which the City of Johannesburg falls under (SANS 10000-XA 2011). It is described as the cold interior (SANS 10000-XA 2011). To satisfy the regulation, the orientation and shading of G1 buildings should adhere to the requirements of SANS 204. These include that the maximum energy demand for these buildings should not exceed their stipulated 80V/m², that provisions are made for natural ventilation in the buildings and that efficiency in terms of the implementation of HVAC systems in the buildings is accounted for. Therefore, the orientation and shading of the buildings must make provision for natural ventilation and less use of HVAC systems as well as keep the peak energy demand of the building equal to or below 80V/m².

The external walls of the buildings must be in accordance with the requirements of 4.4.3 which refers to external walls and requirements for masonry walls and non-masonry walls (SANS 10400-XA 2011). Masonry is comprised of building structures from single units which are laid and bound together with mortar (Muresan 2019). Bricks, stone and concrete are the most commonplace materials used in masonry (Muresan 2019). Buildings C and D of the study are built from brick walls. In terms of SANS 10400-XA, other masonry walling types not covered in the building regulation must be in accordance with the SANS 10400-K regulation which covers all the wall types and the requirements they must meet to satisfy the building regulation (SANS 10400-XA 2011). Fenestration should be in accordance with the requirements of part 4.4.4 of SANS 10400-XA. Fenestration refers to the 'arrangement, proportioning and design of the windows and doors in the building' (Merriam-Webster 2020: 1)

To satisfy requirements for the building envelope of SANS 10400-XA, roof assembly construction must adhere to the requirements of 4.4.5 which addresses roof assemblies (SANS 10400-XA 2011).

Should there be in-slab heating it should be in accordance with the requirements of 4.4.2 which covers flooring, particularly under floor heating (SANS 10400-XA 2011). Services that consume energy or control energy consumption such as heating must adhere to the requirements in SANS 204 and hot water systems must comply with 4.1 of SANS 10400-XA which covers hot water supply in buildings (services exclude cooking facilities and portable appliances).

The second part below deals with the energy consumption and efficiency of the buildings.

Table 4- SANS 10400-XA: Maximum annual consumption per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	**Description of building**	**Maximum energy consumption kWh/m2**					
		Climatic zone					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	420	400	440	390	400	420
A2	Theatrical and indoor sport	420	400	440	390	400	420
A3	Places of instruction	420	400	440	390	400	420
A4	Worship	120	115	125	110	115	120
F1	Large shop	240	245	260	240	260	255
G1	Offices	200	190	210	185	190	200
H1	Hotel	650	600	585	600	620	630

1	2	3	4	5	6	7	8
Classification of occupancy of building	**Description of building**	**Maximum energy consumption kWh/m2**					
		Climatic zone					
		1	**2**	**3**	**4**	**5**	**6**
NOTE 1 The annual consumption per square metre shall be based on the sum of the monthly consumption of 12 consecutive months. NOTE 2 Non-electrical consumption, such as fossil fuels, shall be accounted for on a non-renewable primary energy thermal equivalence basis by converting megajoules to kilowatt hours.							
a The climatic zones shall be as given in annex A.							

Source: SANS 10400-XA(2011:8)

The second aspect of SANS 10400-XA which the study is interested in is the energy consumption of buildings. The section of the building standard that the study is interested in is table 4 which has been recreated exactly as it appears in the standard. The table above provides the legislated values for maximum annual consumption figures per building classification in each climatic zone according to SANS 10400-XA. The first column speaks to the classification of occupancy of building. This is the usage type of the building and each building usage type has a specific code. The description of each building is given in the next column to elaborate further on the exact usage of the building. The buildings being researched for this study are office buildings therefore their building classification is G1 and their description is offices. The 3rd to 8th column speak to the climatic zones from 1 to 6 . According to SANS 10400-XA(2011:12) climatic zone 1 is cold interior, climatic zone 2 is temperate interior, climatic zone 3 is hot interior, climatic zone 4 is temperate coastal, climatic zone 5 is sub-tropical coastal and climatic zone 6 is arid interior. Furthermore, for each climatic zone, the threshold energy consumption in kWh/m² is specified for each building type. Since the study is focusing on office buildings in the City of Johannesburg, the building classification is G1 and their climatic zone is 1 which is the cold interior as mentioned above. This is the climatic zone that the City of Johannesburg falls under. For G1 buildings which fall under the 1st climatic zone, the maximum annual consumption energy threshold is 200 kWh/m^2. One of the participants said that measurements of energy demand is a stipulation for certification however, due to the fact that the research is focused on actual annual energy consumption and Carbon emissions in retrofitted certified green buildings of office use which are already existing buildings, it was decided that data on theoretical annual energy consumption and demand for the green buildings being studied was not necessary for the study. Two of the participants recognised SANS 10400-XA as being more stringent and therefore effective than the certification tool which they described as more of a framework which provides guidance. However, the other participants noted that the EBP V1 Tool was developed taking into account amongst others, the stipulations in SANS 10400-XA.

4.3.1.4 National Energy Act 34 2008

In line with the Constitution of South Africa, one of the goals of the South African government was to develop comprehensive energy laws which would fulfil the purpose of providing sustainable access to modernized cost-effective and reliable energy (Warnich 2018). The main aims of the act are to 'secure diverse energy resources and ensure that they are accessible in sustainable quantities and are affordable to the economy of the country in support of economic growth and to decrease poverty in tandem with fulfilling environmental management obligations and enhancing cooperation amongst the various sectors of the economy' (Government of South Africa 2020:1). The National Energy Act also aims to 'provide for energy planning, increased generation and use of renewable energies, emergency energy supply, holding of strategic energy feedstocks and carriers, adequate investment and proper upkeep and access to energy infrastructure' (Government of South Africa 2020:1). Finally, the act also aims to 'provide measures for the provision of selected data and information regarding energy demand, supply and generation as well as to establish an institution which will be responsible for promoting efficient generation and usage of energy and energy research' (Government of South Africa 2020:1).

The section of the act which is most relevant to this study is the development of the South African National Energy Development Institute (SANEDI) as it is a legislated institution which addresses energy issues. SANEDI, an agency of the Department of Energy (DoE), is mandated to 'direct, monitor and conduct energy research and development, promote applied energy research and technology innovation, as well as undertake measures to promote the uptake of green energy and energy efficiency throughout the economy' (National Energy Act 2008: 11). This would include the construction industry which is a key sector in South Africa.

The functions of SANEDI which are relevant to this study are listed below exactly as they appear in the act: (see the National Energy Act 2008: 11-12)

(a) energy efficiency—

(i) undertake energy efficiency measures as directed by the Minister

(ii) increase energy efficiency throughout the economy;

(b) energy research and development—

(i) direct, monitor, conduct and implement energy research and technology development in all fields of energy, other than nuclear energy;

(cc) commercialisation of energy technologies resulting from energy research and development programmes;

Source: National Energy Act of 2008

The most relevant functions for this study of SANEDI is its mandate to increase energy efficiency throughout the economy which includes the construction industry which is central to the success of the economy. This has direct implications for buildings as to enhance energy efficiency in the construction industry it is vital that buildings become more energy efficient. Other functions which are the responsibility of SANEDI which are important to the study are energy research and development particularly directing, monitoring, conducting and implementing energy research and technology development (National Energy Act 2008). The commercialisation of energy technologies resulting from energy is also important. These functions are critical as the potential for the invention of new technologies which enhance energy efficiency in buildings and the construction industry is enhanced and the resultant commercialisation of these technologies can enhance the local economy and boost the green economy as well as result in job creation.

4.3.2 Provincial Legislation and Institutional Frameworks

There are no mandatory environmental and building legislations and institutional frameworks which govern energy consumption, Carbon emissions reduction and green buildings in Gauteng which were identified by the participants. However, all stipulations are covered in the national mandatory institutional frameworks as already identified above.

4.3.3 Local Government Legislation and Institutional Frameworks

The City of Johannesburg is of great socio-economic importance as it is the financial hub of the country and the location of many of the country's businesses and companies (CoJ Climate Change Adaptation Plan 2009).The city has identified climate change as negatively affecting its growth and development (CoJ Climate Change Adaptation Plan 2009) Therefore, interventions which result in climate change mitigation and adaptation are key for the city's infrastructure. The following items of legislation and institutional frameworks were identified as being the jurisdiction of the city by the participants: The City of Johannesburg Green Building Policy and the City of Johannesburg Green Building by-laws. One of the participants explained that they were due to be completed by 2020 however upon further investigation the researcher found that they still had not been completed. The CoJ Green Building Policy, which is still in development, will be used as a guideline for building more environmentally friendly new buildings in Johannesburg. The purpose of the City's Green Building by-laws which are still in development is to ensure the implementation and abidance to the City of Johannesburg's Green Building Policy.

4.3.4 Private Sector

The only form of framework identified for the private sector was a guide identified by GDID. This guide is the Nedbank Carbon Foot Printing guide however it was found on further analysis by the researcher that the guide is only applicable to Nedbank buildings which do not form part of this study.

4.3.5 Non-Profit Organisations

The only item of legislation or institutional framework which was identified by the participants as being developed by NPOs for this study was the GBCSA's certification toolkits. The GBCSA was established in 2007 with the aim of offering opportunities for South African businesses and real estate entities to understand how to benefit from Green Building investment and the potential drawbacks associated with it (Theunissen 2016). In response to the emergence of the green building industry, following the lead of other GBCs worldwide, the GBCSA is frequently spearheading change advancing past even governments to address matters surrounding unsustainable development (Halliday 2008). These include legislation and institutional frameworks around green buildings. In order to implement their mandate, the GBCSA developed certification toolkits based on the Australian certification system and toolkits as the two countries have similar environments (GBCSA 2018).

There ae various certification toolkits for the various types of buildings and their usage. The buildings being researched for this study are certified retrofitted buildings of office use therefore according to the participants they fall under the existing building stock. Both property companies who provided data for their buildings confirmed the rating tool used to certify them. They were rated using the GBCSA'S EBP V1 Tool which is the tool used to certify existing buildings. A description of the stipulations in the tool are given below:

Green Building Council of South Africa's Existing Building Performance V1 Tool (EBP V1 Tool)

According to the EBP V1 Tool, before a building can get certification after retrofitting/modification it must show that any changes made have resulted in improved energy performance and emissions reduction which will qualify it for green certification (Existing Building Performance V1 Tool Technical Manual 2014). To achieve this, the building must undergo a process of performance evaluation during its certification period (Existing Buildings Performance V1 Tool Technical Manual 2014). The building will be evaluated on the performance of the nine environmental categories as stipulated in the EBP V1 Tool of which each has a number of credits they are assessed on (Existing Buildings Performance V1 Tool Technical Manual 2014). The categories are management, indoor environment quality, energy, transport, water, materials, land use and ecology as well as emissions (Existing Buildings Performance V1 Tool Technical Manual 2014: viii). Points are awarded in each credit which make up the categories for actions that highlight that the project has met the overall objectives of Green Star South Africa and the specific aims of the Green Star South Africa rating tool (Existing Buildings Performance V1 Tool Technical Manual 2014: viii).

For the purpose of this study only the categories of energy, emissions and innovation are looked at in detail however due to the fact that the buildings achieved certification through the tool it can be deduced that they also performed in the other categories. Therefore, according to the Existing Buildings Performance V1 Tool Technical Manual (2014) the requirements for the energy and emissions categories as follows:

4.3.5.1 Environmental Categories

Energy

Energy considers the use of energy in the building operations. The credits in the energy category target the overall reduction in terms of energy consumption and reductions of GHG emissions associated with energy generation.

The total points allocated for energy is 27 points.

Points are allocated for:

1. Energy consumption (25). This is with regards to GHG emissions reductions in the building operations.
2. Peak electricity demand (2). This is in recognition of operational practices which result in the reduction of peak demand on infrastructure which supplies electricity.

In particular one of the participants identified the second credit Peak Electricity Demand as significant to demonstrate that the building's Peak Demand Performance meets the required benchmarks set out in the credit. This must be an improvement on SANS 10400-XA requirements where applicable or an improvement on a historical baseline where it is not. For the purpose of this study peak energy demand figures were not requested or required as the study focused on actual energy consumption performance of the buildings. However, as illustrated in table 10 below, Building G did manage to reduce on its peak energy demand baseline. Furthermore, according to the information in the case studies of the buildings on the website of the GBCSA, the buildings being researched in this study obtained scores for the energy category therefore they performed in each credit.

Emissions

All the emissions credits target the environmental impacts of a projects' emissions or substances which are emitted from the site. The aim of this is to award the building for the reduction in GHG emissions related to operational practices concerning equipment like refrigeration, as well as the reduction in overall pollution.

The points allocated for this is 4.5 points.

The points are allocated for:

1. Refrigeration: The aim of this credit is encouraging the operational practices that limit the environmental impacts of refrigeration equipment in the building (2).
2. Legionella: The aim of this credit is the recognition and encouragement in terms of implementation and utilisation of a water management process which intends to minimize the risks associated with Legionnaires' disease (1).
3. Storm Water: The aim of this credit is the recognition of site-related practices which minimise the disturbance of natural hydrology and also minimizes pollution (1.5).

The only credit of interest is refrigeration as this has been mentioned in 4.2.3 above as one of the internal factors which increase energy consumption and Carbon emissions in the green buildings which are being studied. However according to the information in the case studies of the buildings on the website of the GBCSA, the buildings being researched for this study obtained scores for the category of emissions therefore they performed in all three credits.

Innovation

Additional Credits are also given to Innovation. This credit recognises innovations and environmentally sustainable building management and operations over and above that which is required in the EBP V1 building rating tool.

Up to 10 points are given.

Points are also awarded within credits for achieving performance-based objectives and for adopting policies and procedures to improve a project's environmental impact (Existing Building Performance V1 Tool Technical Manual 2014: x). To be eligible for Green Star South Africa Existing Building Performance Rating assessment, there is eligibility criteria that buildings must first meet:

4.3.5.2 Building Characteristics

To be eligible for the Green Star South Africa Existing Building Performance Rating assessment, the buildings must meet the following eligibility criteria: (see the Existing Building Performance V1 Tool Technical Manual 2014: x)

1. The building must be occupied at a minimum of 70% occupancy throughout the performance period, which is a consecutive 12 months, and the vacancy rate be below 30%.
2. The building in its entirety is not certified.

Table 6 below shows that during the benchmark period of all three buildings the occupancy rate of the buildings was above 70% and Property group 1 which owns the buildings confirmed that they had not yet received certification. Therefore, the buildings met the requirements for assessment. In addition to this, the EBP V1 Toolkit indicates which building types qualify for certification if the tool is to be utilised. The table below shows which buildings are eligible.

Table 5: Building Types eligible to register without GBCSA Eligibility Ruling

Building Type	Classification of Occupation (SANS 10400-A)
Office Buildings	G1-Offices
Retail Developments	F1- Large Shop
Public Assembly	A1- Entertainment
	A4- Worship
	C1- Exhibition Hall
	C2- Libraries
	C2- Museum
Educational	A3- Places of Instruction

Source: Existing Building Performance V1 Tool Technical Manual (2014: xii).

This study is focusing on buildings which are of office use and according to the table their classification is G1. Therefore, based on this information in the table, the buildings further qualified for assessment.

4.3.5.3 Conditional Requirements

'In order to achieve a Green Star SA – Existing Building Performance Rating, the project's submission must be submitted by a Green Star SA - Accredited Professional' who is trained on the tool (Existing Building Performance V1 Tool Technical Manual 2014:xiv). This fulfils the first credit under the category management, which is EB-MAN-1 Accredited Professional, which stipulates that an accredited professional trained on the tool must be assigned as part of the project team by the owners of the project or facilities managers of buildings who aim to certify their buildings (Existing Building Performance V1 Tool Technical Manual 2014). The purpose of the accredited professional is to guide the owners/facilities managers with the incorporation of Green

Star SA aims and processes throughout the certification period (Existing Building Performance V1 Tool Technical Manual 2014).

According to the information in the case studies of the buildings on the GBCSA's website the project teams assigned for certification of the buildings included consulting companies whose expertise is, amongst other things, the certification of buildings. These companies guided the project teams throughout the process of certification Therefore, the buildings researched in this study met the conditional requirements as stipulated above.

4.3.5.4 Timing of Certification

The following requirements apply in terms of timing of certification for the building: According to the Existing Building Performance V1 Tool Technical Manual (2014: xiv):

1. The building must be operational for a minimum of 12 months after final completion.
2. The building's 'performance period', the period under which the building's performance is measured, is to be 12 consecutive months.
3. Energy and water performance periods must end within 90 days of each other.
4. The project must submit for certification within 90 days of the end of the building's 12 month performance period.
5. Certification is valid for 3 years from the end of the certified performance period.
6. Thereafter re-certification will need to be undertaken.
7. Re-certification can take place at any time within the 3 year period, but the project's rating will lapse if not re-certified within 3 years.
8. Annual submission during the 3 year period will be required for:
    - 8.1 Energy consumption data
    - 8.2 Water consumption data

In table 6 in section 4.4 below, the data provided on the buildings indicate that the first 2 requirements were met as the three periods (benchmark, certification and post-certification) are

12 months long which show that the buildings were operational for at least 12 months. Furthermore, as indicated in the table, the months of the certification period are consecutive to each other. Requirements 3 and 4 were also met as the buildings managed to achieve certification. If they had not been met, the buildings would not have been able to achieve certification. In terms of requirements 5 to 8, according to the information in the case studies of the buildings, the buildings are all due for recertification. The periods of certification for Buildings C and D lapsed in 2019 and the period of certification for Building G lapses in 2020. However, the presence of the case studies on the GBCSA's website indicates that the buildings are still considered to be certified.

The relevance of each legislation and institutional framework presented above will be discussed in greater detail in Chapter 5. The participants identified a great number of items of legislation and institutional frameworks but only the ones which were relevant to this study were selected. The vast majority of them were guidelines and policies which are obligatory but not enforceable. These are identified in Chapter 1. This would seem to suggest that although South Africa has an impressive collection of legislation and institutional frameworks which address the environment, climate change, buildings and energy they are poorly implemented because they are not mandatory and thus difficult to enforce and monitor. However, the fact that they do exist answers and proves the research question.

4.4 Building Rating Performance Tools and their Impact on the Performance of Green Buildings

This section was interested in exploring the extent to which the application of building rating performance tools and certification of buildings impacts the performance of green buildings in terms of their energy efficiency and Carbon emission. 12 participants took part in this section of the study. In order to establish this, the section was separated into two different sub-sections. The first sub-section details the application and certification process of the certification tool which has been identified by the participants as being relevant for this study which is the Green Star SA EBP V1 Tool. This would assist in addressing the question of the sufficiency and efficacy of the tool and uncovering weaknesses, if any, in its application. The second sub-section examined the energy consumption and Carbon emissions for the buildings being researched for this study over a 36-month period. This is important as trends observed in their Carbon emissions and energy consumption would assist the study in addressing the question whether certifying buildings makes them more energy efficient and reduces their Carbon emissions. The research examined the energy consumption and Carbon emissions in all three periods for which data was provided; the benchmark/baseline period, the certification period and the post-certification period of each building. Each cycle is 12 months long. Due to the fact that the building's energy consumption cycles start on different months, it was decided that the months would be named periods. The data was then analysed by plotting graphs which were analysed for any trends. The buildings were also compared to each other. Temperature data was sourced from the South African Weather Service. The second sub-section also examined the sustainability features of the building as well as the building envelope.

In view of this, this section explored the influence and the impact that the Green Star SA EBP V1 Tool has on the energy efficiency and Carbon emissions of buildings

The data presented in the table below for the three buildings utilised for this study are used for each sub-section.

4.4.1 The Certification Process of the Green Star SA EBP V1 Certification Tool

Table 6: Complete Data for the Performance of the Retrofitted Certified Green Buildings of Office Use for the Study

P		Building C					Building D					Building G				
M	**DP**	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***
1		2014-10-01	76,26	72,45	91%	27,4	2014-09-01	66,74	63,41	97%	27,2	2015-08-01	158,64	150,70	100%	25,2
2		2014-11-01	65,38	62,11	91%	25	2014-10-01	115,36	109,59	97%	27,4	2015-09-01	158,29	150,38	100%	26,1
3		2014-12-01	67,32	63,95	91%	27,5	2014-11-01	70,86	67,32	97%	25	2015-10-01	169,78	161,29	100%	30,3
4		2015-01-01	80,78	76,74	91%	28,6	2014-12-01	117,38	111,51	97%	27,5	2015-11-01	130,80	124,26	100%	29,6
5		2015-02-01	76,24	72,43	88%	29,5	2015-01-01	79,83	75,84	97%	28,6	2015-12-01	145,53	138,25	100%	31,7
6		2015-03-01	68,15	64,75	88%	27,1	2015-02-01	113,42	107,74	97%	29,5	2016-01-01	152,47	144,85	100%	29,5
7	Benchmark	2015-04-01	60,81	57,77	88%	24,8	2015-03-01	108,24	102,83	95%	27,1	2016-02-01	151,93	144,34	100%	30,5
8		2015-05-01	66,61	63,28	88%	25,4	2015-04-01	77,67	73,79	95%	24,8	2016-03-01	133,74	127,06	100%	27,7
9		2015-06-01	87,07	82,71	88%	19	2015-05-01	74,68	70,94	89%	25,4	2016-04-01	153,68	146,00	100%	26,5
10		2015-07-01	80,90	76,86	88%	19,9	2015-06-01	82,74	78,61	90%	19	2016-05-01	166,98	158,63	100%	21,2
11		2015-08-01	69,24	65,78	88%	25,2	2015-07-01	91,47	86,90	90%	19,9	2016-06-01	211,92	201,32	100%	19,3
12		2015-09-01	71,94	68,34	92%	26,1	2015-08-01	76,71	72,88	90%	25,2	2016-07-01	196,75	186,91	100%	19,2
		Total	**870,70**	**827,16**	**89%**	**25,46**	**Total**	**1075,11**	**1021,35**	**95%**	**25,55**	**Total**	**1930,50**	**1833,98**	**100%**	**26,40**
1		2015-10-01	82,10	78,00	92%	30,3	2015-09-01	79,83	75,84	90%	26,1	2016-08-01	194,80	185,06	100%	23,3
2		2015-11-01	79,28	75,31	92%	29,6	2015-10-01	97,12	92,27	90%	30,3	2016-09-01	179,42	170,45	100%	26,3
3		2015-12-01	97,68	92,79	92%	31,7	2015-11-01	93,26	88,59	91%	29,6	2016-10-01	133,05	126,40	100%	28,6
4	Certification	2016-01-01	78,11	74,20	92%	29,5	2015-12-01	67,84	64,45	92%	31,7	2016-11-01	151,56	143,98	100%	27,6
5		2016-02-01	85,17	80,91	92%	30,5	2016-01-01	90,28	85,77	96%	29,5	2016-12-01	137,12	130,26	100%	28,5
6		2016-03-01	63,31	60,14	95%	27,7	2016-02-01	96,41	91,59	97%	30,5	2017-01-01	128,70	122,26	100%	27,2
7		2016-04-01	69,49	66,01	95%	26,5	2016-03-01	86,84	82,50	97%	27,7	2017-02-01	143,30	136,13	100%	26,2

P		Building C					Building D					Building G				
M	**DP**	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***	**MP**	**MWh**	**tCO2e**	**Occ***	**Temp***
8		2016-05-01	57,67	54,79	95%	21,2	2016-04-01	81,33	77,26	97%	26,5	2017-03-01	129,63	123,15	100%	27,3
9		2016-06-01	59,99	56,99	95%	19,3	2016-05-01	76,83	72,98	97%	21,2	2017-04-01	121,17	115,12	100%	24,4
10		2016-07-01	63,75	60,56	94%	19,2	2016-06-01	96,58	91,75	97%	19,3	2017-05-01	141,64	134,56	100%	22,1
11		2016-08-01	64,17	60,96	94%	23,3	2016-07-01	100,88	95,84	97%	19,2	2017-06-01	138,61	131,68	100%	21
12		2016-09-01	58,10	55,20	97%	26,3	2016-08-01	86,47	82,14	97%	23,3	2017-07-01	141,54	134,46	100%	21,3
		Total	**858,81**	**815,87**	**94%**	**26,26**	**Total**	**1053,65**	**1000,97**	**95%**	**26,24**	**Total**	**1740,53**	**1653,51**	**100%**	**25,32**
1	**Post Certification**	2016-10-01	70,08	66,57	97%	28,6	2016-09-01	89,56	85,08	97%	26,3	2017-08-01	108,87	103,43	97%	22,1
2		2016-11-01	60,83	57,79	97%	27,6	2016-10-01	82,76	78,62	94%	28,6	2017-09-01	109,38	103,91	66%	27,4
3		2016-12-01	58,40	55,48	97%	28,5	2016-11-01	83,55	79,37	94%	27,6	2017-10-01	119,04	113,09	66%	25,9
4		2017-01-01	55,61	52,83	97%	27,2	2016-12-01	80,67	76,64	94%	28,5	2017-11-01	120,14	114,13	70%	28,2
5		2017-02-01	55,77	52,98	97%	26,2	2017-01-01	87,38	83,01	94%	27,2	2017-12-01	129,73	123,24	70%	27,7
6		2017-03-01	52,38	49,76	92%	27,3	2017-02-01	80,19	76,18	94%	26,2	2018-01-01	132,59	125,96	70%	29,6
7		2017-04-01	46,88	44,54	92%	24,4	2017-03-01	72,81	69,17	94%	27,3	2018-02-01	136,99	130,14	95%	26,9
8		2017-05-01	54,32	51,61	95%	22,1	2017-04-01	83,02	78,87	94%	24,4	2018-03-01	136,99	130,14	100%	26,2
9		2017-06-01	58,60	55,67	100%	21	2017-05-01	69,97	66,47	94%	22,1	2018-04-01	152,59	144,96	100%	24,5
10		2017-07-01	51,12	48,57	100%	21,3	2017-06-01	69,97	66,47	94%	21	2018-05-01	152,59	144,96	100%	22
11		2017-08-01	49,33	46,87	97%	22,1	2017-07-01	86,18	81,87	89%	21,3	2018-06-01	131,27	124,70	100%	20,9
12		2017-09-01	50,60	48,07	97%	27,4	2017-08-01	89,37	84,90	89%	22,1	2018-07-01	152,04	144,44	97%	19
		Total	**663,91**	**630,71**	**97%**	**25,31**	**Total**	**975,43**	**926,66**	**93%**	**25,22**	**Total**	**1582,22**	**1503,11**	**86%**	**25,03**

Source: SAWS and Property Group 1 (2019 and 2020)

Where

P=Period (sub-divided into months

M=Month

MP=The Metering Period which shows the exact date when the energy consumption was measured for that month.

DP=The data period of the energy consumption of the buildings over a 12 month period (benchmark data, certification/performance cycle data and post-certification data)

MWh=The energy consumption of the building every month in Megawatt hours

tCO_{2e}=Carbon emissions in tonnes

Occ*=Occupation of the building in percentage

Temp*=Temperature in °C

The period column of the table is sub-divided into months starting consecutively from 1 to 12. The months 1 to 12 define the data periods. The months in the period column are directly linked to the metering period which gives the exact date of the month. It is important to note that for each building the metering period starts on different months and years. That is why it was decided to allocate numbers to the months for uniformity. Furthermore, it is important to note that the months are consecutive to each other as one of the stipulations of the EBP V1 Tool is that data for certification (both benchmark and certification period) must be collected over a 12-month period consecutively. Linked to the months is the energy consumption of the buildings converted to MWh and Carbon emissions in tonnes for each month. The energy consumption of the buildings was provided in kWh however, due to the Carbon emission factor used by Property Company 1 for their buildings being $0.95tCO_2e/MWh$, the energy consumption was converted to MWh to calculate the Carbon emissions. Occupation of the buildings in percentage was also recorded for each month in the 3 data periods. This data is important as another one of the stipulations of the EBP V1 Tool is in order for buildings to qualify for certification, during the benchmark and certification period the building must be operational and at least 70% occupied as highlighted in section 4.3. Therefore, the data provided proves that the buildings did meet the qualifications for certification. Lastly temperature data for each monthly period was provided to determine the impact of temperature on the energy consumption and the Carbon emissions of the building. Rows for total figures were added. These were especially significant to show the totals for the energy consumption and Carbon emissions figures for each data period to highlight whether any increases or decreases occurred which would ultimately assist in answering whether certification resulted in more energy efficiency in the buildings and less Carbon emissions from the buildings.

For buildings to qualify for certification through the EBP V1 Tool they have to demonstrate that they have met the energy stipulations in SANS. For the sake of this study annual energy consumption for the existing buildings being utilised in this study during the benchmark period will also be calculated to establish whether they fall within the prescribed energy threshold in SANS 10400-XA for office buildings. This will assist in investigating whether certification is necessary to enhance the energy consumption of buildings because if the annual consumption of the buildings is within the threshold of SANS 10400-XA, it can be argued that the building standards are enough to ensure energy efficiency in buildings and environmentally sustainable buildings without having to certify them. Two of the participants of the study as mentioned in section 4.3 responded that the SANS 10400-XA building standard is stringent enough and certification tools, especially for existing buildings, act more as a guidance framework for green building. The table below indicates the energy consumption thresholds per annum per the description of the buildings, the classification of their occupancy and the climatic zone which was taken from SANS 10400-XA.

Table 7: Maximum annual consumption per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	**Description of building**	**Maximum energy consumption kWh/m2**					
		Climatic zone					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	420	400	440	390	400	420
A2	Theatrical and indoor sport	420	400	440	390	400	420
A3	Places of instruction	420	400	440	390	400	420
A4	Worship	120	115	125	110	115	120
F1	Large shop	240	245	260	240	260	255
G1	Offices	200	190	210	185	190	200
H1	Hotel	650	600	585	600	620	630
NOTE 1 The annual consumption per square metre shall be based on the sum of the monthly consumption of 12 consecutive months. NOTE 2 Non-electrical consumption, such as fossil fuels, shall be accounted for on a non-renewable primary energy thermal equivalence basis by converting megajoules to kilowatt hours.							
a The climatic zones shall be as given in annex A.							

Source: SANS 10400-XA (2011:8)

The table above provides the legislated values for maximum annual consumption figures per building classification in each climatic zone according to SANS 10400-XA. The first column speaks to the classification of occupancy of building. This is the usage type of the building and each building usage type has a specific code. The description of each building is given in the next column to elaborate further on the exact usage of the building. The buildings being researched for this study are office buildings therefore their building classification is G1 and their description is offices. The 3rd to 8th column speak to the climatic zones from 1 to 6. According to SANS 10400-XA, climatic zone 1 is cold interior, climatic zone 2 is temperate interior, climatic zone 3 is hot interior, climatic zone 4 is temperate coastal, climatic zone 5 is sub-tropical coastal and climatic zone 6 is arid interior (SANS 10400-XA:12). Furthermore, for each climatic zone, the threshold energy consumption in kWh/m² is specified for each building type. Therefore, for example, the legislated maximum energy consumption per metre squared per annum for a hotel in the cold interior zone is 650 kWh/m² however in the temperate coastal zone it is 600 kWh/m². The buildings being researched for this study are office buildings in the City of Johannesburg. The City of Johannesburg falls under the cold interior climatic zone thus the legislated maximum energy consumption per annum for the buildings is 200 kWh/m². This figure is calculated by adding the monthly energy consumption figures per square metre for 12 consecutive months in an annum. The legislated maximum energy consumption in kWh/m² per annum for each building type in each climatic zone was determined as part of the country's National Determined Contributions in line with the country's global commitments to decreasing its GHG emissions.

Prior to the researcher converting the energy consumption into MWh it was provided in kWh and this is what will be used. The floor area of the buildings was provided in m² and is tabulated below. Although Nett Lettable Area (NLA) is commonly used to calculate the energy efficiency threshold of office buildings per annum, the property company who provided the data to the researcher only provided the Gross Lettable Area (GLA) of the buildings so this is what will be used. The GLA of the building is inclusive of the Nett Lettable Area (NLA).

Table 8: A Table showing the Gross Lettable Area of the Buildings:

Building	Benchmark		Certification		Post-Certification	
	GLA (m²)	kWh	GLA (m²)	kWh	GLA (m²)	kWh
Building C	8710	870699,22	8710	858807,88	8710	663909
Building D	8460	1075106	8460	1053651	8460	975433,98
Building G	8803	1930502	8803	1740532	8803 (until 2017/10/01) then 9108 (from 2017/11/01 to 2018/05/01).	1582218

Source Property Company 1 (2019, 2020)

Where:

GLA=the Gross Lettable Area in m²

kWh=the energy consumption of the buildings per annum in kWh

The figures in the table above show the gross lettable area and total energy consumption in kWh for each building during each data period (benchmark, certification and post-certification). For example, for Building C during the benchmark period its GLA was 8710m² and its total energy consumption 870699,22kWh. The figure for the total energy consumption was taken from data provided in table 6 above and the GLA was provided by Property Company 1. During the certification period, Building C's GLA was 8710m² and its total energy consumption was 858807,88 kWh. During its post-certification period its GLA remained 8710m² and its total energy consumption was 663909 kWh. The significance of this information is that it will be used to calculate the annual energy consumption of the building during its benchmark period. The figures obtained will be compared to the maximum annual energy consumption threshold for office buildings in the City of Johannesburg which has been identified as 200 kWh/m². The information also shows that the energy consumption has been steadily decreasing from the benchmark to the post certification period. Therefore, this indicates that certification of the building did contribute to its enhanced energy efficiency. The same will be applied to the other two buildings.

Therefore for the Benchmark period:

Building C:

kWh/m²/a=kWh/GLA=870699,22/8710=99,97

Building D:

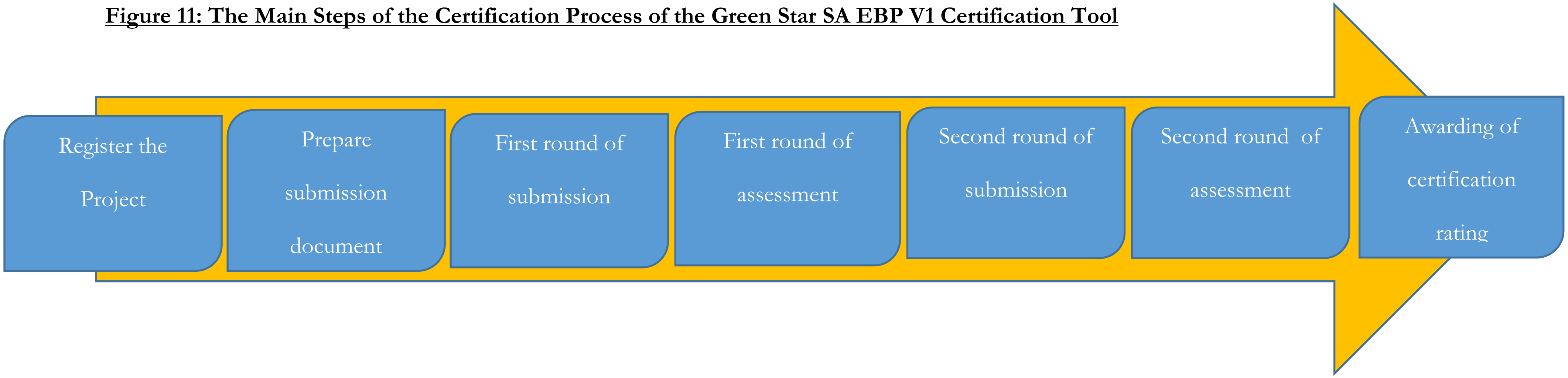
kWh/m²/a=kWh/GLA=1075106/8460=127,08

Building G:

kWh/m²/a=kWh/GLA=1930502/8803=219,30

The results show that Buildings C and D were within the maximum annual energy threshold of 200 kWh/m². for office buildings in the City of of Johannesburg prior to certification and Building G fell slightly out of it. However, it must be stressed that the calculations used GLA, which is larger than NLA, as this was the only floor area which was provided by the Property Company. Thus, the actual annual energy consumption is likely to be less than the calculated figures. Therefore, it can be argued that generally office buildings in the City of Johannesburg are consuming energy within their stipulated SANS 10400-XA maximum annual energy consumption threshold. However, as the buildings performed better in terms of their energy consumption from their benchmark period to the post-certification period, it can be concluded that certification of the buildings also contributed to their continuous enhanced energy efficiency.

Figure 11: The Main Steps of the Certification Process of the Green Star SA EBP V1 Certification Tool



Source: Goosen (2009) and Existing Building Performance V1 Tool Technical Manual (2014)

The main steps of the certification process are illustrated in the figure above. They are described in further detail below as observed by Goosen (2009: 14-16)

1. Project Eligibility

Prior to the registration of the project, it is determined whether it is eligible for certification. Once it is eligible, the process of certifying the project can commence.

2.Registration of Project

The building project is then registered. If it is already registered with the GBCSA, it then declares the intention to pursue certification under a specific rating tool. An executed agreement of certification is sent to the owner of the building project upon registration. This must be sent to the GBCSA to finalise a project registration. Part one of certification fee (50%) is paid upon registration of a project.

3. Preparation of the Submission document

It is critical to ensure that documentation for all credits claimed adhere to the 'Documentation Requirements' which are outlined in the tool as well as the submission template which is provided for each credit within the Certification Engine

As well as this documentation, it is required that the following general documents are uploaded to the 'General' section of the Certification Engine.

1. Site drawing showing extent of the building and project site.
2. The area schedule showing the full Gross Floor Area of the building attempting to obtain certification.
3. The completed Scoresheet, AP Declaration & Submission Checklist
4. All contained in 'Scoresheet & General Info' spreadsheet.
5. Any other applicable GBCSA correspondence, clarifications or approved alternatives (TC's and CIR's).

No points will be granted by any assessor unless it is demonstrated that all the requirements have been met precisely as detailed in the Technical Manual and requested in the Submission

4.Energy & Water Benchmarking

For Office buildings, projects will have the choice of submitting the Energy Consumption and Water Consumption credits (Ene-1 and Wat-1) for assessment in advance of submission of all the other credits for assessment. The Energy & Water performance will be assessed and a formal Energy & Water Benchmarking Certificate issued to the project by the GBCSA.

The following information is mandatory to be submitted for Energy & Water Benchmarking:

1. Completed Submission Templates for Ene-1 and Wat-1 credits with all supporting documents as prescribed in the templates.

From the submission of the Energy & Water benchmarking information to the GBCSA, results will be provided within 5 weeks of submission.

5.Round 1 Submission

From the date of receipt of the project's submission of all targeted credits which comprises the first round, the GBCSA provides the assessment results within 7 weeks. Projects must submit all the required documents through the Certification Engine (www.certificationengine.org).

The GBCSA will carry out a pre-assessment submission quality review of a project submission before the commissioning of a review by the assessors. A project may need to resubmit the submission prior to assessment if the submission quality review indicates that the quality of the submission would result in an invalid or extended assessment. There is no fee for the pre-assessment completed by the GBCSA.

6.Round 1 Assessment

The assessor(s), will evaluate the submission. Recommendations will then be made to the GBCSA on the rating which should be awarded. The GBCSA will forward the results of the assessment to the project contact and the applicant. At this point a rating could be achieved. If the applicant is satisfied with the rating achieved the certification process will be completed.

However, if this is not the case, the assessors may seek additional information from the applicant supporting their claims, or may request corrections to certain credits which have not been achieved. If such a situation occurs, the project team have to submit the required documentation for credits 'to be confirmed' in the second round of submission.

7.Round 2 Submission

If the client is satisfied with the results of the first submission, the process of certification ends at step 6 and the rating achieved is accepted. However, if the client wishes to improve on the results of the first submission or further information or documentation is required for certification of the project, round 2 submission continues as a step during certification. For the sake of this study, the steps in the certification process will include the Round 2 submission to illustrate how certification is achieved via 2 submissions.

Upon receiving the results of the Round 1 Assessment, the project can be required to submit documentation for credits 'to be confirmed'. The project will need to provide the Round 2 submission within a 90 day period of the first round of assessment results being provided. Each project only has one opportunity to resubmit which may include:

1. Additional or revised documentation to confirm fulfilment of Credit Criteria;
2. New credits which were not targeted in Round 1. However, it is important to note that for these credits there will be no opportunity for two rounds of assessment.

From the date of receiving the Round 2 submission at the GBCSA offices, the GBCSA will provide the Round 2 assessment results in 5 weeks.

8.Round 2 Assessment

Assessment of the second round of submission will follow the same procedures as for the first round of assessment.

9.Awardance of Ratings

9.1 Certified Rating Awarded

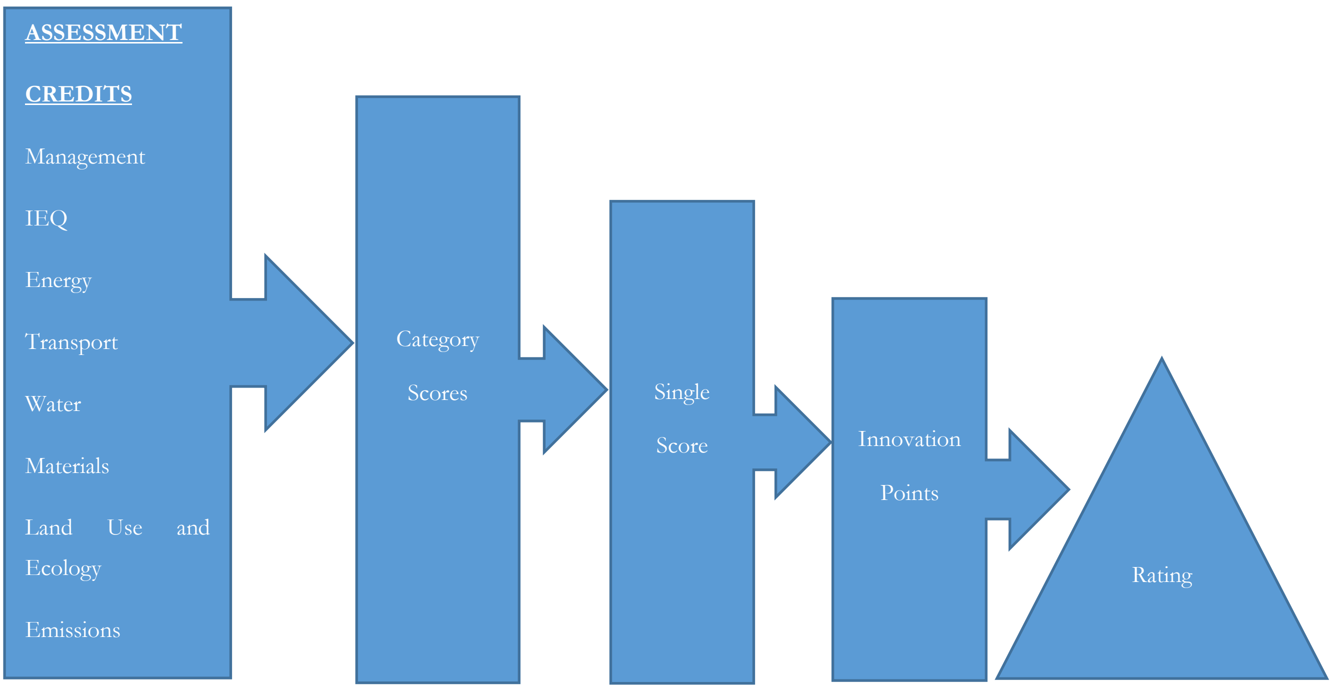
If the assessment validated the project's achievement of the required score, the GBCSA will award a Certified Rating and inform the Applicant.

9.2 Certified Rating Not Awarded

If a desired Certified Rating is not attained, the project can in certain circumstances be permitted to Appeal select credits for a fee to re-asses it. The GBCSA can be contacted for further details in this regard

The figure below illustrates the types of credits which can be obtained in an assessment and how the credits are assigned scores and the building attains subsequent rating.

Figure 12: Structure of the Green Star SA scoring system



Source: Existing Building Performance V1 Tool Technical Manual (2014)

The figure above illustrates which environmental impact categories are assessed and how the scoring system leads to the actual rating for the building. During the certification period, various credits within the categories are assessed and points are awarded in each credit depending on how well the building performed in terms of illustrating that it has fulfilled 'all the objectives of Green Star SA and the particular aims of the Green Star SA rating tool' (Existing Building Performance V1 Tool Technical Manual 2014: viii). For example, as illustrated in section 4.2, the energy category is divided into the credits energy consumption and peak electricity demand respectively and each is located a score. This is the same for the other categories. The Category Score is 'determined for each category based on the percentage of credits achieved' (Existing Building Performance V1 Tool Technical Manual 2014: ix),

For example, the emissions category in the EBP V1 Tool has a total of 4.5 points which can be achieved for the various credits as described in section 4.2. If after the assessment a building scores a total of 2 points, that means using the equation illustrated in Chapter 3 under section 3.6 the category score will be:

Category Score=(2/4.5)x100=44%.

The single score which is the overall score of the building assessment is calculated by "adding all the Category Scores together including the 'Innovation points' "(Existing Building Performance V1 Tool Technical Manual 2014:ix). The highest possible score is 100, with a further ten points for innovation thus the highest score which can be achieved is 110 (Existing Building Performance V1 Tool Technical Manual 2014).

According to the GBCSA, 'the Green Star SA rating is determined by comparing the overall score with the rating scales' (Existing Building Performance V1 Tool Technical Manual 2014: ix) The rating scales were illustrated in table 3 under section 4.2. The table is illustrated again below:

Table 3: Green Star Africa – Existing Building Performance Rating Bands

Overall Score	Rating	Represents
10-19	One Star	Approaching a Better, Greener Building
20-29	Two Star	Approaching a Better, Greener Building
30-44	Three Star	Good in terms of Practice
45-59	Four Star	Best in terms of Practice
60-74	Five Star	Excellence in terms of South African Standards
75+	Six Star	Excellence in terms of World Leadership

Source: Existing Building Performance V1 Tool Technical Manual (2014)

Therefore, if a building achieves an overall score of 70 after assessment, it achieves a 5 star certification rating which indicates that it is excellent in terms of South African Standards with regards to its environmental performance. It must be noted that for this study although the buildings were assessed on all the credits, actual final rating and GLA were used to select them for the study. This was due to the fact that Property Group 1 and the GBCSA indicated that it is extremely unlikely that any two buildings would score the same on all the credits. Therefore, for uniformity the final rating and GLA were used to select the sample of buildings.

The following characteristics of the building have to be met for them to be eligible for certification as described in section 4.3 under the EBP V1 Tool (see Existing Building Performance V1 Tool Technical Manual 2014: xi)

Building Characteristics

1. The building must be occupied at a minimum of 70% occupancy throughout the performance period and the vacancy rate be below 30%
2. The building in its entirety is not certified

From the data presented in table 6 above, during the benchmark/baseline period of the buildings all three buildings were above 88% in terms of occupation, and therefore the vacancy rate was below 30%. The buildings were not certified at all, therefore they met the requirements for them to be eligible for certification. Furthermore, from the data provided in table 6 above, the buildings met the conditional requirements and timing of certification stipulated in the tool presented in section 4.3. They were in operation for at least 12 months after final completion of the certification process as 12 months of post-certification data was provided for them. The table also shows that the performance/certification period for each building was 12 consecutive months which was a stipulation that also had to be met. Since the buildings obtained certification it can be assumed that they met the time frames in terms of the end of the energy and water performance periods.

From the information provided in their case studies and the information presented in section 4.3 about the EBP V1 Tool, it was established that each building received a 4 star rating meaning that they are Best in terms of Practice in the industry.

In terms of re-certification, the property company which owns the buildings, Property Company 1, will in the future have to recertify the buildings as it is a mandatory stipulation in the tool for it to occur in order for the buildings to maintain certification. Property Company 1 indicated that the standard rating for which they aim for their buildings is 4 star and they also informed the researcher that normally buildings will aim for a higher rating during re-certification e.g 5 star or 6-star. Since the buildings have only been certified once, it is necessary that they are re-certified in order for them to maintain their certification and aim for a higher rating than the current 4-star rating of the buildings. According to the data provided in table 6 under monthly period, all three buildings are due for re-certification as three years have passed since the end of their certification performance periods. However, on further investigation into their case studies on the GBCSA website indicated the buildings are still identified as being certified therefore it must be assumed that they are still certified.

Another important issue for this study was to determine the efficacy of the tool. In view of this, the participants were asked to comment on a range of factors which would influence the tool in this regard and their responses are presented in the table below.

Table 9: Factors which Influence the Efficacy of the Tool

			Response							
			Y		No		NR		N/A	
No.	Type of Factors	Sample (n)	Count	%	Count	%	Count	%	Count	%
1	Enhances performance	12	6	50%	1	8%	2	17%	3	25%
2	Ease of application	12	1	8%	3	25%	5	42%	3	25%
3	Expense of application	12	7	58%	0	0%	2	17%	3	25%
4	Quality of tool	12	4	33,5%	1	8%	4	33,5%	3	25%
5	Understandability of tool	12	4	33,5%	4	33,5%	1	8%	3	25%
6	Preference over other tools	12	8	67%	0	0%	1	8%	3	25%

Source: based on fieldbased surveys (2019, 2020)

Where: n=sample size

Y=Yes

N=No

NR=No Response

N/A=Not Applicable

%=Percentage

Count=Number of responses

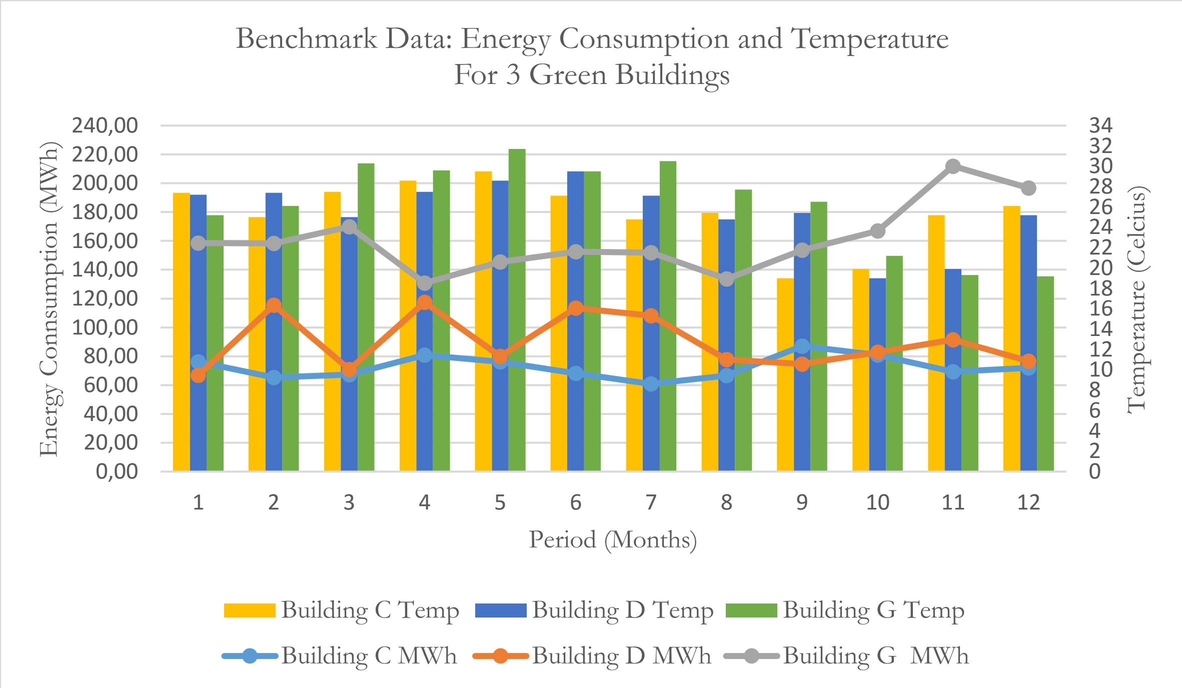
In terms of the tool enhancing the performance of the green buildings with regards to energy efficiency and reduced Carbon emissions it is suggestive that 6 (50%) of the participants answered yes, 1 (8%) answered no, 2 (17%) had no response, i.e they did not know, and 3 (25%) said that this was not applicable. In terms of ease of applying the tool for certification it is suggestive that 1 participant (8%) said yes it was easy to apply, 3 participants (25%) responded no it was not easy to apply, 5 participants (42%) had no response and 3 participants (25%) responded that this was not applicable. The question of how expensive it is to apply for certification using the EBP V1 Tool was also posed to the participants and the responses were as follows; 7 (58%) said that it was expensive, 0 (0%) replied that it was not expensive, 2 (17%) responded that they had no response and 3 (25%) responded not applicable. The quality of the tool was also an important factor to consider for the study and the following responses were received from the participants; 4 (33,5%) said it was of high quality, 1 (8%) said it was not of high quality, 4 (33,5%) had no response and 3(25%) responded not applicable. A critical factor to consider about the EBP V1 Tool is how simple it is to understand. This affects the usage of the tool and the participant's responses were as follows; 4(33,5%) said the tool was simple to understand, 4(33,5%) said that the tool was not simple to understand, 1(8%) had no response and 3(25%) responded not applicable. Finally, the preference of the tool to use for certification of buildings by clients over other certification tools like LEED (American buildings rating tool) and BREEAM (British building rating tool) was also explored. The participants responded as follows;8 (67%) said that the tool was preferred over other rating tools, 0 (0%) responded no, 1(8%) had no response to the question and 3 (25%) responded not applicable.

The participants who responded 'not applicable' to the factors stated that the efficacy of the tool depended on the individual experiences of the client's and their project teams who chose to apply it for certification of their buildings. One of the participants also mentioned that for an existing office building to be certified using the EBP V1 tool it did not necessarily have to undergo any retrofits as long as it met all the stipulations and could prove that it is efficient in consuming energy and reducing Carbon emissions.

4.4.2 The Impact of Certification on the Performance of the Buildings in terms of Energy Consumption and Carbon Emissions

This section was interested in examining the actual performance of the buildings being utilised for the study once they have received certification using the EBP V1 Tool. In order to determine this, the following graphs were constructed which examined the buildings' performance in terms of energy efficiency and Carbon emissions reduction in the benchmark, certification/performance cycle and post-certification period; the buildings performance in terms of energy efficiency and temperature in the benchmark, certification/performance cycle and post-certification period and the buildings performance in terms of Carbon emissions reduction and temperature in the benchmark, certification/performance cycle and post-certification period. It was important to also graph the energy consumption and Carbon emissions against the temperature to determine whether temperature is central in how the buildings consume energy and emit Carbon. In view of this the results are shown below:

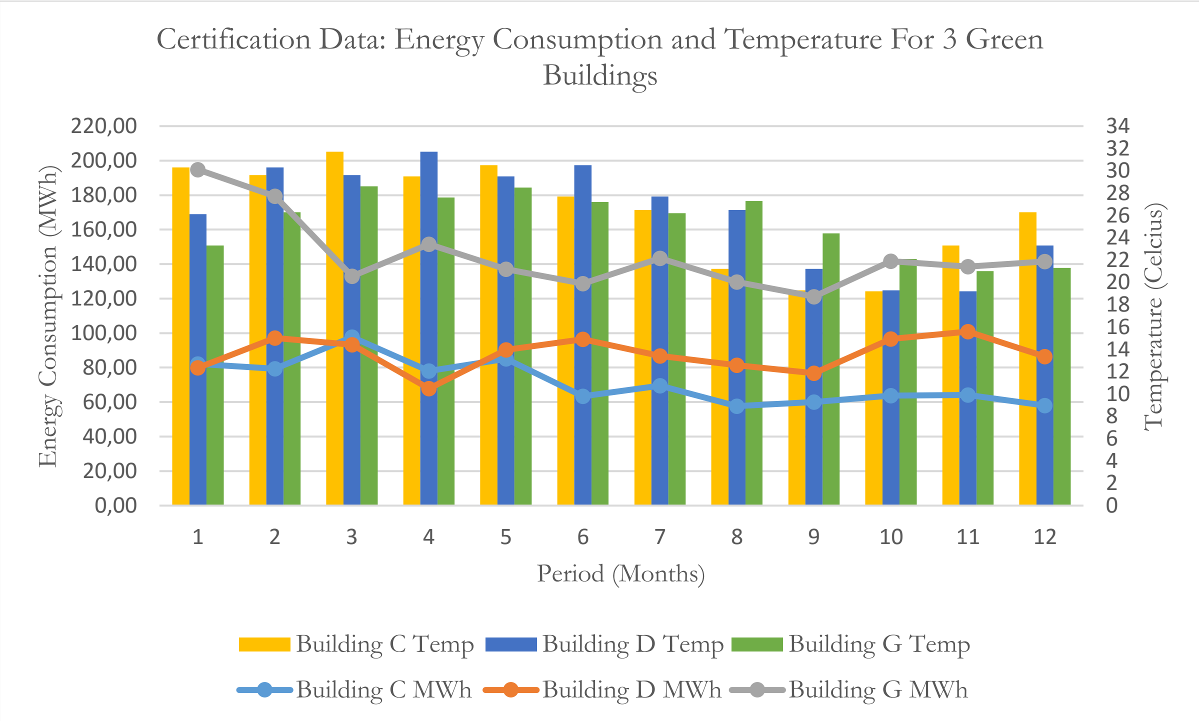
<u>Figure 13: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Temperature during the Benchmark Period</u>



Source: Based on fieldbased surveys (2020).

The graph above shows the buildings' energy consumption against temperature during the benchmark period. The graphs were plotted using data provided in table 6 above. The following trends were observed: In terms of energy consumption, Building G consumes significantly more energy than Building C and Building D. Building C consumes the least energy with Building D's consumption lying between that of Building G and Building C. Furthermore, Building G's energy consumption peaks when the temperature for its given benchmark period is at its lowest at Month 11. Therefore, it consumes more energy when it is colder. In contrast Building D's energy consumption fluctuates during the months when the temperature is highest from Months 1 to 7 but starts to level out as the temperature generally starts to lower from Months 8 to 11. However, interestingly even as the temperature suddenly rises in its benchmark period in Month 12 its energy consumption remains low as compared to the other hotter months. Compared to the other buildings, Building C's energy consumption stays relatively consistent regardless of the temperature during its benchmark period with only slight increases in Month 4 when the temperature is among its highest and from Months 8 to 10 as the temperature lowers to its coldest range.

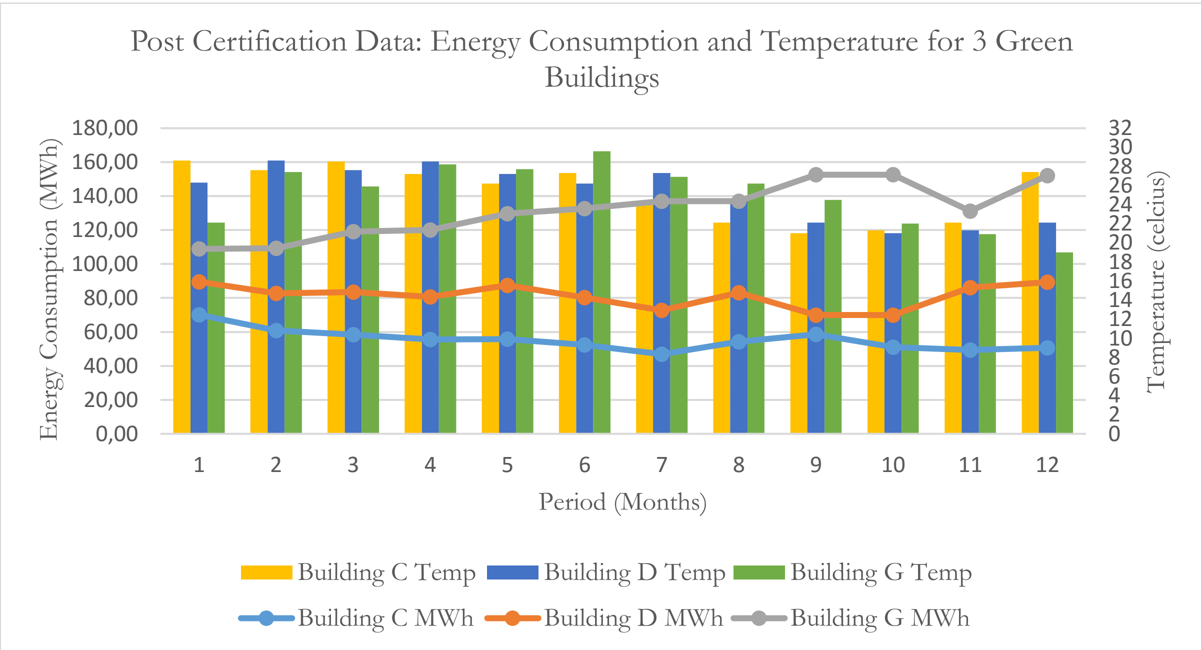
Figure 14: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Temperature during the Certification Period



Source: Based on fieldbased surveys (2020).

The graph above shows the buildings' energy consumption against temperature during the certification period. The graphs were plotted using data provided in table 6 above. The following trend are observed: during this period, as compared to the benchmark period, Building G's energy consumption has decreased significantly. Its energy consumption is highest in months 1 and 2 and as the temperature for its period gets higher its energy consumption relatively evens out from Months 3 to 12 with slight fluctuations in Months 4, 6, 7 and 9. However, it still consumes significantly more energy than Buildings C and D. Building D's energy consumption has also decreased from the benchmark period and has levelled out with far less fluctuations than in its benchmark period. However, there are noticeable fluctuations in Months 4, and 9. Interestingly, these fluctuations happen when the temperature is highest in Month 4 and when the temperature is at one of its lowest ranges in Month 9. From Month 9 to Month 11 the energy consumption of the period increases slightly again as the temperature is at its lowest and then decreases when the temperature starts to increase. Building C continues to consume the least amount of energy as compared to the other buildings and shows a steady downward trend from Month 4. There are only slight fluctuations in Month 3, 5 and 7. Interestingly, these slight fluctuations happen when the temperature is nearly at its highest but is decreasing. However, like the other Buildings, Building C has consumed less energy than in its benchmark period.

Figure 15: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Temperature during the Post Certification Period

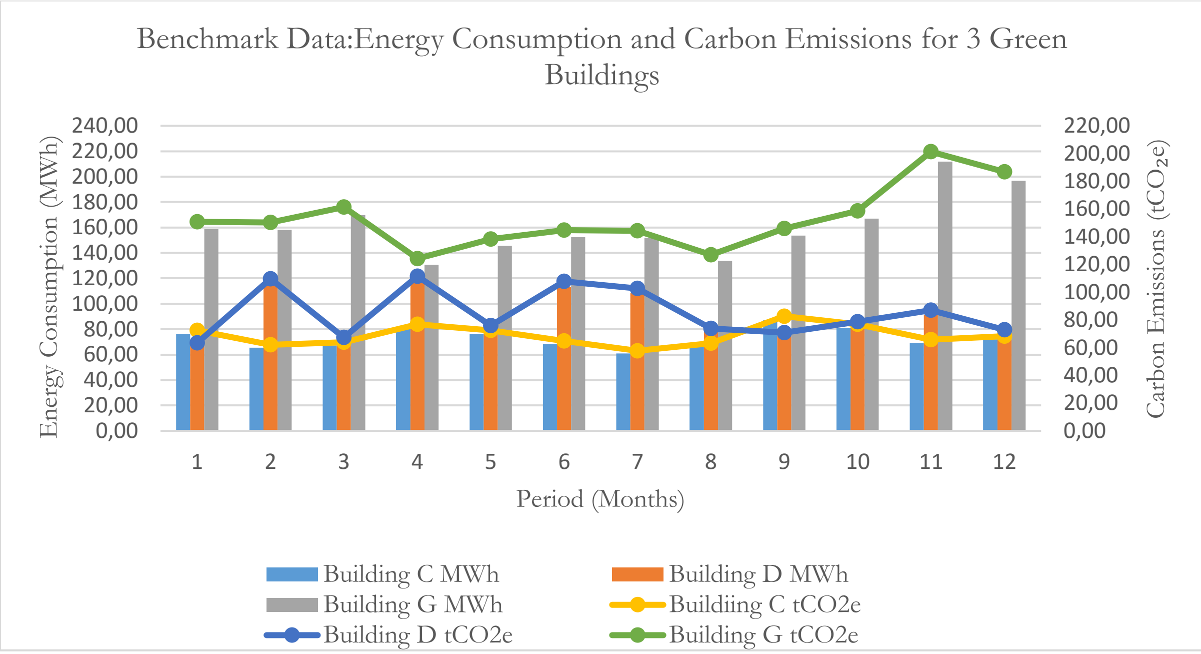


Source: Based on fieldbased surveys (2020).

The graph above shows the buildings' energy consumption against temperature during the post-certification period. The graphs were plotted using data provided in table 6 above. The following trend are observed: During this period, as compared to the certification period, Building G's overall energy consumption has continued to decrease however it starts to steadily increase from Month 3 to 12 with a slight dip in Month 11. Importantly, this increase is observed as the temperature starts to decrease therefore indicating that the building tends to consume more energy during the colder months. It still consumes significantly more energy than Buildings C and D. Building D's energy consumption has also decreased from the certification period and has levelled out with far less fluctuations than in its benchmark and certification period. However, there are slight fluctuations in Months 5, and 8 with the energy consumption starting to slightly increase from Months 10 to 12. This indicates that similarly to Building G, the building starts to consume more energy in the colder months. However, it's important to note that its overall energy consumption has decreased from its benchmark and certification period. Building C continues to consume the least amount of energy as compared to the other buildings and it's energy consumption seems to have completely levelled out. The only slight increases are in Months 8 and 9. Like the other buildings there is a slight increase in energy consumption during the colder months, namely months 8 to 10, however as the temperature starts to increase its energy consumption decreases again. Like the other Buildings, Building C has consumed less energy than in its benchmark and certification period.

The following section will examine the energy consumption of the Buildings against their Carbon emissions.

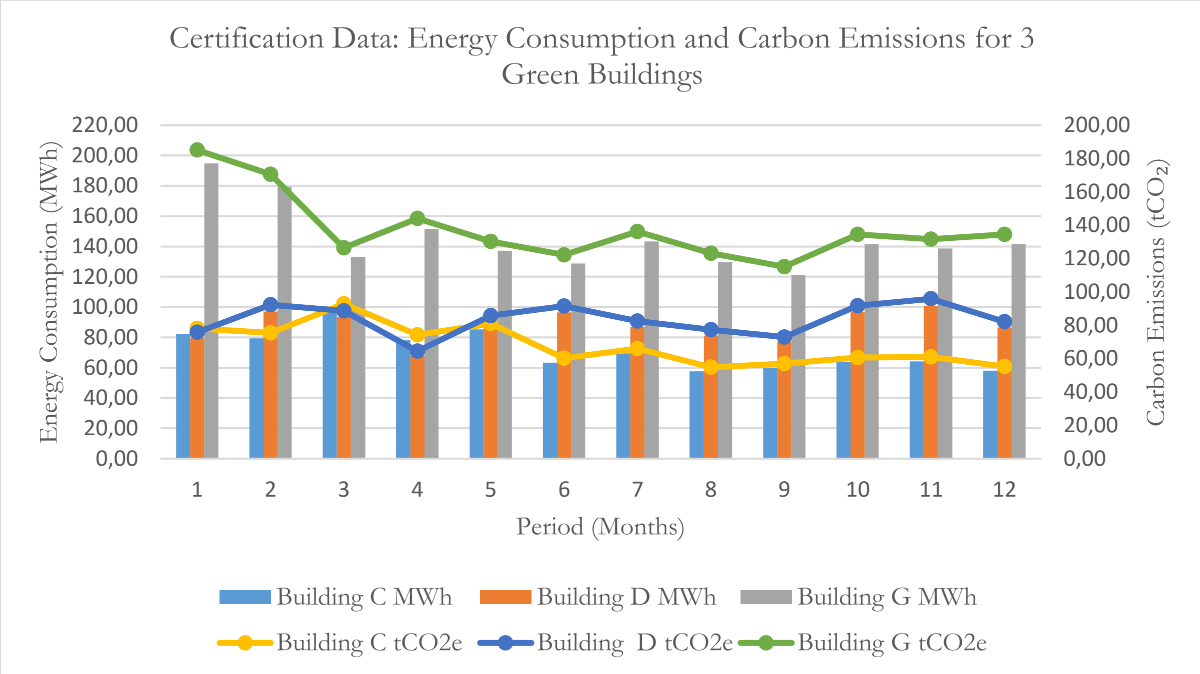
Figure 16: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Carbon emissions during the Benchmark Period



Source: Based on fieldbased surveys (2020).

As observed in the section above, Building G consumes more energy than Building C and D therefore its Carbon emissions are higher than Building C and Building D. Interestingly, the Carbon emissions follows the same trend as the energy consumption. As the energy consumption decreases or increases, the Carbon emissions do the same. This can clearly be observed from Months 8 to 12 where as the energy consumption increases, the Carbon emissions increase. This is also the case for Buildings C and D. Interestingly, the Carbon emissions for Building G is significantly higher than for Buildings C and D. Building C's Carbon emissions stay relatively constant and the energy consumption has also stayed relatively constant. Building D's Carbon emissions have fluctuated the same manner as its energy consumption has fluctuated over its benchmark period.

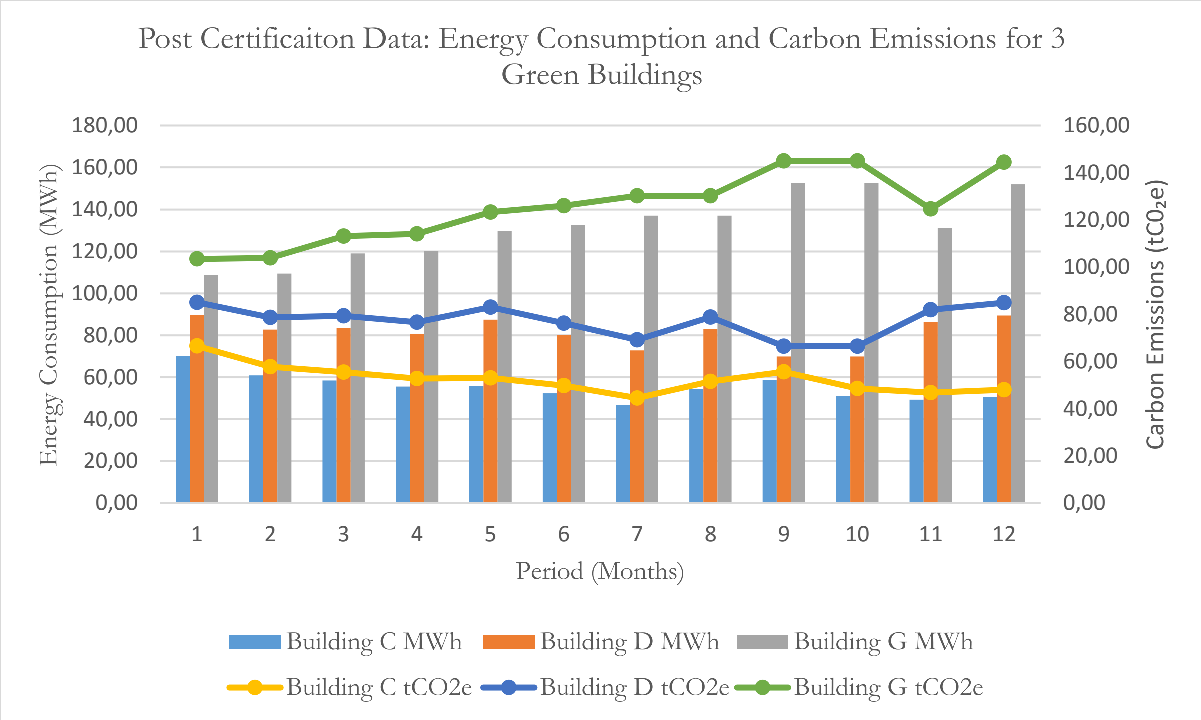
Figure 17: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Carbon emissions during the Certification Period



Source: Based on fieldbased surveys (2020).

The energy consumption and Carbon emissions for all three buildings have decreased in the Certification period. As discovered in the above section however, what is interesting to note is that the Carbon emissions still follow the same trend as the energy consumption of the Buildings. This indicates that the higher the energy consumption of the building, the higher its Carbon emissions and vice-versa. Building G's Carbon emissions still remain significantly higher than Building C and D. however show a decreasing trend from peaks in Months 1 and 2, which relatively level out from Months 3 to 12. Building C and D's Carbon emissions have also levelled out however there are slight fluctuations in the Carbon emissions of Building D over the 12 month period with Carbon emissions being at their highest during Months 2, 6 and 11 which coincides with the energy consumption. Building C's Carbon emissions are the lowest as compared to the other Buildings which is in keeping with its low energy consumption in comparison with the other buildings. However, Carbon emissions gradually decrease and even out relatively from Month 5.

Figure 18: A Graph Showing how the Buildings Performed in Terms of Energy Consumption against the Carbon emissions during the Post Certification Period

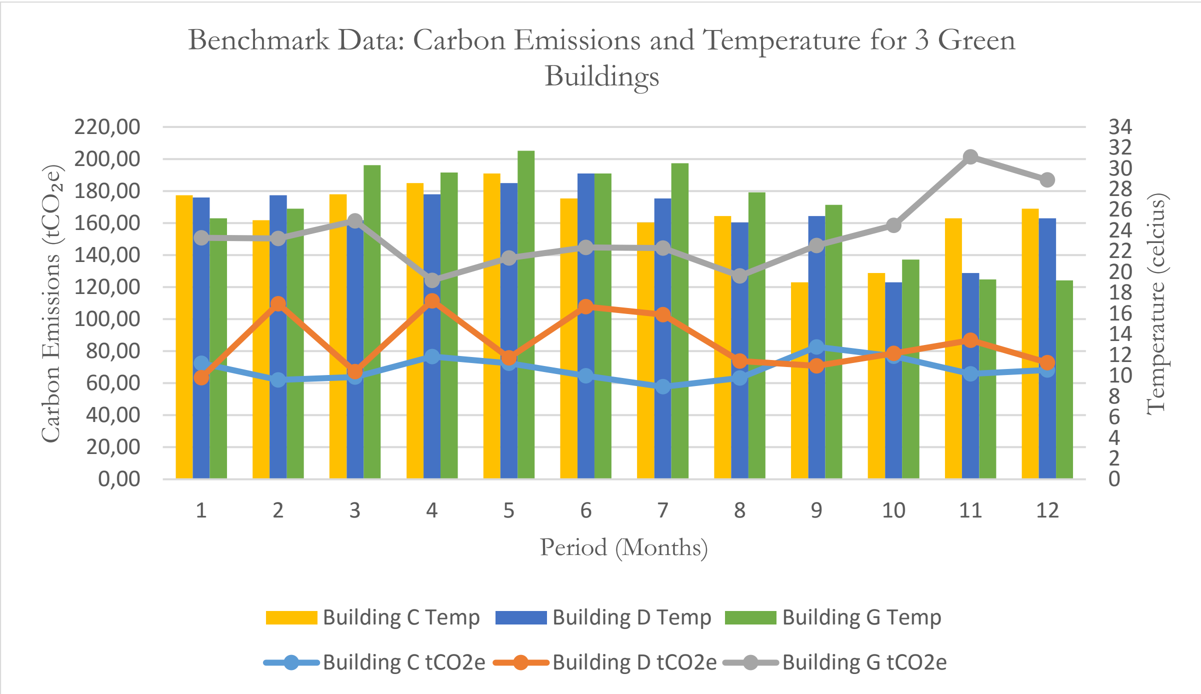


Source: Based on fieldbased surveys (2020).

The energy consumption and Carbon emissions for all three buildings have decreased further in the Post Certification period as compared to in the benchmark and certification period. What is interesting to note is that the Carbon emissions for Building G are still significantly higher than for the other buildings and steadily start to increase again with only a slight dip in Month 11. This is in keeping with the gradual increase in energy consumption of the building in this period. Building D. however, shows a generally decreasing trend in Carbon emissions up until Month 10 with slight fluctuations in Months 5 and 8. However, Building D's Carbon emissions start to increase from Month 11 and Month 12 of its post certification period in keeping with its increasing energy consumption during this period. Building C's Carbon emissions are the lowest as compared to the other Buildings which is in keeping with its low energy consumption in comparison with the other buildings. From Month 1 and 2, which is when its Carbon emissions are at their highest, they start to decrease and level out. Its Carbon emissions are lowest in Month 7.

The next section explores the relationship between the Carbon emissions and temperatures during the various periods.

Figure 19: A Graph Showing how the Buildings Performed in Terms of Carbon emissions against the Temperature during the Benchmark Period

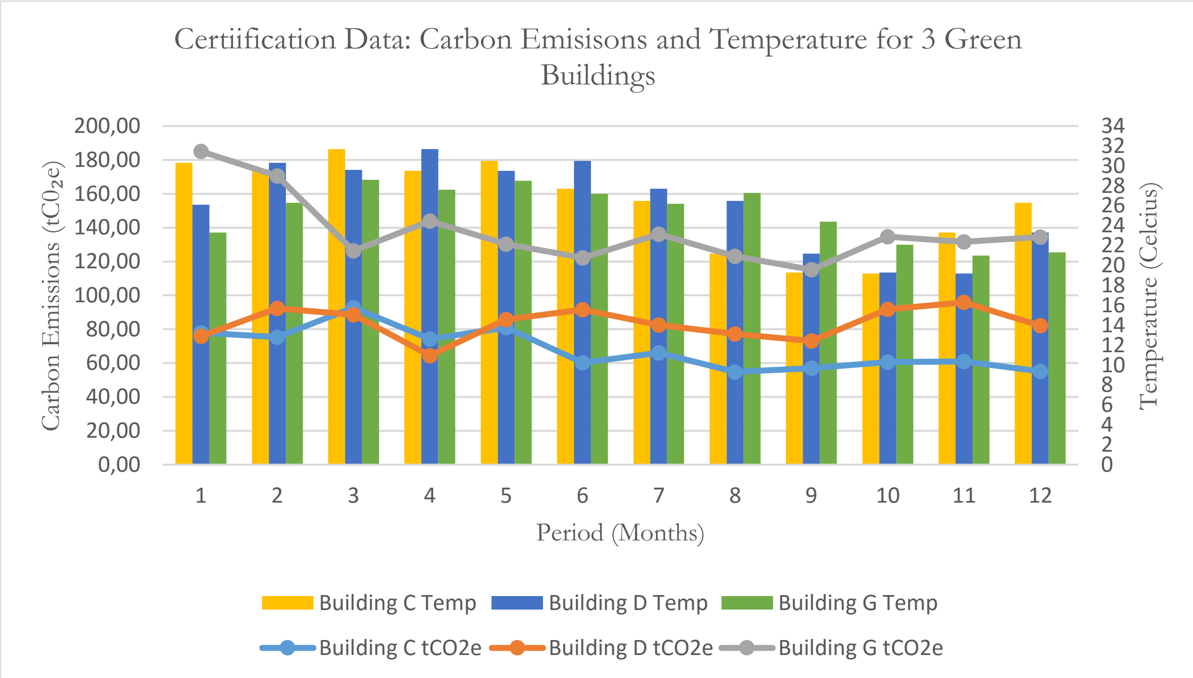


Source: Based on fieldbased surveys (2020).

The graph above shows the buildings' Carbon emissions against temperature during the benchmark period. The graphs were plotted using data provided in table 6 above. Interestingly, the graph is identical to the graph showing energy consumption against temperature during the benchmark period for all three buildings. This is to be expected as there is a direct correlation between Carbon emissions and energy consumption in buildings therefore, temperature would affect Carbon emissions the same way that it affects energy consumption so the same trends are observed.

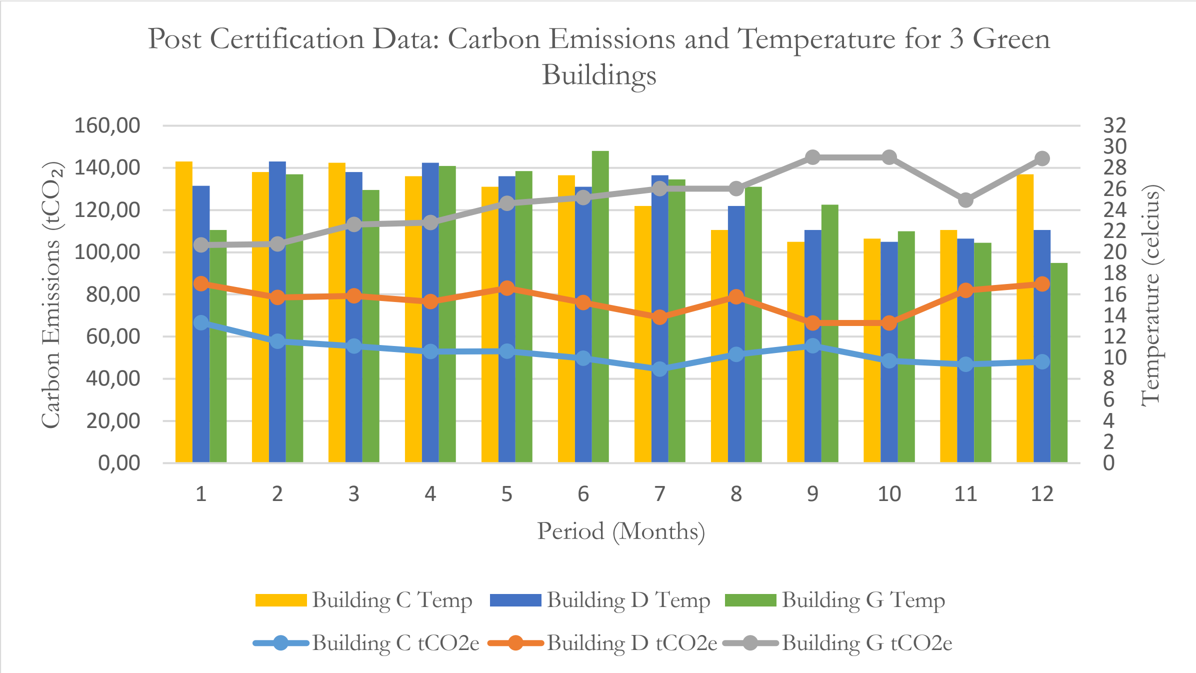
This is true as well for the buildings' Carbon emissions against temperature performance during the certification and post-certification period as seen in the figures below. The graphs were plotted using data provided in table 6 above. As is observed with the energy consumption, the overall Carbon emissions of the building steadily decrease from the benchmark to the post-certification phase

Figure 20: A Graph Showing how the Buildings Performed in Terms of Carbon emissions against the Temperature during the Certification Period



Source: Based on fieldbased surveys (2020).

Figure 21: A Graph Showing how the Buildings Performed in Terms of Carbon emissions against the Temperature during the Post-Certification Period



Source: Based on fieldbased surveys (2020).

The data presented above provided a critical finding for this study. The graphs for Energy consumption vs temperature are identical to the graphs for Carbon emissions vs temperature. This therefore indicates that there is a direct correlation between energy consumption and Carbon emissions thus the trends observed in both sets of graphs, energy consumption vs temperature which is graphs 13 to 15 and Carbon emissions vs temperature which is graphs 19 to 21, are identical. The trends observed are as follows:

In terms of the benchmark period for both sets of graphs, an analysis of Building C indicates that energy consumption and emissions increase slightly at month 4 which is January for the building as can be evidenced in table 6 which indicates mid-Summer. The energy consumption and Carbon emissions increase significantly from month 8 to 9 which represent May and June which are the end of Autumn and the Beginning of Winter respectively. Building D's energy consumption and Carbon emission fluctuate from months 1 to 7, with the peaks at months 2 which is October signifying mid Spring, month 4 which is December indicating the beginning of Summer and month 6 which is February of the next year signifying the last month of Summer. From month 8 which is April signifying mid-Autumn, the temperature starts to even out. Building G's energy consumption significantly peaks in month 11 which for its benchmark time period is August which signifies the end of Winter.

In terms of the certification period for both sets of graphs, the data presented shows that for Building C, temperature decreases in month 4 which is January for its time period signifying mid-Summer. There are slight fluctuations in Month 3 which is December signifying the beginning of Summer, month 5 which is February signifying the end of Summer and month 7 which is April which signifies mid-Autumn. Building D's energy consumption and Carbon emissions fluctuate for month 4 and 9 which signify December and May of the next year signifying the beginning of Summer and the end of Autumn respectively. From months 9 to 11, which are May, June and July and signify the end of Autumn to mid-Winter, the energy consumption and emissions increase significantly. Building G's energy consumption and emissions peak at months 1 and 2 which signify August and September which signify the end of Winter and the beginning of Spring in its time period. From that point, the energy consumption and emissions start to generally even out.

In terms of the post-certification period for both sets of graphs similarly to the other periods all three buildings have decreased their energy consumption and Carbon emissions. For Building C the most notable changes is in Month 7 where there is a slight dip which is April and Month 9 where there is a slight increase which is June for its time period. These signify mid-March and the beginning of Winter. In month 10, which is July the consumption and emissions start to decrease again. For Building D, there are slight fluctuations in months 5 and 8 of its time period which are January and Autumn. From months 10-12 which are June to August the energy consumption and emissions start to increase again. For Building G the energy consumption and emissions steadily increase for months 3 to 12 which is October to July of the next year according to its time period.

There is only a slight dip in month 11 which is the month before July, June which signifies the beginning of Winter.

Figures 16 to 18 detail the energy consumption versus the Carbon emissions of the building. During the benchmark period, Building C's Carbon emissions vs its energy consumption remains generally constant with no major fluctuations. Building D experiences significant fluctuations from months 1 to 3 which signify September to November signifying the beginning and end of Spring, months 3 to 5 signifying the transition to Summer which overlaps into the next year with months 4 and 5 being December and January and from months 5 to 8 which are January to April signifying the mid-Summer to mid-Autumn. For Building G the most significant increase was from months 10 to 12 which are May, June and July which signify the end of Autumn and the transitioning to Winter.

During the certification period for Building C, the most notable fluctuations between months 3 and 5 which signify December to February of the next year, as seen in table 6. This signifies the entire Summer period. From that point on in the remaining year, the Carbon emissions start to even out. For Building D, the most notable fluctuations are in months 2, 6 and 11. Month 2 is October, month 6 is February of the next year and month 11 is June. This signifies mid Spring, the end of Summer and the beginning of Winter. For Building G there is a significant decrease in months 1to 2 which are August and September and signify the end of Winter and the beginning of Spring. From there, the energy consumption evens out with an increase in month 11 which is June, signifying the beginning of Winter.

During the post-certification period for Building C, there is a notable decrease in Carbon emissions from months 1 to 2 which are October and November signifying the beginning to mid Spring. The lowest month for Carbon emissions is month 7 which is April which signifies mid-Autumn. For Building D, there are slight fluctuations at months 5 and 8 which are January and April respectively. These signify mid Summer and mid Autumn respectively. The Carbon emissions then increase from months 11 to 12 which are July to August signifying mid Winter to end of Winter. The trend observed for Building G indicates that there is a steady increase with peaks between month 9 and 10 which are April and May signifying mid to end Autumn. There is a decrease in month 11 which is June which signifies the beginning of Winter.

From all the graphs seen above, it is clear that certifying the buildings has had a positive impact on them in terms of the energy consumption and Carbon emissions. The buildings have become more energy efficient with their energy consumption overall reducing from their certification period and maintaining a downward trend post-certification, and their overall Carbon emissions following the same trend as well. There is a direct correlation between the energy consumption and Carbon emissions of the buildings and the graphs have also shown that temperature plays a role in the energy consumption and the Carbon emissions of a building. Generally during hotter and colder weather, the buildings consume more energy and emit more Carbon. However, certification of the building seems to mitigate this. The following characteristics are observed about the buildings, including their Building envelopes and sustainability features which were added to the buildings.

Table 10: Characteristics of the Green Buildings

	Building C	**Building D**	**Building G**
Building Envelope	Exterior: • brick façade • aluminium framed windows Interior: • carpeting • porcelain tiles • dry walls • glass/aluminium partitioning Large windows Atriums	Exterior: • brick façade • aluminium framed windows Interior: • carpeting • porcelain tiles • dry walls • glass/aluminium partitioning Large windows Atriums	Raised parking plinth East façade with opening and filigree sunscreen West façade with opening Atrium Painted three cone-shaped sculptural skylights

	Building C	Building D	Building G
Building Sustainability Features	Sustainable plans, policies and programmes for: • green cleaning materials • green equipment • energy and water metering • Grounds-keeping • Stormwater management • Green procurement • Management of solid waste and material Energy efficient lighting-fluorescents fitted with high frequency ballasts. Flow restrictors Water efficient toilets External Shading and Blinds	Sustainable plans, policies and programmes for: • green cleaning materials • green equipment • energy and water metering • Grounds-keeping • Stormwater management • Green procurement • Management of solid waste and material Energy efficient lighting-fluorescents fitted with high frequency ballasts. Flow restrictors Water efficient toilets External Shading and Blinds	• Retrofitted electronic ballasts energy efficient luminaires • Sustainable plans, policies and programmes for: • Building Users • Green Leasing • Green Travel • Green Procurement and Purchasing • Landscape • Operational Waste and Material Management • Landscape and Hard Surface Management • Integrated Pest Management
Performance Audits and other Measurements	• Indoor air quality • Thermal comfort • Acoustic quality • Daylight and artificial lighting levels	• Indoor air quality • Thermal comfort • Acoustic quality • Daylight and artificial lighting levels	• Indoor environment surveyed • Performance levels measured • Confirmed good levels of fresh-air • Confirmed good levels of lighting comfort • Improvement of 20% in terms of energy consumption • Excellent level of thermal comfort conditions • Excellent level of natural daylight

	Building C	Building D	Building G
			• Calculated improvement of 46% above the peak demand baseline achieved
Gross Lettable Area	**8710m²**	**Estimated 8460m²**	**Estimated 8803m² until 2017/10/01 then increase to estimate 9108m² from 2017/11/01**

Source: GBCSA case studies of buildings and Paragon Group (2020)

The information provided above appears to support the fact that the buildings may have also become more energy efficient as well as have reduced their Carbon emissions due to the buildings' characteristics including the building envelope and retrofitting measures put in place to make the office buildings more efficient and environmentally sustainable. The effect of these characteristics and retrofitting measures on the energy consumption and Carbon emissions of these buildings will be discussed in greater detail in Chapter 5.

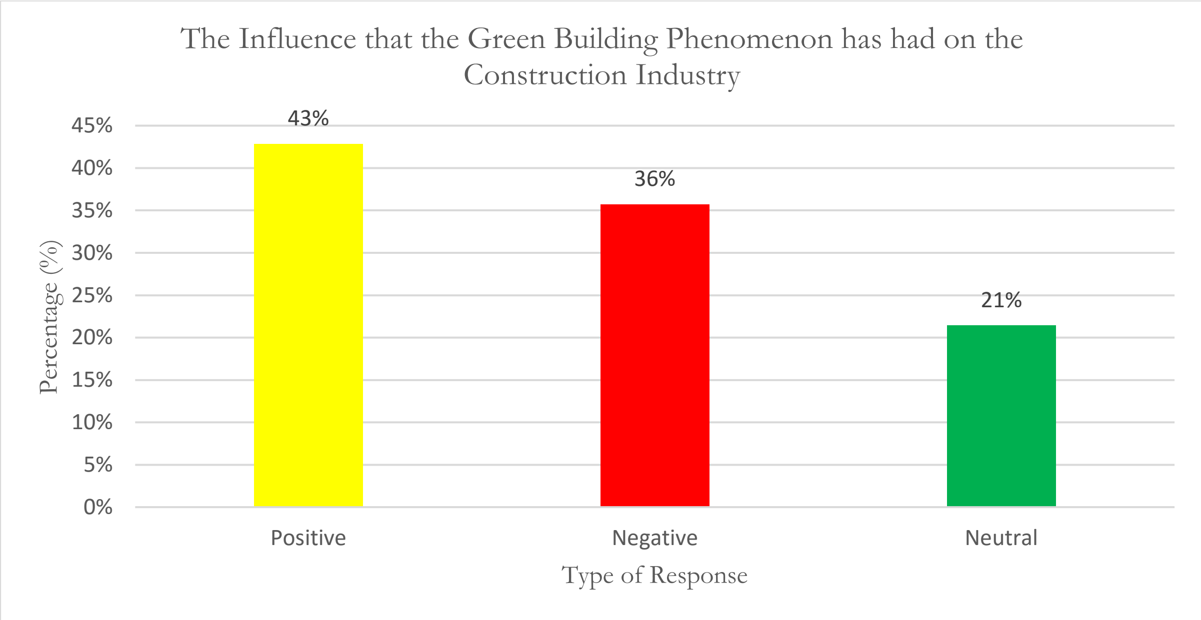
4.5 The Influence that the Green Building Phenomenon has had on the Construction Industry in South Africa and the Incentivisation of Green Buildings in the Country.

This section was interested in exploring the extent to which the construction industry has been influenced by the phenomenon of green building in the country and the incentivisation of green buildings in the country. As in the first section, for this part of the study the researcher used open ended questions and used thematic analysis to derive the main responses. Firstly, the influence of the green building phenomenon on the construction industry was presented. The second sub-section and third sub-section explores the current incentives for green building and further incentives which can be awarded. For this section, 11 participants responded. 1 participant did not respond to the questions sent to them. In this section, participants contributed multiply to the various viewpoints for the effect of green building on the construction industry and responses in terms of the types of incentives. Therefore, it was decided that the responses would be graphed. Although this section looks at South Africa holistically, it can be argued that as the City of Johannesburg is the epicentre for green building in the country, the empirical evidence will also give an accurate portrayal for the green building landscape in the city. In view of this the following results were achieved:

4.5.1 The influence that the Green Building Phenomenon has had on the Construction Industry

The acceleration of green building in the country is expected to impact most economic sectors such as energy. With the uptake of green building in recent years in the country, it is critical that the impact of this phenomenon on the construction industry be examined. The construction industry supports and is supported by various economic sectors such as the transport and manufacturing industry which provide the materials, technology and transportation for it to function. Therefore, the implications of these impacts will be widespread for the country's economy particularly its efforts to transition to a lower Carbon economy. In view of this, this section explores the influence of the green building phenomenon on the construction industry. The question posed was 'how has the construction industry been influenced and responded to green buildings in South Africa and why? It was as important to establish the impact(s) as it was the general influence as this would give detailed insight as to how the construction industry is adapting with the emergence of green building. The results are presented below:

Figure 22: A Graph illustrating the influence of the Green Building Phenomenon on the Construction Industry



Source: Based on fieldbased surveys (2019, 2020)

Based on the data presented in Figure 22, there are three main responses which the participants provided positive, negative and neutral. The participants responded that the overall impact was positive 43% of the time. It was followed by the impact being negative 36% of the time with the least impact being neutral at 21%. It is important to recall that multiple participants responded for each type of response. Therefore, one participant could have given a response to all three, explaining what the positive impact had been, the negative impact had been and whether there had been an impact at all.

The positive impacts are listed as follows:

1. Leaders in the field are now looking into the future to build regenerative buildings and communities and not just more efficient buildings which do less damage.
2. The private sector construction industry is leading in the practice of green buildings.

3. There is growing awareness of green buildings.
4. There are courses on green buildings for various professionals in the industry therefore a growth in skills.
5. Large schemes have been initiated to retrofit fluorescent strip lights with LEDs.
6. There is growing consciousness of selecting greener materials for construction.
7. There is bigger buy into much greener appliances (solar heating, electricity to gas boilers, refrigeration, transition to renewable energies. This is for enhanced energy security as Eskom electricity is expensive.
8. Savings are achieved on operating costs for the rest of the lifecycle of the building.
9. With SANS 10400-XA becoming mandatory construction of building envelopes improved (for example low income housing).
10. Responsible disposal of all building waste.
11. Sourcing of materials that are close to site. This helps reduce the embodied energy of the building.
12. Reduced use of water in construction.
13. Alternative use of material in concrete such as ash and recycled plastics.
14. More implementation of green buildings and green building principles.
15. The construction industry is sensitised to do the right thing.

Negative and neutral impacts on the construction industry participants identified will be discussed in greater detail in Chapter 5.

The negative impacts are listed below:

1. With regards to the public sector scarcity of skills and capacity to enforce green building practices.
2. It is more expensive for the end user to build green (client).

3. Climate Change has resulted in installation of more HVAC systems but in order to reduce energy consumption and reduce Carbon emissions HVAC systems need to be used less.
4. The pricing of the construction industry increases.
5. When the client or end users want to construct a green building it increases the work load for the construction.
6. When clients or end users want to build green it increases sub-contractor costs.
7. Affordability to implement green technologies is a challenge (especially for smaller companies with marginal profits).
8. There is a lack of awareness and training (especially in less developed areas such as rural areas).
9. In addition to that, the novelty of the green building industry and lack of government support has resulted in economic opportunism and corruption (some technology companies selling poor quality alternative technologies to unassuming constructors and clients).
10. Transition is hard because there is a need to reskill.
11. Investment costs for green technology are higher and there are higher capital costs (risks involved) (marketing is a factor). This results in scepticism.

The neutral impacts are listed below:

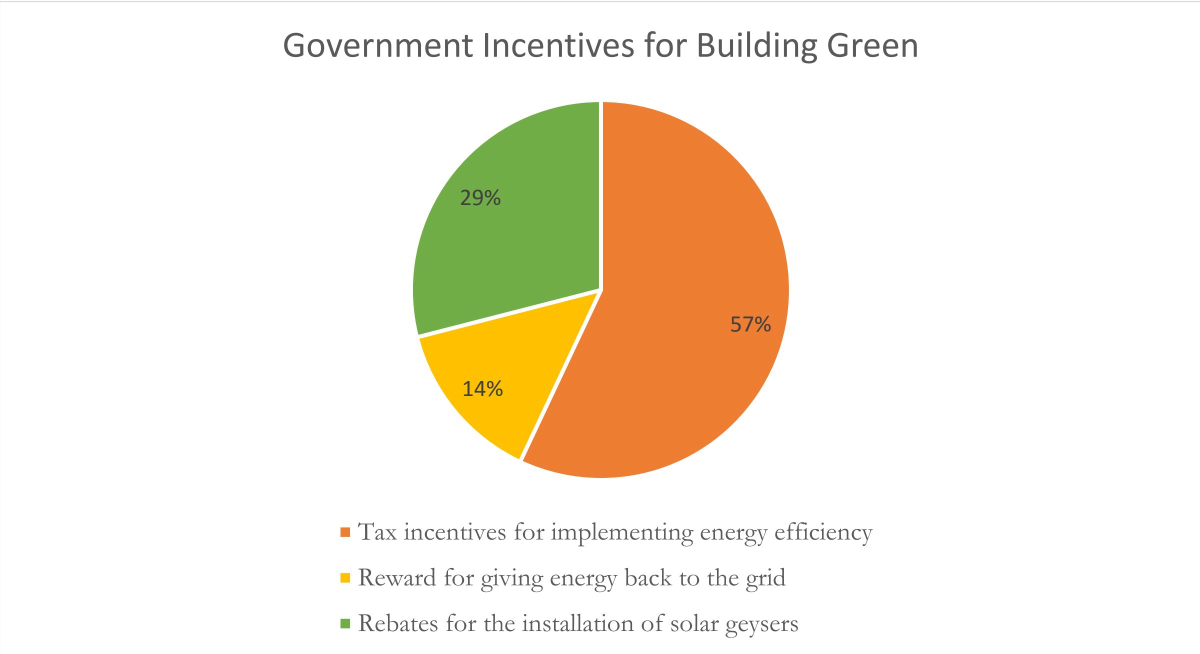
1. Constructors do not have a problem as they will build whatever is requested of them.
2. There is .no enforcement for green buildings therefore it largely depends on the client and the end user.

Based on the data that has been collected, it appears that the construction industry has mostly been impacted by the green building phenomenon in a positive manner. However, that negative and neutral impacts do exist indicates that there are compelling challenges in implementing green buildings in the country, particularly in terms of the types of negative impacts indicated.

4.5.2 The Incentives for Constructing Green Buildings in South Africa per Sector

In this section, the researcher aimed to establish which incentives already exist for construction of green buildings in the country and therefore in the City of Johannesburg. The incentives were categorised into three of the main economic sectors in the country: government, private sector and non-profit organisations. The other sectors such as the research institutions, the academic sector and civil society mainly offer support to these three sectors. They do this in the form of provision of scientific data, studies in the field, fora, meetings, awareness campaigns as well as provision of information through booklets, guidelines and policies. They are also involved in lobbying for the sector. In view of this, the following results were obtained.

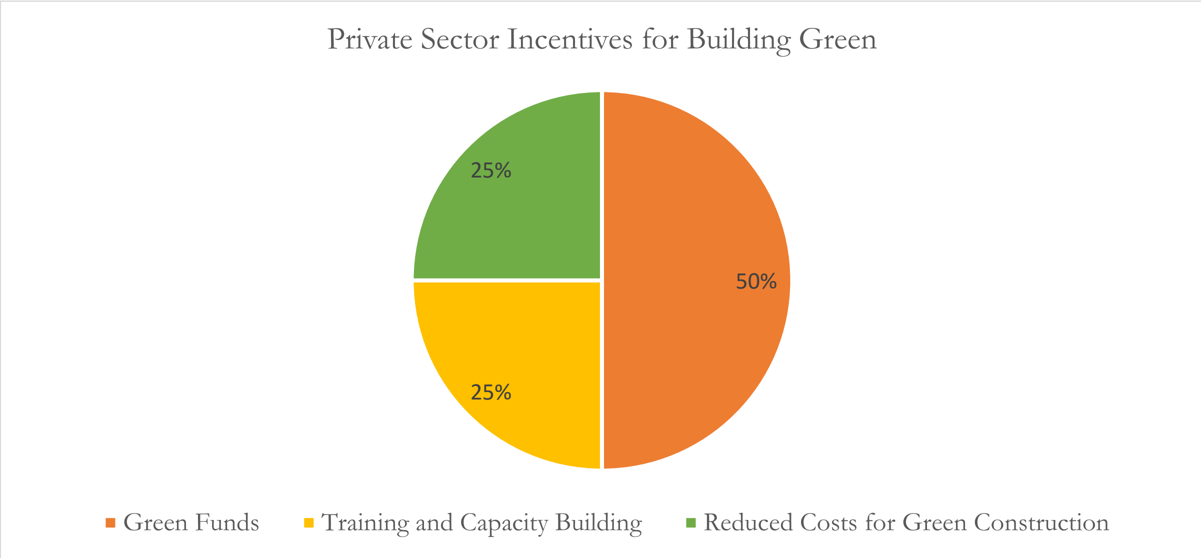
Figure 23: A graph illustrating the incentives given by Government for the implementation of green buildings



Source: Based on fieldbased surveys (2019, 2020)

As in the previous section, participants contributed multiply to the various incentives provided to increase green building uptake in the country. Therefore, it was decided that the incentives would be graphed. Tax incentives for implementing energy efficiency was mentioned the most with 57%, followed by rebates given for the installation of solar geysers at 29% and rewards for giving energy back to the grid was mentioned the least at 14%. It can thus be deduced that for owners of buildings of office use the incentive to retrofit them to enhance their energy efficiency and reduce Carbon emissions would be tax incentives from government. Such an incentive is provided for in the Carbon Tax Act of 2019 mentioned in section 4.3.

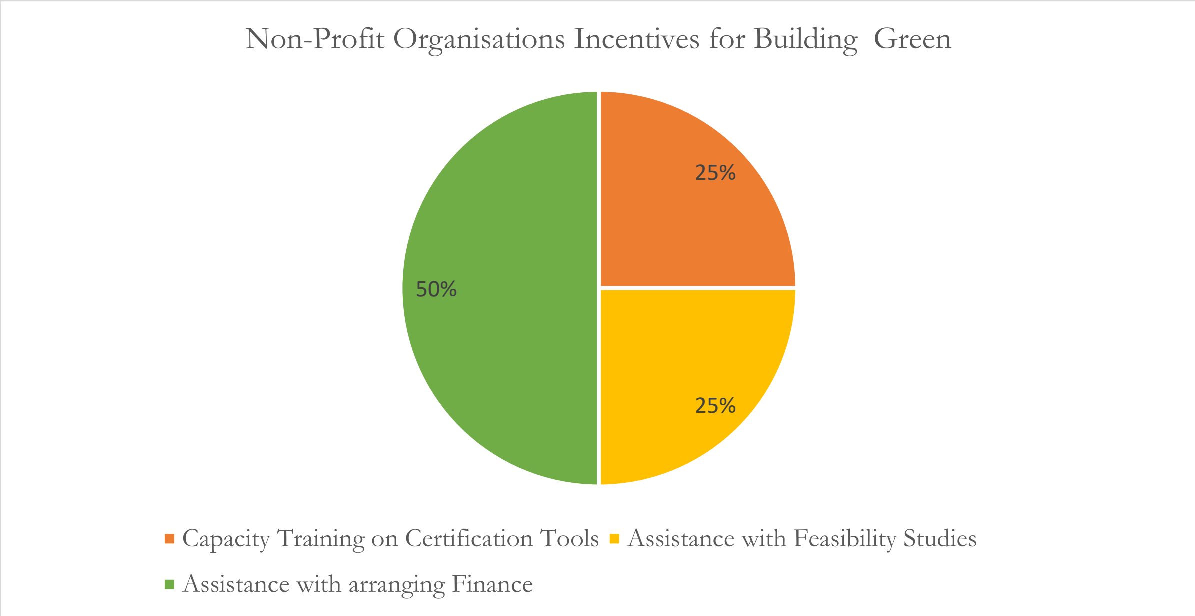
Figure 24: A graph illustrating the incentives given by the Private Sector for the implementation of green buildings



Source: Based on fieldbased surveys (2019, 2020)

Based on the data provided, in the private sector, green funds were mentioned the most as the incentives provided for implementing green buildings at 50% by the participants. Training and capacity building to other sectors as well as reduced costs for green construction were mentioned equally by the participants at 25% each respectively. It can thus be deduced from the graph that the provision for funding to construct green buildings is the most common incentive given by the private sector.

Figure 25: A graph illustrating the incentives given by Non-Profit Organisations for the implementation of green buildings



Source: Based on fieldbased surveys (2019, 2020)

Based on the data provided, it was mentioned the incentives provided by non-profit organisations were mostly assisting with arranging finance for green building at 50% and assistance with feasibility studies and capacity training on the use and implementation of certification tools followed with 25% each respectively. Interestingly, the incentives provided by non-profit organisations for the implementation of green buildings were mostly technical aimed at building capacity on certification tools and helping potential clients assess the practicalities of implementing green buildings. These are critical skills which would otherwise be unattainable for clients as the costs associated with them are very high.

From the data presented above it can be deduced that the incentives which exist in the SA for the implementation of green buildings are substantial however it is crucial to explore further whether these are being utilised by potential clients and whether they are well known or advertised to interested parties inside and outside the industry. :This will assist in understanding the rate at which the construction of green building is occurring and the rate of implementation of sustainability criteria in buildings for energy efficiency and reduced Carbon emissions.

Table 11: Types of incentives which can be given to key players in the Green Building Sector to encourage green buildings

No.	Type of Incentives	Sample (n)	Response			Total
			Y	**NR**	**N/A**	
1	Subsidies	11	36%	28%	36%	100%
2	LED lights	11	36%	28%	36%	100%
3	Green buildings funding	11	36%	28%	36%	100%
4	Lifecycle costing and analysis aid	11	36%	28%	36%	100%
5	Recognition awards	11	36%	28%	36%	100%
6	Brand awareness	11	36%	28%	36%	100%
7	Carbon tax implementation	11	36%	28%	36%	100%
8	Green building certification	11	36%	28%	36%	100%
9	Green building financial aid	11	36%	28%	36%	100%
10	Tax rebates	11	36%	28%	36%	100%
11	Government bulk bonuses	11	36%	28%	36%	100%
12	Faster approval times	11	36%	28%	36%	100%
13	Information sharing and capacity building.	11	36%	28%	36%	100%
14	New and alternative technologies and materials.	11	36%	28%	36%	100%

Source: Based on fieldbased surveys (2019, 2020)

Where:

(n)=sample

Y=Yes

NR=No Response

N/A=Not Applicable

The study was also interested in exploring additional incentives which could be given to further enhance green building and certification in South Africa. In order to determine this, the researcher posed the question 'what more can be done to incentivise building green in South Africa? The question was targeted for all the key players in the construction industry namely developers, planners, government, the construction industry and private sector. The number of participants who responded to this question was 11 due to 1 participant not responding to questions forwarded to them. Due to the fact that the number of participants was an odd number, it was decided that percentages instead of numbers would be used for them in the table. In view of this, the responses were as follows: All in all, 14 incentives were identified as listed above in the table proving sufficiently that the green building industry can be further enhanced in the country. Interestingly, for each incentive there was an equal number of participants who said that it was applicable, an equal number of participants who had no response to the incentive and an equal number who said that the incentive was not applicable. For each incentive listed, it is suggestive that 4 (36%) of the participants think that they are important. For each incentive, 3 (28%) of the participants had no response and 4(36%) said that it was not applicable. The participants who had no response indicated that they did not know of any incentives which could be given to encourage further uptake of green buildings in the country. The participants who responded that it was not applicable to give further incentives indicated that this was due to the fact that the construction industry would construct whatever the client requested regardless of whether it was green buildings or nominal buildings so there would be no significant differences in the uptake of green buildings.

Chapter five will go into detailed analysis of the research findings presented in this chapter. Positioning the research findings in the context of existing information and literature will give an accurate picture of the implications of the study on the primary perspectives of certified green buildings in terms of climate change mitigation.

CHAPTER FIVE

ANALYSIS AND DISCUSSION

5.1 Introduction

This chapter aims to present an analysis and discussion of the findings of this study. The importance of this study was to investigate the role that retrofitted certified green buildings of office use in the City of Johannesburg play in mitigating climate change. Furthermore, legislative instruments and their implementation were important to investigate the proliferation of green buildings countrywide as well as the influence of the green building phenomena on the construction industry.

In view of the above, this chapter is presented in a manner, which engages the research objectives, which were outlined in *section 1.4* of this dissertation. The first objective is to measure the energy efficiency and emissions of green buildings. Secondly, a discussion on whether there are gaps in the existing legislation and institutional frameworks which affect the implementation of green buildings is presented. The third section is dedicated to discovering challenges, if any, in building performance rating tools in South Africa and how they are applied which affect how green buildings monitor and maintain their energy efficiency. Lastly, the incentivising of constructing green buildings and mainstreaming energy efficiency in buildings for the construction industry in SA is presented.

5.2 The Measurement of the Energy Efficiency and Carbon Emissions of Green Buildings.

As pointed out in Chapter one of this dissertation and later in the empirical evidence presented in Chapter four, one of the things that this study was interested in was to determine whether certification of retrofitted buildings of office use in the City of Johannesburg resulted in them becoming more energy efficient and reducing their Carbon emissions during their operational lifecycle. To do this their energy consumption prior to, during and post their certification period was measured and provided to the researcher and their Carbon emissions for all three periods calculated. The energy used by the buildings is metered electricity from the Eskom Grid. The information was provided by Property Company 1 who owns the buildings. This is further supported by Van Calster et al (2015) who state that, for example, in the USA consumption of all energy from the building stock, mostly comprising of residential and commercial buildings, is 41% with 73% of electricity produced being used. This is further supported by Lucon et al (2014) that most greenhouse gas emissions are Carbon emissions from electricity use in buildings. From the data presented in table 6 in the previous chapter, it was established that all three buildings, Building C, D and G reduced their energy consumption steadily over all three periods (benchmark, certification and post-certification). The reason as to this trend occurring is that one of the conditions of the GBCSA is that for a building to be certified using any of its tools, it must be able to demonstrate during its certification application period that it is using less energy than during its benchmark period. Both sets of data are provided to the GBCSA during the certification process as illustrated in Figure 11 in Chapter 4. Since the buildings being researched for this study were certified using the EBP V1 Tool this condition would have applied to all three buildings.

The buildings all received certification however, according to stipulations in the EBP V1 Tool, to maintain their certification they have to apply for recertification every three years. The property company which owns the buildings, Property Company 1, must ensure that even after certification is achieved the building continues to maintain or decrease its energy efficiency. As demonstrated in table 6 in the previous chapter, it is observed that all three buildings have decreased their energy consumption during their post-certification period. Additionally, according to the trends observed in the graphed results of the buildings energy performance and Carbon emissions data from Figures 13 to Figures 21 there is a direct correlation between energy consumption and Carbon emissions in buildings. Hence it was also demonstrated that their Carbon emissions reduced over all three periods. One can thus argue that it is evident that the certification of the buildings has resulted in them becoming more energy efficient and resulted in them reducing their Carbon footprint. This validates that they are effective tools for assisting with climate change mitigation.

Additionally, the study was also interested in identifying the main factors which contribute to increased energy consumption and Carbon emissions in buildings. The main factors were further subdivided into general factors, specific factors, internal factors and external factors. This was important as they impact the consumption of energy in buildings and their Carbon emissions. Hence there is an important link to them when measuring the energy efficiency and Carbon emissions in buildings. According to Godoy-Shimizu et al (2018:846) they observe that 'energy consumption in the operation of buildings is determined by a large number of variables, including distinct architectural and engineering design choices, as well as broader factors such as occupancy behaviour and the external environment'. This supports the findings in Chapter 4 which identified that under specific factors poor designs was the leading subfactor influencing energy consumption and Carbon emissions, under internal factors it is occupant behaviour and external factors play a role, especially temperature. Additionally, Abdulla and Alibaba (2017) found that office buildings utilise a greater amount of energy than other types of commercial buildings because of the way office activities are conducted. There are various types of usages for buildings and office use is one of them. This therefore supports the findings of this study that under general factors building use type is the subfactor which impacts the energy consumption and Carbon emissions of a building the most and as the buildings being researched for this study are office buildings, it further validates the findings of this study. Thus, when the findings of this study are examined and compared to existing literature and previous studies carried out, it is apparent that the same can be said of office buildings in the City of Johannesburg. and the three buildings C, D and G being researched for this dissertation. Thus, we can further speculate that this this can also be applied to the Buildings A, B, E and F.

When considering specific factors, poor designs of the building was identified as the leading factor determining the energy consumption of a building. The United States of America's Department of Energy (2015) found that consumption of energy in buildings is dependent on good architecture linked with well-designed energy systems as well as on proper maintenance and operation of the building once it has been occupied. However, this has bigger implications for new buildings as opposed to existing buildings which are the focal point of this study. Therefore, in this way, the findings of the United States of America's Department of Energy (2015) would suggest that in contrast to the buildings being researched for this study, architecture and design only play a significant role in new buildings. This was to be expected as the study focused on existing buildings whose design modifications are largely limited to retrofits as seen in table 10 in Chapter 4. .However, Tatham Wilkes (2013) argue that mandating SANS 10400-XA has resulted in the improvement of building envelopes in South Africa due to the compulsory specifications in designing and constructing buildings to make them more energy efficient. The stipulations in the mandatory SANS 10400-XA apply to both new builds and existing buildings. Therefore, they support and are similar to the findings of this study. Building height, interestingly enough, was not individually identified as a specific factor in the study. When investigating the factors behind building performance, Baker and Steemers (1994) submit that it is possible for height to account for a 2.5 times variation in consumption of energy. This explains why, in section 4.4 in Chapter 4 data collected indicates that Building G uses more energy and emits more Carbon than the other two buildings. As described in Chapter 3 Building G has 8 floors of office space whereas the other two buildings have 2 floors. It can be argued that building height forms part of building design therefore it is covered under the subfactor designs.

Furthermore, as the private sector construction industry is leading in the practice of green buildings in South Africa, the challenge of poor designs in buildings, particularly privately owned buildings, is further reduced. This applies particularly to the buildings being researched in this study as they are privately owned green buildings. However, although effective building design is more critical at the construction phase of a building, the study conducted by the USA Department of Energy (2015) also acknowledges that poor designs in existing buildings can be addressed through retrofitting to improve energy efficiency and reduce the Carbon footprint. This can be achieved through considering technologies which can be used to achieve this (USA Department of Energy 2015). This proves the findings of this study and supports the results as seen in table 10 whereby the various retrofitting measures which the buildings have undergone are described. However, retrofitting existing buildings can be challenging and it is important to highlight the types of technologies which can be utilised for existing buildings (USA Department of Energy 2015). Furthermore, physical and technological retrofits of buildings present considerable financial costs (Ali et al 2020). This is similar to the findings of this study under Chapter 4 whereby some of the negative impacts of the green building phenomenon on the construction industry were identified as being cost and capacity related. The most relevant of these findings were that; particularly with regards to the public sector, skills and capacity for the enforcement of green building practices are scarce, affordability to implement green technologies is a challenge (especially for smaller companies with marginal profits), investment costs for green technology are higher and there are higher capital costs (risks involved)(marketing is a factor) which results in scepticism and it is more expensive for the end user to build green (client).

However, independent studies carried out by the GBCSA suggest on average the savings that certified green buildings can make in terms of reduced energy consumption is up to 85% less energy, 65% less potable water and reduction of the amount of waste generated is 65% less than that which has to be taken to landfills than non-certified buildings (Green Economy Summit Report 2010). Furthermore, studies carried out indicate that green buildings are said to actually decrease operating costs in the long run due to their energy and resource efficiency, as well as their increased durability and decreased cost of maintenance (Johnston and Gibson 2008). Therefore, the findings from the various studies are similar to this study which discovered that it is feasible and effective to mitigate the effects of poor designs in existing buildings through retrofits by building modification and adding energy efficient technology. The presence of upfront costs can be mitigated as it will decrease the cost of the building through energy consumption savings and operational costs in the future.

Buildings C, D and G have all undergone retrofits as evidenced in Chapter 4 in table 10.

Buildings C and D have undergone the following retrofits:

1. Large windows and atriums which have been incorporated. These have allowed for increased natural daylight into the office.
2. Metering of energy and water consumption. This has allowed more efficiency in using water and energy as occupants are able to monitor their energy and water consumption.
3. Energy efficient lighting-fluorescents. This has resulted in reduced energy consumption, especially for lighting.

Building G has undergone the following retrofits:

1. A raised parking plinth. This was designed to allow rigorous plant growth. Plant growth is also effective in curbing excessive Carbon emissions as plants absorb Carbon Dioxide.
2. The careful placement of openings on the east and west facades. This improves the circulation of air in the building.
3. The filigree sunscreen on the eastern façade. This assists with promoting natural lighting.
4. Energy efficient lighting-fluorescent. This has resulted in reduced energy consumption, especially for lighting

The retrofits above for all three buildings have been similarly identified and further supported as being effective by studies done by the USA Department of Energy (2015) who state that LED's, easily installed insulation, window design, window and window covering controls have a positive impact and decrease the overall consumption of energy in retrofitted buildings. Furthermore, increased thermal comfort and air quality can also be attained, as seen through the retrofits in

Building G, through including landscaping and improved building envelope (USA Department of Energy 2015).The implications of these findings is that mitigation of the challenge of poor designs can be achieved with adequate retrofits which address excessive energy consumption and Carbon emissions.

In terms of internal subfactors the study uncovered that occupant behaviour is the factor most responsible for energy consumption in buildings. This supports Godoy-Shimizu et al (2018) findings. Studies conducted by Noubissie-Tientcheu et al (2019) and Kaminska (2019) in Poland similarly found that occupant behaviour affects a building's energy performance due to the actions and interactions of the occupants in the buildings. Therefore, it can be deduced that occupant behaviour influences all the other internal sub-factors such as lighting, plugs, use of mechanical equipment and refrigeration. The usage of HVAC systems was identified as the second highest subfactor contributing to energy consumption by the study. Yuan et al (2016), who did a study of government office buildings in Qingdao China, were of a similar view that air conditioning systems are generally accepted to be significant contributors to energy consumption in buildings. Use of HVAC systems by occupants is highly dependent on external factors such as temperature. Thus, there is an interrelationship between internal and external factors which drive up energy consumption in buildings The implication of this for studies such as this one is that it presents an opportunity for notable savings in energy consumption due to the fact that occupant behaviour is regarded as a soft factor with regards to energy savings in buildings as opposed to design modification (Ali et al 2020). This is because it requires the least physical and financial intervention while bringing significant gains (Ali et al 2020). For example, a case study of the Department of Public Works: Batho Pele House Building in Tshwane illustrates that measures such as effective 'training of the building management staff as well as issuing a Building Users' Guide to the building owner', can result in positive changes to occupant behaviour to ensure efficient energy usage in office buildings (SALGA 2017: 21). Therefore similarly, retrofitted office buildings can implement the same measures to ensure savings on energy consumption and reduction in Carbon emissions.

Temperature is identified as the subfactor contributing the most to energy consumption in office buildings in terms of external factors. The seasons of the year are defined by the temperature thus there is a direct link between the external sub-factor seasons as well. Furthermore, temperature has an interrelationship with internal factors as it impacts occupant behaviour. According to Abdulla and Alibaba (2017) the glazed envelopes of existing office buildings result in glare, increased heat in summer, reduced heat in winter, and increasing cooling and heating loads, specifically in hot and arid climates. This would influence occupant behaviour and the use of systems such as HVAC systems and refrigeration. According to the study, the data presented in table 10 in Chapter 4 has illustrated how the buildings have mitigated this through retrofits. When the building envelopes and sustainability features of the researched buildings were explored it was found that for Buildings C and D, that the interior of the building envelope is characterised by, amongst other things, dry walls and glass/aluminium partitioning and the external envelope of the building is characterised by a brick façade and aluminium framed windows. The building envelope of Building G has already been discussed in the paragraph above. Brick facades are energy efficient and provide warmth in Winter and cooling in Summer (Brickworks Building Products 2019). This is because brick is able to harness natural sources of energy (Brickworks Building Products 2019). The natural density and the thermal insulating qualities of clay, which is what brick is made of, moderates building temperature and reduces energy consumption rates (Brickworks Building Products 2019). Glass/aluminium partitioning in office buildings allow for more natural light to come in as they are more opaque, therefore assisting in reducing energy consumption in the form of lighting in office buildings (Fusion Partitions Ltd 2019). This is further supported and similar to the findings of Johnston and Gibson (2008) who argue that materials which are increasingly being used to construct green buildings have become more reliable as competition in the manufacturing industry rises due to market forces.

Therefore, the implications of these findings is that knowing which factors increase energy consumption and Carbon emissions in buildings and understanding how they do it assists in achieving the solutions required to address them. Furthermore, retrofits have been proven to be amongst the best methods to achieve energy efficiency and Carbon emissions reductions in existing office buildings. Therefore, these findings also have positive implications for the large existing building stock in the City of Johannesburg in terms of decreasing Carbon emissions and therefore mitigating climate change. This will assist the city and indeed the country to move to the goal of a lower Carbon economy and a just and sustainable society for all (Climate Change Bill 2018). The findings also have implications for policy makers to formulate behaviour training strategies to reduce energy consumption which will increase environmental and social responsibility. Furthermore, these findings can also support the green economy in SA in terms of increasing demand in the market for local technology development. Local manufacturing of renewable energy technologies which can be installed as part of retrofitting the existing building stock have the ability to create local jobs (Davidson and Winkler 2003) Furthermore, this can assist in developing local manufacturing capacity and decreasing reliance on imported components as the technological industry is extremely vulnerable to changes in exchange rates (Davidson and Winkler 2003).

5.3 Existing legislation and institutional frameworks which affect the implementation of green buildings

In SA the 'law and energy nexus requires a multidisciplinary approach as well as a multi-pronged adoption of diverse policy instruments to effectively transform the country's energy use patterns' (du Plessis 2014:1). A large number of laws have been introduced to stimulate the transformation of energy production and usage. Specific legislation and instruments relevant to this study are discussed below. This is similar to a study conducted by Pitcher (2019) who observed that the improvement of energy efficiency of buildings is a priority for governments globally who are passing laws which increase the thermal efficiency regulation and encourage decreased-energy consumption in buildings.

The South African constitution is the supreme law of the country and all the acts which make up the laws of the country and regulations to implement them emanate from it. For the purpose of this study Section 24 under the Bill of Rights in the constitution was relevant as it speaks to the right to a healthy environment for all citizens. This is similar and supported by Macguire and McDaid (2017) who observe that acts and regulations regarding water, air, land protection, and energy along with GHG emission reductions relating to climate change mitigation are directly linked to human rights issues (Macguire and McDaid 2017). Further studies have shown that like South Africa, nations around the world are confronted by ecological hardships (Daly 2012). Therefore, similar to the findings of this study regarding the Constitution of South Africa, most countries have developed a legal system for the protection of the environment (Daly 2012). Globally nations differ regarding how they place environmental protection. South Africa places environmental protection at the highest level. Since 1971 of the 193 national constitutions in the world 149 include specific mention of environmental rights as well as responsibilities (Boyd 2014). According to Boyd (2014:6) 'this includes the majority of nations belonging to the Organization for Economic Cooperation and Development, the Commonwealth, La Francophonie and even the Organization of Petroleum Exporting Countries'. It is also inclusive of the 'bulk of countries in Africa, the Americas (with the exception of North America), Asia-Pacific, Europe and the Middle East/ Central Asia' (Boyd 2014: 6).

Since 1998, government has introduced energy-efficiency measures in policy and legislation (Halsey et al 2017). Part of the requirements of the National Energy Act 34 of 2008 was to establish the SANEDI (National Energy Act 34 of 2008). SANEDI is crucial as it is one of the leading entities involved in energy research and resource efficiency (SANEDI 2020). This is relevant to the study as SANEDI's research directly impacts energy efficiency in buildings as their mandate includes energy efficiency and renewable energy (SANEDI 2020). The other programme is research, data development and innovation (SANEDI 2020). Such innovation can lead to inventions and exposure to renewable and energy efficient technologies which can be installed in buildings thus contributing to their energy efficiency. In addition to this, regulatory bodies such as the National Energy Regulator of South Africa (NERSA) were established (Halsey et al 2017).

Existing information, however, suggests that in addition to these new regulatory bodies being established, a new path for energy expansion which has the potential for realisation of equality in the context of sustainability needs the redevelopment of energy policy in the country (Macguire and McDaid 2017). Provisions for this were already initiated in 1998 when the government published a White Paper on the Energy Policy of the country addressing energy efficiency in all sectors (du Plessis 2014). The paper was not identified in Chapter 4. Existing evidence indicates that the reason for this is that the policy is outdated (Halsey et al 2017). Following from this, the Climate Change Response White Paper was developed and provides for mitigation and adaptation responses (Macguire and McDaid 2017). The study did not divulge these as they are merely policies and not mandatory legislation, however they have implications for the study as future developments of mandatory legislations and instruments emanate from these policies.

It is critical for the energy sector to undergo the process of transformation to ensure that societal, environmental and societal justice occurs (Macguire and McDaid 2017). Macguire and McDaid (2017) identified that environmental fiscal reform which includes a Carbon tax on emissions, can potentially result in the achievement of energy sector transformation. This supports the findings of the study which identified that the national Carbon Tax Act 2019 is significant in terms of transforming energy consumption and Carbon emissions in all sectors of the economy. According to the stipulations in the Act, as laid out in Chapter 4 commercial/institutional buildings qualify for a Carbon Tax if they have the capacity to combust 10 MW(th). The Carbon Tax Act was only signed into law and effective from the 1st of June 2019. Due to the COVID 19 pandemic and the economic stimulus package announced by the president, the filing requirement and the first Carbon Tax payments which were due by the end of July is delayed to the 31 October 2020 (South African Revenue Services 2020). In addition to this, applications for Carbon Tax registration/licencing were only announced on the 20 July 2020 on the SARS website (South African Revenue Services 2020). Furthermore, Tarrif Amendments for the Carbon Tax were only announced on the 7 August 2020 (South African Revenue Services 2020). Thus, from the information given above it can be deduced that although the Carbon Tax has come into effect, it is not yet implemented in the country. However, the amount of thermal energy combusted by the buildings per annum would have to be provided to determine whether they qualify for a Carbon Tax. As this information was not central to the aim of this study and the processes to get the Carbon Tax Act implemented are still underway, it can be concluded that the Act and this aspect of the Act is currently out of the scope of the study and not applicable yet. However, research of implementation of existing Carbon Tax schemes worldwide seem to indicate that the Carbon Tax system in South Africa is likely to be effective as some countries have developed direct taxes on fossil fuels or Carbon emissions as a tool for discouraging the consumption of energy (UNEP 2009). For example, several European countries have imposed taxes on energy use or energy-related Carbon Dioxide emissions (UNEP 2009). These include the UK who have developed a climate change levy which is a tax on electricity provided by fossil fuels levied on energy consumers in the United Kingdom (UNIDO 2009). The objective of the levy is to give an incentive for enhanced energy efficiency and reduced Carbon emissions for electricity consumers excluding the domestic and transport sectors (UNIDO 2009). Furthermore, studies have shown that there are benefits which accompany taxes which directly impact the entire life-cycle of buildings and have the potential to positively influence and strengthen other legislative instruments such as Standards (UNEP 2009). A potential use for these taxes is that finances raised from them can be diverted to energy efficiency programs(UNEP 2009).

The government announced that as of May 2012, all buildings (new and extensions) must comply with the energy consumption in buildings provisions in the amended National Building Regulations (Tucker 2017). These minimum standards are for managing energy in buildings (Tucker 2017). This supports the findings of the study which identified these as the SANS building

Standard 10400-XA which is for energy usage in buildings. Furthermore, SANS 10400-XA also deals with reduction in Carbon emissions (Mustapha 2016). Another new energy standard was developed which is the SANS204 standard, which is for green building in South Africa (Mustapha 2016). The South African Bureau of Standards (SABS) is the custodian of the SANS building standards (Council of Science and Industrial Research 2019). As SANS 10400-XA is a mandatory standard, it is enforced by the National Regulator of Compulsory Standards (NRCS) (Council of Science and Industrial Research 2019). The study focused on assessing the buildings' energy performance as nominal buildings before certification. The energy efficiency benchmarks in SANS 10400-XA used was that which states that the actual energy consumption of an office building must not exceed 200 kWh/($m^2 \cdot a$) in the City of Johannesburg. Calculations in Chapter 4 strongly indicate that already the buildings were below the threshold energy consumption of 200 kWh/($m^2 \cdot a$) during their benchmark period and progressively their energy consumption got lower in their certification and post certification period. The values of the peak energy demand of the building's were not requested as the study was focused on actual energy consumption from the buildings. However, the property company who provided data confirmed during the data collection phase that their buildings met all the SANS stipulations therefore it can be deduced that the buildings met the stipulations for the peak energy demand. This is further supported by Building G which recorded improvement of 46% above the peak demand baseline achieved. Despite the fact that the buildings are SANS approved, Mustapha (2016) argues that SANS 10400-XA is being implemented poorly in the country and this therefore impedes the uptake of green building. This is supported by Umar and Khamidi (2014) who are of the view that in sub-Saharan Africa, overall it has been found that there is insufficient enforceable energy efficiency specifications for buildings and lack of adequate sustainable design awareness among building experts. These findings are dissimilar to those of this study which found that the buildings being researched are SANS compliant. However, it must be noted that the buildings being researched belong to private property companies who, as has been demonstrated multiple times in the study, are at the forefront of green buildings and have the technical and financial capacity to implement green building requirements and legislation. In addition to mandating SANS 10400-XA, multiple International (ISO) standards have also been published to support greening of buildings in terms of regulation (Tucker 2017). These address different aspects of the building from the design to the usage of energy (Tucker 2017). The ISO standards were published in Government Gazette 34586 on 9 September 2011 in accordance with the National Building Regulations and Building Standards Act 103 of 1977 (Tucker 2017). The implications of these findings is very crucial. They signify the earliest steps that the government has taken to mandate elements of green building such as energy efficiency and reductions of Carbon emissions in the construction of buildings. More crucially, they also address the greening of the existing building stock. However, as Mustapha (2016) argued, the slow implementation of these standards is impeding the greening of buildings. In support of this, studies have shown that building standards and codes which have been developed properly for the local climate and have strong energy efficiency requirements which are well enforced tend to be the most successful and cost-effective (Lucon et al 2014). Thus, the implications of the findings of this study in this regard is that although the buildings being researched are SANS compliant, it is important that government implement standards properly for them to be effective.

The City of Johannesburg indicated that they were in the process of developing the CoJ Green Building Policy and the CoJ Green Building by-laws. Current research seems to suggest that they are still in development. The CoJ Green Building Policy will be used as a guideline for new buildings in Johannesburg and the CoJ Green Building by-laws will make the implementation of the City of Johannesburg's Green Building Policy enforceable according to law. The fact that by-laws are being created also strongly indicate that they will be monitoring by the city of the implementation of the policy. It is recommended that the policy not only focus on new green buildings but also greening of existing buildings. The city can take guidance from similar green building policies which have been developed by local municipalities in the country such as the that of the Msunduzi Municipality in Kwa-Zulu Natal (Msunduzi Municipality 2014) and the City of

Tshwane's Green Building Policy and by-laws which are currently under review (City of Tshwane Environmental Management Department 2012). The City of Tshwane's Green Building Policy and by-laws take into account SANS 10400-XA stipulations as minimum considerations to include for energy efficiency in buildings and they try to improve on it (City of Tshwane Environmental Management Department 2012).

Existing literature supports the city's commitment to promoting energy efficiency and reducing Carbon emissions in their buildings. An example of this is the large-scale projects discussed in Chapter 4 being undertaken by the city to retrofit its existing buildings with lighting which promotes energy efficiency and reduced Carbon emissions. These finding are supported by the Tokyo Metropolitan Government (2014) who did a case study of energy programmes around the world and found that the City of Johannesburg has already earmarked 104 municipal buildings for energy efficiency improvements with some already having undergone lighting upgrades resulting in significant reductions in greenhouse gas emissions. There are also other cases in city metropolitans around the world which are similar to these. For example, New York City initiated a programme called the 30x17 programme (meaning 30% reduction by 2017) (Tokyo Metropolitan Government 2014). The aim of the programme is to encourage retrofitting as a method to reduce a large portion of GHG emissions from municipal operations (Tokyo Metropolitan Government 2014). In addition to this, the Constitution further mandates local government through the Municipal Systems Act 32 of 2000 to guarantee that the right to a clean and healthy environment is attained (SAHRC 2002). The Municipal Systems Act was not identified by the participants but it is critical to the study as it mandates local government to protect the environment through integrating the activities of all three spheres of government for the socio-economic elevation of communities in harmony with the local environment (SAHRC 2002). (Municipal Systems Act 32 of 2000). This aligns with the principles of sustainable development and Section 24 of the Constitution.

The EBP V1 Tool developed by the GBCSA was used to certify all the buildings used in this study. The GBCSA indicated that the buildings should first be compliant with statutory legislation prior to being able to qualify for certification. All the buildings for which the researcher received data have been certified green. The benchmarks in the tool tries to push the buildings to go above what is legislated and push them even further to long term sustainability. This is further supported by the fact that the following stipulations of SANS 10400-XA regarding energy consumption are interwoven into the EBP V1 Tool:

1. ENE-1 Compliance Path 4
2. ENE-2 Reduce Peak Electricity Demand performance. demonstrated that the building's Peak Demand Performance meets the required benchmarks set out in the credit (improvement on SANS 10400-XA where applicable, or improvement on a historical baseline where not).

For emissions:

1. Refrigeration: The aim of this credit is encouraging the operational practices that limit the environmental impacts of refrigeration equipment in the building (2).

2. Legionella: The aim of this credit is the recognition and encouragement in terms of implementation and utilisation of a water management process which intends to minimize the risks associated with Legionnaires' disease

3. Storm Water: The aim of this credit is the recognition of site-related practices which minimise the disturbance of natural hydrology and also minimizes pollution

As discussed above although the stipulations were not central to this particular study since the buildings all qualified and received certification it can be deduced that they were met. However, according to the data reviewed in Chapter 4 certification is a voluntary and not mandatory process. Certification and labelling is important to green building owners as they provide objective evaluation of a building's impact on the environment (Halliday 2008). Furthermore, worldwide some cities, such as New York, have integrated green building and energy performance standards into their processes for issuing permits regarding the design of new buildings or refurbishment of existing municipal buildings (Tokyo Metropolitan Government 2014). These are employed as pre-requisites for financial or non -financial incentives (Tokyo Metropolitan Government 2014). The data provided in Chapter 4 does not indicate that the City of Johannesburg has done this. Given that there are a number of benefits which come with Green Star South Africa certification, the City of Johannesburg could apply the same principle (Goosen 2009 and Tobias et al 2009). This has implications for the study and municipal governance overall when it comes to energy efficiency and Carbon emissions reductions in buildings as building rating systems and codes are important to apply as they set minimum standards for construction, renovation and operation for green buildings (Tobias et al 2009). Furthermore, it has been proven worldwide that, strong city legislative frameworks which are complemented by voluntary certification are needed for the critical guidance of emerging green building markets such as in the City of Johannesburg (Brittlebank 2015). Therefore, Arkesteijn and van Dijk (2010).argue that certification of existing buildings can assist in identifying factors to improve energy performance.

Data collection in Chapter 4 did not identify any significant legislation and institutional frameworks developed by NGO's and Civil Society in South Africa, however on further analysis of existing literature it was found that policy options, some which are significant for the study, exist. A few examples include; "Depending on Renewable Energy: South Africa's Best Development Path" by 350.org in 2015, "Renewable Energy Vision 2030 –South Africa" by WWF in 2014, "Powering the Future, Renewable Energy Roll-out in South Africa" by Greenpeace in 2013 and The Energy Governance Initiative of SA (a network of CSOs) "Smart Electricity Planning" in 2013 (Macguire and McDaid 2017). The reasons why these are important for the study is that these address the key themes of transitioning to renewable energy as the primary source of energy for industries, improved governance of energy and they promote energy efficiency (Macguire and McDaid 2017).

Furthermore, the data provided in Chapter 4 did not make any mention of communities and individuals and how they are affected and contribute to environmental and building legislation and institutional frameworks in the country. On further analysis, studies have shown that openness, transparency and participation affirms human's dependence upon the biophysical environment, therefore justifying the need for public knowledge of energy provision (Macguire and McDaid 2017). Therefore, the public's participation in the development and approval of these legislative frameworks is crucial and exposes a gap in the study as it was not identified. Public participation needs to be enhanced and impact policies significantly (Macguire and McDaid 2017). Furthermore, Richardson and Razzaque (2006) are of the view that many environmental laws worldwide have incorporated public participation as part of the process in decision-making. Individual citizens and corporations have called for greater and more transparent involvement in consultation as well as accountable decision making (Richardson and Razzaque 2006). Fortunately, the law in South Africa makes provision for public participation in various ways such as public meetings, commenting publically on bills and involvement in integrated development planning in municipal plans (du Plessis 2008). Public participation, however, must surpass mere consultation on legislative planning but should include the whole society, especially marginalised communities in the actual implementation of legislation (Macguire and McDaid 2017). Studies in Mexico have indicated that effective public participation in environmental decision-making has been made possible through public awareness and understanding of scientific data produced because of accelerating environmental issues (Elaw 2015).

The data which has been presented and analysed has demonstrated that SA has legislation of high quality with existing institutions to implement them. However, the existence of progressive policies is not adequate enough as they must be successfully implemented (Macguire and McDaid 2017). Implementation has also been hindered by prolonged parliamentary processes which take extended lengths of time to complete (Macguire and McDaid 2017). Democratic institutional platforms exist to address these issues, such as the National Economic Development and Labour

Council (NEDLAC), but they lack transparency therefore they cannot be used effectively (Macguire and McDaid 2017). This creates conditions which can facilitate patronage, corruption and manipulation by individuals with vested interests (Macguire and McDaid 2017). Therefore, overarching political and governance matters must be attended to in order for the legal system to function. The implications of the findings of this study is that policy alignment should be improved for climate change ambitions to be achieved. This should be supported by processes for prioritisation of strategic issues as well as interactive decision making (Macguire and McDaid 2017). Furthermore, government departments must function in a coordinated manner and align their policies to ensure environmental human rights. Additional implications that this study has is that governance, intergovernmental coordination and decision making amongst all three spheres of government must be improved for successful implementation, enforcement and monitoring of legislation and institutional frameworks whether they are mandatory or voluntary. The City of Johannesburg as well as other local governments has started with certification of its new office buildings such as the City of Johannesburg's Council Chambers (SALGA 2017). However, the City can take guidance from other metropolitan governments around the world such as Tokyo and collaborate with the GBCSA to incorporate minimum standards stipulated in their certification tools, such as the EBP V1 Tool, in the development of their Green Building Policy and Green Building By-Laws. This will be particularly helpful for existing buildings as few policies which address greening existing buildings are present.

5.4 The Application of Building Performance Rating Tools and how they affect the Monitoring and Maintenance of Energy Efficiency in Green Buildings in South Africa.

Energy performance certification has been identified as an essential instrument which can aid governments in minimising energy usage in buildings (International Energy Association 2010) Therefore. certification can assist governments achieve national energy targets and improve environmental, social and economic sustainability in the construction sector (International Energy Association 2010). In addition to this, direct benefits which can be realised through certification include: energy and Carbon Dioxide emissions reductions, increased public awareness of climate change as well as improved data on buildings which can be utilised for future policy development to enhance energy efficiency in buildings (International Energy Agency 2010).

The first section of Chapter 4 illustrated how buildings achieve certification and rating. It also discussed the efficacy of the EBP V1 Tool. Figures 11 and 12 in Chapter 4 detailed the manner in which buildings undergo certification and receive a rating utilising the EBP V1 Tool. It was important to highlight this as it contributes to the understanding of the efficacy of the tool. As was illustrated in table 9, only 33,5% of the participants indicated that the tool was simple to understand. This poor percentage uncovered by the study is similar to and is supported by the argument of the International Energy Agency (2010) that certification is an intricate process, which needs extensive knowledge of what a building is comprised of and the understanding of a building as an integrated structure. Furthermore, this is also supported by Naidoo (2009) who argues that there is lack of education on green buildings, particularly in the Sub-Saharan Context (Naidoo 2009). However, these findings are disputed by the stipulations in the EBP V1 Tool itself. For project certification, clients have to appoint an accredited professional to undertake the certification process of the buildings (Existing Building Performance V1 Technical Manual 2014). This accredited professional has to have attended the Green Star SA Accredited Professional- Existing Building training courses (Existing Building Performance V1 Technical Manual 2014). Furthermore, they have to have passed the associated examination of the course and be registered with the GBCSA as an Accredited Professional for Existing Buildings (Existing Building Performance V1 Technical Manual 2014). This is mandatory for certification utilising the tool as one of the credits given is for management which stipulates that an accredited professional has to be appointed. This is true for all 3 buildings utilised in the study. According to the case studies of all 3, a project team was assigned to get the buildings certified. The project team consisted of the owners of the buildings as well as consultants whose expertise is in certification of existing buildings. Therefore, this mitigates the assertion that the tool is hard to understand. This is further supported by the fact that the certification process of each building is managed internally by a case manager (GBCSA 2020). Each certification is also further subjected to independent third-party individuals who provide feedback to the case manager and project team/accredited professional in a transparent manner (GBCSA 2020). This also impacts the implication that the tool is difficult to apply. The indication was that only 8% of participants found the tool easy to apply. However, with a qualified project team working on the certification of the buildings and with the building owners being part of this, applying the tool is therefore far easier. The wider implications of these findings is that they can enhance the esteem of certification of green buildings especially because experts have been involved in the process of certification. Therefore, given the evidence put forward in the technical manual, the findings of this study that the tool is not easy to understand and is difficult to apply are rendered insignificant.

The ability of the tool to assist green buildings in enhancing their performance is next discussed. From the data provided in table 6, it is clear that the amount of energy consumption of each building steadily decreases from its benchmark period to its post-certification period. Therefore, this will also be true of the Carbon emissions of the building as there is a direct relationship with energy consumption and Carbon emissions. That the buildings lower their energy consumption during their certification period supports the fact that the process of the buildings undergoing certification helps in energy efficiency. The improved energy performance is in all likelihood due to the retrofits done to the office buildings. Indeed, according to the Existing Building Performance V1 Tool Technical Manual (2014), a building must demonstrate prior to receiving certification that during its certification period it has decreased its energy consumption even further than during its benchmark period. The fact that the data illustrates that the buildings have further decreased their energy consumption after certification strongly indicates that certifying the buildings has increased their energy efficiency and therefore enhanced their performance.

However, this disputes the findings when other certification tools are considered. For example, LEED certification has been criticised for not necessarily assisting buildings in energy savings (Ameri et al 2019). This is further supported by opponents to green buildings who have cited amongst other issues, in the long run green buildings don't work (Johnston and Gibson 2008). However, these arguments have widely been disputed as green buildings are said to actually decrease operating costs in the long run due to their energy and resource efficiency, as well as their increased durability and decreased cost of maintenance (Johnston and Gibson 2008). Therefore, the implications of these findings is that they can assist in increasing demand for more energy efficient buildings as well as proving why there is a strong need for certification of the existing building stock in order to assist government in improving the energy efficiency and Carbon reductions of the building stock.

The expense of applying the tool appears to be the most problematic aspect of it. The majority of participants indicated that it was expensive to apply. This is supported by Goosen (2009) who observes that the first part of the certification fee (50%) is paid upon registration of a project. In addition to that is the payment which has to be made to the accredited professionals involved in the certification of the project. This is also supported by Naidoo (2009) who argues that green building in sub-Saharan Africa, of which South Africa is a part of, is hampered due to high levels of poverty, limited government support, lack of public awareness and a need of education of the sector. All these factors require financial and technical capacity to address them (Naidoo 2009) The cost of certification for buildings which are 5000m² to 19900m², the certification fees for members is R65750 and non-members it is R86950 (GBCSA 2020). As a result of the above, the growth of the green building industry in SA has largely been spearheaded by the private sector. Therefore, it can be concluded that it is indeed expensive to certify office buildings using the EBP V1 Tool. The implications of this finding is of concern, especially for government, as the majority of the existing building stock is publicly owned and the expense of certification could potentially decrease the popularity of the tool. Furthermore, local government has other competing services to provide such as sanitation and water, health and education which are considered more crucial by communities. Therefore, funds which could be utilised for retrofitting and certifying existing buildings are often redirected.

The quality of the tool was also put forward as an aspect which impacts its efficiency. The tool itself has already been discussed at length in section 5.3 however the most pressing issue brought forward in this regard was that the tool is not mandatory to apply and acts as more of a guiding framework. This finding is supported by Sebake (2009) who observed that a large proportion of the green building rating tools which exist remain voluntary. It is therefore critical that the potential and actual performances of these tools are differentiated (Sebake 2009). Therefore, some participants indicated that it does not make such a big impact. This they claim is due to the fact that the savings in energy consumption in retrofitting and certifying existing buildings is far less during its operational lifecycle as a building consumes the most energy in its construction phase. These findings are supported by Edén et al (2003) who argue that in order to positively influence a building's performance, sustainability criteria should be incorporated at the initial stage of a building's construction. The implications of this is that during this phase the building builds up embodied energy. Embodied energy is not taken into account in the EBP V1 Tool however. This presents a possible gap in the tool which must be looked at as material or technology used to retrofit existing buildings has to be transported from offsite to the buildings. The interviewees also indicated that most of the energy savings in retrofitting come from changes in lighting which cumulatively, even through the operational phase of the building is significantly smaller than in any other phase of the building's lifecycle. This is supported by the projects being undertaken by the City of Johannesburg to retrofit its existing buildings with LED lights.

The last aspect of the tool taken into account is the preference of the tool for certification of buildings.. This aspect of the tool scored highest at 67%. as seen in table 9 under Chapter 4. These findings are dissimilar to the studies of Amiri et al (2019) who found that LEED, which stands for

Leadership in Energy and Environmental Design, is the most commonly used certificate worldwide. Furthermore, LEED certification symbolises sustainability achievement worldwide which would indicate that LEED is a more preferable certification tool to apply (Amiri et al 2019) However participants indicated that the preference of the Green Star South Africa EBP V1 Tool is due to the fact that South African clients prefer the tool because it was developed for the South African context. This finding is further supported by the GBCSA which states that the tool is based on the Australian system and was evolved to fit the South African context (Existing Building Performance V1 Technical Manual 2014). The International Energy Agency (2010) also argues that the extent of efficiency of certification tools depend on many factors including: the local climate. Therefore, tools which have been created or adapted for buildings in their climate are more effective.

Furthermore, participants indicated that other tools like BREEAM and LEED are preferred by international corporations which base themselves in South Africa. Since their buildings are certified using those tools, they will certify their South African office buildings using the same tools. However, as discussed in the previous chapter it must be noted that the efficacy of the tool significantly depends on the individual experiences of clients who apply it to their buildings. The building owners who certified utilising the tool in this study were satisfied with the efficacy of the tool, however the green consultant who participated indicated that the tool acts mainly as a guiding framework. They also indicated that certification tools are much more effective when applied to new buildings than existing buildings because they can influence the construction of the building and ensure that energy efficiency measures are implemented from the start of the lifecycle of the buildings.

Therefore, the implications of these findings is that overall the EBP V1 Tool itself is quite effective if implemented properly in the country. The weakness of the tool is that monitoring of the performance of the buildings is exclusively dependent on the owners of the building. It is not a mandatory process. The only stipulation in the tool which helps mitigate this is the fact that after 3 years the buildings have to undergo re-certification to maintain their certification (Existing Building Performance V1 Technical Manual 2014). In addition to this, the fact that it is not mandatory and comes with expenses associated with certification, mean that its uptake is much lower than it could be.

The other aspect of the tool looked at its impact on the actual Carbon emissions and energy consumption of the buildings. This is illustrated in figures 13 to figure 21. From analysis of all the graphs, Building G consumes more energy and emits far more Carbon Dioxide than all the other three buildings. This is potentially due to two reasons. This first is its usage. As well as office spaces, the building hosts a gym, which is part of a large chain, and eateries. These additional uses would increase the energy consumption of the building

The location of the building also affects its energy consumption. In comparison with the other buildings which are located in more suburban surroundings, Building G is located in the Rosebank central business district in close proximity to the Gautrain station and the Rosebank Mall particularly. It is also in close proximity to other office buildings and schools. Being in the centre of such a busy area where there are additional elements at play like heavy traffic, the building could be further subjected to the phenomenon of the Urban Heat Island (UHI). The Urban Heat Island occurs when heat is created from energy caused by people, traffic and industrial activity in big cities causing them to be much warmer than their surrounding areas (National Geographic 2020). When houses, shops, commercial and industrial buildings are constructed and located close together as in central business districts, it can create a UHI resulting in the immediate surroundings of the buildings becoming much warmer (National Geographic 2020). This could increase the energy consumption of the building internally in order to cool it as was discussed in section 5.2. However, this is disputed by SALGA (2017) who argue that a building located where public transport is accessible emits less Carbon Dioxide.

In Chapter 3, it was mentioned that Building G is located close to the Rosebank Gautrain Station, the taxi rank and is on the bus routes. Furthermore, Building G has eight floors of air-conditioned office space. According to Yuan et al (2016), there is a direct positive correlation between the number of building stories and air conditioning when it comes to energy consumption savings in offices. This has resulted in the increase in popularity of high-rise office buildings with central air conditioning such as Building G (Yuan et al 2016). Therefore, it can be surmised that the energy consumption and Carbon emissions of Building G in contrast to Building C and D is due to higher occupancy density allowed by the building stories and additional usage due to the gym and eateries.

Figures 13 to 15 and figures 19 to 21 looks at the relationship between temperature and energy consumption as well as temperature and Carbon emissions for all three buildings during their benchmark, certification and post-certification periods. Correlating energy consumption to weather is important as seasonal temperatures have an impact on building energy consumption (Department of Minerals and Energy 2005). Furthermore, Hong et al (2013: 3) argue that 'weather plays a unique and significant role as it directly affects the thermal loads and thus energy performance of buildings.' This supports the data presented in Chapter 4 which shows that the trends identified in figures 13 to 15 depicting energy consumption versus temperature are identical to figures 19 to 21 depicting Carbon emissions versus temperature. This indicates that energy consumption and Carbon emissions are directly proportional to each other and weather and temperatures impact both the same way.

The trends picked up in the graphs in Chapter 4 of the energy consumption and Carbon emissions against the temperature and the energy consumption against Carbon emissions shows that the effect of the buildings undergoing certification is positive as the energy consumption and Carbon emissions decrease steadily for all graphs from the benchmark to the post-certification periods. This is due to the fact that the less energy a building is consuming, the less Carbon it is emitting. This can be attributed to the buildings undergoing the retrofitting measures discussed in section

5.2 which causes them to be more energy efficient regardless of the external factors such as temperature. The sustainable retrofitting measures discussed in section 5.2 would result in the buildings relying less on conventional energy consuming measures. For example, all the buildings underwent lighting retrofits as detailed in table 10 in Chapter 4 so the consumption of energy from lighting reduced significantly resulting in less Carbon emissions. These findings are similar to the findings of a study done by Sesana et al (2019) on mitigating climate change in the cultural built heritage sector in Europe which found that energy used in heritage buildings can be reduced through refurbishments such as improvements in the thermal performance of the building envelope.

Furthermore, better usage of the buildings by the occupants could also be a factor. The performance audits and measurements may have also assisted in ensuring that the indoor environment of the buildings is healthy and occupants use the buildings more efficiently further reducing their energy consumption and Carbon emissions. The findings of this section of the study also demonstrate that seasonal variation and transitioning have an impact on energy consumption and Carbon emissions on buildings. Seasonal variation and transitioning was observed in the fluctuations of energy consumption and Carbon emissions in the graphs throughout their data periods. This is supported by Li et al (2015) who are of the view that global warming has strong effects on a building's energy requirement and consumption as their heating and cooling needs are related to temperature conditions and weather variations. Furthermore, it is important that seasons and temperature be taken into account in the assessment and benchmarking of building performance as the outdoor temperature is not constant (Department of Minerals and Energy 2005). The implications of these findings support the view that revealing the impact of climate change, seasons and temperature variation on building energy consumption is beneficial for not only making efficient energy saving measures but also reducing pollutant or greenhouse gas emission (Li et al 2015). Furthermore, the findings also demonstrate that the EBP V1 Tool has worked in enhancing the performance of the buildings. These findings are similar to those of the

International Energy Agency (2010) who observe that for existing buildings, energy certification enhances the energy performance of the buildings thereby abetting the improvement of energy efficiency of the building stock in the country. Therefore, certification can assist governments achieve national energy targets and improve environmental and socio-economic sustainability in the construction sector as well as enhancing monitoring and maintenance (International Energy Agency 2010).

5.5 The Incentivisation of Constructing Green Buildings and mainstreaming Energy Efficiency in buildings for the Construction Industry in South Africa.

As stated in Chapter 4, this section was interested in exploring the extent to which the construction industry has been influenced by the phenomenon of green building in South Africa and the incentivisation of green buildings in the country. From figure 22 it can be deduced that there were three main responses: positive, negative and neutral. Overall, the impact of the green building phenomenon on the construction industry in South Africa has been positive (43%). These findings are similar to the research done by McGraW Hill in South Africa that suggests that the green building industry is rapidly increasing and overtaking other global green building industries(Windapo 2014). According to the McGraw-Hill Construction smart market report, the expectation is that 51% of corporations in South Africa will experience increased levels of green building activity and that green building will become standard within the construction industry (Windapo 2014). Despite these findings, Baloi (2003) argues that the construction sector is still limited in its efforts to go green, as it still depends on the implementation of sustainability measures from other sectors of the economy such as the manufacturing industry which manufactures the construction materials and components needed for the construction industry. However, this is disputed by the positive impacts 1, 3, 4, 6 and 13 identified in Chapter 4 which are: leaders in the field are now looking into the future to build regenerative buildings and communities and not just more efficient buildings which do less damage, a growth in awareness of green buildings, courses are available on green buildings for various professionals in the industry therefore a growth in skills, there is growing consciousness of selecting greener materials for construction and alternative use of material in concrete such as ash and recycled plastics. These positive impacts which have been identified in Chapter 4 are further supported by the Tokyo Metropolitan Government (2014) which observes worldwide cities offer information through free or subsidised energy audits, assessments, guidebooks or seminars focused on green buildings, energy efficient operations or energy efficiency retrofits. According to studies done, these include cities in the US such as New York who have also developed programmes targeting low -income households, as an example, by providing them with affordable improvements to their HVAC systems (Tokyo Metropolitan Government 2014).

In terms of the negative impacts on the construction industry (36%), the most significant ones identified are impacts 1, 2, 4, 6, 7, 8 and 10 which are: with regards to the public sector lack of skills and capacity to implement green building practices, it is more expensive for the end user to build green, the pricing of the construction industry increases, when clients or end users want to build green it increases sub-contractor costs, affordability to implement green technologies is a challenge (especially for smaller companies with marginal profits), there is a lack of awareness and training (especially in less developed areas such as rural areas) and transition is hard because there is a need to reskill. These findings are similar to the ones discovered by Johnston and Gibson (2008) who are of the view that barriers to green buildings include the upfront cost of constructing them due to the higher cost of some of their building components, training people in new techniques of constructing green buildings as well as the perceived unattractiveness of green buildings due to their alternative designs and material used as well as the belief that in the long run they don't work due to the quality of materials used (Johnston and Gibson 2008). Most of these negative impacts are cost related. However, these have widely been disproved as green buildings are said to actually decrease operating costs in the long run due to their energy and resource efficiency and increase their durability and decrease their cost of maintenance (Johnston and Gibson 2008). This offsets the negative impacts number 2, which states that it is more expensive for the end user to build green (client), number 4, which states that the pricing of the construction industry increases as well as negative impact 6 which states that when clients or end users want to build green it increases sub-contractor costs. Also, the belief that green buildings don't work in the long run due to the quality of materials being used is disputed and dissimilar to the findings of Johnson and Gibson (2008) who found that materials which are increasingly being used to construct green buildings are becoming more and more reliable as competition in the manufacturing industry rises due to market forces. The fact that in the long run green buildings reduce costs is further supported by the GBCSA's studies which found that in South Africa despite the perception that green building cost a lot to implement and operate compared to non-green or nominal buildings, no data exists to support this (GBCSA 2016). Instead benefits around green buildings in South Africa include lower operating costs, particularly savings in energy and water usage, with a study conducted by the GBCSA in 2018 finding that Green Star South Africa buildings profiled in the study had energy savings between 25% to 50% compared to conventional buildings (GBCSA 2018). Green buildings also exhibited higher returns on assets (GBCSA 2018). This therefore offsets the high upfront costs. In terms of negative impacts related to training and upskilling (1, 8 and 10) it has already been proved that under the positive impacts, training and capacitating of people around green buildings in the construction industry is already in place in the country. Therefore, the findings of these studies conducted support the fact that the impact of the green building phenomenon has been positive overall.

In term of the neutral impact on the construction industry (21%), the following were identified; constructors do not have a problem as they will build whatever is requested of them and there is no enforcement for green buildings therefore it largely depends on the client and the end user. Currently, one of the best ways to track enforcement of efficiency measures in green buildings is through certification of green buildings. However, in South Africa this is optional and not mandatory. Voluntary certification can be beneficial for stakeholders who are enthusiastic about the energy performance of their buildings and wish to divulge it (International Energy Agency 2010). Therefore, enforcement of green building standards is largely monitored by the implementation of mandatory laws such as the SANS 10400-XA as mentioned in section 5.3.

From the findings above, overall the impact of the green building phenomenon on the construction industry in South Africa has been positive. Data from studies conducted have shown that there are larger benefits than barriers to constructing green buildings and savings, especially on operational costs in the long run. Training and capacity building, as well as growing awareness, the acceptance of alternate materials for constructing green buildings and the use of alternative technologies to increase energy efficiency and reduce Carbon emissions have also strengthened the case for green buildings in the country. Although certification of buildings remains optional, the SANS 10400-X series building standards, which includes SANS 10400-XA, have been legislated in the country therefore making it mandatory for the integration of principles of green building into construction practices and for future planning of developments of buildings. This takes into account various sustainability measures including energy efficiency and Carbon emissions reductions which are the focus of this study.

In the next sub-section, the researcher aimed to establish which incentives already exist for the development of green buildings in the country and therefore in the City of Johannesburg. The incentives were categorised into three of the main economic sectors in the country; government, private sector and non-profit organisations. The reason why these three were the only sectors which were selected for the study was that the researcher found that during the data collection phase these sectors are the ones which develop the main legislation and institutional framework for the implementation of green buildings in the country and city. The other sectors such as the research institutions, the academic sector and the civil society mainly contribute to these three sectors. They do this in the form of provision of scientific data, studies and reports in the field, many which are funded by the sectors discussed below and lobbying for green buildings and environmental sustainability.

The second part of this section was dedicated to identifying the incentives which already exist per sector to stimulate building green in the country. According to figure 23, the government incentives are mainly tax incentives for implementing energy efficiency (57% of the time), rewards for giving energy back to the grid (14% of the time) and rebates for the installation of solar geysers (29% of the time). These findings are similar to those of the Tokyo Metropolitan Government (2014) who observe that utilities often provide energy efficiency grants and rebates for initiatives such as installation of solar geysers, which the City of Johannesburg and national government has already started implementing. For larger existing office buildings, the biggest incentives come from tax incentives and giving energy back to the grid. Incentives for tax are provided for in the Carbon Tax Act of 2019. However, as evidenced in section 5.3 the Carbon Tax Act is yet to be implemented. Furthermore, Halsey et al (2017) are of the view that the proposed carbon tax has a high number of exemptions which should be reduced to ensure that there is sufficient incentive to reduce emissions. However, studies have shown that the granting of tax incentives have proven to work in other cities around the world such as Tokyo where tax incentives have been made available through the Energy Saving Promotion scheme which target small to medium enterprises (Tokyo Metropolitan Government 2014). These incentives spare individuals and corporations from the enterprise tax when they introduce energy efficient equipment and renewable energy facilities (Tokyo Metropolitan Government 2014). Furthermore, in South Africa other tax incentives given by government include those given through the Energy Efficiency Demand Side Management (EEDSM) programme managed by the Department of Minerals and Energy (DMR 2020). The EEDSM programme supports municipalities in reducing electricity consumption by improving their energy use through providing them with grants for the planning and implementation of energy efficient technologies such as energy efficiency in buildings (DoE 2020). It was first initiated in the Integrated Resource Plan 2010–2030 which introduced energy efficiency and a demand side management financial incentive scheme with measures to be introduced for commercial buildings including offices (Macguire and McDaid 2017). Therefore, the findings of MacGuire and McDaid as well as the Tokyo Metropolitan Government regarding tax incentives are similar to and support the findings of this study that not only do tax incentives work they are already in implementation in the country. Other examples of City governments giving incentives for existing buildings include the Retrofit Chicago Residential Partnership which provides free energy efficient fixtures such as programmable thermostats and showerheads as well as rebates on larger appliances like qualifying air conditioners (Tokyo Metropolitan Government 2014). Such funding is also in place in the country as similarly, SANEDI is also linked to a number of funding programmes such as the Sustainable Use of Natural Resources and Energy Finance programme (SUNREF II) which provides funding focused on renewable and energy efficiency projects which any sector can apply for (SANEDI 2020). Office building owners and companies can thus apply to use this funding vehicle to implement energy efficiency measures in their buildings thus also reducing their Carbon emissions. (SANEDI 2020). Another example around the world which supports this is the programme Salix in the United Kingdom which is working with the public sector to reduce Carbon emissions through investment in energy efficiency measures and technologies in the United Kingdom (UNIDO 2009).

In terms of the private sector, as evidenced in figure 24 the main incentives are providing Green Funds (50% of the time) , training and capacity building to other sectors (25% of the time) and reduced costs for green building (25% of the time). The incentives for building green provided by the private sector are mostly cost related. This is supported by the existing literature in South Africa which suggests that the growth and evolution of the green building industry has mostly centred around the private sector in important metropolitans such as the City of Johannesburg. However, studies by Halsey et al (2017) have demonstrated that constant downgrading of South Africa's credit rating by ratings agencies have had a major impact on the availability and cost of new finance, as well as compounding the burden of existing loans, which contributes to difficulties in accessing funding for transformation in the energy sector. However, in the same study it has been demonstrated that this has been mitigated by the fact that since the initiation of the Renewable Energy Independent Power Producer Procurement Programme (REI4P programme) much larger private investors have entered the renewable energy market in SA, including, in some cases, private commercial banks (Halsey et al 2017). Therefore, this is similar to and supports the findings of this study that funding is available for green building. Other funding initiatives for the private sector which exist which supports the findings of this study is the Green Climate Fund. The Green Climate Fund is particularly of critical importance to this study as it plays a pivotal role in shifting and catalysing financial flows managed by the private sector into low-emission and climate-resilient investments in developing countries' (GCF 2020: 1). South Africa is a developing country which would benefit from such funds. In addition to this the private sector is particularly keen on greening buildings and constructing green buildings as certification of buildings increases their appeal and marketability as well as increases their independence from Eskom as the main energy supplier (GBCSA 2018). Thus, the incentives for building green are strong in the private sector as there is also a business case for them. These will apply strongly for the buildings which the study is utilising as they are privately owned certified retrofitted office buildings.

In terms of Non-Profit Organisations (NPOs), as evidenced in figure 25 capacity training on the use and application of certification tools and assistance with feasibility studies were incentives given 25% of the time each but the incentive given the most was assistance in arranging finance (50%). The incentives given are mainly capacitating and providing technical skills. Participants in the study identified the GBCSA as the main non-profit organisation providing capacity training on the use and application of certification tools in the country. The council has been conducting training with the public sector in this regard. Non-profit organisations are also assisted by government frameworks in terms of guidance on how to access funding for green buildings as well as drawing on their own resources to capacitate other sectors (National Climate Change Response White Paper 2011). These findings are similar to and supported by the existence of other NPOs such as the Ecobuild Top 50 – Non-profit organization Green Building Initiative which is dedicated to fast tracking the adoption of building practices which result in resource efficient, healthier, and environmentally sustainable buildings (AI Global Media Ltd 2019). Other NPOs who provide similar incentives as those discovered in the findings of this study are GBCs of other countries in order to transform building industries by motivating for the adoption of good building practices. (Economic Policy Forum 2016). These include the GBCs of the United States and the United Kingdom as well as others around the world and they all function under the umbrella of the WGBC. This is further supported by Kuzwayo (2017) who is of the view that GBCs are critical players as they provide the knowledge, tools and create the platforms for collaboration and co-creation. Furthermore, in sub-Saharan Africa the GBCs form part of the Africa Region Network of Green Building Councils (Kuzwayo 2017). According to Kuzwayo (2017) the four key strategies they focus on are:

1. To support robust regulatory and voluntary frameworks.
2. To recognise and scale local building materials and practices.
3. To train the green building professionals of the present and the future.
4. To direct foreign and domestic investment to green building.

This section was also interested in further incentives which can be given to key players in the construction sector to encourage green buildings. According to the data presented in Chapter 4, only 36% (4) of the participants identified these incentives. 28% of the participants (3) had no response and 36% (4) of the participants said it was not applicable. Of the incentives listed in Chapter 4, they have already been discussed in the above paragraphs in this section and are already being implemented such as green building funding and green building financial aid, tax rebates, information sharing and capacity building as well as the implementation of LED lights and new and alternative technologies and materials. The Carbon Tax has been signed into law in 2019, however is yet to be implemented. Others; such as green building certification are completely voluntary. Linked to the green building certification are recognition awards for building green and brand awareness and faster approval times. These are also strongly linked to the business case for building green which was discussed in the above section. Subsidies, lifecycle costing and analysis aid as well as government bulk bonuses have also been cited. Lifecyle costing and analysis aid also falls under green building financial aid. However, Halsey et al (2017) argues that despite the existence of incentives, transparency is required and all the information on current subsidies must be made available. Currently, a large proportion of this information is not available to the public. Proper financial decision making on energy source costs is possible when the relevant information is accessible (Halsey et al 2017). In order to make decisions as to the type of funding to take, the pertinent information on existing market instruments and energy costs have to be collected and made available to interested and affected parties (Halsey et al 2017). This finding therefore presents an opportunity for the study and has wider implications for the study that information sharing on these incentives can further influence the uptake of green buildings and sustainable construction in the country.

A gap in the study which was identified is the presence of non-financial incentives. Non -financial incentives can include expedited permit processes and allowances for extra floor area bonuses in the case of new green building developments (Tokyo Metropolitan Government 2014). However, these are less common for existing buildings. Some examples of non-financial incentives in other city governments is the Green Mark Gross Floor Area Incentive Scheme in Singapore which grants owners of existing buildings extra floor area if considerable energy efficiency enhancements have been made to achieve a Gold Plus or Platinum rating for their Green Mark certification scheme (Tokyo Metropolitan Government 2014). These type of initiatives can also be adopted and modified for the South African context and implemented by local governments. This therefore presents an opportunity in the study for the City of Johannesburg to leverage off of other successful non-financial incentives programmes being offered around the world and implement them in a manner which takes into account the local context. The Tokyo Metropolitan Government has also been dispensing energy efficiency textbooks for various sectors as well as free seminars based on the textbook (Tokyo Metropolitan Government 2014). Awareness raising programmes, which can be face to face or web-based, are also a form of non-financial incentives (Tokyo Metropolitan Government 2014). For example, the city of Stockholm offers online brochures on being climate smart in the office (Tokyo Metropolitan Government 2014). However, as presented in the data in Chapter 4, awareness raising programmes have been identified as already being implemented particularly in the construction industry to the various stakeholders to promote green buildings.

Therefore, from the analysis above it is clear that the impact that the green building phenomenon has had on the country is mostly positive. Incentivisation of green buildings is already occurring with the main incentives centre around financing and training. However, some of them are directed to public buildings. Since the buildings which the study is utilising are privately owned certified retrofitted office buildings, it can thus be deduced that the private sector incentives are the ones which apply the most to these buildings. Other incentives, such as the Carbon Tax of 2019 which would potentially affect the buildings in this study, are yet to commence. The fact that the buildings utilised for this study managed to achieve certification indicates that capacity and technical skills exist with their owners. This would support the existing literature that the private sector has largely been behind the growth of the green building industry. The implications of the findings of this study in the broader sense is that application of incentives provided by all spheres of society will fast track and popularise green building. This will further enhance social responsibility and environmental sustainability in the building industry however it is important that knowledge of these incentives is dispensed publicly and the right avenues be made available for interested parties to access them. Non-financial incentives should also be implemented as rigorously as financial incentives as they mainly dispense crucial knowledge of the green building environment and its benefits. Leads could be taken from existing non-financial incentives however it is important that they be adapted to all building usage types and particularly existing building stocks.

The knowledge and understanding of the factors which influence energy consumption in office buildings in the City of Johannesburg assists in the development of appropriate legal and institutional frameworks to address the impact they have on the environment and climate change. The legislation described in this study addresses the environment, climate change, energy, buildings, buildings standards and certification toolkits. The study has also illustrated that despite the existence of appropriate legislation and institutional frameworks the effectiveness of this legislation is dependent on its implementation. Different actors such as national, provincial and local government play a role in the development and implementation of environmental and building legislation. Other actors include the private sector, civil society and non-profit organisations. Although all three sectors primarily focus on lobbying for green buildings some guidelines and policies have been developed by them or with their assistance. Academic and research institutions play a critical role in providing relevant studies and data.

The most significant frameworks which are crucial to green buildings which have been developed in South Africa by non-profit organisations are the certification toolkits of the GBCSA. These toolkits were developed to respond to the rapid increase of green building in the country which has largely been spearheaded by the private sector. For the purpose of this study, the EBP V1 Tool was analysed as it was relevant for the study as the tool is applicable to the operational retrofitted existing office buildings which formed the basis of this study. It was discovered that generally, certifying buildings using the EBP V1 tool results in them enhancing their energy efficiency and reducing their Carbon emissions. Challenges exist, however, such as the cost of implementing the certification tool and monitoring its effectiveness as it is a voluntary instrument. Furthermore, the tool does not make provision for embodied energy which it is recommended to do as in the case of retrofitted buildings, materials and technologies for retrofitting are often transported to the site of the buildings from other locations thus energy is embodied in the building through the transport of the materials and product delivery.

In order to mitigate the challenges with legislation and certification tools which have been mentioned above as well as to enhance the uptake of green buildings in the country, interventions such as incentives have been implemented by government, private companies and non-profit organisations. These incentives include Carbon taxes, subsidies, grants, training and capacity building and recognition awards. Although the existence of these incentives have been established, it has been highlighted that knowledge of them is limited therefore measures must be taken by the agents who offer them to publicise them.

Furthermore, it has been established through this study that generally the green building phenomena has had a positive impact on the construction industry and as more legislation becomes mandated and subsidies increasingly utilised for green building the positive impact will be greater. The challenges of constructing green buildings are greatly mitigated by the benefits of constructing green buildings therefore it is expected that in the foreseeable future the impact on the construction industry will be enhanced. Therefore, all the sections of this study are linked together. It can thus be deduced from the results of this study that the perspectives of green buildings in climate change mitigation-in the study area of the City of Johannesburg-are generally positive and therefore green buildings are effective tools to be used for climate change mitigation.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter is dedicated to presenting a summary of the findings of this study. Therefore, the chapter outlines the key findings, particularly those which demonstrate that the research questions outlined in chapter one of this study have been answered. In addition, the chapter discusses the recommendations for the various stakeholders. These recommendations advocate the continued transformation of the construction industry to become more environmentally sustainable and the role of certified green buildings in mitigating climate change by increasing energy efficiency and reducing Carbon emissions. Lastly, we reflect on the limitations of the study as well as the research gaps, which could potentially inspire future research in green buildings, legislation, certification systems and climate change mitigation.

6.2 Summary of key findings of the research

Green buildings and sustainable construction have emerged as one of the leading topics in the 21st century as the world continues to grapple with intensifying climate change, mostly exacerbated by anthropogenic activities, and the adverse impacts it has on the environment. In fact, it is evident from the existing literature that climate change mitigation, particularly, is of great concern as the vast majority of environmental challenges caused by climate change are due to emissions of GHGs. Of these GHGs, Carbon Dioxide is the most prevalent. The literature examined for this study provides strong evidence that Sub-Saharan Africa and the countries which make up the region is particularly vulnerable, including South Africa. This is due to the socio-economic conditions of these countries. In particular, the construction industry has emerged as one of the biggest emitters of GHGs and also the industry where the biggest gains can be made in mitigating climate change in the country. Buildings of commercial use such as office buildings in major cities have great potential to play a role in the mitigation of climate change, specifically in terms of becoming more energy efficient and thus reducing their Carbon emissions.

Retrofitting of Existing Buildings

Since the vast majority of these buildings are existing building stock, retrofitting them is a key process in making them more sustainable and further green certification of these buildings assists in them maintaining or improving on their energy consumption and reducing their Carbon emissions. However, certification in developing countries like South Africa is currently a voluntary process which provides a guiding framework therefore it is imperative for mandatory legislation and institutional frameworks to exist and be implemented adequately to ensure that sustainability criteria is mainstreamed into all facets of building.

Therefore, in view of the above, the study established that South Africa, like all other developing countries, is vulnerable to the effects of climate change and is the highest emitter of greenhouse gases in the Sub-Saharan region due to its economy being heavily reliant on fossil fuels. The most prevalent of these is Carbon Dioxide. Therefore, it is imperative that the country put in place climate change mitigation measures. Based on the interactions with the participants, the construction industry in the country has been identified as one of the highest emitters. Office buildings in the City of Johannesburg are high consumers of energy and emit high amounts of Carbon.

Factors which increase Energy Consumption and Carbon Emissions

Factors that drive up the consumption of energy and Carbon emissions are mainly the building usage, occupant behaviour as well as the external temperature. The external temperature influences the behaviour of the occupants in terms of their use of appliances in the building such as HVAC systems. Another big contributing factor is poor building designs however for this study existing office building stock was used in the research therefore the retrofitting measures taken to make the buildings more energy efficient and reduce Carbon emissions were the main focus.

Environmental and Building Legislation and Institutional Frameworks

Further interaction with the existing literature uncovered that there is adequate existing legislation and institutional frameworks in South Africa which cover all aspects of climate change and all facets of building which are necessary to make the construction industry more sustainable and increase the uptake of green buildings. All these are aligned with the international agreements on climate change that South Africa has committed to such as the Paris Agreement of 2015. The Constitution of the country enshrines the environmental rights of all South Africans in the Bill of Rights and informs all the acts which govern climate change and Carbon emissions such as the Carbon Tax Act of 2019. There are other acts which regulate energy such as the National Energy Act 34 of 2008. Legislation such as the building standards SANS 10400-X series has been made mandatory to ensure sustainable buildings and construction which assist in the greening of buildings. Particularly, SANS 10400-XA which regulates energy efficiency. There are also many policies and guidelines which provide a framework for dealing with climate change and the construction of green buildings. In South Africa, the establishment of the GBCSA has culminated in the development of certification toolkits for all types of buildings. However, this is a voluntary process with costs involved. The City of Johannesburg is in the process of developing its own Green Building Policy and Green Buildings By-laws.

Challenges in Implementation of Green Buildings

However, the challenge for the City and the country in general is the implementation of these laws and institutional frameworks as well as compliance with them. Human interaction with the participants revealed that what hinders implementation is a lack of financial and technical capacity as well as poor governance. Thus, the country continues to struggle in terms of decreasing Carbon emissions. Therefore, the retrofitting of existing office buildings and their certification has been led primarily by the private sector as that is where the bulk of the financial and technical capacity is. Furthermore, there is a business case for the certification of green buildings of office use as they appear more attractive to clients who are looking to 'do the right thing' as awareness of climate change and its negative environmental impacts increases. However, it is up to owners of certified green buildings to monitor and maintain their own buildings as there is currently no existing mandatory systems in place in the City and indeed the country to do so.

Performance of Certified Retrofitted Office Buildings in the City of Johannesburg

Nonetheless, available data demonstrates that certification of retrofitted buildings of office use in the City of Johannesburg results in them becoming more energy efficient and reduces their Carbon emissions. Green Star South Africa certification toolkits developed by the GBCSA are the most popular rating tools as they are developed specifically for the South African Environment. The Existing Building Performance V1 toolkit which is used to certify retrofitted office buildings in the City of Johannesburg was developed taking all available national and international environmental and construction legislation, guidelines and standards into consideration therefore it is of acceptable quality. Furthermore, the toolkit ensures that certified buildings maintain or perform better on their energy consumption and Carbon emissions in order to remain certified by stipulating that they must re-certify 3 years after their certification period. However, human interactions with the tool have revealed that there is opposition to the fact that the tool is of high quality as it is not mandatory to apply and is difficult to understand. Furthermore, there is sufficient doubt that the tool actually assists in enhancing buildings energy performance and Carbon emissions reduction as there is a belief that it merely offers a guiding framework for green building and that the existing legislation and the mandatory SANS 10400-XA building standard is more robust and stringent. Other challenges associated with the tool are the expense of applying it. It is also the onus of owners of certified retrofitted office buildings to ensure that their buildings are constantly performing optimally in this regard. However, existing literature has widely disproved these findings as certification of buildings involves the use of experts and application of the EBP V1 Tool particularly requires constant monitoring to ensure buildings are improving or maintaining their energy consumption and Carbon emissions. The study has also demonstrated that a number of financial incentives exist should clients wish to green their buildings.

Impact of the Green Building Phenomenon on the Construction Industry

In general, the construction industry has been impacted positively by the increasing phenomenon of green buildings. In various professions in the industry, increased awareness has resulted in capacitation in terms of training and the focus has turned to building regenerative buildings and communities. Major retrofitting schemes in the public sector have started to occur, particularly with the replacement of traditional lights with LED lights and there has been an increased uptake in green technologies, building practices and sustainable construction materials. While challenges still remain, particularly in terms of capacity building in the public sector and expense for the client, such as small companies to invest in green building, green building technologies and certification, these are somewhat offset by existing incentives from government, the private sector and non-profit organisations. Critical incentives such as Green funds and other financially linked incentives like tax incentives, subsidies, training on certification and certification tools currently exist. Awareness campaigns have also been signified as existing. Further, more can be done in terms of incentivising certified green buildings in the country through dispensing knowledge of existing incentives, creating more subsidies and Carbon tax implementation. A national bank could also be established to provide low-cost financing for renewable energy projects.

In view of the above it is clear that generally there is a positive perspective towards sustainable building and retrofitted certified green buildings of office use as generally they demonstrate that they perform better in terms of energy efficiency and reducing their Carbon emissions. However, their implementation and monitoring is relatively slow due to the challenges in implementing the existing legislation which is further exacerbated by financial and technical constraints as well as poor governance and misalignment in the public sector. However, increasing awareness of climate change and the role of green building in terms of mitigation, as well as support from various sectors in terms of incentives and further potential incentives being given has resulted in a generally positive outlook for the future of certified green buildings in the country.

6.3 Recommendations for the role that Certified Green Buildings can play in Climate Change Mitigation

Sustainable construction and green buildings have emerged in the 21st century as central to achieving sustainable development. Additionally, the general perspective is that they are important in terms of mitigating climate change. It is evident from the findings of this study that in the City of Johannesburg, retrofitting and green certification of existing office buildings is slow due to the constraints of financial and technical capacity particularly in the public sector which is further exacerbated by the fact that existing legislation and institutional frameworks are also not adequately implemented. Thus, making it even harder to monitor green buildings. Indeed, most are voluntary and act as guidelines. Therefore, they are mainly implemented in the private sector where financial and technical capacity exists and there is a business case for them. However, with increasing awareness of climate change the various sectors which make up the economy of the country are starting to transform and incentivisation of green building is starting to accelerate their uptake making the prospects for the future of green buildings in South Africa generally positive. Therefore, because climate change mitigation and green building requires a collective effort, this study's recommendations have been divided according to the different stakeholders.

6.3.1 Recommendations for National Government

The role of governance in SA needs to be addressed in order to fully realise the positive outcomes of policy and legislative reform specifically those focusing on improved energy futures. Corruption, vested interests, and political interference should be minimised for policies to be effective. The role of the National Energy Regulator of South Africa (NERSA) could also involve evaluating policy implementation, as well as becoming an independent body to manage infrastructure tenders to reduce patronage and nepotism. Furthermore, NERSA should be provided with sufficient funding to function optimally. A dedicated institutional facility or platform should also be established to co-ordinate fair energy transition. This could form part of the mandate of the National Planning Commission. The Department of Planning, Monitoring and Evaluation should be capacitated to enforce policies so that they are converted into meaningful action.

6.3.2 Recommendations for the City of Johannesburg:

It is widely acknowledged that government, particularly local government such as the City of Johannesburg, faces many challenges specifically in terms of capacity in implementing green buildings and implementation of existing legislation. One cannot overemphasize the importance of local governments role in this regard. In view of this, as the custodians of legislation which governs climate change, the construction industry and buildings this study recommends that government looks to securing funds for training public officials in local government to implement the legislation adequately. It is further recommended that the Carbon Tax Act of 2019 be enacted so that the mitigating measures in the legislation can be applied. This is to ensure that scarce environmental resources are protected and South Africa is able to fulfil its obligations to the people and honour its promises in the international agreements it has ratified. Service delivery is the mandate of local government and this relies heavily on the optimal condition of the existing environmental infrastructure. Furthermore, it is also recommended that the City of Johannesburg looks into public-private partnerships with Non-Profit Organisations like the GBCSA. This can assist in order to secure the financial and technical assistance it needs in greening and certifying their own office buildings which are mostly existing buildings and also assist in mainstreaming energy efficiency and Carbon emissions standards in the development of their policies for green and sustainable buildings. The study also demonstrated that there is a lack of monitoring of compliance to legislation for certified green buildings so local government can look into forming bodies similar to the red ants who monitor illegal squatting and buildings to monitor green buildings to ensure they are meeting and even enhancing their performance.

6.3.3 Recommendations for the Private Sector:

One can argue that by far the private sector is the most established in terms of sustainable construction and green buildings. In fact, the vast majority of retrofitted certified office buildings are owned by private companies or private property companies. Therefore, this study recommends that the private sector continues with the commendable work it has done in the industry however, it is recommended that it also extends assistance to the public sector in terms of helping with providing technical and financial capacity and both sectors can build a relationship which will ease the implementation of sustainable building and green buildings. Both sectors need to engage and support each other and indeed local and provincial departments such as the Gauteng Department of Infrastructure Development and the Gauteng Department of Economic Development to find the best solutions for implementation and to develop frameworks and mobilise institutions. This can be done through engaging each other at existing inter-sectoral platforms such as provincial Climate Change Indabas, provincial Climate Change Forums, Developers Forums and Inter-Governmental platforms like provincial Environmental Coordination Forums. The advantage of these platforms is that other stakeholders in the industry can be engaged such as the academic sector and civil society. Localised and more condensed versions of these forums can be initiated between the City of Johannesburg and the Private sector and Non-profit Organisations. It is recommended that these bodies sit on regular intervals such as on a monthly basis so that they remain relevant and up to date with the current status of climate change and green buildings.

6.3.4 Recommendations for Non-Profit Organisations:

Non-Profit Organisations are already starting to play a vital role in the uptake of green buildings. This study has uncovered that raising awareness about climate change and training being given to other sectors such as the public sector on certification and rating tools as well as introduction of green buildings and green building principles are already initiated. It is recommended that these initiatives be continued and that Non-Profit Organisations also assist in accessing Green funds for sectors like the public sector. Also, NPO's can also provide assistance in terms of doing practical work such as lifecycle costing and analysis for clients who want to green their buildings and certify them.

6.3.5 Recommendations for the Construction Industry:

The study has established that in the country the construction industry is starting to adapt to the realities of climate change and the green building phenomenon. It is recommended that the construction industry continue to grow in becoming a fully sustainable industry and also raise awareness, capacitate and reskill the professionals in the field such as developers, planners, surveyors, engineers etc. in green buildings and green building principles. This is so that the industry can mainstream sustainability principles, particularly in terms of energy efficiency and Carbon emissions reduction, into its functioning. This way, any additional costs or work challenges which may potentially come with building green or retrofitting buildings to become green is already accounted for in terms of sub-contractor costs and professionals are confident and competent enough to choose high quality technologies and materials which they will be able to use in construction. Additionally, the construction industry should adapt to using sustainable local materials sourced closer to the site of construction so that hidden energy such as embodied energy of buildings is drastically reduced.

6.3.6 Recommendations for Academic Institutions:

The academic and research institutions in the country such as the CSIR and higher education institutions are at the forefront of providing the most relevant, comprehensive scientific, technological and socio-economic information about climate change, sustainable development and green buildings through studies which have been conducted locally and internationally. It is recommended that these continue so that they can correctly inform and influence the development of appropriate legislation in government for all spheres and decisions made in all sectors of the economy which involve the industry.

Benchmarking Studies

Benchmarking studies should also continue where the industry in South Africa can be compared to those of other countries in the world which have successfully managed to implement sustainable construction and buildings. This is so that the country can develop a working model suited to the local conditions with which it can achieve its climate change and sustainability goals. Furthermore, higher education institutions are encouraged to develop and provide integrated courses and degrees which focus on environmental sustainability which incorporate climate change including mitigation, energy, sustainable construction, green buildings, certification and buildings rating tools as well as the legislation and institutional frameworks governing them from an undergraduate level so that the requisite skills that are needed are developed from the outset and the challenge of technical capacity is addressed.

6.3.7 Recommendations for future research:

All studies have limitations. Therefore, this study may have had its own limitations. The study was limited to retrofitted certified green buildings of office use in the City of Johannesburg because of time constraints and financial resources. Future studies could consider incorporating more certified green buildings of varying usage types thus resulting in a larger sample size and studying the impact that the application of the other tools and resultant certification have on the performance of the green buildings. Therefore, the results may not be generalised for the entire stock of certified green buildings as there are many such buildings in the City. Further studies can examine the actual tools themselves to find out whether they are sufficient and effective for certification.

Components of a Green Buildings

The study only examined energy consumption and emissions in buildings. Therefore, based on the findings of this study, it is evident that there is a need for further studies on perspectives of green buildings in terms of other components which make up a green building such as efficiency in water consumption, enhancement of indoor environmental air quality, land use and ecology, the use and reuse of materials, how they help in the reduction of transport and promote alternative transport uses and the role that management plays in the adoption of environmental principles. Further studies can also focus on innovation in green buildings and the socio-economic impact they have in the City of Johannesburg and other areas. These can be combined with any of the other studies mentioned above.

Data Granularity

The energy consumption data provided to the researcher was global data which took into account all the energy consumption in the building, even in spaces which are not occupied like lifts, lobbies, parking etc. It was the wish of the researcher to have more refined data such as specific energy consumption of HVAC systems, plugs, lighting etc. in occupied spaces so that the researcher could have more exact results for the study and the researcher was confident that this could be achieved as the buildings all have metering systems installed which monitor energy consumption. However, as the owners of the certified green buildings being used for this study, the property companies are the custodians of energy consumption data in the buildings and provided the researcher only what they were prepared to give therefore the researcher had to make use of the data given. Therefore, to the best knowledge of the researcher, the data provided was accurate. Future studies should try to ensure the attainment of more granular data so more accurate results can be obtained from the research of these buildings.

Studies in other research sites

In addition to the above, the study focused on the performance of the green buildings in terms of energy efficiency and Carbon emissions reduction in the City of Johannesburg. The City of Johannesburg falls under a certain temporal and climatic zones which are different to other cities such as the City of Tshwane and the City of Cape Town as an example. Therefore, the performance of retrofitted certified green buildings of office use when it comes to energy consumption and Carbon emissions may differ due to the differing temporal and climatic conditions of those cities. Also, temperature data provided by the South African Weather services is generalised and is measured using altitude and so is more related to that than the urban heat island effects. It is highly recommended that future studies examine the urban heat island, its effects and their impact on green buildings and their surroundings particularly in large metropolitan cities like the City of Johannesburg. This will provide a more accurate account of how these buildings perform overall.

LIST OF PERSONAL COMMUNICATION

Pers. Com 2019a Interview with respondents in Green Building Council of South Africa on the 1 April 2019 and the 19 July 2019.

Pers. Com 2019 and 2020b Interview with Green Consultants on the 19 of March 2019, 6 of June 2019 and 5 February 2020

Pers. Com 2019 and 2020c Interview with provincial authorities in the Gauteng Department of Agriculture and Rural Development on the 11 July 2019 and 6 February 2020

Pers. Com 2019 and 2020d Interview with provincial authority Gauteng Department of Infrastructure Development on the 31 January 2020 Gauteng Department of Infrastructure Development

Pers. Com 2019 and 2020e Interview with respondent in the Council of Scientific and Industrial Research on the 3 June 2019 and 14 February 2020

Pers. Com 2019 and 2020f Interview with respondents in the local authority, City of Johannesburg on the 5 of June 2019 and the 12 February 2020.

Pers. Com 2019g Interview with respondent in tertiary institution on the 10 March 2020

Pers. Com 2018, 2019 and 2020h Interview with respondent in Banking institution on 23 September 2019 and 12 February 2020

Pers. Com 2019i Interview with personal respondents in Property Company 1 on the 19 September 2019

Pers. Com 2019j Interview with personal respondent in Property Company 2 on the 17 April 2019

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Appendices

APPENDIX A: Human Research Ethics Clearance Certificate (will be attached in final submission)

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Makgalemele

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H18/11/17**
PROJECT TITLE	Perspectives on the effectiveness of green buildings in climate change mitigation: A study of Sandton and the broader Sandton node
INVESTIGATOR(S)	Miss M Makgalemele
SCHOOL/DEPARTMENT	GAES/
DATE CONSIDERED	16 November 2018
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	12 February 2022

DATE 13 February 2019 **CHAIRPERSON** J. Knight
(Professor J Knight)

cc: Supervisor : Professor M Simatele

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature

17 / 09 / 2020
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX B: Participant Information Sheet (Interview respondents)

Participant Information Sheet

Dear Sir/Madam

My name is Malesotse Cecilia Makgalemele and I am a Masters student in the school of Geography and Environmental Studies at Wits University in Johannesburg. As part of my studies I have to undertake a research project, and I am investigating *perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.* The aim of this research project is to find out how effective certified green buildings are in climate change mitigation.

As part of this project I would like to invite you to take part in an interview. This activity will involve responding to a series of interview questions and will take around forty five to sixty minutes. With your permission, I would also like to record the interview using a digital device. If you are not comfortable with this I will only proceed to take notes.

You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym to represent your participation, in my final research report. However, if you are speaking in a professional capacity and would like to be identified as an expert/professional in the field then you may be identified based on your official role. If you experience any distress or discomfort, we will stop the interview or resume another time.

If you have any questions afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you upon request. If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone + 27(0)11 717 1408, email Shaun.Schoeman@wits.ac.za

Yours sincerely,

Malesotse Cecilia Makgalemele

Researcher: Malesotse Makgalemele

Email address: 0609172D@students.wits.ac.za

Phone number: 072-965-1427/066-488-1711 (Mob)/(011)-240-3412 (Office)

Supervisor: Professor Mulala Simatele

Professor of Environmental Management and Sustainability Science

University of Witwatersrand

Department of Geography & Environmental Studies

School of Geography, Archeology and Environmental Studies

Email address: mulala.simatele@wits.ac.za

Phone Number: (0) 11-717-6515 (Office)/083-383-6884 (Mob)

APPENDIX C: Consent form (Interview respondents)

Consent Form

Title of project: Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg

Name of researcher: Malesotse Cecilia Makgalemele

I ……………………………………….. agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

I agree that my participation will remain anonymous YES NO (please circle)

I agree that as an expert in the field my identity may be revealed YES NO

I agree that the researcher may use anonymous quotes in her research report YES NO

I agree that the interview may be audio recorded YES NO

I agree that the information/data I provide may be used YES NO
anonymously by other researchers following this study

…………………………………… (signature)

…………………………………… (name of participant)

…………………………………… (date)

APPENDIX D: Interview Guide-Green Building Council of South Africa

<u>Interview Questions for Green Building Council of South Africa</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg*

<u>A: General Questions</u>

1) What is the core business of the organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) Please elaborate on the SA Green Star Rated Tool and how was it developed?
2) Why was their the need to develop a tool specific for South Africa and not use other existing tools such as LEED/BREEM etc.?
3) How many green star certified buildings in Sandton and Broader Sandton Node?
4) Is there a rising popularity in greening buildings and getting certification?

4.1) If so, what are the reasons.

5) What is the current rate that buildings are going green and applying for certification?

6) In the council's experience, why would some buildings choose to become more green and sustainable, but not necessarily get certified, whereas others go further and become certified green buildings?

7) What is (if there is any) the difference in terms of performance when it comes to energy consumption and emissions between the two buildings mentioned above?

8) What must be taken into account if a building wants to be certified green?

9) What other things are taken into account when certification is applied for ((building position, lights, computers, telephones, heaters, fans, air conditioners, kettles, microwaves, fridges)?

10) Do green star certified buildings maintain this improvement and continue to comply with standards, including recertification? (Y/N)

10.1) If not, what are the reasons?

11) In which sector do most buildings which apply for certification fall: Public or Private sector? Please choose one.

11.1) Why is this?

12) Are the green certified office/commercial buildings in Sandton and Broader Sandton Node GBCSA certified buildings or other LEED/ EDGE certified buildings as well?

12.1) If so, what (if any) is the difference between the two certifications and what makes an office building go for a particular type of certification?

13) Is employee satisfaction taken into account with green building certification?

14) In the council's opinion, what are the main impediments to the effective implementation of green buildings in the city?

15) In the council's opinion, what more can be done to improve and incentivise the greening of office/commercial buildings and encourage building owners to get green certification for their buildings?

C: Technical information required:

If you are in a position to share the following information, may you please provide me with:

1) Map of all the green star certified office/commercial buildings in Sandton and the Broader Sandton Node
2) Energy usage of green star certified office/commercial building from when it was a nominal building
3) Energy usage of office/commercial green star certified building from when it was newly certified
4) Emissions score of office/commercial green star certified building from when it was a nominal building
5) Emissions score of office/commercial green star certified building from when it was newly certified
6) Year by year Energy usage of office/commercial green star certified building (from 2008-2017)
7) Year by year Emissions score of office/commercial green star certified building (from 2008-2017)

8) If applicable:

8.1) Energy usage of office/commercial green star certified building from when it was re-certified

8.2) Emissions score of office/commercial green star certified building from when it was re-certified

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX E: Interview Guide-GDARD

<u>Interview Questions for Gauteng Department of Agriculture and Rural Development</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg*

<u>A: General Questions</u>

1) What is the core business of the organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) What is the current state of climate change in the province of Gauteng?
2) Which industries are the biggest contributors to climate change in Gauteng (e.g transport, building, manufacturing etc.)?
3) What is the current state of the city of Johannesburg in terms of climate change mitigation? (I.e what measures, if any, have been put in place to mitigate negative climate change in the city)
4) What policies, plans, programmes etc. exist in terms of promoting climate change mitigation?

4.1) Which are mandatory

4.2) Which are optional

4.3) How well are all these being implemented?

5) How much pollution (in terms of emissions) do the buildings in the City of Johannesburg (particularly the Sandton area and the broader Sandton node) produce?

6) Have mitigative measures/policies, plans etc. been targeted at buildings, particularly office buildings, in their operational life cycle?

6.1) If so which ones exist?

6.2) If not, why?

7) Does the department collaborate with other stakeholders when it comes to the field of greening of buildings and sustainability looking particularly at office buildings?

7.1) If so, how is this achieved?

8) What role does the department play as the environmental authority in the province to promote greening of buildings and sustainable development?

9) If you are in the position to share the following information:

9.1) Trend in data in average energy usage in office/commercial buildings from (2008-2017)

9.2) Trend in data in carbon emissions in office/commercial buildings from (2008-2017)

9.3) Overall trend of increase of carbon emissions in the City of Johannesburg and how much of this is attributed to office/commercial buildings?

10) If you are in a position to share the following information has the department got any data about:

10.1) Energy usage of office/commercial buildings which are certified green in Gauteng? (Particularly from 2008-2017)

10.2)Carbon emissions of office/commercial buildings which are certified green in Gauteng? (Particularly from 2008-2017)

10.3) Energy usage of office/commercial buildings which are sustainable however are not certified green in Gauteng? (Particularly from 2008-2017)

10.4) Carbon emissions of office/commercial buildings which are sustainable however are not certified green? in Gauteng (Particularly from 2008-2017)

11) In the absence of the above is there any other source where I can get this information from who keeps records of the energy usage and carbon emissions?

12) What is the organisation's view on building performance rating tools for certification of buildings such as the South African Green Star Rating Tool?

11.1) Do these have any meaningful impact on the buildings performance in terms of energy usage and carbon emissions?

11.2) From a policy and legislative perspective, what more can be done to improve the greening and sustainability of buildings such as those found in the Sandton area and the broader Sandton node?

12) What does the future hold for green buildings and sustainable construction in the province and the country as a whole?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX F: Interview Guide-GDID

<u>Interview questions for Gauteng Department of Infrastructure Development</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of the Gauteng Department of Infrastructure Development?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) What are the core principles for the effective and efficient operation and maintenance of a building in terms of energy usage and carbon emissions from buildings?

2) Has the phenomena of climate change and sustainable development had an impact on how infrastructure must be developed and changed to take into account climate change realities in Gauteng?

3) What changes, if any, have been proposed and/or implemented to make Gauteng office buildings more resilient and sustainable to the effects of climate change and to aid in mitigation?

4) Have new/reviewed principles for green and sustainable building operation been implemented?(Y/N)

4.1) If so, what are these

4.2) How effective have they been in terms of mitigating the negative effects of carbon emissions in buildings?

5) How do the technical and design elements of a building affect its ability to make it green and more sustainable in terms of energy efficiency and emissions? (building positioning, angles etc.)

6) How many of Gauteng's office buildings, particularly those in Sandton and the Broader Sandton Node, are also managed by Gauteng Department of Infrastructure Development?

6.1) Of these office buildings, how are they performing in terms of energy usage

6.2) Of these office buildings, how are they performing in terms of carbon emissions?

6.3) If you are in a position to can you share any data on the above?

6.4) If you are not in a position to, can you please kindly refer me to where the data can be sourced?

6.5) Of these buildings, which are new (built from the ground) and which are refurbished?

7) Are any new green buildings earmarked for the future in Gauteng, particularly in Sandton and the broader Sandton node?

8) Following the two questions above, how many of these buildings are owned by the public sector?

9) To the department's knowledge, is their a list of buildings currently operating in the Sandton CBD and the Broader Sandton Node which have not been certified as green buildings, however have undertaken measures to become more sustainable and environmentally friendly?

10) If these buildings exist, is there any data on their performance from 2008 to 2017 in terms of energy consumption and carbon emissions?

11) Is there a working relationship between the department, the Green Building Council of South Africa, City of Johannesburg and Council of Scientific and Industrial Research etc. to promote the greening and sustainability of buildings meant for office use?

12) Are there any plans, programmes, policies or legislation in existence for the greening of office buildings? (institutional frameworks)

12.1) If you are in a position to, please provide a list of them and their accessibility

12.2) Of these, how many are mandatory and how many are optional?

13) How effective has it been to implement these policies, plans legislations etc.?

14) Has the carbon tax for buildings been implemented yet? (Y/N)

14.1) If so, how (if it has already begun) is it being measured per building?

15) What is government's plans for the future to promote sustainable construction and promoting green buildings?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX G: Interview Guide-CSIR

<u>Interview Questions for Research Institutions</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of the organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) May you please outline the main research which has been done around the green building industry and sustainable construction in South Africa?

2) Of this research, what is the core aspect of it and why? (i.e what is it that people are most interested in researching about green buildings and why?)

3) How have buildings rating systems impacted the green building industry in South Africa?

4) Has the enactment of the building regulations SANS 204 and SANS 1004XA for minimum energy usage in buildings affected the energy usage of buildings?

4.1) How well have the building regulations been implemented?

4.2) What is the effect so far of their implementation?

1) How strong is the overall institutional framework governing the infrastructure and construction industry, as well as the environment in South Africa?

5.1) How well is the legislation known and understood?

5.2) How well is its implementation?

2) Overall, has research shown green buildings as being more efficient than nominal buildings and other sustainable buildings in terms of energy usage and emissions?

6.1) If so, why?

6.2) If not, why not?

3) What are the gaps in the knowledge about green buildings in South Africa? (i.e what more has to be researched about green buildings in the country)

8) How do green buildings link to the manufacturing and industrial sector?

8.1) Can manufacturing and industrial buildings also be retrofitted to being green buildings?(Y/N)

8.1.1) If yes how can this be done?

8.1.2) If no, what are the factors limiting this?

9.) If you are in a position to share the following information may you please provide me with data reflecting the following:

9.1) Energy usage and carbon emissions in nominal office/commercial buildings in the Sandton and the broader Sandton node (2008-2017)

9.2) Energy usage and carbon emissions in certified green office/commercial buildings in the Sandton and the broader Sandton node (2008-2017)

9.3) Energy usage and carbon emissions in certified green office/commercial buildings in the Sandton and the broader Sandton node (2008-2017)

9.4) Energy usage and carbon emissions in sustainable office/commercial buildings in the Sandton and the broader Sandton node (2008-2017)

10) In the absence of the above information is there any other source which can provide me with the information?

11) Given your experience in this field, what do you believe is the future of sustainable construction and green buildings in South Africa?

12) Is there anything else you would like to discuss related to this topi

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions for clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX H: Interview Guide-Environmental Consultant

<u>Interview Questions for Environmental Consultants specialising in Green Buildings</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of this organisation?
2) What services does the organisation offer in terms of green buildings and sustainable construction?
3) How long has the organisation been in operation?
4) When were you first appointed to work for this organisation?
5) How long have you been working for this organisation?
6) What is your function within this organisation?

<u>B: Specific Questions</u>

1) When did the demand for sustainable developments and green buildings become so significant that a market was created for them?

1.1) If possible please give the year or timeframe?

2) How big is the market for green buildings?

2.1) Is it growing and at what rate?

2.2) Alternatively, is it declining and at what rate?

2.3) Is it stagnant and why?

2.4) Are you in a position to share any data on the above aspects? (Growth charts from 2008 to 2017).

3) Has the demand for sustainable developments and green buildings increased over the years? If so

3.1) What are the factors driving the demand?

3.2) If not, what are the factors inhibiting this demand?

4) In your opinion, what is the main motivation for clients to want to build sustainably or go green?

5) In terms of the clientele:

5.1) What sector do they mainly come from? Public/Private?/Individuals/Business

5.2) Why is this sector the most interested in building sustainably and going green?

6) Compared to building conventionally, is building sustainably or green buildings more expensive for clients?

6.1) If so, what are the factors driving up the cost?

6.2) If not, what are the factors reducing the cost?

7) As a consulting firm in your experience which part of the lifecycle of a building is its most energy intensive and releases the most carbon emissions?

7.1) If you are in a position to, please provide the main reasons for this?

8) Is embodied energy taken into account when considering the energy use of a building?

8.1) How is embodied energy calculated/factored in the energy usage of a building?

8.2) Which part of the building's lifecycle is embodied energy the most?

9) What are your thoughts about green buildings and building rating systems which give green certification like Green Star rating tool, LEED/BREEM?

10) In your experience as a consultancy, is it significant for a building to receive green certification?

10.1) Why is this so?

11) When clients come for your services in terms of building sustainably and greening their buildings, is receiving green certification one of their goals?

11.1) If so, what makes them attracted to getting green certification?

11.2) If not, what makes them indifferent?

12) In which areas are sustainable buildings/green buildings the most concentrated in the City of Johannesburg? (suburbs, cbd's, etc.)

12.1) What would you say are the reasons for them being mostly concentrated there?

13) If you are in a postion to may you please elaborate on green buildings in the Sandton CBD and the broader Sandton Node?

13.1) When was the market for green buildings established and started growing in this area?

13.2) What makes areas like Sandton and the Broader Sandton node attractive for investing in green builidngs?

13.3) Which sector is the main investor in Green buildings in the Sandton area and the broader Sandton node? Public/Private? Why is this?

13.4) Which clients are the most interested in going green in the Sandton area (corporate, business, residential?)

13.5) If you are able to answer this question, of the green buildings in the Sandton area, how many are office/commercial buildings?

13.6) How many of these are certified green buildings?

13.6.1) Of these which are Green Star certified (the South African rating tool for green buildings)

13.6.2) What influenced the choice for Green star certification instead of LEED/BREEM certification?

14) How would you rate client satisfaction with certified green buildings in the Sandton Area?

15)If applicable, do you offer any assistance to green buildings to get certified?

15.1) If so, what is the process in doing this?

16) In your opinion as a consulting firm, what are the benefits of a building being certified green?

16.1) If benefits exist, please elaborate on them?

17) In your opinion as a consulting firm, what are the drawbacks of a building being certified green?

17.1)If drawbacks exist, please elaborate on them?

18) What are the main achievements in the sustainable development and green building industry in South Africa, particularly looking at Gauteng?

18.1) What has been the main driving force behind these achievements?

19) What are the main challenges and gaps in the market in the sustainable development and green building industry in South Africa, particularly looking at Gauteng?

19.1) What are the causes of these challenges?

20) In terms of opportunities, what more can be done in the market in the sustainable development and green building industry in South Africa, particularly looking at Gauteng?

21) In your experience as an environmental consulting firm, what is the future for the development of green buildings and sustainable development and construction in South Africa, particularly for areas like Sandton?

22) How can the industry expand in the country?

23) Compared to the rest of the world, where does South Africa stand in terms of the sustainable construction and green building industry?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX I: Interview Guide-Property Company 1, 2 and 3

Interview Questions for Real Estate Companies specialising in Green Buildings and Sustainable Buildings

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

A: General Questions

1) What is the core business of this organisation?

2) What services does the organisation offer in terms of green buildings and sustainable construction?

3) How long has the organisation been in operation?

4) When were you first appointed to work for this organisation?

5) How long have you been working for this organisation?

6) What is your function within this organisation?

B: Specific Questions

1) Has there been a significant increase in the demand for 'green buildings' in the property market?

1.1) If so, what are the factors driving this demand?

2) What types of 'green buildings' are the most popular amongst clients; residential, office/commercial, retail etc?

2.1) In your experience, why is this?

3) Is there a specific market that is targeted for green buildings in the property market? (Y/N)

3.1) If yes why is this?

4) Who is the main clientele for green buildings?

4.1) What are the factors influencing this?

5) From which sector do you draw most of your clientele? Public or Private Sector?

5.1) Why is this?

6) Where are the majority of green buildings you have sold/refurbished located in Johannesburg?

6.1) How many of these are located in Sandton CBD and the broader Sandton Node?

7) What types of buildings are these? Residential, office/commercial, retail etc?

8) How many of these buildings are certified green buildings?

9) Is the clientele of green buildings mainly owners or letters?

9.1) Why is this?

10) What is the average occupation period of a green building in Sandton and the broader Sandton node?

10.1) What affects this occupation period?

11) As a company in your experience, what is the general occupational experience of tenants letting/renting/owning green buildings in the Sandton Area?

11.1) If negative, what are the factors affecting their experience?

11.2) If positive, what are the factors affecting their experience?

12) Are green buildings more costly or cost-effective to occupy and maintain?

12.1) What are the factors contributing to their costliness (if applicable)

12.2) What are the factors contributing to their cost-effectiveness? (if applicable)

13) What (if any) occupational and maintenance issues often arise from the green buildings? (replacing lights, ventilation, etc.)

14) Following from the question above, how often does maintenance have to be carried out on green buildings you manage?

15) How would you rate tenant satisfaction with green buildings? Specifically office/commercial spaces?

15.1) Why is this?

16) In terms of energy usage and carbon emissions related to energy usage, how do these green buildings compare to other non-green buildings?

17) Are you in a position to share information on any data you may have regarding energy usage and carbon emissions of the green office/commercial buildings you manage from the year 2008 to 2017?

18) Certification of green buildings is becoming more popular and increasing, particularly in areas like Sandton. In your experience, what is driving this?

19)Are certified green buildings more attractive to prospective clients? (Y/N)

19.1) If so, what about them makes them more attractive to prospective clients?

20) What other potential benefits/drawbacks come with occupying green buildings other than those concerning energy usage and carbon emissions?

21) What are the challenges in the real estate industry concerning green buildings, if any?

22)In your experience as a real estate company, are there any gaps in the green property industry in South Africa?

23) In your experience as a real estate company, is there any more that can be done to enhance the green property industry in the country and broaden its appeal? (Y/N)

23.1) If so, what can be done?

24) In your experience as a real estate company, what would you say is the future of green buildings in the property market in South Africa?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX J: Interview Guide-Banking Institution

<u>Interview Questions for Facilities Managers of Certified Green buildings</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of this organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

6) When was the organisation certified green?

7) If applicable, has the building re-applied for certification as per the requirements of the Green Building Council of South Africa?

8) If the above question is not applicable, when is the building due to apply for re-certification?

<u>B: Specific Questions</u>

1) Is the building a new certified green building or a retrofitted certified green building?

2) If you are in a position to, may you please share the design and technical aspects of the building from when it was a nominal building to it becoming a certified green building? (images and drawings can also be accepted?)

3) What changes had to be made to the design of the building and the technical aspects for it to become certified green? (lighting, ventilation, noise etc.)

4) What types of materials have been used in the construction/retrofitting of the building in order to make it green? (bricks etc.)

5) Where were these materials sourced from?

6) How were they transported to the building site?

7) How do each of these materials affect the energy usage and carbon emissions of the building?

8) What was the cost of these materials individually?

8.1) Were they cheaper and more accessible than conventional materials?

8.2) Were they more expensive and inaccessible than conventional materials?

9) Has the use of these alternative materials improved the performance of the building in terms of energy usage and carbon emissions during its operations?

9.1) If possible, do you have any data you are willing to share to support this?

10) Has the use of these materials improved the operational cost of the building in terms of energy consumption and emissions?

11) Has the use of these materials lowered the carbon footprint of the building in terms of energy consumption and emissions during the lifecycle of the building?

12) Are there any alternative energy technologies installed in the building? (Y/N)

12.1) If so what are they?

12.2) How have these affected the energy usage and emissions from the building?

12.3) Have they increased energy usage and emissions?

12.4) Have they decreased energy usage and emissions?

12.5) Does any data for this exist (Y/N)?

12.6) Are you in a position to share any data of this (if it is available) over the 2008 to 2017 period?

13) If applicable, have alternative energy saving technologies affected the level of complexity of managing the building? (Y/N)

13.1) If so, how?

13.2) And if not, why not?

14) Have alternative energy saving technologies driven up the cost of operating and maintaining the building? (Y/N)

14.1) If yes, how?

14.2) If no, how?

15) What other factors affect the proper operation and management of the building in terms of energy efficiency and emissions (building position, natural sunlight, computers, telephones, heaters, fans, air conditioners, kettles, microwaves, fridges?

16) Is the varying use of these appliances during the different seasons of the year factored into the overall energy consumption and emissions of the building?

16.1) If so, are you in a position to share any data on this?

17) As a manager of the building, do you see any room for improvement or additional changes necessary for reducing further energy usage and emissions from the building?

17.1) If so, what are these?

18) Since being certified green, has the building maintained or even further reduced its energy usage and carbon emissions? (Y/N)

18.1) If so, how?

18.2) If not, why?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX K: Interview Guide-City of Johannesburg

<u>Interview Questions for the City of Johannesburg</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of the organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) How many office buildings are being managed by the city of Johannesburg?
2) What is the general age of these office buildings?
3) What is the general condition of these office buildings?
4) If you are in a position to may you please provide the energy use and emission pattern of these office buildings? (particularly from 2008-2017)
5) Of the certified green buildings in the Sandton area and the broader Sandton Node, how many are also under the management of CoJ?
6) How has the energy usage and emissions of these buildings improved since they were nominal buildings?

7) What policies etc. exist for greening of office buildings in the City of Johannesburg (mandatory and optional)?

8) How effective have these been in terms of implementation in terms of:

8.1) Energy use reduction

8.2) Carbon emissions reduction

9) The City of Johannesburg has just committed to being part of the C40 network of cities which aims for buildings to have net zero carbon emissions.

9.1) Please elaborate on the C40 Network and what their vision and mission is?

9.2) How much of this is being done in collaboration with other stakeholders?

9.3) Who are those stakeholders?

10) How is the net zero carbon emissions for buildings going to be achieved?(i.e has the city laid out plans already about how they are going to achieve net zero carbon emissions in buildings?)

10.1) Is it only targeted at nominal buildings or also certified green buildings or both?

11) When is the C40 mandate going to be implemented?

12)How is the energy usage and emissions of the building going to be measured?

13) Has the carbon tax been taken into account in the city's plans to reduce emissions in buildings?(Y/N)

13.1) When is this going to be initiated?

14) What are the main impediments to greening and sustainable development of buildings in the City?

15) In the city's view, what incentives can be put forward to promote greening and sustainable development of buildings?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX L: Interview Guide-Johannesburg City Power

<u>Interview Questions for Johannesburg City Power</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of the organisation?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) Overall, how much energy is consumed by office/commercial buildings in the City of Johannesburg and how much emissions are attributed to them? Can you give an estimate percentage wise?

2) Of these how many are:

2.1) Government owned and are of commercial/office use?

2.2) Privately owned and are of commercial/office use?

3) What energy policies, programmes, plans, legislation etc. is in place for cleaner use of energy and lower emissions from buildings for the City of Johannesburg?

5) How effective have the newly enacted SANS 204 and SANS 10400XA been in promoting a sustainable environment in South Africa and ensuring that infrastructure incorporates energy-saving practices as a basic standard in buildings?

6) Does the City of Johannesburg collaborate with other stakeholders when it comes to Green Buildings? (Y/N)

6.1) If so what format does the collaboration take?

6.2) If not, why not?

7) Is there any indication that, in terms of energy use and emissions, certified green buildings perform better than nominal buildings?(Y/N)

8.1) If yes, why?

8.2) If not, why?

9.) Does the city own certified green buildings (Y/N)

9.1) If yes, how many of these are retrofitted?

9.2) How many are not retrofitted

9.3) Of the buildings above, are these certified green buildings more energy efficient?

9.4) If no, why does the city not own certified green buildings?

9.4.1) Are there current plans, developments to green buildings or to build new green buildings?

10) What is the future of green buildings in the City of Johannesburg

APPENDIX M: Interview Guide-Company which calculates Carbon for Buildings

<u>Interview Questions for Company which calculates Carbon for Buildings</u>

<u>Good day Sir/Madam:</u>

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg*.

<u>A: General Questions</u>

1) What is the core business of the Gauteng Department of Infrastructure Development?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) What is the importance of calculating Carbon Emissions from buildings?
2) What factors are important to take into account when calculating the Carbon Emissions of a building?
3) What is the difference between the Carbon Footprint of a building and the Carbon emissions of a building, if any.
4) In your experience in this field, how do the emissions of certified green buildings compare to those of nominal/ normal buildings is there an:

(i) Increase

(ii) Decrease

(iii) No significant change

(iv) For whichever selection you chose above, what are the main reasons for this?

5) Can you please elaborate on the formulas used to calculate Carbon emissions from these buildings in terms of:

(i) Lighting

(ii) Water pumps

(iii) HVAC

(iv) Geysers

(v) Plugs

(vi) Fixed Equipment

6) How important is the floor area or volume of the building when working out carbon emissions?

7) How important is the building envelope in terms of calculating carbon emissions of the certified green building and how would one go about this?

8) Is it important to include unoccupied spaces such as basements, parking, lobbies, reception areas when working out the carbon emissions of a certified green building?

9) Are external factors (such as carbon emissions from transport sources) important for working out carbon emissions from certified green buildings?

    (i) If so, how is this calculated?

10) What coefficients are used to work out carbon emissions for certified green buildings and is there significance in using either one (i.e does it matter if you use the Eskom coefficient etc.)

11) Are you in a position to provide Carbon Emissions data for certified green buildings?

    (i) If not why?

12) Can you please elaborate on the environmental legislation that exists on carbon emissions in the country, specifically that pertaining to buildings and green buildings?

13) What is the Carbon tax and can you please elaborate further on it?

(i) What is the expected impact of it in terms of carbon emissions from buildings in the future.

(ii) How is it going to be implemented?

(iii) What benefits are expected to be reaped from it?

14) In your experience, what are the gaps that exist in the legislation regarding the implementation of carbon emissions, particularly those which regulate carbon emissions in buildings?

15) In your opinion how can carbon footprint reduction by buildings be incentivised (you may include by all spheres of government such as the private sector, government, NPO's etc.)

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX N: Interview Guide-Academic Expert

<u>Interview Questions for Academic Experts</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this interview with you and your organisation. I am conducting this interview in order to get research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>A: General Questions</u>

1) What is the core business of the University?

2) How long has the organisation been in operation?

3) When were you first appointed to work for this organisation?

4) How long have you been working for this organisation?

5) What is your function within this organisation?

<u>B: Specific Questions</u>

1) Sustainable development has been lobbied by the international community as a way to adapt to adverse environmental impacts associated with climate change caused by increased GHG emissions such as carbon dioxide. In the construction industry, how is sustainable development defined?
2) There is also a lot of academic research around sustainable construction. How did the concept of sustainable construction come about?

2.1) What is its link to sustainable development?

3) What is meant specifically by sustainable construction?
4) When did the idea of sustainable construction reach South Africa?

5) Has the idea of sustainable construction been an attractive option for the construction industry in South Africa?

6) Do any meaningful incentives exist for sustainable construction in South Africa?(Y/N)

6.1) If incentives exist, is it possible to list them?

7) What are the benefits of sustainable construction (if any)?

8) What are the disadvantages of sustainable construction (if any)?

9) Is there a link between green buildings and sustainable construction?

9.1) If so, how do green buildings link with sustainable construction?

10) What is the rate of transformation in the South African construction industry to going more green?

10.1) If it is fast, why and what are the factors affecting this?

10.2) If it is slow, why and what are the factors affecting this?

11) How does the rate of transformation compare to the construction industry in the rest of the world?

12) Are there any inhibiting factors in the South African construction industry as a whole to transforming to becoming green?(Y/N)

12.1) If so, what are these inhibiting factors? If not, what has driven the increasing transformation?

13) What has been the role of government so far in terms of promoting and supporting a more sustainable construction industry and green buildings?

14) What are the main factors which increase energy consumption and emissions in buildings?

14.1) General

14.2) Specific

14.3) Internal

14.4) External

15) Whose mandate is it to develop green building legislation, strategies, policies, guidelines etc. in the country?

15.1) Government

15.2) National

15.3) Provincial

15.4) Local

15.5) Private sector

15.6) Civil Society

15.7) Non- Governmental Organisations

16) Is there existing legislation and institutional frameworks in South Africa which have helped promote the development and implementation of green buildings? (Y/N)

16.1) If yes, can you list these and give their function?

16.2) National

16.3) Provincial

16.4) Local

16.5) Other sector

16.6) If no, why do they not exist?

17) Looking at existing legislation governing the construction industry and the environment, how strong and effective is the institutional framework in promoting sustainable development and green buildings?

18) Where has the response to constructing green buildings been the strongest, public sector or private sector? Please choose one

19) Why is this?

20.) Following the above two questions what are the plans (if any) to incentivise green buildings in South Africa from:

20.1) Government

20.2) Private Sector

20.3) NGO's

21) How has the construction industry been influenced and responded to green buildings in South Africa and why?

21.1) Positive

21.2) Negative

21.3) General

22) What more can be done to incentivise building green in South Africa for:

22.1) Developers

22.2) Planners

22.3) Government

22.4) The construction Industry

22.5) Private sector

23) Some Green buildings achieve their status by becoming certified. What is your opinion on certification systems like LEED/BREEM and Green Star?

24) Has the existence and application of green certification systems like LEED/BREEM and the Green Star certification (South Africa and Australia) had any meaningful impact on these buildings (I.e is there a significant difference in these buildings in terms of energy efficiency and reduced carbon emissions to others which may be sustainable, but not certified?)

25) Have these certifying systems had any meaningful impact on the South African construction industry as a whole?

26) What are the experiences that people involved in the construction industry have had with applying building certification tools in terms of:

26.1) Ease of application:

26.2) Expense of application

26.3) Quality of certification tool

26.4) Ease of understanding the tool

27) Which building certification tools are more popular and widely applied and are best suited to the South African property market by stakeholders in the industry and why?

27.1) Green Star Africa

27.2) LEED

27.3) BREEM

27.4) Other

28) Is it significant for buildings to be certified green or not?

29) Can a building still be considered a sustainable building even if it is not a certified green building?

30) In your research and experience, is there any significant difference in the energy usage and carbon emissions of certified green buildings compared to nominal buildings?

30.1) What are the factors contributing to these differences?

31) In your research and experience, is there any significant difference in the energy usage and carbon emissions of certified green buildings compared to sustainable buildings which are not certified?

31.1) What are the factors contributing to these differences?

32) South Africa, out of all the countries on the continent, has the fastest growing green building industry. What are the main motivating factors for the growth of green buildings in South Africa?

33) The growth of green buildings in South Africa, however, has largely been concentrated in some areas only like the City of Johannesburg, particularly Sandton and the broader Sandton node. What are the factors influencing this?

34) Have there been any unexpected and unintended consequences, good and/or bad to developing green buildings?

35) Outside of the buildings itself, what are the impacts (good and bad) of green buildings to the area they are in?

36) Which certified green buildings perform better, retrofitted green buildings or new green buildings? Please choose one

36.1) Why is this?

37) In your opinion, what is the most likely growth trajectory for green buildings and the sustainable construction industry in South Africa in the future?

38) Are there incentives to building green in South Africa for:

38.1) Developers

38.2) Planners

38.3) Government

38.4) The construction Industry

38.5) Private sector

38.6) What more can be done?

39) In your opinion, what more can be done to promote green buildings and a sustainable construction industry in South Africa in the future by:

39.1) Government

39.2) Public sector

39.3) Private sector
39.4) Academia
39.5) Research councils
40) What are the gaps in the South African construction industry inhibiting/delaying the widespread construction of green buildings?

40.1) What can be done to address this?

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX O: Follow up Interview Guide

<u>Follow up Interview Questions for all stakeholders</u>

Good day Sir/Madam:

Thank you for hosting me today and allowing me to do this follow up interview with you and your organisation. I am conducting this interview in order to complete my research for my Master's dissertation titled *Perspectives on the effectiveness of green buildings in climate change mitigation: A study of the City of Johannesburg.*

<u>Follow up Questions</u>

1) What are the main factors which increase energy consumption and emissions in buildings?

1.1) General

1.2) Specific

1.3) Internal

1.4) External

2) Whose mandate is it to develop green building legislation, strategies, policies, guidelines etc. in the country?

2.1) Government

2.1.1) National

2.1.2) Provincial

2.1.3) Local

2.2) Private sector

2.3) Civil Society

2.4) Non- Governmental Organisations

3) Is there existing legislation and institutional frameworks in South Africa which have helped promote the development and implementation of green buildings? (Y/N)

3.1) If yes, can you list these and give their function?

3.1.1) National

3.1.2) Provincial

3.1.3) Local

3.1.4) Other sector

3.2) If no, why do they not exist?

4) Do other policies, guidelines, strategies exist in South Africa to promote the development and implementation of green buildings? (Y/N)

4.1) If yes, can you list these and give their function?

4.2) If no, why not?

5.) Following the above two questions what are the plans (if any) to incentivise green buildings in South Africa from:

5.1) Government

5.2) Private Sector

5.3) NGO'

6) How has the construction industry been influenced and responded to green buildings in South Africa and why?

6.1) Positive

6.2) Negative

6.3) General

7) What more can be done to incentivise building green in South Africa for:

7.1) Developers

7.2) Planners

7.3) Government

7.4) The construction Industry

7.5) Private sector

8) Does the implementation of certification tools for buildings assist them in becoming more 'green' (Y/N)

8.1) If yes, how do they make a difference to the way the building performs in terms of energy consumption and carbon emissions?

8.2) If no, why are they not necessary?

9) Is it mandatory (legislated) for a building to be certified in order to classify it as 'green' in South Africa? (Y/N)

9.1) If yes, why?

9.2) If no, why not?

10) What are the experiences that people involved in the construction industry have had with applying building certification tools in terms of:

10.1) Ease of application:

10.2) Expense of application

10.3) Quality of certification tool

10.4) Ease of understanding the tool

11) Which building certification tools are more popular and widely applied and are best suited to the South African property market by stakeholders in the industry and why?

11.1) Green Star Africa

11.2) LEED

11.3) BREEM

11.4) Other

Thank you very much for your time and conducting this interview with me. Should you wish to share further information or have any questions on clarity or concerns regarding this interview and the nature of the interview please do not hesitate to contact me.

Yours sincerely,

Malesotse Makgalemele

APPENDIX P: Data Collection Template

Data Collection Template

Part One: Benchmark data: Year prior to application for certification

Building:

Description of building:

Characteristics of building/Sketch of building:

Total floor area of building (m^2):

Occupied net floor area:

Unoccupied floor area (m^2):

Classification of Occupancy: G1-Office

Climatic Zone: 1

Occupancy rate in net floor area (either in number or percentage):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Energy Consumption

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Total: KWH/m² per annum:

Part 2: 12 Month Performance Cycle/Transition Data (Year that building applied for certification)

Building:

Description of building:

Changes made to building/Sketch of building:

Total floor area of building (m²):

Occupied net floor area:

Unoccupied floor area (m²):

Classification of Occupancy: G1-Office

Climatic Zone: 1

Occupancy rate in net floor area (either in number or percentage):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Energy Consumption:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Total: KWH/m² per annum

Part 3: 12 month Post Certification Data (Year after building has achieved certification)

Building:

Description of building:

Changes made to building/Sketch of building:

Total floor area of building (m^2):

Occupied net floor area:

Unoccupied floor area (m^2):

Classification of Occupancy: G1-Office

Climatic Zone: 1

Occupancy rate in net floor area (either in number or percentage):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Energy Consumption:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Total: KWH/m^2 per annum