EMPIRICAL STUDY INTO THE BENEFITS OF THE RETROFITTING OF EXISTING COMMERCIAL BUILDINGS TO IMPROVE ENERGY EFFICIENCY, AND THE PROPERTY INDUSTRY'S AWARENESS OF ENERGY RETORFITTING AND THE METHODS USED TO EVALUATE ENERGY RETROFITS WITHIN A SOUTH AFRICAN CONTEXT.

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A research report submitted to the School of Construction Economics and Management, University of Witwatersrand, Johannesburg, in fulfillment of requirements for the degree of Master of Science (Building)

DECLARATION

I, Lesley Joan Lombard, declare that this research is my own unaided work. It is being submitted to the Degree of Masters of Science to the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

Signed:__________________ Date: __________________

This research report is dedicated to all those people

who believed in me when I stopped believing in myself.

ABSTRACT

The world and South Africa in particular, currently finds itself in the midst of an energy crisis, where the demand for energy far outweighs the supply. The historically cheap availability of electricity within South Africa has exacerbated the problem, with the resultant effect of the South African built environment being responsible for approximately 23% of all Green House Gas emissions within the country.

The built environment is therefore being put under immense pressure to adapt, and lower the amount of electricity consumed. The change is being well received by most as rapidly increasing electricity prices are affecting company profits.

This study investigates the concept of energy retrofitting as one of the solutions to the problem. By using a questionnaire and case study, the research explores whether or not existing commercial buildings can be retrofitted in an economically efficient manner that will result in the quantum of electricity they consume being decreased. The findings reveal that this is indeed possible, albeit that the term “economically efficient” is a subjective one.

The study further explores property professionals’ understanding of the concept of energy retrofitting and energy efficiency, and finds that the majority of property professionals do in fact hold a clear understanding of the concept of energy efficiency and energy retrofitting.

Although the hypotheses have been proven to be true, a number of recommendations regarding further study have been made. The study highlights the following recommendations: 1. Future studies in this area should be conducted utilising a larger sample of professionals from across the country as it will allow the research to explore the trends in more buildings and at a more vigorous level;

2. Future research should be conducted into the implementation of energy retrofitting education programs for the layperson;

3. A study of the effect that energy retrofitting has on the rentals that a retrofitted building is able to achieve would be recommended;

4. Lastly this research recommends that a study to identify which elements of a building are most commonly identified by energy audit companies as the primary area to focus on.

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DEFINITIONS AND TERMINOLOGY

BREEAM	Building Research Establishment Environmental Assessment Method
CBA	Cost Benefit Analysis
CDR	Consumer Discount Rate
CIBD	Construction Industry Development Board
CO_2	Carbon Dioxide
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DoE	Department of Energy
DSM	Demand Side Management
EA	Energy and Atmosphere
EU	European Union
ESCOs	Energy Service Companies
GBCSA	Green Building Council of South Africa
GHG	Greenhouse Gas
HVAC	Heating, Ventilation and Air Conditioning
IDM	Integrated Demand Management
IEQ	Indoor Environment Quality
IRP	Integrated Resource Plan
LEED	Leadership in Energy and Environmental Design
MR	Material and Resources
MEPS	Minimum Energy Performance Standards
MYPD	Multi-Year Price Determination
NERSA	National Energy Regulator of South Africa
OECD	Organisation for Economic Co-operation and Development
PCP	Power Conservation Programme
PPP	Purchasing Power Parity
REC	Renewable Energy Certificates
REFiT	Renewable Energy Feed in Tariffs
RBS	Revised Balanced Scenario
SABS	South African Bureau of Standards
SANS	South African National Standard
SAPOA	South African Property Owners Association
SS	Sustainable Sites
WE	Water Efficiency

Diffusion:	The gradual adoption of new process or product innovations by firms and individuals.
Embodied Energy:	Is the energy that is used in making a product. It is an accounting methodology which aims to find the sum total of the energy necessary for an entire product life cycle. This life cycle included raw material extraction transport, manufacture, assembly, installation, disassembly, deconstruction and / or decomposition.
Handpicking:	Handpicking of the sample allows the researcher to control certain aspects of the study, and to focus on the area of research.
Triangulation:	Triangulation refers to the idea of reviewing data from two different points.
Triple Bottom Line:	A phrase contributed by John Ellington in 1994, which describes how the “three phases” of sustainable development (environmental, social and economic) underpin an organizations value and performance

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CHAPTER 1: INTRODUCTION

The production of energy has played a key role in worldwide economic development (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks et al. 2006), and as a result *'Sustainability'* and *'Energy'* have become central topics not only in South Africa but also in the world, with the concepts attracting a significant amount of media attention.

South Africa has abundant reserves of coal, from which most of its energy is produced. Eskom (Eskom 2007) reported that while approximately 90% of the country's electricity is generated via the use of coal-fired power stations, South Africa remains one of the most energy-inefficient countries in the world. This should be a cause for concern.

For many years Eskom has supplied electricity at a relatively low cost when compared to the rest of the world (Eskom 2007), with the resultant effect of the availability and the supply of energy being taken for granted. The country now finds itself in a position where electricity consumption is above the desired levels (DME 2005), with the future supply and cost of electricity being closely examined (Steel Construction 2009).

According to Kucus (2008), "Energy resources are becoming increasingly depleted and one can no longer depend on traditional energy sources. People are increasingly looking at renewable energy and resources that will not harm the environment and can be used in such a way that they do not create undue cost pressures".

The first *Energy Efficiency Strategy* (*"the Strategy"*) for South Africa was published in March 2005, following on from *The White Paper on Energy Policy* published in 1998. The Energy Efficiency Strategy sets energy efficiency targets that are aimed to be achieved by 2015.

The *White Paper on Energy Policy,* published in 1998 states:

"Significant potential exists for energy efficiency improvements in South Africa. In developing policies to achieve greater efficiency of energy use, government is mindful of the need to overcome shortcomings in energy markets. Government would create energy efficiency consciousness and would encourage energy efficiency in commerce and industry, will establish energy efficiency norms and standards for commercial buildings and industrial equipment and voluntary guidelines for the thermal performance of housing. A domestic

appliance-labeling program will be introduced and publicity campaign will be undertaken to ensure that appliance purchasers are aware of the purpose of the labels. Targets for industrial and commercial energy efficiency improvements will be set and monitored".

The implementation of this policy has been inconsistent. The failure to implement the policy resulted in an energy shortage in January 2008, which effectively resulted in the decision to increase the electricity tariff in order to encourage the conservation of power. Since 2010 the price of electricity per kWh has increased from 41.31c per kWh to 65.06c per kWh (NERSA 2011), this equates to a 57.49% increase in a three-year period.

Energy labeling has been included as part of South African Department of Minerals and Energy (DME 1998) 10 year efficiency strategy (DME 2005). National energy labels and minimum energy performance standards (MEPS) are becoming very common throughout the world. These labels can be used to help inform the buyer of the "invisible energy" which the appliance consumes as well as a indication of the minimum energy efficiency levels that the products needs to comply with in order to be saleable (Harrington, Lloyd, Damnics 2004). It should however be noted that within the South African context, although energy labeling does primarily focus on the residential sector, it can have a positive impact on the commercial sector (via the equipment used within the company) (Harrington *et al.* 2004).

The goal of achieving energy efficiency[1] cannot however be looked at in isolation. As *the Strategy* highlights, the important links between social, environmental, and economic sustainability will need to be recognised in order for the energy efficiency goal to be achieved (Energy Efficiency Strategy for the Republic of South Africa 2005).

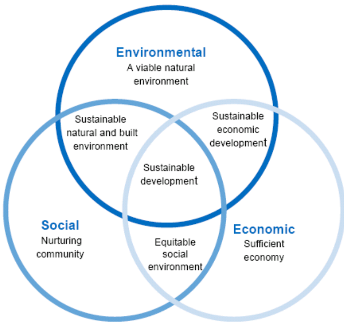


Figure 1: Sustainable Development

Source: www.ci.neenah.wi.us

1.1 Energy Efficiency Within the Context of the Built Environment

As a result of global warming and limited natural resources, countries around the world are being pressurised to reduce their carbon footprint and the amount of energy that they consume (Bennet 2001).

According to *the Strategy*, commercial[2] and public buildings are responsible for 3.5% of final energy consumption, with the majority of the energy being used to power heating, ventilation and air conditioning (HVAC) systems, lighting and office equipment.

Electricity is the primary component contributing towards the operating costs of buildings (SAPOA 2010). The cost of energy in South Africa is increasing at a rapid rate; figure 2 below illustrates this increase across all sectors.

[1]* *Unless otherwise stated, when "energy efficiency/efficient" is referred to in this document, it will refer to energy services provided per unit energy input.*

[2] * *Unless otherwise stated, when a "commercial building" is referred to in this document, it will refer to a commercial building within the South African context.*

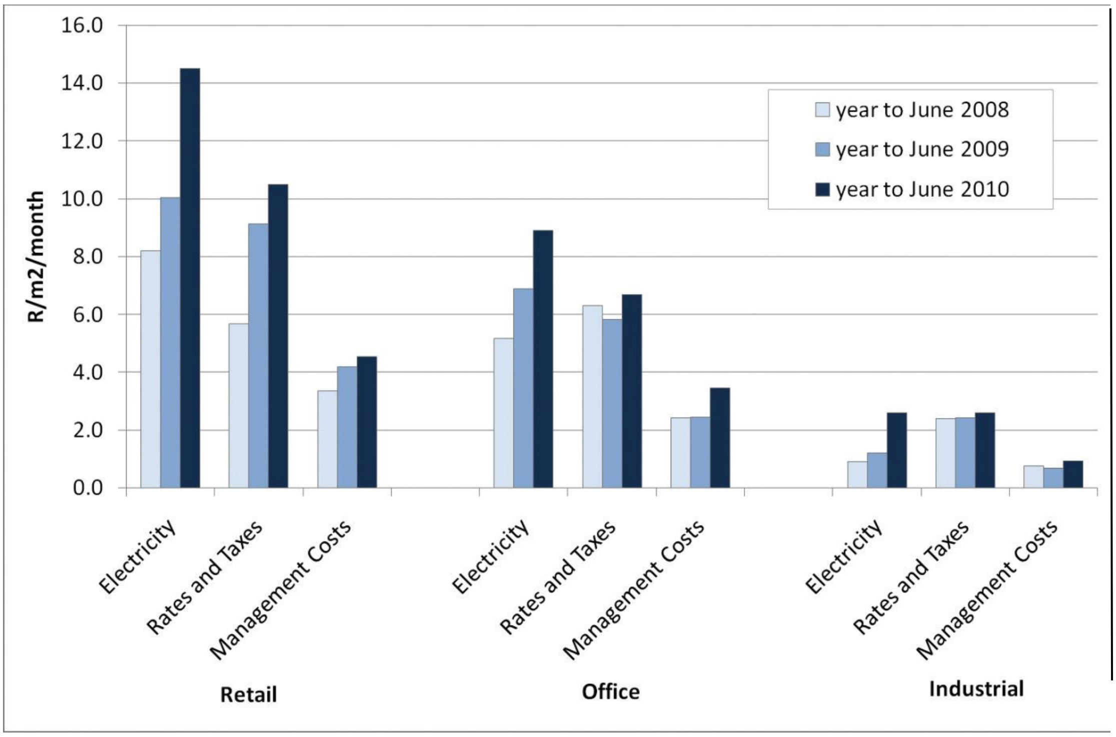


Figure 2: Selected Operating Costs 2008 - 2010, by Sector

Source: SAPOA Operating Cost Report

The figure above suggests that the significant increase in the cost of electricity will inherently have an impact on the overall profitability of the company. There are a number of ways in which one could reduce energy consumption within a building. The simplest way to ensure that buildings consume less energy is to build new sustainable buildings. In the context of the built environment one could focus on "retrofitting" existing buildings in order to improve the energy efficiency of that building (Reddy 1990).

Energy retrofitting is a fairly new concept and one that needs to be understood and further explored within the South African context. Although the idea of implementing energy efficient changes is a novel one, when considering the energy retrofit of an existing building, consideration does need to be given to the capital cost which will be associated with such implementation. The question of whether or not the associated benefits will outweigh the associated costs does need to be closely examined.

1.2. Problem Statement

The world currently finds itself in the midst of an impending and potentially catastrophic energy crisis, where the demand for energy far outweighs the supply.

The historic availability of relatively cheap electricity within South Africa is felt to be one of the primary reasons that commercial buildings have been designed and built in such a way that they are energy inefficient. The built environment is under an enormous amount of economic and social pressure to come up with a feasible solution to meet the current electricity supply problem.

Energy retrofitting of existing buildings is one possible solution to this problem. Although it is not a new concept, it is a concept that does warrant further exploration within the South African context.

It is generally accepted by the property industry that energy retrofitting a building will result in a number of associated benefits, but the extent and quantum of these benefits are unknown (Clinch and Healy 2000). It is often perceived that the capital cost of the retrofit will far outweigh the derived benefit.

1.3 Objectives

The objectives of the study are to:

i. Establish whether or not the energy retrofitting of existing commercial buildings improves the energy efficiency of these buildings;

ii. Establish whether or not it is economically efficient to retrofit existing commercial buildings within South Africa;

iii. Identify what property professionals' understanding of the terms *energy efficiency* and *energy retrofitting* is, and;

iv. To understand what methods professionals utilize in order to test the financial viability of a proposed energy retrofitting project.

1.4 Research Questions

The fundamental questions that this research report poses are as follows:

i. Does energy retrofitting of commercial buildings contribute to the improved energy efficiency of these buildings?

ii. Is it financially / economically feasible to retrofit an existing commercial building within South Africa, in order to make it optimally energy efficient?

iii. What does the property industry understand by the terms *energy efficient* and *energy retrofit*?

iv. How is the economic viability of an energy retrofit project measured?

1.5 Hypothesis

Based on the above research questions the following hypotheses have been proposed;

Hypothesis 1:
Retrofitting an existing commercial building, in an economically efficient manner, will result in an improvement in the buildings energy efficiency.

Hypothesis 2:
Property professionals operating within the South African market lack an understanding of the concept of energy retrofitting of existing commercial buildings.

1.6 Scope and Limitations

The research will be limited to, and examines the opinions of a sample of property professionals based in and across the Gauteng Province. All professionals included in the sample were selected based on their current involvement in the commercial property industry within the Gauteng Province.

The building included in the case study has been selected and examined in order to determine what effect a basic energy retrofit would have on the operating costs of the building, and in order to establish a possible payback period of the expended capital. The case study research is only limited to a single building within the Gauteng Province. This was primarily due to the lack of availability of quality information as well as financial constraints.

The research was limited to a building where information could be obtained. The building was selected based on the following factors:

- Plans could be obtained;
- The actual energy consumption could be determined;
- Detailed capital cost associated with the retrofit could be obtained.

Although the retrofitting of a building covers many aspects relating to, and associated with the reduction in energy consumption, the subject research will be limited to the electricity component relating to energy efficiency. The research further was limited to examining the financial benefits associated with the retrofitting of an existing commercial building, and did not examine the other benefits associated with the retrofitting exercise.

In deriving a payback period all factors besides forecasted increases in electricity process were kept constant.

1.7 Significance of the Study

Electricity is the one of the primary components contributing to the running costs of a building, across all building sectors. Electricity is also the cost component of operating costs which is currently increasing at the highest rate. This cost will continue to increase as the increases have already been approved by government. The higher the operating costs of a building, the lower the profit margins of a company. With profit being the primary focus of most organisations, it is imperative that costs be kept to a minimum, in order for a company to remain competitive in the current economic climate.

The study aims at highlighting the fact that the retrofitting of an existing commercial building will result in the building being more energy efficient. A building that is more energy efficient will require less electricity in order to effectively function. A decrease in energy consumed will result in a decrease in operating costs. A decrease in operating cost will result in an increase in a company’s profit margin. With increased profit margins being the ultimate goal of most companies, a decrease in the consumption of electricity is considered to be fundamental. In addition to increased profit a building that is consuming less electricity is also contributing less CO_2 emissions into the atmosphere and the occupants of that building will therefore also be considered to be a ”greener” and more sustainable company. This is important as countries around the world are being pressurized in order to reduce their carbon footprint.

The research further aims to highlight that an energy retrofit can be carried out in an economically efficient (financially feasible) manner, with a reasonable “payback” period being incurred. A reasonable payback period is considered to be a period that will be short enough in order to make the retrofit appealing to both landlords and the tenants.

The buy-in of property professionals is critical to the success of energy retrofitting projects. The research further aims to highlight the way in which property professionals currently understand and view the concept of energy retrofitting within the context of commercial buildings, and aims at understanding their viewpoint of whether they feel that retrofitting an existing commercial building is economically feasible and whether or not they feel that the retrofitting of an existing commercial building will in fact result in a reduction in electrical consumption.

1.8 Structure of the research report

The study is organized in five chapters.

Chapter 1 provides an introduction to the study, laying out the background, problem statement, objectives, research questions, hypothesis, scope and limitations as well as the significance of the report.

Chapter 2 comprises of a literature review, detailing previous literature, which relates to the research topic.

Chapter 3 explains the research methodology, and details the approach adopted by the researcher.

Chapter 4 details and analyses the results of the data collected.

Chapter 5 discusses the results of the research questionnaire.

Chapter 6 summarizes the report, and makes conclusions and recommendations based on the findings of the research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

South Africa is currently producing 42,000MW of power, against the current required demand of 38,000MW. It is projected that demand for power will soon outweigh the supply (Eskom 2007).

With the primary source of energy being derived from the fossil fuel coal, South Africa is amongst the highest emitters of Greenhouse gas (GHG) Carbon Dioxide (CO_2) per capita in the world (DME 2005) and as a result is extremely vulnerable to the effects caused by climate change (www.nbi.org.za). As expected, Eskom, the primary supplier of power within the country, and the power-sector are therefore currently the largest contributors to CO_2 emissions within South Africa (The Daily Maverick 2011).

There is significant evidence to suggest that the CO_2 emissions, which are released through the burning of fossil fuels, are a major contributor to global warming (Poterba 1991) and it is therefore imperative that the production of energy is steered in a sustainable direction.

The way in which electricity is generated and transported has a fundamental impact on the local environment and climate change, it can therefore be said that the manufacturing of energy is critical to the economic and social development of South Africa (Winkler 2003).

In 2009, the Construction Industry Development Board (CIBD) reported that the South Africa's building sector is responsible for 23% of all the GHG emissions within the country. Urbanisation is said to be one the primary reasons for the earth’s natural environment deteriorating. An increasing demand for housing and schooling, is resulting in new buildings and infrastructure being developed, which is resulting in an increasing demand for power, and hence the construction of new power stations.

The aforementioned increase in urbanisation is resulting in an increased demand for the earths’ natural resources, and is having a significant negative impact on the earths’ natural environment (Alusi et al. 2010). Looking forward, the production of energy must move towards cleaner energy in order to reduce GHG emissions, as a means of mitigating climate change. In a recent report published by the Royal Institute of Chartered Surveyors (RICS), it was stated by Tim Kasten that, “Africa is urbanising at a very rapid pace. Some of the solutions of the past are not necessarily going to be able to take us into the future”.

Since the first oil price shock in 1973, there have been significant publications and discussions regarding energy efficiency, and the impact that energy efficiency could have on the economic output of a country (Golove, Eto 1996; DME 2005). The production and utilisation of energy has and will continue to be fundamental to the economic development of the world (Davidson et al. 2006).

This is of particular relevance in developing countries such as South Africa, where there is room for a significant positive impact to be made, by improving the countries energy efficiency. In a paper by Alusi et al. (2010), it was stated "The pathway taken by urban development over the next few decades will play a crucial role in the trajectory of worldwide greenhouse gas emissions and natural resource depletion". Ninety three percent of South Africa's energy is derived from coal fuel. This is extremely high when compared to the world average of 39%. South Africa is therefore one of the top 20 GHG emitters in the world and, as a result thereof, is one the major contributors to climate change (The Sustainability Handbook Pg 34).

For the past century urban electricity has been marketed as something which will always be available, and as a consequence very few people have historically performed a cost / benefit analysis in relation to the utilisation of energy (Kirshen 2003). Further, within the South African context, many argue that the "utilisation of energy" or "energy-efficiency" is the least of South Africa's problems, as the country currently faces many other, more significant challenges relating to health, education and poverty. Bennett (2001) suggests that although this may be the case, the role of "energy" and "energy efficiency" is possibly a key element in helping to solve these challenges.

In April 2008 Eskom instituted load shedding within the country in order to help stabilize the national grid (Sebitosi 2008). The South African Government, along with Eskom, has embarked on short-term projects such as scheduled load shedding, or Integrated Demand Management (IDM) in order to help alleviate the immediate demand for power.

Eskom has described load shedding to the consumer in the following manner: "Load shedding is a controlled way of sharing the available capacity between all customers. The objective is to avoid total blackouts throughout the affected area when demand exceeds supply". (Eskom 2007).

As a result of the demand for electricity being fairly inelastic, a short-term price increase is not likely to deter users from consuming electricity, hence the importance of IDM. This is accepted by many to be a short term solution to the problem.

The benefits of the IDM program has been summarized below:

- A reduction in demand on the network;
- Delays in the immediate need for additional power stations to be constructed in order to meet the high demand for power;
- Continued low cost of electricity;
- Opportunity for the development and funding of incentives for projects and products.

(Eskom 2010)

Although short-term solutions such as these are important as there is a need to alleviate immediate pressure, we will need to look forward and focus on long-term solutions in order to alleviate the problem completely.

Longer-term energy goals have been set by the Department of Energy (DoE). These include, amongst others, the Integrated Resource Plan (IRP2010), which will also aid in helping achieve these goals. The IRP2010 prescribes the number and type of power stations which will be commissioned and decommissioned within South Africa over the next few years will. But, however novel all of these plans are, they will not be sufficient to meet the country's energy supply / demand requirements of the future in isolation. Citizens (end users), and the country as a whole, will need to adopt energy efficient technology and change their consumption behavior if we are to meet the energy goals that have been set for the country.

2.2 Energy Production

Historically energy has been a fairly cheap commodity (Eskom 2007). However, as a result of the current supply of electricity being above desired levels (DME 2005), the future cost of electricity is currently being closely examined, and the cost of electricity is increasing at a rate that is being felt by all. As set detailed in paragraph 2.1 above, Eskom has instituted load shedding within the country in order to help stabilize the national power grid (Sebitosi 2008), as demand for energy was exceeding the supply thereof. Eskom reports that "Peak demand for electricity has risen by around 15% in the last decade, due to the growing South African economy". The result of this increase in demand is that Eskom is often not able to meet the demand for electricity during peak hours (Eskom 2007). In order to address the issue of the increase in demand for energy, as well sustainability issues associated with energy production, the DoE have introduced an Integrated Resource Plan (IRP2010) for South Africa.

2.2.1 The Integrated Resource Plan for South Africa

The Integrated Resource Plan (IRP2010) for South Africa was promulgated in March 2011. The IRP2010, initiated by the DoE forecasts South Africa's energy demand up until 2030 and outlines a plan to build a "new fleet" of power stations, in order to meet this forecasted future demand. Although the IRP2010 has in theory been finalised the document is expected to remain a 'working document', which is to be revised approximately every two years.

The IRP2010 sets out a plan that governs the building and decommissioning of a mix of power stations. The IRP2010 is a long-term plan, one that does not mitigate the short-term problems faced by South Africa, with regards to the power shortage. The planned mix of energy options includes: hydrocarbon, renewable, nuclear, and pumped storage. The long-term plan is expected to result in investment in the region of R1.7 trillion (The daily maverick 2011).

Table 1 summarises the policy adjusted IRP.

	Committed Build											New Build Options													
	RTS Capacity (coal)	Medupi (coal)	Kusile (coal)	Ingula (pumped storage)	DOE OCGT IPP (diesel)	Co-generation, own build	Wind	CSP	Landfill, hydro	Sere (wind)	Decommissioning	Coal (PF, FBC, Imports)	Co-generation, own build	Gas CCGT (natural gas)	OCGT (diesel)	Import Hydro	Wind	Solar PV, CSP	Renewables 9Wind, Solar, CSP, Solar PV, Landfill, Biomass, etc.)	Nuclear Fleet	Total new build	Total system capacity	Peak demand (net sent-out) Froecast	Demand Side Management
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
2010	380	0	0	0	0	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	640	44535	38885	252
2011	679	0	0	0	0	130	200	0	0	0	0	0	103	0	0	0	0	0	0	0	1112	45647	39956	494
2012	303	0	0	0	0	0	200	0	100	100	0	0	0	0	0	0	0	0	0	0	703	46350	40995	809
2013	101	722	0	333	1020	0	300	0	25	0	0	0	124	0	0	0	0	0	0	0	2625	48975	42416	1310
2014	0	722	0	999	0	0	0	100	0	0	0	0	426	0	0	0	200	0	0	0	2447	51422	43436	1966
2015	0	1444	0	0	0	0	0	100	0	0	-180	0	600	0	0	0	400	0	0	0	2364	53786	44865	2594
2016	0	722	0	0	0	0	0	0	0	0	-90	0	0	0	0	0	800	100	0	0	1532	55318	45786	3007
2017	0	722	1446	0	0	0	0	0	0	0	0	0	0	0	0	0	800	100	0	0	3068	58386	47870	3420
2018	0	0	723	0	0	0	0	0	0	0	0	0	0	0	0	0	800	100	0	0	1623	60009	49516	3420
2019	0	0	1446	0	0	0	0	0	0	0	0	0	0	474	0	0	800	100	0	0	2820	62829	51233	3420
2020	0	0	723	0	0	0	0	0	0	0	0	0	0	711	0	360	0	0	800	0	2594	65423	52719	3420
2021	0	0	0	0	0	0	0	0	0	0	-75	0	0	711	0	750	0	0	800	0	2186	67609	54326	3420
2022	0	0	0	0	0	0	0	0	0	0	-1870	0	0	0	805	1110	0	0	800	0	845	68454	55734	3420
2023	0	0	0	0	0	0	0	0	0	0	-2280	0	0	0	805	1129	0	0	800	1600	2054	70508	57097	3420
2024	0	0	0	0	0	0	0	0	0	0	-909	0	0	0	575	0	0	0	800	1600	2066	72574	58340	3420
2025	0	0	0	0	0	0	0	0	0	0	-1520	0	0	0	805	0	0	0	1400	1600	2285	74859	60150	3420
2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600	1600	2200	77059	61770	3420
2027	0	0	0	0	0	0	0	0	0	0	0	750	0	0	805	0	0	0	1200	0	2755	79814	63404	3420
2028	0	0	0	0	0	0	0	0	0	0	-2850	2000	0	0	805	0	0	0	0	1600	1555	81369	64867	3420
2029	0	0	0	0	0	0	0	0	0	0	-1128	750	0	0	805	0	0	0	0	1600	2027	83396	66460	3420
2030	0	0	0	0	0	0	0	0	0	0	0	1500	0	0	345	0	0	0	0	0	1845	85241	67809	3420
TOTAL	1463	4332	4338	1332	1020	390	700	200	125	100	-10902	5000	1253	1896	5750	3349	3800	400	7200	9600	41346			

Table 1: Revised Balance Scenarios

Integrated Resource Plan for Electricity 2010-2030 Revision 2 FINAL REPORT, Pg 9

Nuclear Power:

South Africa currently has one nuclear power station. Koeberg nuclear power station, situated in the Western Cape, has a capacity of 1800MW. The IRP currently proposes that by 2030, new nuclear power stations will contribute an additional 9600MW of power, resulting in nuclear power contributing a total of 11,400MW (or 13.4%) of the total power generated within the country.

Nuclear power, although considered a cleaner form of energy when compared to coal, is still viewed as being a *risky* form of energy. While South Africa does have plans to build new nuclear power stations, a number of countries have postponed/suspended the approval of new nuclear reactors post the Fukushima disaster, of 2011, which has raised a number of controversial questions with regards to the safety of nuclear power plants and nuclear energy.

Renewable Energy (Wind Solar CPS, Solar PV, Landfill, Biomass, etc):

Renewable energy currently contributes very little to the total primary supply of power within the country (Winkler 2003), with this form of energy still being viewed as being prohibitively expensive. The IRP2010 indicated renewable energy currently contributes only 7.73% of the total demand.

South Africa's primary source of energy is derived from fossil fuels, which are created over hundreds of years, and are not being replenished at rates equal to which they are being consumed. Furthermore, stated previously, the burning of fossil fuels is one of the primary contributors to CO_2 emissions. Investment into renewable energy is important in order to reduce the carbon footprint of the country.

In terms of the IRP2010 it is projected that renewable energy will contribute an additional 16,264MW of power by 2030. This is considered to be significant when compared to the current 2,535MW that is currently being generated, equating to almost 6.5 times what is currently being generated.

Hydrocarbon (Coal, OCGT (diesel), CCGT (gas)):

Coal is the primary source of energy in South Africa. Over the next 20-year period it is projected that nine coal power plants will be decommissioned (10,902MW). Although there is a clear drive towards renewable energy, coal power stations will continue to be built.

2.2.2 Future Costs of Electricity in South Africa

The comparatively low cost of electricity in South Africa (when compared to the rest of the world), has resulted in energy being wasted (DME 2005). State owned Eskom, is currently the primary supplier of electricity within Southern Africa. Eskom supplies approximately 95% of all of South Africa's electricity, while also supplying electricity to Lesotho, Swaziland, Botswana, Namibia, Zimbabwe and Mozambique (Mbendi Information Services 2010).

Although Eskom does hold the monopoly within the Southern African electricity market, with 26 power stations[3] situated throughout Southern Africa, it is not able to increase the price of

[3] Annexure A: List of Power Stations situated in Southern Africa

electricity at will, as it is regulated by the National Energy Regulator of South Africa (NERSA 2011).

NERSA, established in 2005, is the regulating body for the energy sector, responsible for implementing South Africa's energy plan. This includes generation, transmission and distribution of electricity within Southern Africa (Eskom 2007). NERSA's mission statement is stated as follows: "To regulate the energy industry in accordance with government laws, policies, standards and international best practices in support of sustainable development" (NERSEA 2011).

In 2006 NERSA introduced a Multi-Year Price Determination (MYPD) process, a tool that is utilised in order to determine the annual electricity price adjustment. In order for the proposed price increase to be approved by NERSA, it is a requirement that it be fully justified and motivated.

On the 24th February 2010 NERSA approved MYPD2. Based on this the following energy prices increases are anticipated in the near future.

Eskoms National Tariff

2010/2011	24.8% increase	(R0.33/kwh to R0.415/kwh)
2011/2012	25.8% increase	(R0.415/kwh to R0.52/kwh)
2012/2013	25.9% increase	(R0.52/kwh to R0.65/kwh)

(www.nersa.org.za)

Figure 3 below illustrates the forecasted increase in electricity prices

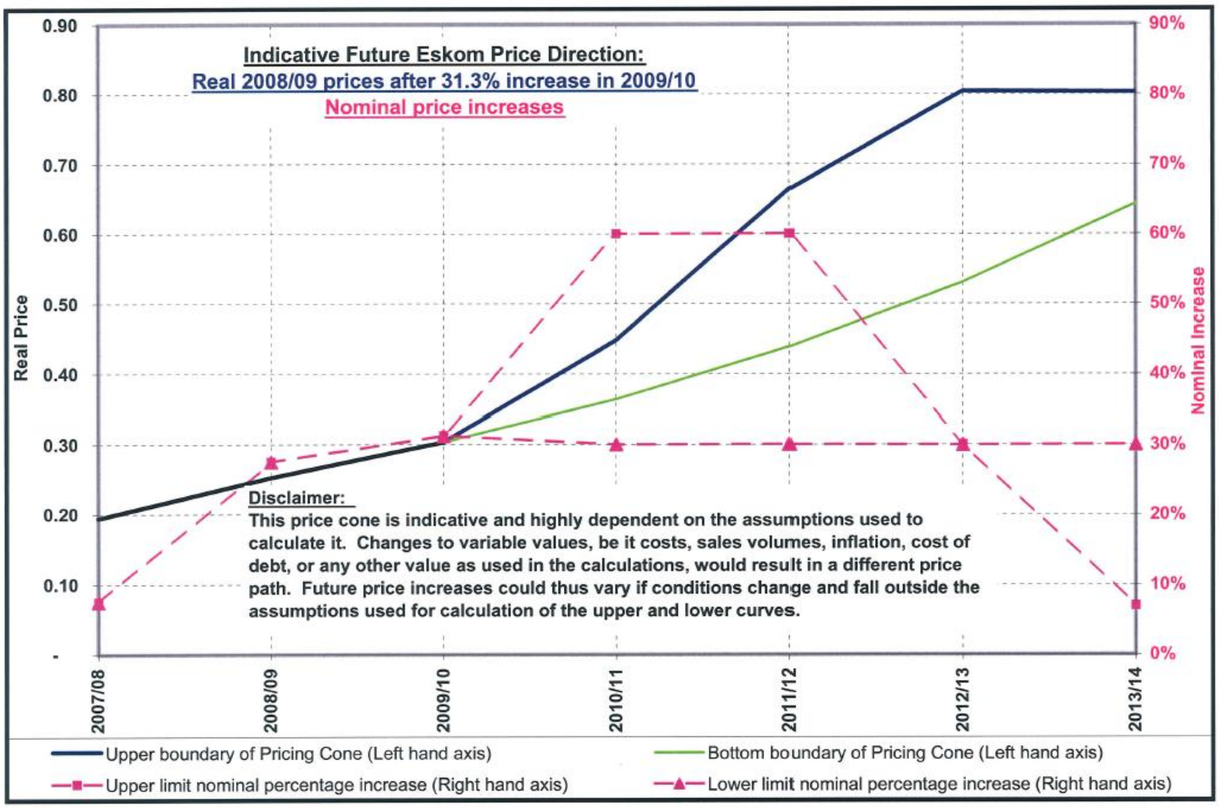


Figure 3: Indicative Future Eskom Price Direction: Real 2008/2009 prices after 31.3% increase in 2009/2010

Source: NERSA 2011

2.2.3 Electricity Consumption and the Construction Industry

Petro (2011) stated, "short term thinking is a human failing that affects many decisions, business and personal". With regards to the building industry this is can be very true. As operating costs increase, the short term thinking of building owners and building occupiers, can ultimately lead to a company's downfall. One cannot ignore that operating costs are increasing, buildings are becoming obsolescent, resources are being depleted and fiscal and regulatory change is taking place.

Figure 4 below illustrates the breakdown in the increase in operating costs per meter squares for a three-year period. It can be seen from the below that the cost of electricity has increased significantly over this period, and based on *Figure 3*, will continue to increase at a significant rate based on the approved MYPD 2 model.

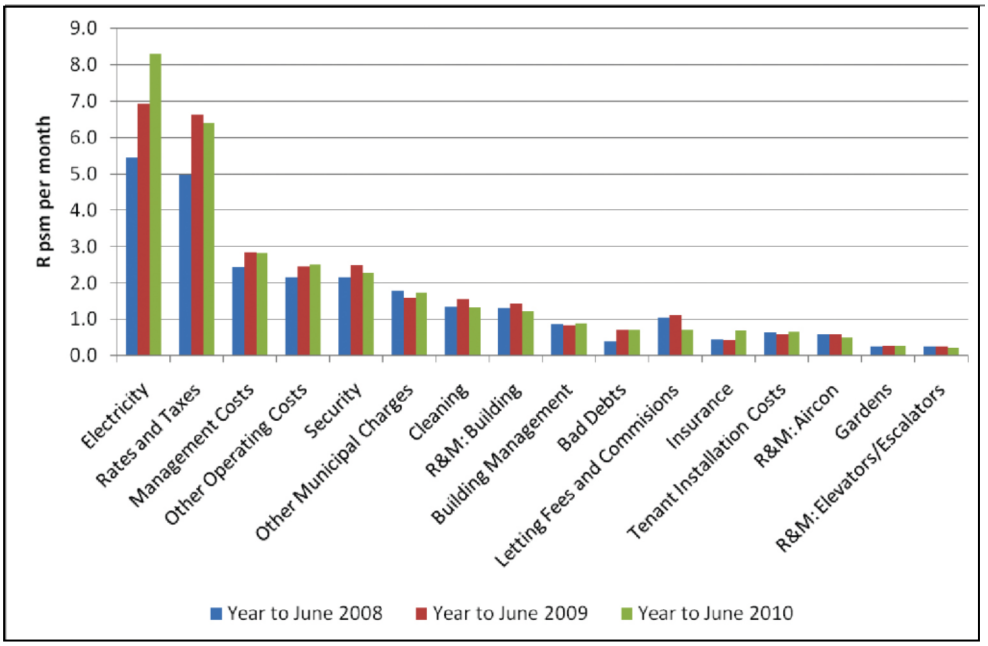


Figure 4: Operating costs 2008 - 2010, all property

Source: SAPOA Operating Cost Report, October 2010

As a result of the built environment being responsible for 45% of all electricity consumed, (Green Building Handbook, South Africa Volume 1, Pg 51), many companies are opting to focus on the triple bottom line[4]. A marginal increase in the cost of electricity will have a significant impact on the bottom line of companies occupying buildings within the country.

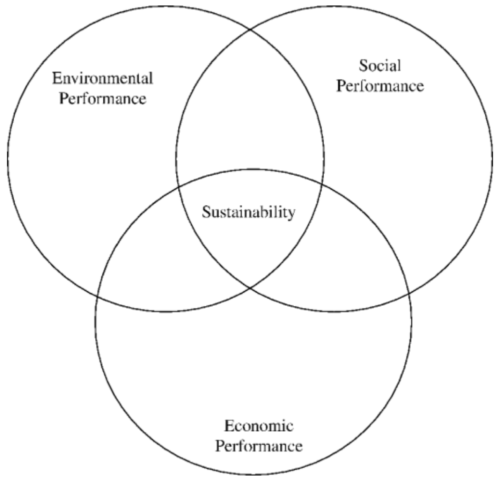


Figure 5: Illustration of the Triple Bottom Line

It is forecasted by many in the property industry that an energy efficient building will no longer be an optional extra but will rather be a determining factor affecting the grading of the space. Only building's which incorporate energy efficient technology will be deemed to be AAA grade quality space.

[4] Triple bottom line is a phrase contributed by John Elingiton in 1994. The phrase describes how organizations account for the 'three pillars' if sustainable development – namely; environmental, social and economic

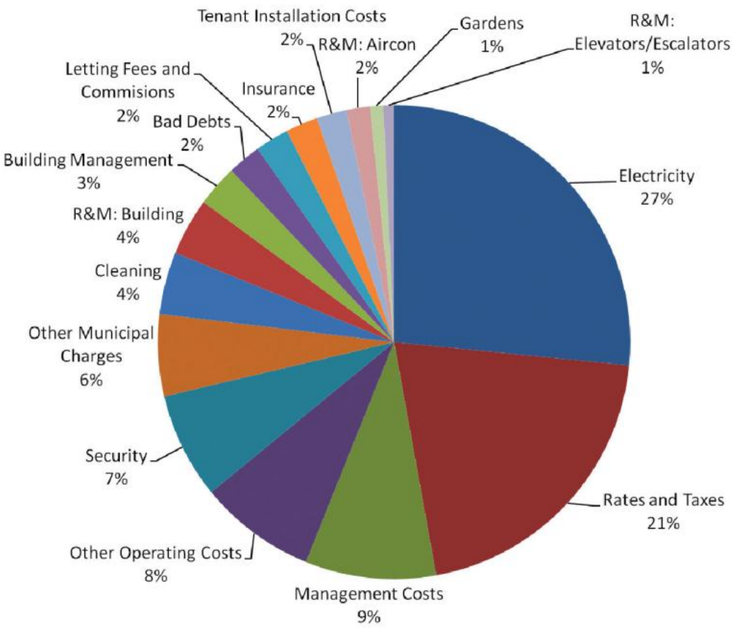


Figure 6: Operating Cost (% of total costs), all property

Source: SAPOA Operating Cost Report, December 2011

In a 2010 report published by the South African Property Owners Association (SAPOA) the above consumption statistices were reported. From this it can be seen that *Rates and Taxes* (21%) and *Electricity* (26.6%) account for the majority of the operating expenses relating to buildings. SAPOA reported that the electricity cost component of operating costs has increased from 20.7% in June 2008 to 22.4% in June 2009 to 26.6% in June 2010. This being said, the overall average cost per meter per month (for the period June 2009 to June 2010) had infact only increased by 1.7% (from R30.70 to R31.10/m^2).

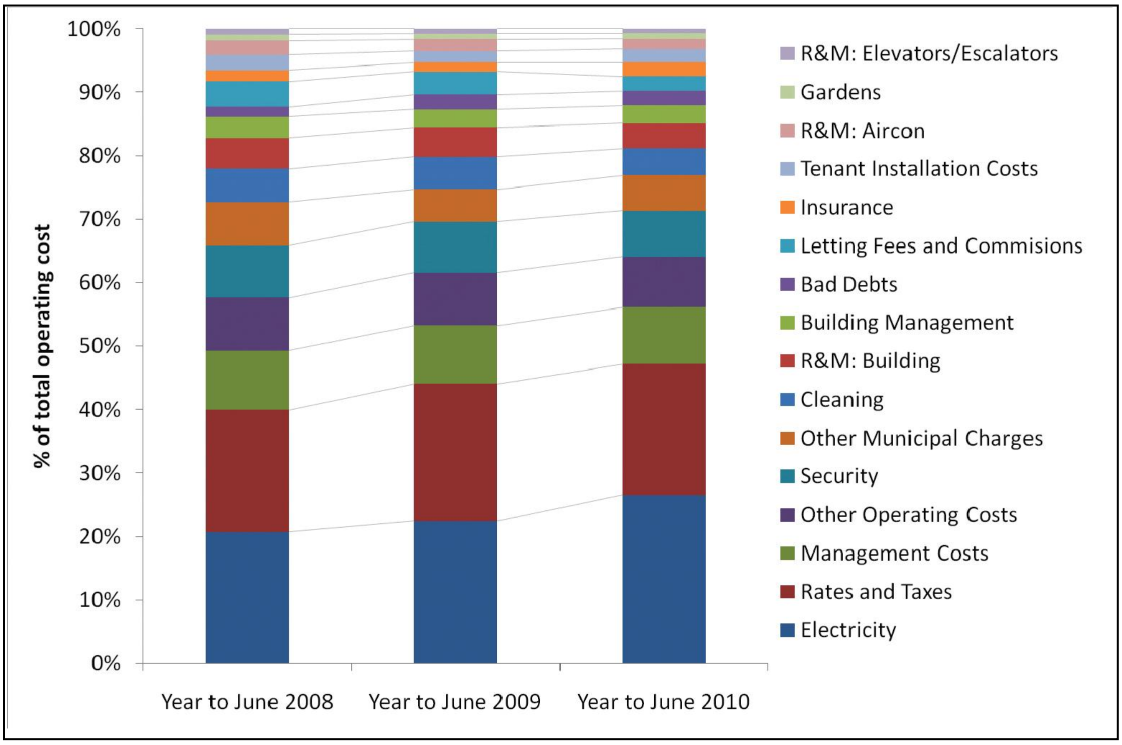


Figure 7: Operating Costs Breakdown 2008 -2010, all property

Source: SAPOA Operating Cost Report, October 2010

NERSA has published the projections of the future costs of electricity. Historically studies have shown that a significant increase in input cost (the cost of electricity) will lead to technological innovation in order to counteract the increase (Jaffe, Newell, Stavins 2004). Figures 6 and 7 clearly illustrate that South Africa currently finds itself in a position where the input cost of electricity is increasing at a fairly rapid rate. South Africans are being forced to adapt in order for profit margins not to be negatively affected.

Some debate the point that if energy efficient technologies were truly cost effective, given an open competitive market, through negotiation between producers and consumers of energy efficient technologies, all truly energy efficient technologies would be utilised in the market (Sanstad 1994). This is however not the case, and one does have to question why. The lack of uptake of the technology in the market does suggest that market failures and market barriers exist within the market (Jones, Bjornstad, Greer 2002).

This argument is however based on the broad assumption that all consumers make rational calculated decisions (Sanstad, Howarth 1994; Jaffe et al. 1994), however we do know that this is not always the case, as such a thing as the *energy efficiency paradox*[5] does exist. Market barriers and failures often lead to underinvestment in technology (Jaffe et al. 2004). This being said, it does need to be recognised that the utilisation of energy efficient technology could potentially hold one of the most effective ways of achieving the immense demands of sustainable development (Sebitosi 2008). If this is true, it could be effectively argued that there is currently a gap in the market.

2.3 Energy Efficiency Gap

Although South Africa is a developing country, when compared to that of developed nations it is evident that South Africa uses a significant amount more energy for every unit of Rand value added (DME 2005), it is widely accepted that the cheap price of electricity has been one of the catalysts encouraging this behaviour.

Selected Energy Inidcators (2010)	Population (million)	GDP (billion 2005 USD)	GDP (PPP) (billion 2005 USD)	Energy prod. (Mtoe)	Net imports (Mtoe)	TPES (Mtoe)	Elect con. (TWh)	CO_2 emissions (Mt of CO_2)	TPES/GDP (PPP) (toe/000 2005 USD)	Elec. Cons./pop. (kWh/capita)	CO_2 / pop. (Co_2/capta)
South Africa	49.99	288.46	473.77	162.41	-17.07	136.87	240.09	346.84	0.29	4 803	2.53
OECD	1232	37494	37113	3879	1672	5406	10246	12440	0.15	8 315	10.1
Non-OECD Europe and Eurasia	338	1 533	3 514	1 769	-629	1 132	1 492	2 606	0.32	4 414	7.71

Table 2: Selected Energy Indicators (2010)

Source: International Energy Agency 2012

From the above table it can be seen that South Africa uses approximately 50% more electricity (in terms of resultant economic output) than countries that form part of the OCED (Organisation for Economic Co-operation and Development) in the context of the countries purchasing power parity (PPP). From the above table it is clearly evident that a “gap” exists between the actual amount of energy that is consumed, and the optimal amount of energy that should be consumed (Spalding-Fecher 2003), and a potential for saving therefore exists.

This “gap” is often referred to as the “energy efficiency gap” (Jaffe et al. 1994). Levine et al. (1994) aptly described the phrase “energy efficiency gap” as “the difference between the actual energy efficiency of many purchased products and the level of energy efficiency that

[5] The energy efficiency paradox suggests that people’s decisions are not always found to be consistent with the associated costs (Jaffe *et al.* 2004)

can be provided for the same products”. The term also refers to “the difference between levels of investment in energy efficiency that appear to be cost effective based on engineering-economic analysis and the (lower) levels actually occurring” (Golove and Eto 1996).

A significant amount of research and development has gone towards improving energy efficiency, however many argue that the building industry has failed to adopt a number of techniques that would assist in making this goal a reality (Jones, Bjornstad, Greer 2002). The manner in which buildings are designed and constructed, are fundamental to the amount of energy that that building will ultimately consume.

2.4 Construction and Design

Consumption statistics indicate that energy consumption within commercial buildings is significantly higher in comparison to other types of buildings (Santamouris and Dascalaki 2002). The performance (energy efficiency) of a building is a direct function of the manner in which it was constructed. Simple flaws in initial design and construction can result in unnecessary wastage of energy. However, investment into retrofitting can partially correct this problem once it already exists (Mills, Friedman, Powell, Bourassa, Calridge, Haasl et al. 2004).

It is a well-published fact that design techniques can be used in order to reduce electricity consumption and improve buildings energy efficiency. Although this is most effective at the design and concept stage (Civil Engineering 2009) a buildings components can be partially adapted after construction. The process of this conversion is known as retrofitting, and will be expanded on later in the study.

Historical studies have estimated that approximately four to five percent of a buildings operating cost are related to energy consumption (Jones et al. 2002), however more recent studies have shown this to be as high as 27% (SAPOA Operating Cost Report 2010). This number is significant and as a result calls for further exploration into how this percentage can be lowered. The lower the operating costs associated with a building, the more appealing it becomes to a potential buyer or occupier. Therefore it is logical to conclude that, the more energy efficient a building is, the more operating costs will be saved, which will positively affect the value and desirability of the buildings (Jones et al. 2002). However, although this may be the case, the promotion of energy efficiency will continue to suffer if no-one takes ownership (Bennett 2001).

As mentioned above, the initial design stage holds the highest potential to design and build a building that will be optimally energy efficient. It should be highlighted that utilizing a low-energy design will not necessarily result in an increase in construction costs (www.eren.doe.gov/femp/) (although this may often be the case). There are a number of design factors which can be taken into account, including: building and room orientation, insulation, and cross ventilation amongst others. This list is by no means exhaustive, but these three elements mentioned will be further expanded on below.

Building Orientation:

In a paper by Shoniwa (2008), he described buildings as periscopes "trained to catch the light, a view, the wind or sun". A well designed energy efficient building will be orientated in such a way that it takes maximum advantage of the suns movement, resulting in reduced energy consumption.

Insulation:

The dictionary defines the term *insulate/insulated* as "protect (something) by interposing material that prevents the loss of heat or intrusion of sound". Based on this definition, it is fair to conclude that the insulation present within a building will have a significant impact on the comfort level of employees. Furthermore the insulation present within a building will have an effect on the amount of electricity that the building consumes as a result of heating and cooling.

Insulation adjusts the rate at which a building loses or gains heat (ie – the buildings ability to restrict the transfer of heat). All materials have the ability to allow heat to penetrate it, however, some materials such as glass and metal allow for easier penetration when compared to other materials such as brick or wood. Appropriate and effective insulation can therefore have a significant impact on the energy efficiency of a building. Insulation materials are measured using an R value, also referred to as resistance or resistivity. The higher the R value the better the insulating ability of the material. It is important to be aware that the R value will differ depending on: the material used; the thickness of material; the density of material and the way in which it is installed.

R values are expressed using the metric units $m^2/K/W$, where:

- m^2 refers to one metre squared of the material of a specified thickness;

- K refers to a one degree temperature difference (Kelvin or Celsius) across the material; and
- W refers to the amount of heat flow across the material in watts.

(http://www.sustainability.vic.gov.au/resources/documents/Insulation_benefits.pdf)

There are different types of insulation namely *Bulk Insulation* and *Reflective Foil Insulation.* Bulk insulation works by trapping pockets of air within a structure, material used in bulk insulation include glass fiber, rock mineral wool and cellulose fiber.
Reflective Foil insulation works by resisting thermal radiation.

Thermal Mass and Building Materials:
Thermal mass can be defined as the measure of a materials ability to absorb and store heat effectively. A heavier or denser material will usually have the ability to store heat for a longer period, and will therefore have a higher thermal rating. Therefore, construction materials such as bricks, concrete and stone have a high thermal mass rating. Incorporating thermal mass in the internal design of building can help to reduce temperature variance; however it is very important that materials with a high or low thermal mass be strategically placed in order to take maximum advantage of their absorption ability.

In winter materials with a high thermal mass can result in the buildings being colder and therefore requiring additional heating. However, in summer materials with a high thermal mass will absorb the heat that enters a building which will result in the air temperature being lowered during the day.

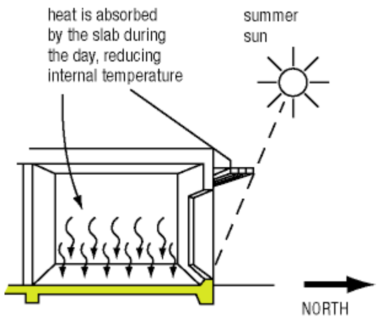


Figure 8: Thermal Mass In Summer
http://www.sustainability.vic.gov.au/resources/documents/Thermal_mass.pdf

Although only three elements of building design and construction have been explored above, there are a number of other important factors which need to be taken into account in the design and build phase of a building project. Site orientation, building form, shading devices, windows and lighting systems are all things which will help to enhance a buildings energy efficiency if approached, installed and utilized correctly.

Buildings within cities can be designed in a way in which they are built to harness the maximum benefit from its natural environment. Maximum benefit is harder to achieve when retrofitting an existing building. Therefore, when developing new precincts it is imperative that a significant amount of time and skill be apportioned to the design aspect of the project.

2.5 Eco Cities

As earlier mentioned, it is becoming evident that the world is moving towards a more sustainable form of development. In an article by Kenworthy (2011), he aptly states "making cities and new urban development more ecologically based and livable is an urgent priority in the global push for sustainability".

In order for a city to be truly classified as sustainable it is not only the urban form of the city which will need to change. Kenworthy (2011) suggests that over and above the urban form, transportation systems, water, waste and energy technology – government will also need to be involved with urban planning reflecting a sustainable agenda. Within South Africa there are currently very few government incentives encouraging sustainable development. However, it is felt by many that government need to start leading by example by occupying sustainable / retrofitted buildings; and that tax incentives should be provided to developers and tenants occupying these buildings.

A number of countries are in the process of producing so called eco-cities, with *Masdar* (located approximately 17 kilometers from Abu Dhabi), the first self-proclaimed "worlds first carbon neutral, zero waste city" being completed towards the end of 2010 (Joss 2011). Other countries to produce eco-cities include amongst others: China, India and Japan.

Although not detailed in this text, there are a number of other initiatives that are taking place in other countries, all with a common goal, and being propelled forward by the looming threat of climate change and rapid urbanization (Joss 2011).

Africa currently has two eco city projects underway, namely, Johannesburg Eco-City and Hacienda Eco City in Mombasa. Although these are both fairly small projects, they are definitely felt to be a step in the right direction.

2.6 Green Buildings

Yundelson (2008) defined a Green Building as *"A high-performance property that considers and reduces its impact on the environment and human health. A green building is designed to use less energy and water and reduce the life-cycle environment impacts of the material used. This is achieved through better siting, design, material selection, construction, operation, maintenance, removal and possible reuse of refuse"*.

Although defined above by Yundelson, there are many other definitions available, and the term *Green Building* often has different meanings to different people in different contexts. The term Green Building does relate to a number of sustainable concepts. However, this research paper will primarily focus on the energy related aspects of Green Buildings, as opposed to all aspects that could help to improve a buildings sustainability.

For the past number of years the concept of Green Buildings has been given a significant amount of attention in countries such as the United States, Australia, and Europe. The concept is however still fairly new in South Africa (Green Building in South Africa Emerging Trends 2009) and therefore it does warrant further exploration in order to understand the benefits and costs associated with buildings of this nature.

In May 2010 the European Union (EU) made an announcement that mandated "nearly zero-energy" buildings. The "nearly zero-energy" policy will be applicable to "all new public buildings in the European Union after 2018 and all new homes and offices in 2020" (Alusi et al. 2010; Harrison 2010). Although South Africa is currently not in a position where government are passing mandatory minimum mandates regarding Green Buildings, it is felt by many that other countries are not far behind the EU in adopting such policies.

The manner in which energy is generated, and subsequently the way in which it is utilised, are both fundamental issues when referring to both "green design" and "sustainable development" (Osburn 2009). In a document prepared for the Department of Environmental Affairs and Tourism (DEAT) the author suggests that "energy efficiency reductions in the construction and operation of buildings, offers one of the single most significant opportunities to reduce man's impact on climate change" (Green Building in South Africa: emerging Trends 2009). One does however need to keep in mind that practically, in different contexts "sustainable development" and "sustainable energy" means different things to different people (Davidson et al. 2006). The *White paper on Energy Policy (1998)* documents South Africa's existing energy policy (DME 2005).

2.6.1 Advantages of Green Buildings

There are a number of direct advantages associated with the development of Green Buildings.

These advantages include:

- Improved Indoor Environmental Quality (IEQ) / Thermal Comfort;
- Energy efficiency;
- Water efficiency;
- Reduced emissions;
- Reduced negative impact on the local environment;
- Reduced operating costs.

Green Building rating tools have been developed by various countries in order to guide developers in optimising the benefits that one can obtain from a Green Building. South Africa's rating tool was developed by the green building council of South Africa, and is known as *Green Star SA***.** This tool will be discussed in more detail further on in this report.

2.6.2 Barriers to the Development of Green Buildings

From the above, it may appear that cost is the only aspect affecting the adoption and inclusion of energy efficient technology into the initial design, however besides costs, there are a number of barriers that can prevent the adoption of energy efficient technology even at the design phase of a development.

Golove and Eto (1996) identified some market barriers preventing the adoption of energy efficient technology. Market barriers such as these prevent investment into, and adoption of energy efficiency technology:

- Misplaced incentives;
- Financing;
- Market structure;
- Regulation;
- Custom and information.

The Green Building Council of South Africa (GBCSA) was established within South Africa, with the primary objective of addressing the barriers that currently exist.

Lack of Knowledge

A lack of knowledge is felt to be one the key drivers which prevent the adoption of energy efficient technology (DME 2005). Jaffe and Stavins (1994) highlighted the important fact that "it is costly for people to learn of an innovation's existence and to learn enough to know if it is profitable to use it". Furthermore, should people be informed, there still remains an element of *uncertainty* which currently exists with regards to the measurable benefits associated with adopting the technology. A number of behavioral studies that have been conducted suggest that the average person will place more importance on the initial capital cost, than on the future operating costs (savings) associated with that purchase (Jaffe et al. 2004). This problem is exacerbated by the historically low price of energy within the South African market (Spalding-Fecher 2003). The problem is even further compounded by the fact that the cost of energy and the marginal utility derived from energy consumption cannot be accurately measured and so the adoption of energy efficient technology is slowed (Gillingham 2009).

The Principle-Agent Problem

The "principle-agent problem" suggests that when issuing instruction for the building specifications, the building owner may not be incentivised to spend any additional capital on energy efficient technology as the end users may be responsible for paying for all utilities consumed, and the additional capital cost may not necessarily result in a significant enough increase in rental income to justify the associated capital cost (Levine et al. 1994). Often the end user is not fully informed with regards to the magnitude of the energy efficient technology employed with the building / or the potential savings that could arise as a result of the technology, which would result in them being unwilling to consider an increased base rental. This is evidence of a market failure that exists (Jaffe et al. 2004). Many argue that installing energy efficient technology won't necessarily result in increased rental, but rather increased demand for the building itself, lowering the long term vacancy factor associated with the building, and hence increasing its inherent value.

Similarly, although the energy efficient technology may be available to the builder (at a marginally increased price), the builder's priority (goal) may not be energy efficiency (unless that was a specific instruction issued by the client); the builder's focus is rather to maximize their profit (Jaffe et al. 1994) and employing the energy efficient technology may not result in this goal being achieved.

Komor et al. (1989) highlight that often small-commercial building owners are not aware of the cost of the monthly electricity bill, and are thus not incentivised to upgrade technology to decrease the cost. This being said, it should be noted that even though implementing energy efficient technology may be cost effective for one firm (or individual), this does not mean that it will be cost effective for everyone, in all situations. Variables such as the consumers discount rate, capital cost, life span of building or equipment, may result in the energy efficient technology not being cost effective to implement (Jaffe et al. 2004).

The development and construction of green buildings can lead to reduced energy consumption, however the costs and benefits of building green does warrant further exploration. A number of building guidelines and rating tools have been developed in order to assist professionals within the construction industry to achieve an effective energy efficient design. SANS204 is one such tool, and it will be discussed below.

2.6.3 South African National Standards (SANS) 204

The South African National Standards 204, commonly referred to as SANS204, was the brainchild of the Department of Minerals and Energy (DME) in their strategy in 2004. It was developed in order to provide a framework within which designers and builders could construct a building in an energy efficient manner (South African National Standard, Edition 3).

The following was responsible for the motivation of energy efficiency within the South African context:

- The consumption of finite resources should be reduced in order to ensure a transition to renewable resources;

- CO_2 and other pollutants need to be reduced substantially;
- Running costs of buildings must be controlled;
- The structure of buildings should be protected and preserved;
- Value is added through energy efficiency measures;
- Comfort can be enhanced;
- Productivity and competiveness can be improved;
- Sustainable jobs are created while the existing infrastructure is retained.

South African National Standard, Energy efficiency in buildings. SANS 204-1:2007 Edition 3)

It should be noted that complying with the standard within the SANS204 document, will not necessarily result in a building being considered a green building, as the standard only focuses on energy efficiency, but following the guidelines contained within the SANS204 document will result in a reduction in energy consumption.

The following Energy goals were set by the DME in the strategy in May 2004:

- Final demand reduction of 12% by 2015 (target set in relation to forecast nations energy demand that the time);
- 15% reduction by 2015 of energy use in industry and mining;
- 15% reduction by 2015 of “parasitic” electrical usage;
- ***15% reduction by 2015 of energy use in commercial and public building sector;***
- 10% reduction by 2015 of energy used by the residential sector;
- 9% reduction by 2015 of energy used for transport.

In order to monitor the achievement of the above goals the following measures have been put in place (DME 2005):

1. Energy efficiency standards;
2. Appliance labeling;
3. Education, information and awareness;
4. Research and technology development;
5. Support of energy audits;
6. Monitoring and targeting;
7. Green accounting.

2.6.4 Current Incentives: South Africa

- *Government Policy and Legislation*

The White Paper on Energy Policy published in 1998 by the Department of Minerals and Energy states, *"Significant potential exists for energy efficiency improvements in South Africa. In developing policies to achieve greater efficiency of energy use, government is mindful of the need to overcome shortcomings in energy markets. Government would create energy efficiency consciousness and would encourage energy efficiency in commerce and industry, will establish energy efficiency norms and standard for commercial buildings and industrial equipment and voluntary guidelines for the thermal performance of housing. A domestic appliance-labeling program will be introduced and publicity campaign will be undertaken to ensure that appliance purchasers are aware of the purpose of the labels. Targets for industrial and commercial energy efficiency improvements will be set and monitored".*

- *South African Building Regulations (SANS 204)*

SANS204, is currently a guideline, which has been published by the South African Bureau of Standard (SABS), which aids in providing guidelines which will help to improve the energy efficiency of a building. The standard is currently voluntary, but it is widely speculated that the standard will be made mandatory by the DoE in the not too distant future.

- *Energy Efficiency Strategy*

These goals were set by the DME in May 2004:

- Final demand reduction of 12% by 2015 (target set in relation to forecast nations energy demand that the time)
- 15% reduction by 2015 of energy use in industry and mining;
- 15% reduction by 2015 of "parasitic" electrical usage;
- ***15% reduction by 2015 of energy use in commercial and public building sector;***
- 10% reduction by 2015 of energy used by the residential sector;
- 9% reduction by 2015 of energy used for transport.

- *Power Conservation Programme (PCP)*

This is a program being facilitated by Eskom as a key government initiative in order to provide a demand-side solution to the current energy crisis that South Africa is facing. The program aims to reduce the demand on the grid through load shedding and power rationing (Eskom 2011).

- *Demand Side Management (DSM)*

Demand side management has been introduced by Eskom (who are collaborating with Energy Service Companies (ESOCs)). According to Eksom the aim is to achieve the following objectives: *"To improve efficiency by reducing the average costs of generating electricity and better utilization of resources"*.

- *Green Power*

Green Power is power that has been generated in a sustainable manner. Although this power is fed onto the national grid, companies who produce green power are able to sell this power through the sale of Green Power certificates (these certificates are also known as Renewable Energy Certificates (REC)). By purchasing Green Power, one is able to reduce ones carbon footprint, while supporting South Africa's renewable energy industry (ARUP, pg 7).

- *Renewable Energy Feed in Tariffs (REFiT)*

In March 2009 NERSA announced the introduction of feed-in tariffs. The Renewable Energy Feed in Tariff (REFiT) is an incentive structure that is aims to encourage the production of renewable energy, by private power producers, through the introduction of government legislation. The REFiT based on a similar system used by European countries, is based on a cost of generation plus a "reasonable profit". According to Thembani Bukula, the chairperson of the electricity sub-committee "The tariff comes as government set a target to meet 10 000 GWh as a contribution to final energy consumption by 2013, to be produced from wind, solar, small-scale hydro and landfill gas". The following technologies considered under the REFiT legislation:

- Landfill gas;
- Biomass;
- Biogas;
- Concentrated Solar Power Trough (with and without storage);
- Concentrated Solar Power Tower (with storage);

- Wind;
- Small Hydro;
- Photovoltaic (ground mounted and rooftop).

- *Eskom Rebate Programme*

In order to assist in effectively managing the demand for electricity, Eskom are currently sponsoring a rebate program. The rebate program referred to as the Standard Product Program is a toolkit calculator that Eskom have designed and built, in order to assess whether or not the energy retrofit carried out by the user, will result in a saving in electrical consumption. If the technology utilized results in a saving, the user will receive a rebate from Eskom. This rebate calculator, and the manner in which the calculator works, has been illustrated in Chapter 4 of this research paper. Ie: Case Study 1 Sheldon Place. It should however be noted that the Eskom rate tool is not a green building rating tool. The current available green building rating tools will be discussed in detail below.

2.6.5 Green Building Rating Tools

A *green building rating tool* can be defined as "tools that examine the performance or expected performance of a 'whole building; and translate that examination into an overall assessment that allows for comparison against other buildings" (Fowler and Rach 2006).

Primarily due to varying climactic conditions, it is not possible to have a standard international rating with which to rate a buildings performance. As a result, various countries have developed different tools with which to *rate* Green Buildings (Yundelson, 2008). There are currently a numerous number of rating tools available. Three of the various tools that are currently available globally, as well as the rating system that is utilized in South Africa, will be further expanded on below.

All of the below rating systems focus primarily on measuring the environmental impact of buildings, and not the financial impact or outcome (Davidson et al. 2006). This is very important to note as this research document focuses on retrofitting a building in a cost effective manner in order to reduce energy consumption, and does not simply examine ways in which a building can be retrofitted in order to reduce energy consumption.

2.6.5.1 Existing Green Building Certifications

A summary of some of the rating tools area tabulated below.

Name of Rating Tool	Developer; Year	Catergories	Versions	Source
BREEAM	Building Research Establishment (BRE) in 1990	1. Energy Use 2. Transport 3. Water 4. Ecology 5. Land Use 6. Materials 7. Pollution 8. Health and well-being 9. Management	1. Offices 2. Housing 3. Healthcare 4. Courts 5. Industrial Units 6. Prisons 7. Retail 8. Schools 9. Multi-residential 10. Neighbourhoods	www.breeam.org
LEED	United States Green Building Council (USGBC) in 1993	1. Energy and atmosphere 2. Water efficiency 3. Sustainable sites 4. Materials and resources 5. Indoor environmental quality (IEQ) 6.Innovation	1. Offices 2. Homes 3. Neighbourhood development 4. Retail 5. Healthcare 6. Schools	www.usgbc.org/LEED
Green Star	Green Builing Council of Australia (GBCAUS) in 2003	1. Energy 2. Transport 3. Water 4. Ecology and use 5. Emissions 6. Materials 7. IEQ 8. Management 9. Innovation	1. Offices 2. Retail 3. Schools 4. Industrial builings 5. Mixed use residential 6. Mixed use 7. Healthcare	www.gbcaus.org

Table 3: Examples of Exisiting International Green Building Rating Tools

Source: Green Building Handbook Volume 1. Pg 30

2.6.5.1.1.BREEAM – United Kingdom

The Building Research Establishment Environmental Assessment Method, or more commonly referred to as *BREEAM*, is the rating system (or assessment tool) developed and used in the United Kingdom in order to rate buildings. This rating system, established in 1990 is widely acknowledged to be the first environmental rating tool for buildings, and as a result has the longest track record. The BREEAM rating tool can be utilised in order to assess a number of different building types including: offices, homes, industrial units, retail units and schools (Fowler et al. 2006). Although BREEAM does have a well established track record, one of the major criticisms of the system relates to the availability of up-to-date, or current information relating to the system.

The tool rates buildings based on nine criteria:

1. Energy use: operational energy and carbon dioxide (CO_2) issues;
2. Transport: transport-related CO_2 and location-related factors;
3. Water: consumption and water efficiency;
4. Ecology: ecological value conservation and enhancement of the site;
5. Land use: greenfield and brownfield sites;
6. Materials: environmental implication of building materials, including life-cycle impacts;
7. Pollution: air and water related issues;
8. Health and well-being: indoor and external issues affecting health and well-being;
9. Management: overall management policy, commissioning site management and procedural issues.

The building is assessed by, assigning points to the individual nine categories, and then combining the points. The overall performance of the building is rated with a “Pass”, “Good”, “Very Good”, “Excellent” or “Outstanding” (Fowler et al. 2006, RICS 2011).

2.6.5.1.2: LEED – United States

Leadership in Energy and Environmental Design *(LEED)* is a third party certification program, founded on a points based rating system. The system was developed in United States, by the U.S Green Building Council in 2000, and is currently the nationally accepted standard within the country. As a result of it being point-based it has the flexibility of allowing one to compare various building which have been designed utilizing different components within the various categories. Points are weighted differently depending on the categories significance in the specific building type (maximum points = 100).

There are six different LEED products which are available to the consumer, namely: New Construction and Major Renovations; Existing Buildings; Commercial Interiors, Core and Shell; LEED for House and Neighbourhood Development.

The US Green Building Council list the following criteria as being the metrics which are measured when rating buildings utilizing the LEED product:

1. *Energy and Atmosphere (EA):* Optimized energy performance; On-site Renewable Energy, Enhanced Refrigerant Management; Green Power.
2. *Water Efficiency (WE):* Water Efficiency Landscaping, Innovation Wastewater Techniques, Water Use Reduction.
3. *Sustainable Sites (SS):* with credits for: Site Selection; Development Density; Alternative Transportation; Storm Water Design; Heat Island Effect and Light Pollution Reduction.
4. *Materials and Resources (MR):* Storage and Collection of Recyclables; Building reuse; Construction Waste Management; Material Reuse; Recycled Content; Regional Materials; Certified Wood.
5. *Indoor Environmental Quality (IEQ):* Quality Air Delivery Monitoring; Low-Emitting Materials, Controllability of Systems; Thermal Comfort; Daylight and View.
6. *Innovation:* in the Design Process and Using a LEED accredited Design Professional.

(Source: US Green Building Council 1995; 9-10)

The LEED rating system is considered by many to be the most comprehensive tool on the market, as it is able to rate a building based upon the buildings specific function, there are however many that criticize the product as one often has to use multiple products in order to rate a single building.

2.6.5.1.3 Green Star - Australia

The Green Star rating tool was developed in Australia, by the *Green Building Council of Australia*. The tool is slightly different from the other rating tools, in that it was developed in order to “assess the environmental performance of buildings in a specific sector (office, retail, healthcare, education) at a distinct phase in the development cycle (design or construction)” (Shoniwa 2008), as opposed to only upon completion of the development.

The tool rates a building with a 1 – 5 star rating depending on a number of sustainability factors such as:

1. *Management:* Credits address the adoption of sustainable development principles from project conception through design, construction, commissioning, tuning and operation;
2. *Energy:* Credits target reduction of greenhouse emissions from building operation by addressing energy demand reduction, use efficiency, and generation from alternative sources;
3. *Water*: Credits address reduction of potable water through efficient design of building services, water reuse and substitution with other water sources (specifically rain water);
4. *Land Use and Ecology:* Credits address a project's impact on its immediate ecosystem, by discouraging degradation and encouraging restoration of flora and fauna;
5. *Innovation:* Green Star seeks to reward marketplace innovation that fosters the industry's transition to sustainable building;
6. *IEQ:* Credits target environmental impact along with occupant wellbeing and performance by addressing the HVAC system, lighting, occupant comfort and pollutants;
7. *Transport:* Credits reward the reduction of demand for individual cars by both discouraging car commuting and encouraging use of alternative transportation;
8. *Materials:* Credits target resource consumption through material selection, reuse initiatives and efficient management practices;
9. *Emissions:* Credits address point source pollution from buildings and building services to the atmosphere, watercourse, and local eco systems.

   Source: www.gbcaus.org

The climate within Australia is very similar to that of South Africa, and as a result the rating system used within South Africa, the *Green Star SA* is largely based on this Australian rating tool.

2.6.5.1.4. Green Star SA – South Africa

Green Star SA is the rating tool used within South Africa. The comprehensive rating tool was developed by the Green Building Council of South Africa (GBCSA) and was constructed around various existing tools, but primarily that of the Green Star (Australia) rating tool which has been detailed above.

The Green Star SA tool was developed with the following primary objectives:

- Establish a common language and standard of measurement for green buildings;
- Promote integrated, whole-building design;
- Identify building lifecycle impacts;
- Raise awareness of green building benefits;
- Recognise environmental leadership; and
- Transform the built environment to reduce the environmental impact of development.

Source: Green Building Technical Manual, November 2008, Pg ix

In order to achieve these objectives the tool has been design to rate buildings and to award credits to buildings based on nine separate categories:

1. *Management:* Credits are awarded for adopting sustainable design principles, from the inception of the project through to the tuning and operation of the building. The aim of the category is to encourage a holistic approach to construction given consideration to the environmental performance of a building throughout its lifecycle;
2. *Indoor Environmental Quality:* Credits are awarded to buildings and workspaces that provide a comfortable and healthy working environment. The category address, occupancy comfort, lighting, indoor air pollutants etc.;
3. *Energy:* This category targets the reduction in energy consumption. Credits are awarded for overall reduction in energy consumption, and rewards buildings that have an overall reduction in greenhouse gas and other emissions associated with energy generation from fossil fuels;
4. *Transport:* The aim of this category is to discourage the use of personal motor vehicles and to encourage the use of alternative transportation. Credits are awarded to buildings that encourages the use of transportation that have low or zero carbon emissions associated with it;
5. *Water:* The category aims at addressing the reduction in the use of potable water and encourages the reuse of water through the building systems design. Credits are awarded for building systems that integrate, rainwater, greywater and blackwater

systems as well as water labeling schemes into the design and construction of the building;

6. *Materials:* The category encourages the reuse of materials into construction as well as the incorporation of recycling initiatives into the scheme;
7. *Land Use and Ecology:* The category aims to highlight the projects impact on the immediate environment, awarding credits to projects that minimize harm and improve the quality of the local ecosystems;
8. *Emissions:* The emissions category addresses the emissions of the building, targeting watercourse pollution, light pollution, ozone depletion, global warming, legionella and sewerage;
9. *Innovation:* Credits for innovation are awarded for buildings that exceed the benchmarks that have been set by the Green Star SA rating tool. The credit encourages, and rewards projects that address issues which are currently not targeted by the Green Star credits.

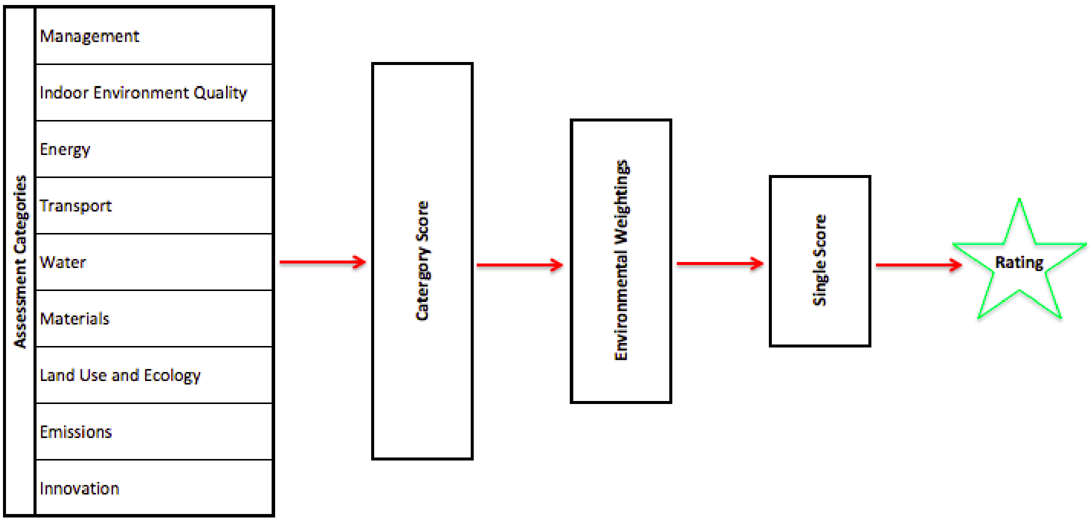


Figure 9: Structure of the Green Star SA Rating System

Source: Green Star Technical Manual, November 2008

Overall Score	**Rating**	**Outcome**
10 - 19	One Star	Not eligible for formal certification
20 - 29	Two Star	Not eligible for formal certification
30 - 44	Three Star	Not eligible for formal certification
45 - 59	Four Star	Eligible for Four Star Certified Rating that recognises / rewards 'South Africa Excellence'
60 - 74	Five Star	Eligible for Five Star Certified Rating that recognises / rewards 'South Africa Excellence'
75 +	Six Star	Eligible for Six Star Certified Rating that recognises / rewards 'World Leadership'

Table 4: Green Star Rating Tool Scores

Source: Green Star Technical Manual, November 2008, pg xii

2.7 Retrofitting

In a paper by Santmouris et al. (2002) it was stated *"Retrofitting of existing buildings presents by far the largest potential for the incorporation of renewable energy technologies and energy efficiency measures into buildings"*.

2.7.1 Retrofitting of Existing Commercial Buildings

"Periodically throughout history a gaping divergence occurs between what societies know to be the visual reality of their cities and what they hold as the visual ideal of what their cities should look like" – Thayer and Richman (1984:192-193)

Although it is most cost effective to implement the principles of sustainable design in the 'Design and Build Phase" (Civil Engineering 2009), an existing building can be retrofitted in order to improve its energy efficiency, thereby holistically making it in total a more sustainable building. It can be said that a city is largely identified and defined by its skyline, which gives it its distinct character. Existing buildings largely make up this character. These buildings, although the primary asset of any city, can also expend a significant amount of resources, such as energy. Retrofitting these buildings can aid in relieving the high demand on resources.

Retrofitting is an exercise that involves altering some physical aspect of the existing building. Although a building can be retrofitted in order to improve a number of aspects relating to the building, this research paper will only focus of the energy aspect of a retrofit.

Investment into retrofitting a building in order to improve its overall energy efficiency does come with an obvious capital cost and associated risk, and although there is currently a huge worldwide drive towards more sustainable construction, these costs cannot be ignored. In the 2005 RICS Green Value Report, Chris Corps was quoted saying: *"Change is not easy. But to all the developers, investors, owners, lenders, appraisers, valuers, agents and especially occupiers, the conclusion is that you ignore green buildings at your cost. Green buildings can provide financial benefit"*.

The associated benefits relating to a new build are somewhat different to those associated with an existing retrofitted building. When designing a new building one has the distinct advantage of being able to look holistically at the overall performance of the building, designing it in order to work efficiently, with one element complimenting the next. However, when retrofitting existing buildings the focus generally shifts to energy (cost) saving initiatives (Mills, Friedman, Powell, Bourassa Calridge, Haasl 2004) as this is seen to be an area which will result in the highest possible associated financial saving which will justify the capital spent.

Historically a number of papers have been published which have focused on the costs associated with the retrofitting of buildings, the majority of these papers suggest that the uncertainty regarding the associated cost / benefit relationship is felt to be one of the most notable deterrents perceived by consumers. Mills et al. (2004) pointed out that although there have been a number of published case studies relating to the cost associated with retrofitting a building, the majority of this information does not correlate, and as a result leaves the consumer with a significant amount of uncertainty associated with the costs and the benefits associated with the retrofitting of existing buildings. Uncertainty regarding costs and payback period is felt to be one of the major barriers to the market.

2.7.2. Process of Retrofitting an Existing Building

The process of retrofitting does not simply involve converting the building to be more efficient. In order to effectively carry out an energy retrofitting it is important that the following guidelines be adhered to in order to achieve maximum results.

- *Assessment of the building:* This can also be referred to as an energy audit. This involves baselining the buildings performance. This is done in order to understand the starting point;
- *Planning:* A proper understanding of the asset / building is required - what is the intended primary use of the building going forward.
- Implementation of the change;
- Measurement of performance: It is important that the improved results be measured, so that the market executives or internal stakeholders are able to understand that the initial capital outlay did result in the objective of a reduction in operating costs being achieved.

2.7.3 Behaviour Change

Although it is important to identify the cost of a retrofit, one needs to be aware that simply retrofitting a building will not result in the most effective reduction in energy consumption. The most effective reduction in energy consumption will only be achieved if / when the behavior of the occupants of that building changes.

Behavior change, although an intangible measurable, can have a significant impact on the ultimate success on an energy retrofit (Fulford 2011).

Fulford (2011), pointed out that there are three elements that one will need to address when implementing an energy retrofit.

- Gain an understanding of the issues and behavior of occupants;
- Communicate the impact of changes to occupants of buildings;
- Focus on collaboration (ie) "a carbon reduction programme is an opportunity to create a positive partnership between property managers and occupants where all parties are helping to achieve a common goal".

South Africa, and the global economy currently finds itself in the midst of a very uncertain economy. This accompanied by increasing environmental pressure, and ever changing legislation is forcing building owners and occupiers to make the retrofitting of existing buildings a priority. Building owners and occupiers are being forced to improve the efficiency of their existing building stock, in order to maintain a competitive business place, and improve the bottom line. In order to ensure that a building is maximally efficient in terms of energy consumption an energy audit can be completed in order to determine he buildings energy efficiency.

2.7.4 Energy Audits

When embarking on an energy retrofit exercise it is important that goals be established. One will need to first establish the current energy efficiency and current system performance. It is important to note that only ten percent of the energy consumed by an incandescent light bulb provides light, while the remaining 90% is released as heat, which will result in the building requiring additional cooling of up to 30%.

An energy audit can help to establish how much, and where the majority of energy is being consumed. An energy audit can be defined as "an investigation of building energy use and identification of efficiency and cost reduction opportunities".

Energy audits are usually conducted in the following manner:

1. Collect and analyze historical energy usage data;
2. Establish an energy breakdown framework for potential energy savings;
3. Review building documentation;
4. Assess equipment;
5. Estimate cost / savings for each energy efficient measure;

(The above measure complies with those set out by AHRAE Level 1).

An energy audit is a very useful tool for existing commercial buildings; however it is also important to ensure that buildings are properly commissioned.

2.7.4.1 Commissioning of Existing Buildings

Commissioning is an up-front cost where a commissioning agent verifies that a building's systems are performing correctly before occupancy. Commissioning can also be defined as a verification that the buildings energy related systems are installed, calibrated and perform according to the intended design and are based on construction documents

The commissioning exercise will aid in exposing equipment problems early on, usually before one-year warranties are up, thus preventing long-term unknown problems for the life of the building. In return, the expenditure here ultimately results in savings and utility and maintenance costs during building operation (Southface. "Lifecycle Economics"). Some people recommend that an 'annual audit' be conducted every quarter, for the first year, after a building has been retrofitted in order to ensure that one is deriving the maximum benefit from the retrofit exercise.

New construction commissioning is somewhat different to commissioning an existing building. When commissioning a new build, one is able to focus on the design and deliverables and make "performance" a priority, focusing on aspects such as thermal comfort and energy efficiency (Mills et al. 2004). Commissioning of an existing building is different as it involves identifying existing "defects" within the building that are preventing it from performing at an optimal level (Mills et al. 2004). It is prudent from a financial point of view, to approach a retrofit in an open minded manner, focusing on the buildings as a whole, and upgrading it at a single point in time (Thorne Amann and Menddelsohn 2005).

Historically commissioning of buildings has proven to improve a buildings' energy efficiency, and as a result lower the associated operating costs (Claridge, Turner, Lui, Deng, Wei, Culp 2002). When considering the decision to retrofit a building, consumers are often focused on a single aspect, and often fail to examine the building in its entirely. This is required in order to achieve the inevitable ultimate goal of lowering operating costs in the most cost effective manner (Thorne Amann et al. 2005).

There are a significant number of spin off benefits, or rather non-energy related benefits that can be achieved via the retrofitting process. These benefits are however often over looked as a result of the increased associated capital cost (Thorne Amann et al. 2005). The energy and non-energy benefits associated with energy efficient technology are discussed further below.

2.7.4.2 Energy and Non-energy Benefits

Energy-efficiency advocates argue that there are a number of non-energy related benefits that can be derived from the utilisation of energy efficient technology. It is often argued that the social benefits associated include things such as: increased productivity and employment; and improved comfort and public health (IEA 2005). Although hard to prove, it is also argued by many that these associated benefits can sometimes out weigh the direct financial benefit gained.

- *Improved indoor air quality and comfort*

A study completed in the United States of America revealed that approximately 90% of the average Americans day is spent indoors. It is therefore imperative that the quality of indoor air be maintained at a superior level. One is able to improve the indoor air by examining and improving: air-conditioning systems, lighting levels, examine types of cleaning materials utilized within the building.

Non-energy benefits include better airflow which could help to improve employee health, and as a result productivity. When one examines the cost of salary, and improved productivity in relation to the savings in energy it is very apparent that the non-energy benefit out way that of the cost of energy saved (Sterling and Collett 1994).

An article published in the *'Existing buildings survival strategy'* journal (Pg 3), listed the following advantages of retrofitting a building:

- *Value adding;*
- *Advantageous when you have acquired a undervalued property;*
- *Makes portfolio work hard;*
- *Aids in complying with recent / upcoming legislation;*
- *Reinforces / strengthens brand reputation;*
- *Improves corporate / social responsibility;*
- *Adapts building portfolio to climate changes where they are occurring;*
- *Carbon disclosure and carbon constraints are becoming unavoidable;*
- *Differentiate portfolio against competition;*
- *Prevent building from being unnecessarily vulnerable to utility blackouts and increases servere weather events.*

Although there may be a significant amount of energy efficiency advantages associated with energy retrofitting, these advantages may not necessarily be translated into an economic efficiency advantage. It is important that in achieving energy efficiency the goal of economic efficiency is also achieved.

2.8 Energy Efficiency vs. Economic Efficiency

Sutherland (1994) proposed that energy efficiency and economic efficiency have different end goals, making it very hard to simultaneously achieve both desirable outcomes.

Although on the surface this may appear to be true, one does need to bare in mind that the two concepts are not necessarily mutually exclusive. Employing energy efficient technology within a commercial building may have non-energy related benefits, as the technology may help to contribute to employees comfort level, health and general wellbeing, which may result in increased productivity levels (Jones et al. 2002), and in a more productive workforce, should result in higher profits (better economic efficiency).

It is not uncommon for a commercial building owner to own multiple buildings. When making the purchase decision to purchase the individual buildings within a portfolio one needs to examine each building looking at the merits as well as weighing up the various risk components associated with ownership. This will involve weighing up the potential income that one would be able to derive from the building (as well as assessing the associated costs).

It is fair to make the assumption that building owners would like their buildings to work at an optimal level, in the manner in which it was designed, providing a healthy and fairly comfortable environment in which to operate (Pietter and Nordman 1995) while minimising the associated running costs. When making the decision whether or not to incorporate the energy efficient technology into the building, it is rational to assume that the user (or purchaser) will conduct *a cost vs. expected benefit* exercise (Jaffe et al. 2004). However, one does need to always keep in mind that the end user and the building owner are often not the same individuals. As mentioned previously in this study, this is often referred to the as the "principal-agent problem" (Jaffe et al. 1994).

Although a higher return may be able to be derived by increasing the energy efficiency of a building, this may not always be the most economical way to increase the return of the building. The other benefits associated with the energy efficient buildings (such as increased productivity) will not be felt by the landlord, but rather by the end user (Jones et al. 2002).

When evaluating the decision to retrofit a commercial buildings, one needs to factor in the associated capital cost, estimated savings in operating costs, improved energy efficiency, potential improved productivity, and present value all aspects to determine whether or not the cost of the retrofit can be justified (Jones et al. 2002). However this is risky, as forecasting potential income and operating costs is not accurate. Over and above this, the discount rate associated with the present value of perceived utility and benefit is very subjective, and as a result will vary amongst individuals (Jones et al. 2002).

A saving in energy is not the only benefit which one gains from energy retrofitting a building. There are a significant number of non-energy related benefits which one will however experience as a result of the energy retrofitting exercise (Sterling et al. 1994). Sterling et al. (1994), further went on to say that the non-energy benefit derived from the retrofit exercise may out way the benefit in savings of operating costs.

It is important to acknowledge that the timing of retrofitting a building will also affect the costs associated. As previously mentioned, retrofitting an existing commercial building will typically be more expensive than integrating the technology and design into the initial construction of the building (Jaffe et al. 1994). The cost associated with the retrofit will have a fundamental role to play in the consumers' decision to proceed. Often consumers feel that if they wait to complete the retrofit (which they acknowledge is needed) the cost will significantly be redeemed. This may in fact be the case, but this will significantly be affected by the rate of diffusion of technology within the current market the consumer finds him/herself in.

2.9 Consumer Discount Rate / Payback Period

The consumer always holds the associated costs and risks, and the way in which these costs are justified is by the *discount rate* that the consumer associates with the risk of the investment (Jaffe et al. 1994). Some suggest that in order for energy efficiency to make "more" economic sense (Bennett 2001) government should offer incentives in order to encourage sustainable / energy efficient development in order to reduce the "risk". This is currently taking place within other countries. As previously discussed, Eskom have recently introduced a rebate program in order to encourage property owners to install energy efficient equipment, thereby decreasing the demand for electricity.

Estimating the payback period is a very subjective task, as different users would apply different discount rates to a single item, and furthermore discount rates applied by an individual would vary depending on the building that they were reviewing.

This being said, calculating a payback period can be done by using the formula below:

$$PV = \frac{\text{Annual Energy Savings (R/yr) x (1 - (1 + d)}^{n}}{D}$$

PV = Present Value

d = Discount rate

n = number of periods

*** *Piette et al 1995, pg 9*

The above calculation is a simple net present value calculation. This calculation does not however take into account any potential variations (future uncertainties) in the inputs, such as a change in the cost of electricity, or a change in the cost of energy efficient technology. The simple net present value calculation therefore does not allow or account for any further benefit that the purchaser may enjoy as a result of the utilisation of the energy efficient technology. As a result when utilising the above calculation to make the decision whether or not to retrofit an existing building with energy efficient technology, now or in the future, the discount rate applied will be affected by the uncertainty about the future, and the decision to retrofit may be delayed as a result (Jaffe et al. 2004).

2.9.1 Factors influencing the consumer discount rate

2.9.1.1 Risk Appetite

The discount rate that is applied will be affected by the consumers 'appetite' for risk, and can be adjusted according to the way in which the consumer perceives the riskiness of the decision that is made. The more risk averse the consumer, the higher the discount rate applied, and the shorter the payback period required (assuming that the present value or cost was fixed). (Jaffe et al. 1994).

2.9.1.2 Uncertainty

The discount rate that is applied when making the retrofit decision will be affected by the consumers level of uncertainty regarding the information relating to the material/product employed, as well as uncertainty regarding the related outcome of the decision made (associated monetary saving). It should be noted that a certain level of uncertainty is reasonable and should be expected, as the decision to retrofit a building is one that cannot be reversed once the capital cost has been spent. The decision made is based on a future where price is uncertain and one may very well elect to delay the retrofit as a result of this uncertainty (Jaffe et al. 2004).

2.9.1.3 Inflated discount rates

A certain school of thought argues that often consumers use significantly inflated discount rates (even as high as 800%/yr) when establishing whether or not an energy efficient purchase can be justified (Ruderman, Levine, McMahon 1987). It should be emphasized that as with most purchasing decisions, there is a certain element of risk associated with this process, which will always remain. Future energy prices are uncertain, and certain technology may be appropriate for a certain individual while it may not suit the needs of another (Jaffe et al. 1994), all these factors will have an important role to play in determining the consumer discount rate that is applied.

When evaluating whether or not it is cost effective in order to adopt an energy efficient or sustainable build technique or product, it is important to utilize *full cost accounting* in making the decision. "Full cost account takes into consideration the implications of social, environmental and economic costs associated with any project. Often the social and environment costs of decisions are not reflected properly in the monetary price paid for a decision. These externalized costs however, are still incurred and paid for by everyone including those with no involvement in a project. If environmental regulation increases, many external costs will be internalised, and often at higher costs than if they had been avoided initially.

Taking full costs into consideration can help development teams understand potential future vulnerabilities and anticipate costs or problems" (Removing Market Barriers and to Green Development).

2.10 Conclusion

The world currently finds itself in a position where it is being pressurized to move in a sustainable direction. Although the above discussion indicates that despite sustainable design, and green buildings being currently catch phrases within the property industry, it is very evident that South Africa has a long way to go before it will be seen as a truly sustainable nation.

The literature indicates that there is currently a lack of information freely available within the South African market. Although the majority agree that there are advantages to green buildings, the full scope of the benefits are hard to quantify. The literature does however indicate that energy retrofitting an existing commercial building will result in a reduction in energy consumption by that building.

The research further indicates that a payback period (although quite subjective) can be established. In order to ascertain whether or not an energy retrofit can be completed in an economically efficient manner.

The lack of accurate information within South Africa, as well as the current pressure that the industry is experiencing globally, does call for further research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The research methodology can be described as the blueprint to achieving the objectives and answering questions that have been raised by the study (Cooper et al. 2005).

This chapter of research will outline the way in which the subject research has been approached. The chapter will highlight the various methods and tools utilized in order to support the hypothesis.

The primary focus of this research was to ascertain whether or not an energy retrofit to an existing commercial building would result in a decrease in the quantum of electricity consumed by that building, and to establish whether property professionals within South Africa have an accurate understanding of the concept of energy retrofitting.

3.2 Research Approach

Research should not merely be considered to be the gathering of information. There are a number of ways in which research can be approached. It is important the appropriate method/tools be utilized in order to most effectively answer / support the hypotheses that have been presented.

Two primary research methods were employed; data collection via questionnaires and a case study. It was felt that it was important that both methods of research be explored in order to corroborate the results that were found.

3.2.1 Questionnaires

Questionnaires were utilized as they have the advantage of being able to be sent to a very large number of people (potentially resulting in a broad and large sample), at a relatively low cost. The questionnaire was further used as it aids the researcher to understand characteristics, opinions, attitudes as well as the general understanding of the respondents.

The questionnaire utilized in this research was fairly structured, and although this is seen as a significant positive and appealing attribute of questionnaires, the structured nature of the questionnaire does come with some drawbacks.

The questions asked in the questionnaire were structured in such a way as to get a better understanding of who the respondents were; however, they were primarily structured around the research objectives.

The intention of the questionnaire was to structure questions in a simple, easy to answer format. The questionnaire did however comprise of a combination of both open and closed-ended questions. There are advantages to both types of questions. Closed-ended questions allow for clear quantitative analysis, while also allowing for misinterpretation of the question. Open-ended questions help to avoid misinterpretation of answers, but provide for more complex data analysis process.

3.2.1.1. Targeted Population

According to Leedy and Ormrod (2005): "The sample should be so carefully chosen that through it, the researcher is able to see all the characteristics of the total population in the same relationship that they would be seen were the research, in fact, to examine the total population".

It is very important that the definition of what the population is (comprises of) be properly and clearly defined. In this research report, the population being studied can be described as *Property Professionals within the greater Gauteng area.* In this study all participants had experience in the property industry and were familiar with the concept of *green design.*

3.2.1.2. Sample Selection

Sampling can be defined as "the process of selecting units (e.g. people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen".
(http://www.socialresearchmethods.net/kb/sampling.php).

A sample was used as time and financial constraints did not allow for a study of the entire population. A sampling method known as *handpicking*[6] was utilized in the sample selection process.

Handpicking was utilized as the sampling method in order to control the validity of the results of the questionnaire. This was achieved by ensuring that the questionnaire was only completed by respondents who had detailed knowledge of the property industry. In order to obtain a sample of people who were involved in the property industry, a list of property professionals was obtained from various professional membership bodies. From this list a random sample of participants was selected. This was done in order to mitigate any potential prejudice in the results.

3.2.1.3 Sample Size

O'Leary (2004) recommends that if statistical analysis is to be done on a sample, the number sampled should not be less than thirty (30), in order for the sample to be a fair representation of the population.

Gay and Airasian (2003), however suggest the following guide lines be followed when deciding on an appropriate sample size:

- For small populations (with fewer than 100 people or other units), there is little point in sampling. Survey the entire population.
- If the population size is around 500, 50% of the population should be sampled.
- If the population size is around 1,500, 20% should be sampled.
- Beyond a certain point (at about 5,000 units or more), the population size is almost irrelevant, and a sample size of 400 should be adequate.

A total of 342 questionnaires were distributed via email. 80 fully completed questionnaires were returned. This equates to a 23.4% response rate, this is felt to fall within the acceptable boundaries for conducting academic research.

[6] Handpicking of the sample allows the researcher to control certain aspects of the study, and to focus on the area of research.

3.2.2 Case Study

Case studies can be described as being exploratory, explanatory or descriptive (Tellis 1997). A case study was utilized in order to test the data results obtained from the questionnaire.

Yin (1994) identified five key components of research design that is important for case studies:

- A study's question;
- Its propositions, if any;
- Its unit(s) of analysis;
- The logic linking data and the propositions;
- The criteria for interpreting the findings.

Source: Yin (1994), pg 20

A number of prominent Gauteng based companies involved in the energy and lighting industry were approached in order to obtain a sample of buildings that had been retrofitted in order to improve the buildings energy efficiency. Only property owners who owned property in the Gauteng region were approached. This was done in order to mitigate any variations in the results which could be as a result of climatic conditions. However, due to the sensitivity and quality of information received, only a single building located in the north of Gauteng was able to be selected for this portion of the research study.

All "raw" information utilized was procured from the energy auditing company. The information received was then further analysed in order to be presented in a graphical way which was meaningful to this research study.

Data was therefore analyzed in order to answer the following questions:

i. Did the energy retrofit improve the energy efficiency of the building?
ii. Did the energy retrofit make economic sense?

3.3 Sources and Treatment of Bias

Although all possible efforts were made to eliminate bias in the report, bias in its entirety could not be eliminated. The following areas of bias were highlighted:

- The sample was chosen from the Gauteng area. This sample although only from the Gauteng area is felt to represent the entire population;
- The human element of personalities (human bias) could not be eliminated from the respondents' answers.

Although the above sources of bias do exist, the reason supporting proceeding with this line of research can be justified.

Although the sample chosen only comprised of property professionals working in the Gauteng area, in order to reduce any further bias, a random sample within the handpicked sample was chosen. This was done in order to eliminate the possibility of pockets of uniform thinking across professions.

When analyzing data all participants were given a number in order to prevent bias of the author when further analyzing the results.

3.4 Analysis and Presentation of Data

3.4.1 Graphs and Tables

The primary way in which the data has been presented is through the use of graphs and tables. Graphs and tables are considered to be an acceptable way of representing the findings in an academic study (Shaw 2003). Vessey (2007) suggests that although graphs and tables may contain the same information the way in which the data is presented is fundamentally different. Data has been analyzed and has been presented in a graphical format of graphs and tables.

3.4.2. Correlation and Regression

"A correlation study examines the extent to which differences in one characteristic or variable are related to differences in one or more other characteristics or variable. A correlation exists if, when one variable increases, another variable either increases or decreases in a somewhat predictable fashion" (Leedy et al. 2005).

Regression analysis is considered to be one of the most commonly utilized tools when analyzing *multifactor data* (Chetterrjee and Hadi 2006). In this research regression parameters were utilized in order to test whether or not there was correlation between the participants various responses.

A study was done to determine whether or not there was a logical and functional relationship which existed between the results of the various questions posed to respondents.

The responses of various questions were then expressed in the form of an equation which allows one to interpret whether or not the decision to complete an energy audit prior to the retrofitting of an existing commercial building, and whether or not the importance placed on the results of this energy audit has any impact on the decision of whether or not to proceed with an energy audit, and whether or not it helped to identify the elements of a building which should take priority in that retrofit.

3.4.3. Triangulation

Williamson (2005) suggests that the triangulation[7] of data collection and analysis, when utilizing mixed use research methods will help the researcher to gain greater understanding of the research.

In this research triangulation has been utilized to compare the data results found in the case study, to that of the data results found in the questionnaire.

[7] Triangulation refers to the idea of reviewing data from two different points.

3.4.4 Documentary Research

When conducting research it is important for the researcher to familiarize him/herself with literature and documents that already exists. It should however be pointed out that is extremely important that reliance is not placed on a single document, but rather on a broad range as to not be biased by a single authors opinion.

A number of papers, journals, online journals, and books were reviewed and incorporated into the *Literature Review* (Chapter 2) component of this document.

3.5 Research Ethics

When conducting academic research it is important that all research be completed and analysed in an ethical manner. Although it may not be the intention of the research, when utilising the responses of human subjects the issue of ethical standards can often be raised (National Bioethics Advisory Commission 2001).

The University of Witwaterand has a strict 'Code of Ethics for Research on Human Subjects' which was adhered throughout this study.

In order to adhere to the code of ethics in this study, a formal letter accompanying the research questionnaire was emailed to all participants detailing the aims and objectives of the study, and requesting their voluntary participation. All questions used in the questionnaire were asked in a non-prejudicial manner.

The privacy of all respondents was a priority, and was respected throughout the study. All respondents were kept anonymous throughout the study, by assigning respondents a number and omitting their names from the report.

All case study information was analyzed and treated with confidentially and will be disposed of after the conclusion of this research report.

3.6 Conclusions

The above chapter summarizes the various research tools and techniques available to a researcher, and highlights a number of techniques' that were utilized within this research study.

All of the research tools were employed with the objective of answering the questions posed by the research paper, namely;

i. Does energy retrofitting of commercial buildings contribute to improved energy efficiency of these buildings?
ii. Is it financially / economically feasible to retrofit an existing commercial building within South Africa, in order to make it optimally energy efficient?
iii. What does the property industry understand by the terms energy efficient and energy retrofit?
iv. How do property professionals measure the economic viability of an energy retrofit project prior to proceeding?

The research approach utilized in this report is primarily quantitative in nature. The results of this research will be presented and analyzed in Chapter 4, and discussed further in Chapter 5. All recommendations and conclusions will be presented in Chapter 6.

Chapter 4: RESULTS AND ANALYSIS

4.1 Introduction

As discussed in Chapter 3, the research contained in this report has been conducted via two methods, namely a data collection through a research questionnaire, and a case study. This chapter of the research will present the results of both research methods.

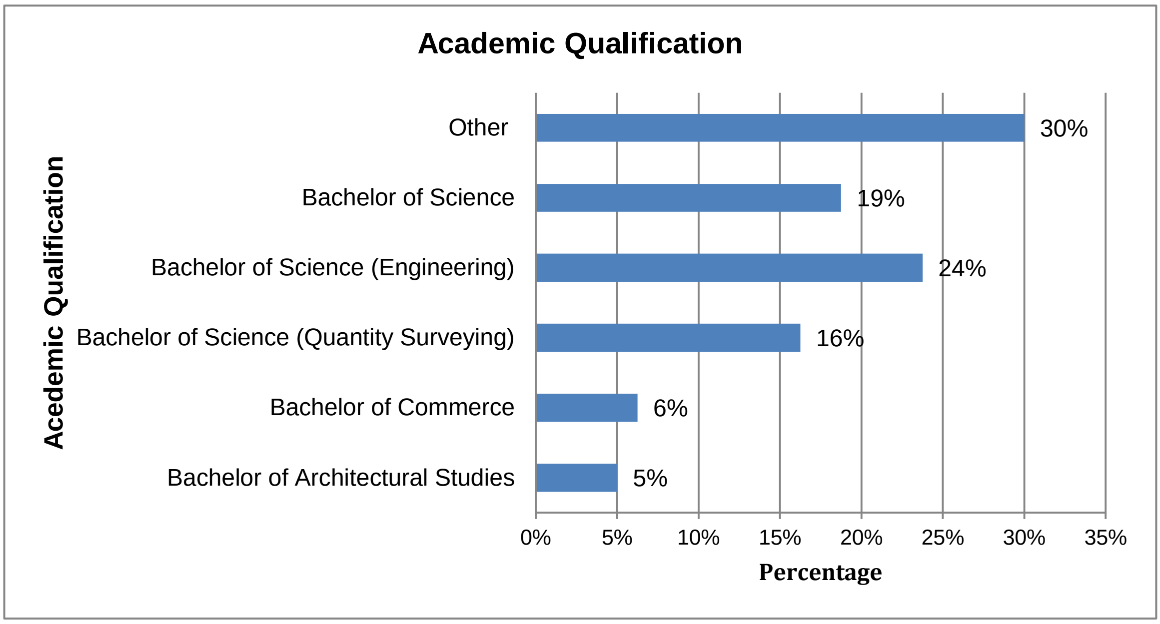
The results of both methods of research have been analyzed and the details of the analysis as well as graph representation of the results have been included below.

4.2 Analysis of Questionnaire Survey

The research survey questionnaire was distributed via email to 342 property professionals. Of the 342 questionnaires that were distributed 80 responses were received. This is equivalent to 23.39% success rate, which is considered to be within the acceptable norm for academic research (Crafford 2007).

4.2.1 Demographic Background of Respondents

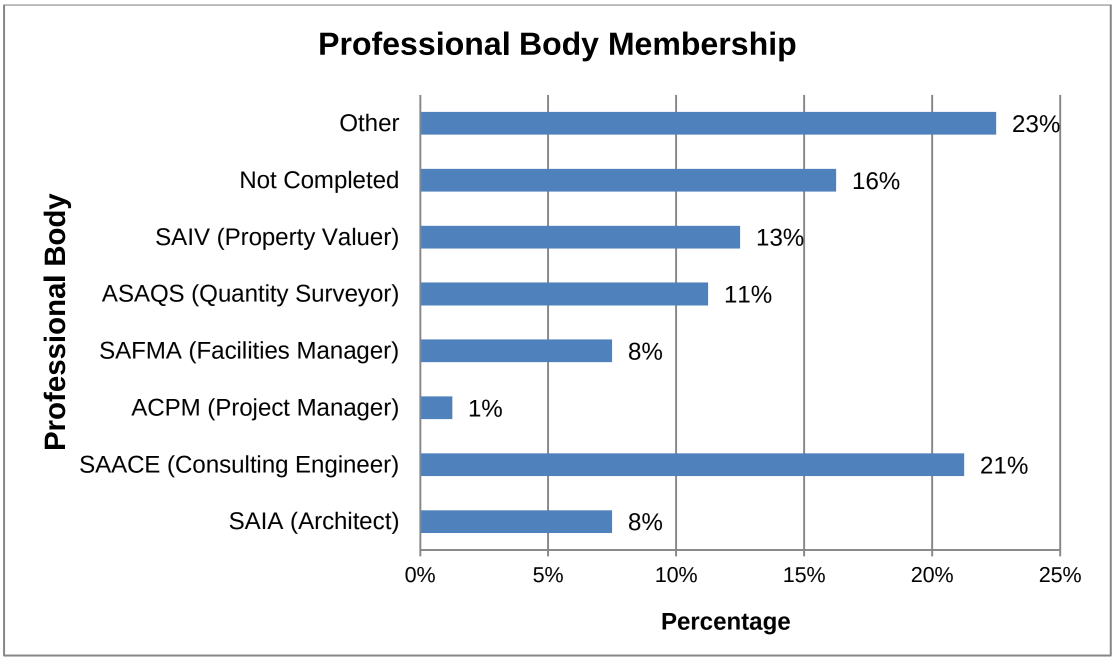
Academic Qualification



Graph 1: Academic Qualification

The sample was found to primarily be made up of participants with an Engineering qualification (24% or 19 participants). This is felt to be good, as it indicates that the sample comprises of a good spread (in terms of professional disciplines) across the population.

Professional Body Membership

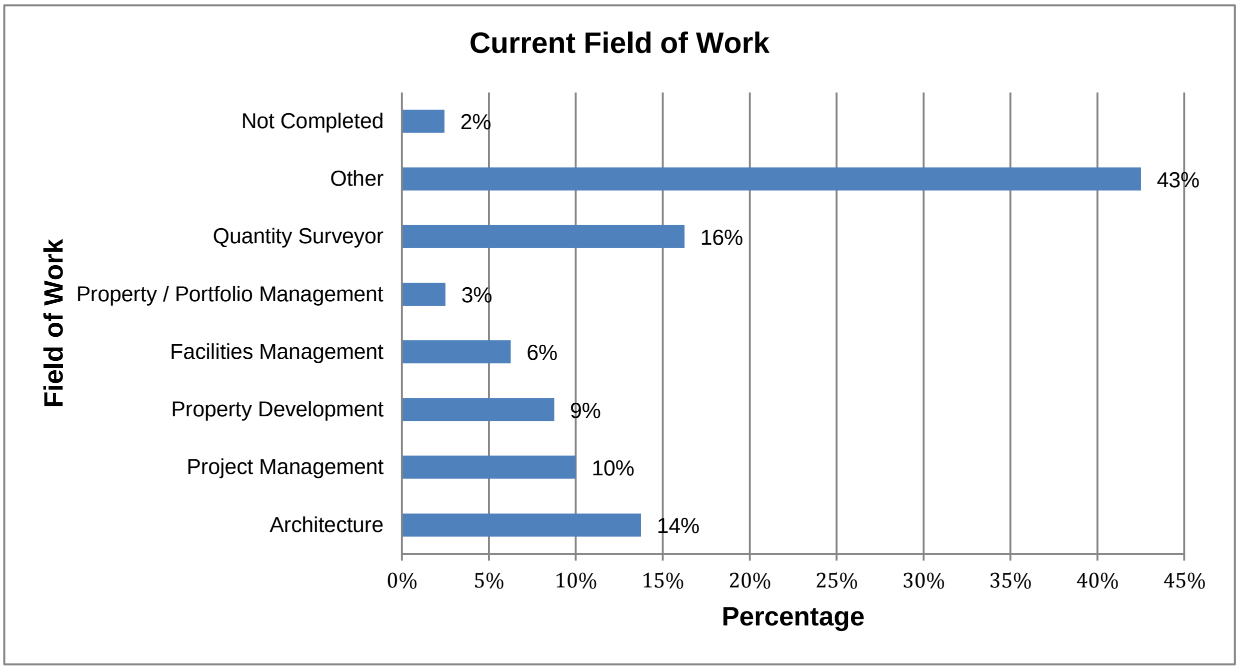


Graph 2: Professional Body Membership

The majority of respondents were found primarily belong to the SAACE (21% or 17 respondents). However 23% (18) of respondents were found to primarily be members of professional bodies that were not listed. The following professional bodies were found to be listed as the primarily professional bodies to which some of the respondents belong:

- SACAP *(South Africa Council for the Architectural Profession)*: 2 respondents (2.5%);
- SAIAT *(The South African Institute of Architectural Technologists):* 2 respondents (2.5%);
- SACPCMP *(The South African Council for Project and Construction Management Profession):* 1 respondent (1.25%);
- GBCSA *(Green Building Council of South Africa)*: 3 respondents (3.75%);
- ECSA *(Engineering Council of South Africa):* 4 respondents (5%);
- SACQSP *(South African Council for the Quantity Surveying Profession):* 2 respondents (2.5%);
- SAICE *(South African Institute of Civil Engineering):* 1 respondent (1.25%);
- ECB *(Engineering Contracting Board):* 2 respondents (2.5%);
- IESSA *(Illumination Engineering Society of South Africa):* 1 respondent (1.25%).

Current Field of Work



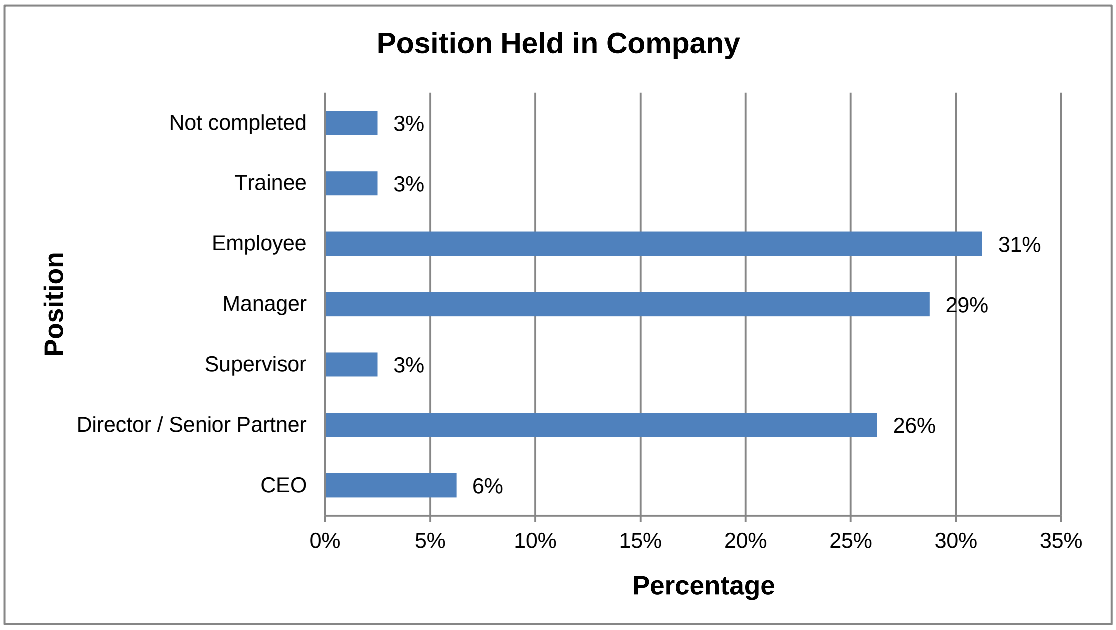
Graph 3: Current Field of Work

The above graph indicates that once again the majority (44%) of respondents were not currently working in one of the fields listed above. Upon further examination, in addition to the above categories the respondents were found to work in the following fields:

- Asset Management: 2 respondents (2.5%);
- Property Valuations: 4 respondents (5%);
- Financial Services: 1 respondent (1.75%);
- Engineering: 7 respondents (8.75%);
- Consulting Engineering: 8 respondents (10%);
- Interior Design: 1 respondent (1.75%);
- Sustainability Consultation: 7 respondents (8.75%);
- Energy Consultation: 4 respondents (5%).

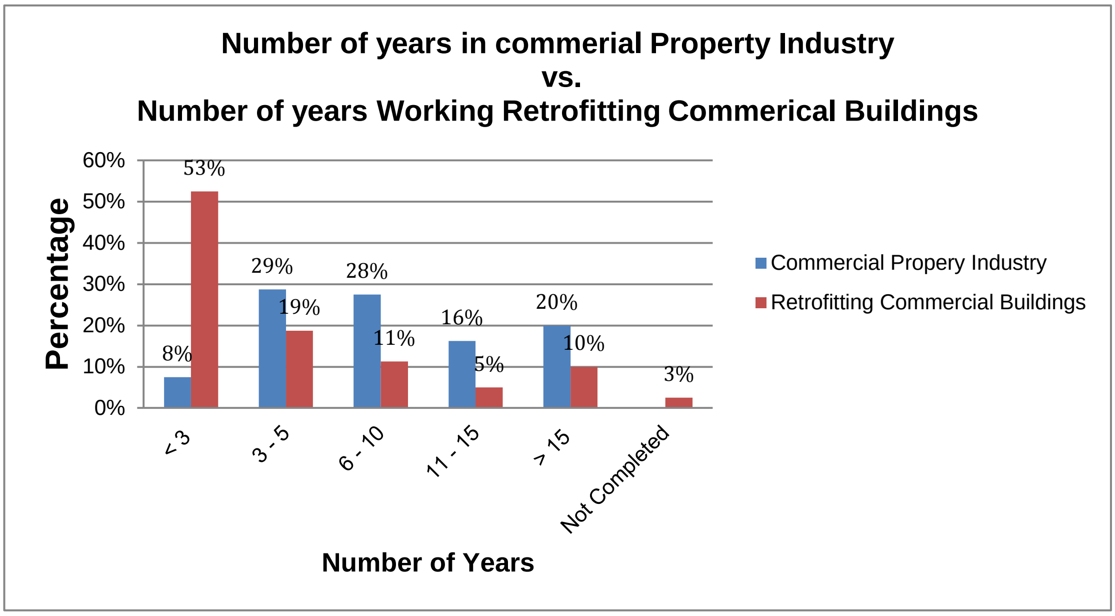
Once again the above results are felt to be good, as it indicates the sample has not been skewed by the responses / opinions of professional from a single disciple.

Position Held in Company



Graph 4: Position Held in Company

Comparison between number of years working in the commercial property industry, and the number of years working retrofitting commercial buildings



Graph 5: Number of Years in Working in the Commercial Property Industry vs. Number of Years Working Retrofitting Commercial Buildings

Graph 5 indicates that the vast majority (92%) of respondents has been working the commercial property industry for more than 3 years, with the majority of the respondents holding senior position within the company (Graph 4). Although this is the case 53% of the respondents have worked in the retrofitting industry for less than 3 years. This supports the literature reviewed which indicates the retrofitting of commercial buildings is still a fairly new concept in South Africa.

Registered Accredited Green Professional

Graph 6 indicated the number of respondents who are current registered as Accredited Green Professionals with the GBCSA, this is felt to indicate that although the retrofitting industry is still fairly new within South Africa, the interest in sustainable design and retrofitting is growing.

Graph 6: Registered Accredited Green Professional

Although the majority of processionals have been working the industry for less than 3 years, Graph 6 revealed that the sample was made up professionals who had been educated with regards to Green Buildings.

4.2.1.1 Summary of Demographic Findings:

An analysis of the demographic background of respondents revealed the following:

- The sample indicated that the respondents represented a group of professionals that were well spread across the industry, working in diversified sectors of the property industry and belonging to varied professional bodies.
- The majority of respondents were found to have completed a Bachelors degree in Engineering (24%), with 64% of the respondents holding a position of that of a manager or higher designation.
- 64% of the respondents had also been working in the property industry for a period of greater than 6 years, while 29% had been working in the retrofitting industry for greater than 6 years.
- 66% of the respondents we registered as being an accredited green professional with the GBCSA.

4.2.2 Retrofitting and Energy Efficiency

Respondents were asked to select the most appropriate definition to describe the term energy retrofitting.

	The process of modernising an old building to make the building appear newer	The process of replacing the light fittings / fixtures within an existing building	A renovating exercise which alters some physical aspects of an existing building	A renovating exercise which aids in reducing the amount of energy a building consumes	Other	Not Completed
Number	1	3	0	67	8	1
Percentage	1%	4%	0%	84%	10%	1%

Table 5: Tabled Response - Definition of Energy Retrofitting

	Social responsibility	It's the "in thing" (marketing)	I wouldn't retrofit	Green building rating	Reduction in energy consumption	Reduction in carbon footprint	Other
Number	2	1	0	1	54	15	7
Percentage	3%	1%	0%	1%	68%	19%	9%

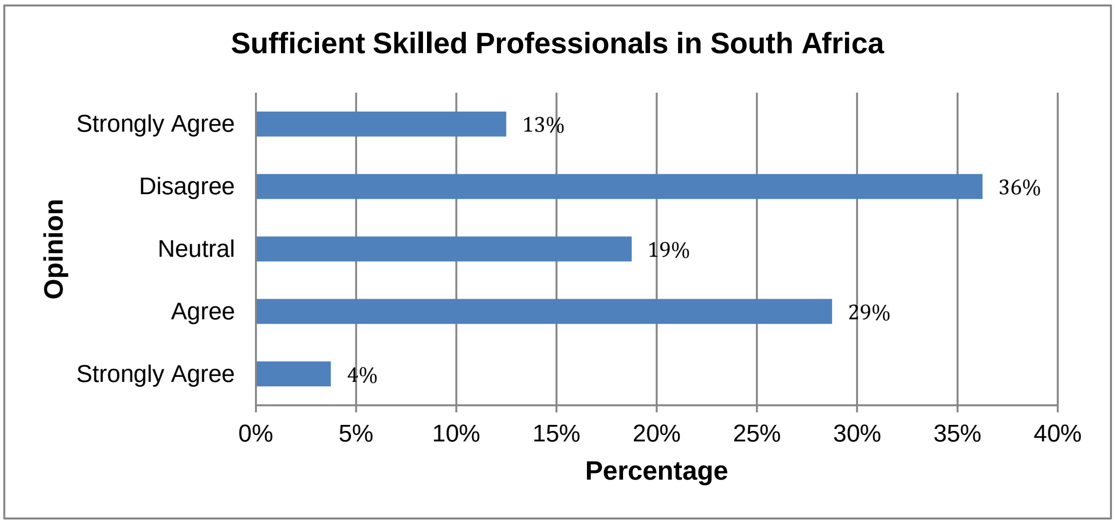
Table 6: Primary Reason for Retrofitting an Existing Commercial Building

Tables 5 and 6 indicate that the majority of respondents have an accurate understanding of the concept of energy retrofitting, and also agree that the primary reason for conducting an energy retrofit is in order that one achieves a *reduction in energy consumption.*

However, although the majority of respondents agree on an appropriate definition of energy retrofitting; as well as the primary reason for which a building should be retrofitted. 59% (47) of respondents indicated that they disagreed with the statement that "Retrofitting an existing commercial building will automatically result in a reduction in consumption". The results of the various questions therefore appear to be contradictory.

The majority (70%) of respondents also indicated that there are a number of negative factors which could affect an energy retrofit. The primary negative factors mostly included; high capital costs, long payback periods and lack of skills within the South African market.

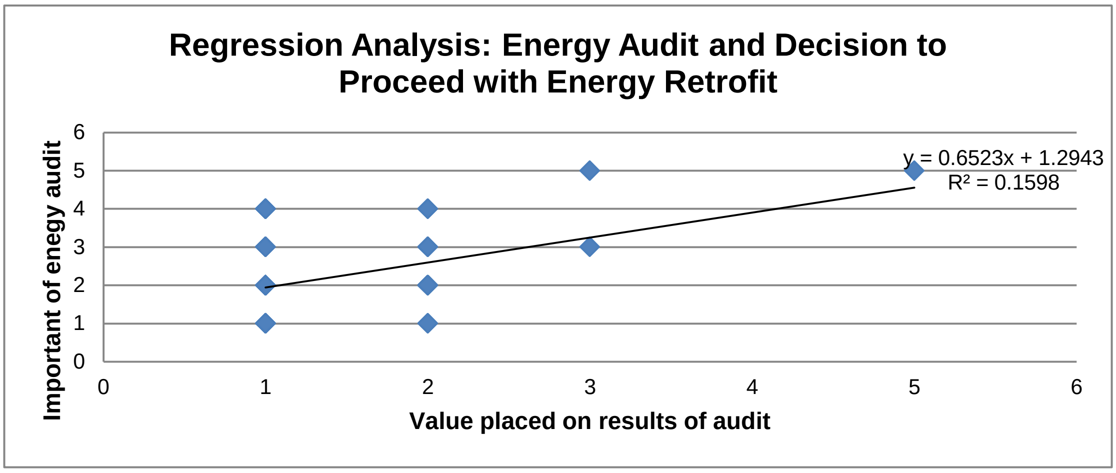
The above statement is further support by Graph 7, which indicates that the majority of respondents didn't feel that there are sufficient skilled professionals in South Africa to effectively carry of an energy retrofit.



Graph 7: Opinion Graph - Sufficient Skilled Green Professionals in South Africa

4.2.3 Pre-Retrofit Process

Graph 8 indicates the correlation between: how important respondents felt it was in order to conduct an energy audit prior to completing an energy retrofit, and, how much reliance the respondents placed on the results of the energy audit when making the decision whether or not to retrofit an existing commercial building.



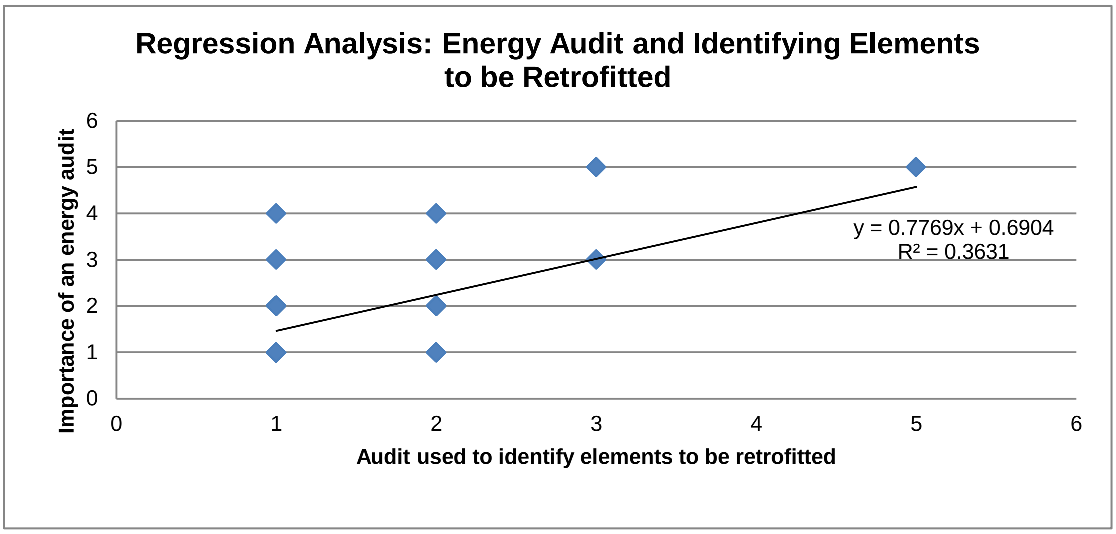
Graph 8: Regression Analysis: Energy Audit and Decision to Proceed with an Energy Retrofit

From the Graph 8, it can be seen that the regression line is $y = 0.6523x + 1.2943$, this equates to a correlation coefficient of 0.3997, which indicates a poor correlation between the two factors.

This is an unexpected result as 66% (53) respondents indicated that it is extremely important that an energy audit be completed prior to an energy retrofit. However, the above results indicate that when making the decision to proceed with an energy audit, the same importance is not placed on the findings of the audit.

From the above results (Graphs) it therefore appears that it is illogical to complete an energy audit prior to the retrofitting of an existing commercial building, however, although this is the case, the results of Graph 9 indicate that the primary reason for professionals completing an energy audit prior to a building being retrofitted is in fact not to make a decision as to whether or not to proceed with an energy retrofit, but rather to identify which elements of the building require retrofitting.

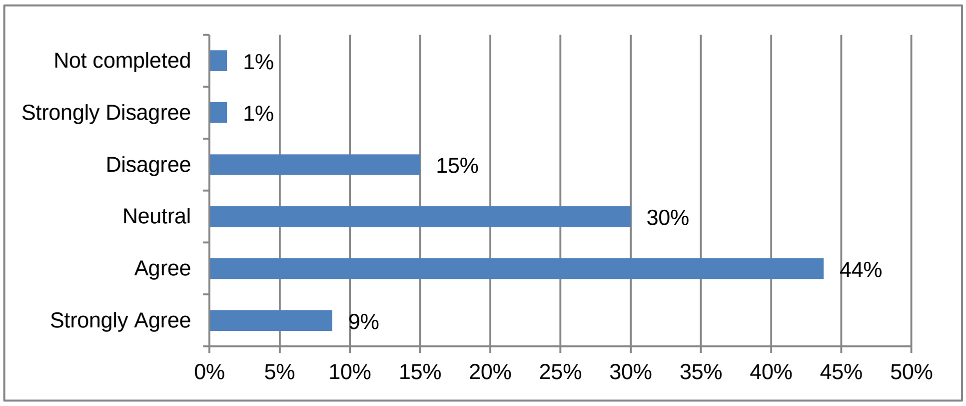
Graph 9 showing a regression line of $y = 0.7769x + 0.6904$, which illustrates the correlation between: the importance placed on completing an energy audit prior to an energy retrofit and, the reliance placed on this energy audit in determining which elements of a commercial building should be retrofitted. The graph illustrates a correlation coefficient of 0.6026, which is felt to indicate a fair correlation.



Graph 9: Regression Analysis: Energy Audit and Identifying Elements to be Retrofitted

4.2.4 Economic Aspects of an Energy Retrofit

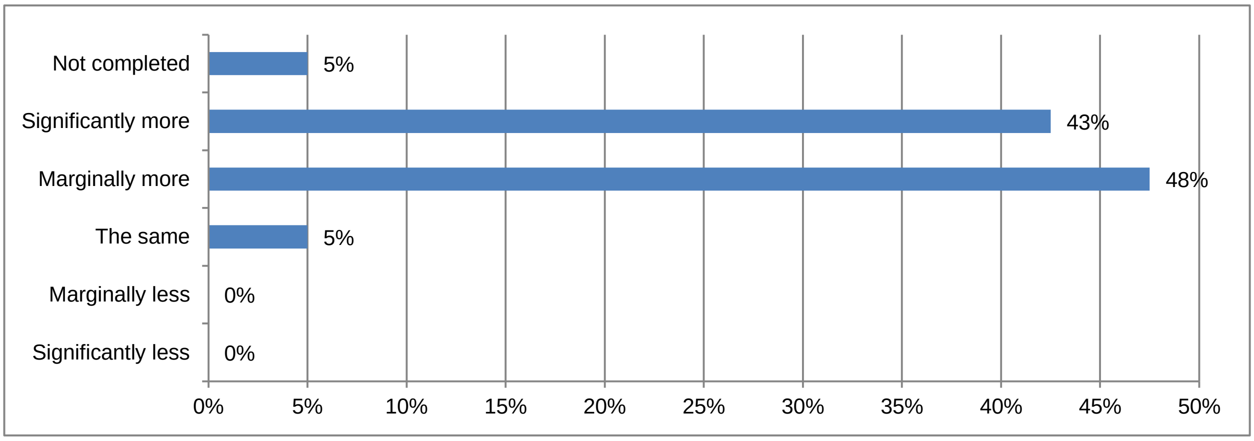
Product availability



Graph 10: Product Availability in South Africa

Although the majority of respondents 44% (35) indicated that there are sufficient products available in South Africa in order to effectively carry out an energy retrofit, a large portion of the respondents remained neutral. This is felt to indicate that uncertainty exists within the South Africa market. This conclusion is supported by the literature, which indicates that the concept of energy retrofitting within South Africa is a new one.

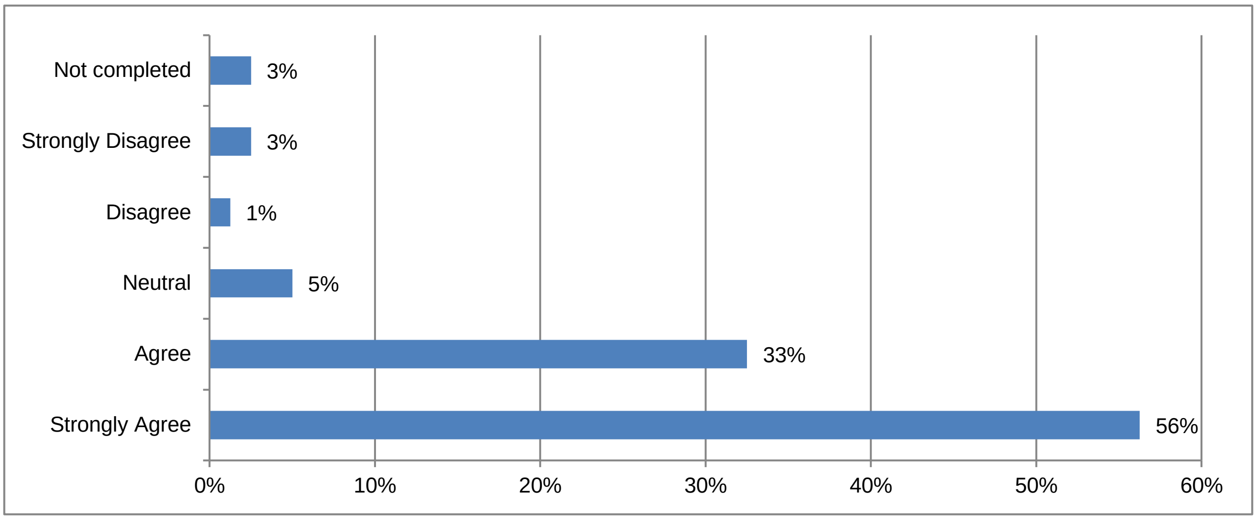
Cost of energy efficient products



Graph 11: Costs of Energy Efficient Products

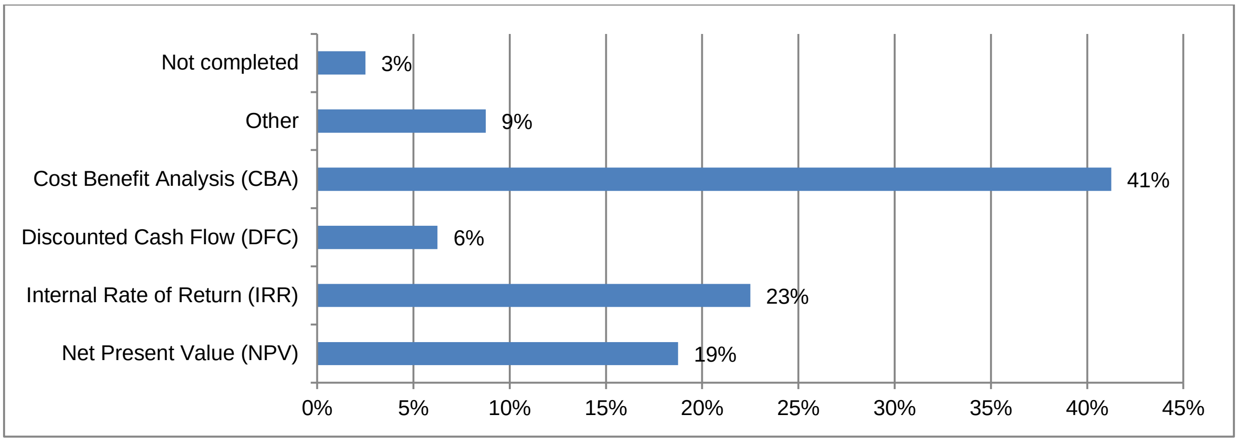
The majority of respondents felt that energy efficient products cost more than that of regular products, while a large portion felt that it cost significantly more. This is felt to support the literature which indicates that there is uncertainty as to whether or not an energy retrofit can be completed in an economically efficient manner**.**

Importance of a Cost Benefit analysis prior to an energy retrofit



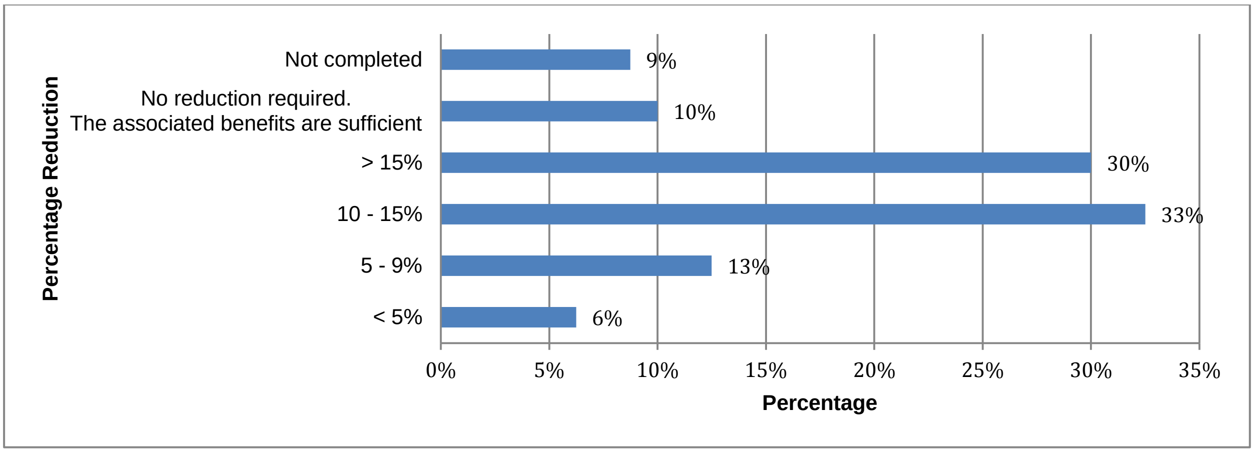
Graph 12: Importance of a Cost Benefit Analysis Prior to an Energy Retrofit

Tools currently utilized to measure the economic viability of an energy retrofit



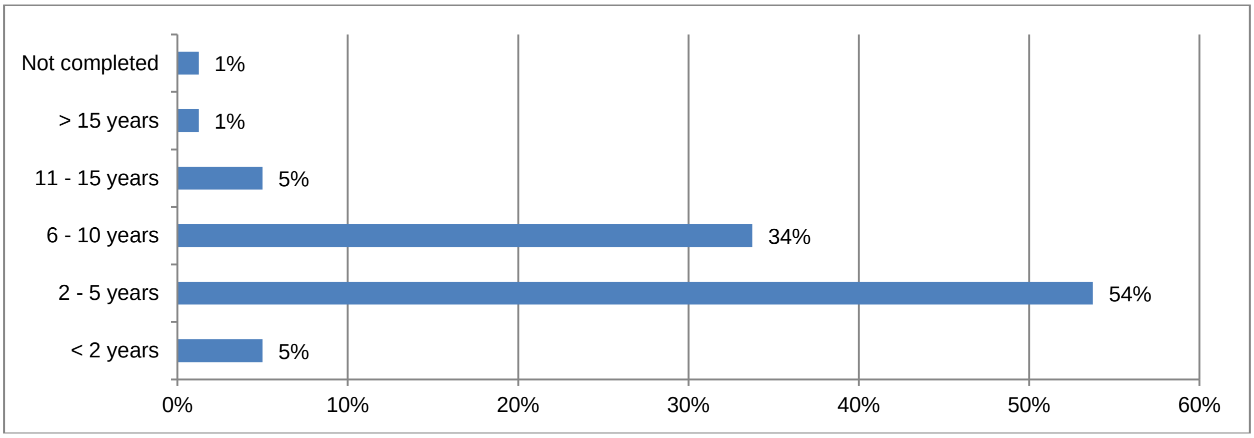
Graph 13: Tools Currently Utilized To Measure The Economic Viability Of An Energy Retrofit

Energy reduction required in order to proceed with an energy retrofit



Graph 14: Required Energy Reduction

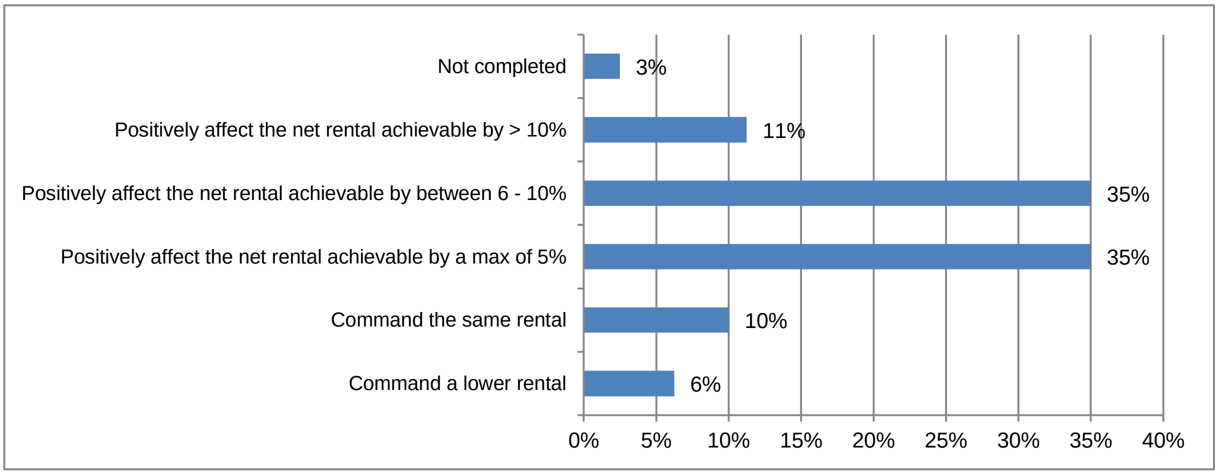
Payback period required in order to proceed with an energy retrofit



Graph 15: Payback Period Required In Order To Proceed With Energy Retrofit

Graph 12 indicated that the majority of respondents felt that it is important that some sort of a cost benefit analysis be completed prior to an energy retrofit being completed; with the majority indicting that the primary tools utilized in order to access the economic viability of an energy retrofit was the Cost Benefit Analysis tool. Graph 14 indicates that the majority of respondents would require a payback period of less than five years in order to proceed with an energy retrofit. It can therefore be concluded that a maximum of a five year period would be considered to be an acceptable as payback period when conducting a cost benefit analysis.

Effect of an energy retrofit on the base rentals of a commercial building



Graph 16: Effect Of An Energy Audit On The Base Rentals Of A Commercial Building

Graph 16 indicates that the majority respondents feel that an energy retrofit will have a positive impact on the base rentals of a commercial building. Should this be the case, it can be concluded that an energy retrofit would result in the value of that commercial building being increased, when valuing it on a forward yield basis.

4.3 Analysis of Case study: Sheldon Place

A number of energy auditing firms were approached in order to obtain a suitable example of a building which had recently under gone an energy audit and was in the process of being retrofitted. A number of buildings were examined, but due to a lack of availability of information only the data of a single building could be used in order to test the conclusions of the questionnaire. All information below was provided by an energy auditing company in

Gauteng, all data was analyzed and incorporated into graphs in order to graphically display the results.

Description of Building

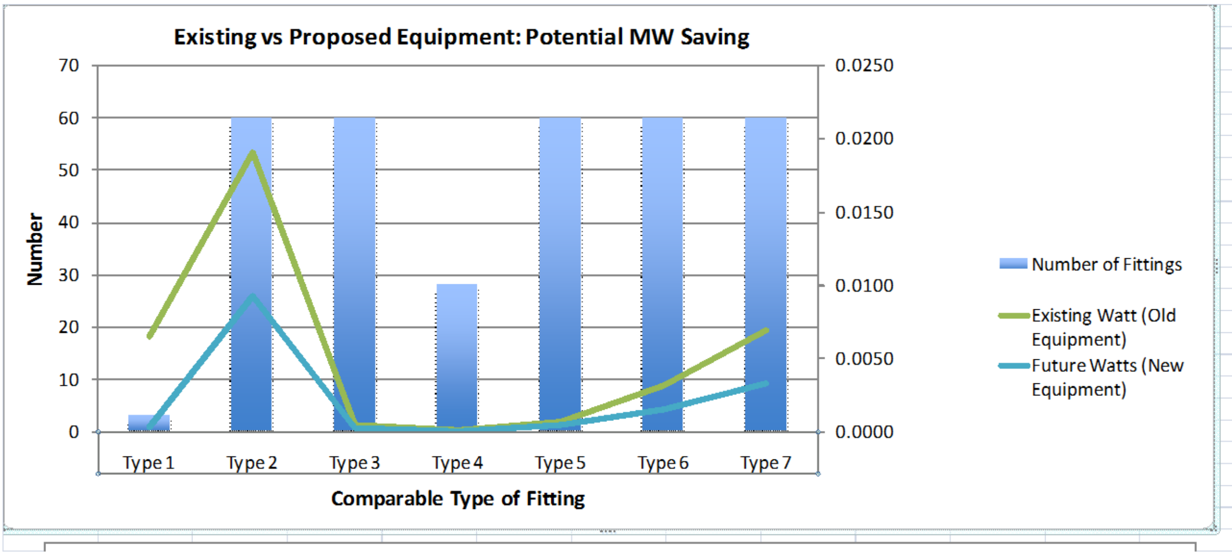
Complex Name:	SS Sheldon Place
Location:	Lonehill, Gauteng

At the request of the information provided the type of light fitting will be kept confidential.

The first question that was asked, when looking at the buildings data, was *"Did the energy retrofit improve the energy efficiency of the building?"* The purpose of this question was to establish if the energy retrofit had any correlation (be it positive or negative) to energy consumption of that commercial building.

The second question that was asked when examining the data was *"Did the energy retrofit make economic sense?"* The objective behind this question was to establish whether or not it was in fact financially feasible to proceed with the energy retrofit of an existing commercial building, given the associated capital costs and the potential associated monetary saving which would be derived from such a retrofit. Although the effect of an energy retrofit may have a positive impact on the electricity consumption of that commercial building, the associated saving may not be economically justified by the associated capital cost.

The third question or element that was examined looked at the real return and asked the question of where the real breakeven point of the investment was. This was used in order to determine whether or not the payback period was within an acceptable range to that of the consumer / professional.

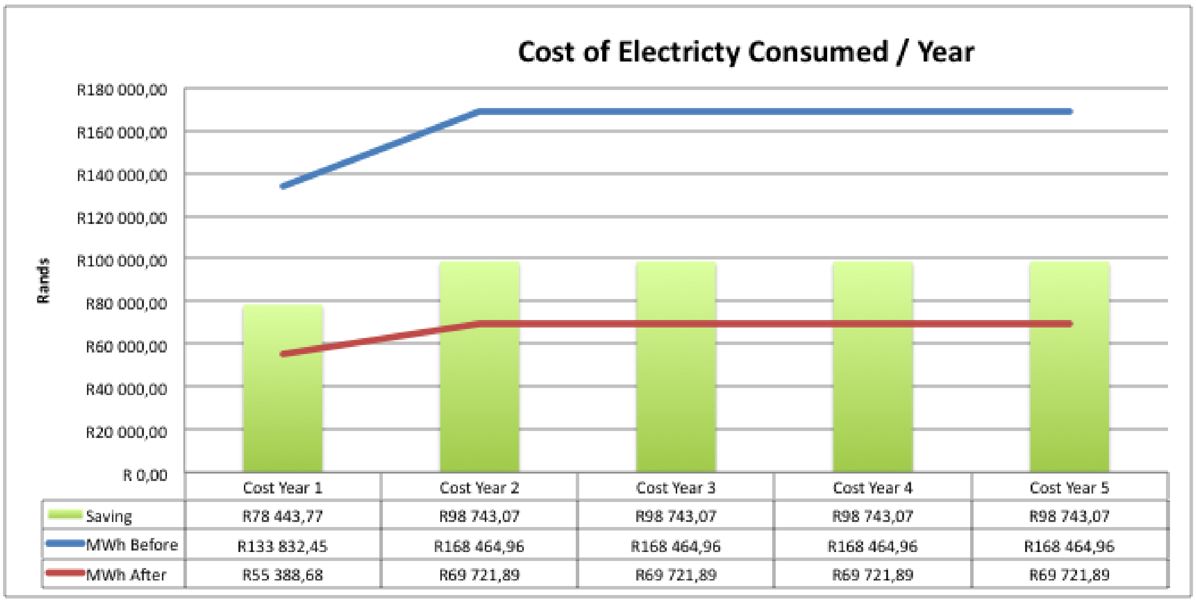


Graph 17: Existing vs Proposed Equipment: Potential MW Saving

The above graph illustrates the comparison between the amounts of electricity which is currently consumed by existing equipment (light bulbs) compared to the amount of electricity which would be consumed should the existing equipment be replaced by the proposed energy efficient equipment.

From the above it can be seen that there are currently seven different types of light fittings present within the building. The highest electricity-consuming fitting is fitting *Type 2*. From graph 1 it can also be seen that changing fitting *Type 2* to an energy efficient fitting would result in a significant saving.

The graph clearly illustrates that should the new technology be installed there will be a resultant effect on the amount of electricity which is consumed. In order to quantify the monetary effect of this decrease in electricity consumed, the watts need to be converted to Rands. This is illustrated in Graph 18 below.

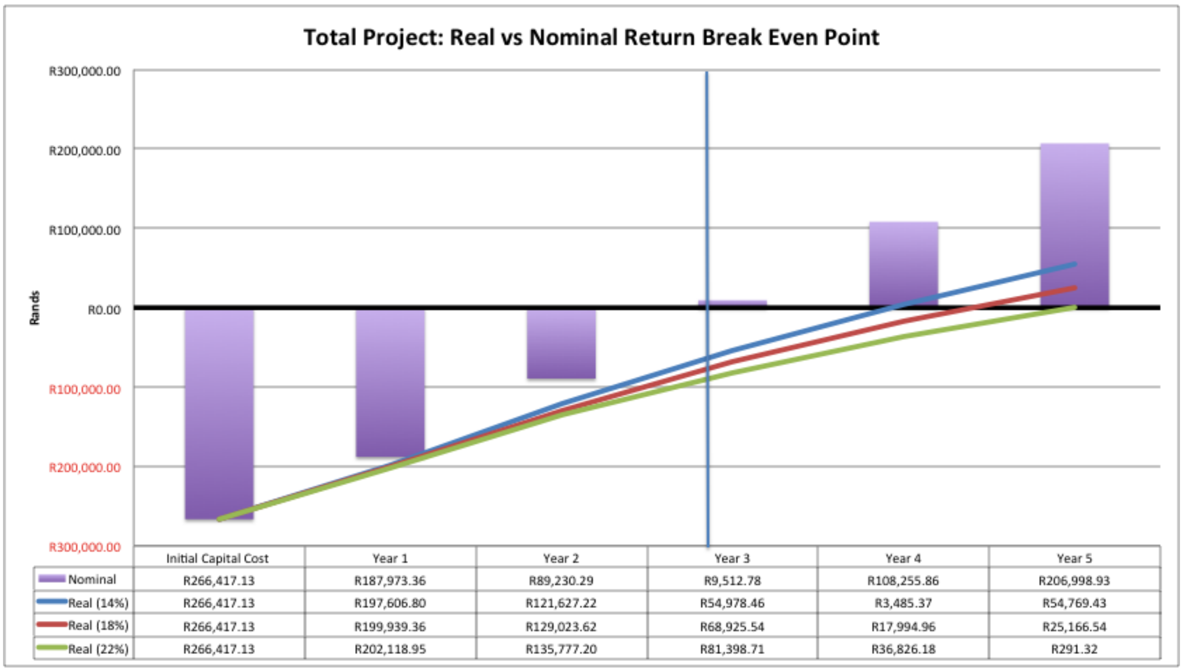


Graph 18: Cost of Electricity Consumed Per Year

The resultant MWh saving if the proposed equipment were to be installed would equate to 189.89MWh/annum, or R78,443.77 (58.61%) in the first year. The above model has been based on the currently electricity price of R0.4131 which has been escalated according to the predicted future price of electricity as determined by the MYPD2 model to the future years, in order to indicate the most accurate result possible.

Although this saving over the period does appear to be somewhat significant upon initial illustration, one does need to stay cognizant of the following: in order to the retrofit to be completed an initial capital sum will need to be spent, this capital cost does come with an associated opportunity cost, and the projected savings will need to be discounted in order to account of the effect of time vale of money. As a result of the opportunity cost of the initial capital which would need to injected into the energy retrofit project, a projected payback period will need to be determined in order to determine whether the costs can be justified by the savings incurred.

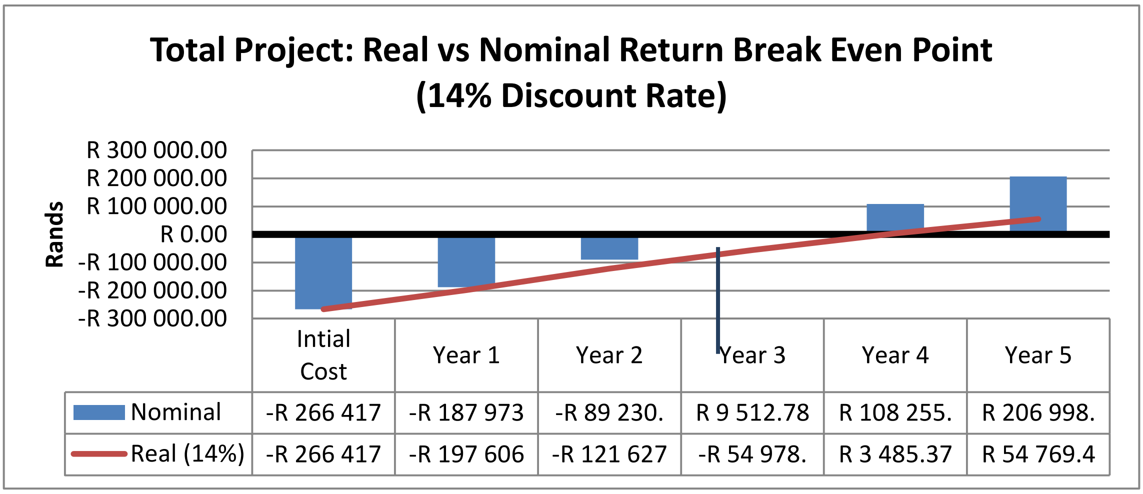
The *Real vs Nominal Return* breakeven point has been illustrated in graph19 below.



Graph 19: Total Project: Real vs Nominal Return Break Even Point

As discussed in the literature review chapter of this research report, different consumers will apply different discount rates, depending on their risk profile, and will require different payback periods in order to justify the capital investment into the energy retrofitting of a building.

Graph 19 illustrates the various breakeven points which would result depending on the different discount rates applied, From the above it can be clearly seen that the higher one discount rate (ie) the higher ones risk appetite the higher the associated discount rate one would be willing to apply.



Graph 20: Total Project: Real vs Nominal Return Break Even Point (14% Discount Rate)

The above graph shows the very important difference between the real and the nominal return breakeven point If one were to apply a 14% discount rate to the investment – the nominal payback period is equal to approximately 2.3 years, however the *real* payback period equates to 3.4years. This is a very important difference, and one that has to be taken into account when making the decision to retrofit a building.

From the above case study it is clear that the retrofit will result in a cost saving. The payback period will vary depending on the consumer's appetite for risk.

Chapter 5: DISCUSSION OF RESULTS OF QUESTIONNAIRE

5.1 Introduction

Chapter 4 presented and analyzed the results of the research. This chapter will discuss the results in relation to the research proposal.

5.1.1. Questionnaire Respondent Sample

The sample size achieved on the questionnaire sample is considered to be acceptable with a response rate of 23.4% (80 respondents). This is based on O'Leary (2004) who recommends that a sample size should be not less than 30, and Crafford (2007) who estimates a response rate of between 7 - 40%, in order for a statistical analysis to be completed and for it to be a fair representation of the population.

The results also indicated that the sample represented a good cross section of the built environment; this was felt to be very important as it helped to eliminate potential bias which could arise amongst professions.

5.2 Evaluation of Results in Relation to Research Question

5.2.1 Can energy retrofitting an existing commercial building, improve the energy efficiency of that building?

Case Study:

The simple lighting retrofit completed revealed there was a significant reduction in the quantum of energy consumed (Graph 17) and therefore the total cost per annum of electricity consumed (Graph 18).

The case study therefore indicates that an energy retrofit can improve the energy efficiency of a commercial building.

Questionnaire:

- Table 1 indicated that the majority (84%) of respondents agreed that they would define the term energy retrofitting as "A renovating exercise that aids in reducing the amount of energy a building consumes".

- *Table 2* indicated that the majority (68%) of respondents agreed that the primary reason for completing an energy retrofit would be in order to achieve a reduction in energy consumption. This further supports the findings of the case study.

  Although the majority of respondents (59%) also indicated that retrofitting an existing commercial building would not automatically result in a reduction in energy consumption. Lighting levels, air quality and heating were all indicated as being extremely important to employees productively levels and one of the secondary reasons for completing a retrofit.

Conclusion on Findings
The results of both the case study and the questionnaires indicate that the primary reason that an energy retrofit would be completed be would be in order to reduce energy consumption.

Based on the findings above it can therefore be accepted that the energy retrofitting of an existing commercial building will result in a reduction in commercial buildings energy consumption.

5.2.2 Can energy retrofitting of existing commercial buildings within South Africa, be done in a manner that makes economic sense?

In order to answer this question, the following 'sub-questions' needed to be asked.

- Are there sufficient products and skills available within South Africa to efficiently complete an energy retrofit?
- What do these materials cost in comparable to regular materials?
- What reduction is energy composition would be required to justify the capital cost of an energy retrofit?
- Would a building which had undergone an energy retrofit command a higher rental than a similar building which had not been retrofitted?
- What payback period would be required in order to make the decision whether or not to proceed with an energy retrofit?

Case Study:
From the case study it can be seen that a 58.61% energy reduction was achieved in the first year after the energy retrofit was completed (*Graph 18),* this equates to a saving of

R78,443.77 per year, with the real breakeven point being achieved in year 3, post the energy retrofit being completed.

Questionnaire:
Graph 10 indicated that 44% of property professionals felt that there was sufficient products available within South Africa to effectively carry out an energy retrofit, however 91% of these respondents feel that the cost of these materials were either marginally or significantly more expensive than regular products (*Graph 11*), with the majority (36%) of respondents agreeing that there was not sufficient skills available within South Africa to successfully carry out an energy retrofit.

Graph 13 indicated that 63% of respondents would require a greater than 10% reduction in energy consumption, while 54% indicated that they payback on the capital spend would need to be achieved within a 2 – 5 year period (Graph 14).

70% of the respondents felt that a commercial building which had under gone an energy retrofit would command a rental of between 5 -10% higher than a building which had not under gone the retrofit. This was primarily indicated as a result of lowered operating costs.

From the above, it is can be concluded that although the cost of energy efficient materials is felt to the higher than the cost of regular materials, the completion of an energy retrofit can be justified as it falls within the respondents required energy reduction and payback period parameter.

Conclusion on Findings
When the results of the case study are looked at in conjunction with that of the questionnaire, they confirm that an energy retrofit can be carried out in an economically efficient manner.

5.2.3. What are professionals understanding of the terms 'energy efficiency' and 'energy retrofit'?

The above question was included in order to gain a better understanding of what property professionals understood by the term energy retrofitting and energy efficiency, and to understand if reliance could be placed on their answers within the questionnaire. The below results indicated that the majority of respondents had a correct understanding of the above terms.

- The majority of respondents (84%) defined energy retrofitting as: "A renovating exercise which aids in reducing the amount of energy a building consumes", with 68% indicating that they felt the primary reason to retrofit an existing commercial building would be in order to achieve a reduction in energy consumption. 70% also indicated that they felt that there were negative factors associated with the retrofitting of an existing commercial building.
- 63% of the respondents defined the term *energy efficiency* as: "The process of efficiently using energy", and went on to say that they didn't feel that there were sufficiently skilled professionals within South Africa who had the ability to effectively complete an energy retrofit of an existing commercial building.

5.2.4 How to do professionals assess the viability of a project?

The above question was raised as to whether or not when making the decision to retrofit an existing commercial building, whether or not this decision was made based on the results of an analytical analysis, indicating which elements of a building should be retrofitted and what the costs and resultant payback period would be, or whether the decision was made despite the results.

In order to answer this question, there was another sub-questions that needed to be answered.

- *Do property professionals feel that it is important that an energy audit be completed prior to an energy retrofit being completed?*

The results revealed that although 66% of the respondents indicated that it is extremely important.

This answer was then tested against the answer to the following question:

- *How much reliance is placed on the results of an energy audit?*

The results further indicated that there was no correlation between the results of the energy audit and the decision on whether or not to proceed with an energy audit.

Although this is the case, further analysis revealed that although minimal reliance in placed upon the energy audit with regards to the decision of whether or not to proceed with an energy audit or not, correlation can be found with regards to the decision of which elements the energy audit indicates one should retrofit. This further supports the result that indicated that the majority of respondents (89%) indicated that it was important that a cost benefit analysis be completed prior to an energy retrofit, however the method is determining the appropriate method that should be utilized in order to measure economic viability was not consistent amongst the respondents.

It can therefore be concluded that although there is a standard viability model for the testing of whether or not to proceed with an energy retrofit, some form of viability testing is always conducted prior to the retrofit commencing.

5.3 Summary of Findings

The discussion of the chapter revealed the following:

i. The exercise of retrofitting an existing commercial building could result in improved energy efficiency of that building. This was suggested throughout the literature review, and has been effectively confirmed by the case study. The case study effectively illustrates a decrease in the consumption of electricity once a building had undergone an energy retrofit.

ii. Completing an energy retrofit of an existing commercial building within South Africa can make economic sense. The literature review suggests that a retrofit will only be considered to be effective should retrofit result in both energy efficiency and economic efficiency. Energy efficiency and economic efficiency are both illustrated in the case study. From the case study it can be seen that the initial upfront capital cost associated with an energy retrofit can be recouped through cost savings over a relatively short period of time.

iii. From the questionnaire it was ascertained that the majority of professionals surveyed did have an accurate understanding of the terms *energy efficiency* and *energy retrofit*.

iv. The questionnaire also illustrated that most professionals will perform a cost benefit analysis prior to assessing the viability of the retrofitting exercise, and prior to making the decision whether or not to proceed with an energy retrofit.

Chapter 6: SUMMARY CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This research sought to better understand the concept of energy retrofitting within the South African market. The aim of this research was to identify whether or not an energy retrofit to an existing commercial building, would result in a reduction in the amount of electricity consumed; to ascertain whether or not this could be completed in an energy efficient manner to further establish whether property professionals within the South African market had an accurate understanding of the concept of energy retrofitting.

The research finds there above to be true. This chapter will identify and highlight the main findings of the research, and will make recommendations based directly on the findings of the research.

6.2 Summary of the Research Study Findings

It is widely acknowledged that the concept of retrofitting is a fairly new one within the South African context. Historically the price of *cheap* electricity has not encouraged sustainable development. However, with increasing electricity prices and pressure globally, South Africa as a developing country currently finds itself in a prime position to transform the existing built environment through the energy retrofitting of commercial buildings within cities.

The idea of energy retrofitting is therefore a novel one; however, retrofitting does come at a cost, and therefore has financial and well as economic ramifications. However, has property owners and tenants feel the effects of increasing electricity prices, they are being forced to examine what the actual economic ramifications of an energy retrofit would be.

6.3 Restatement of the Objectives

The primary objective of the research study was to ascertain whether or existing commercial buildings could be energy retrofitted in an economically efficient manner. The following objectives were identified:

i. To identify whether or not retrofitting of existing commercial buildings improves the energy efficiency of these buildings;
ii. To identify whether or not it is economically efficient to retrofit existing commercial buildings;
iii. Identify what property professionals understanding of the terms *energy efficiency* and *energy retrofitting* is, and;
iv. Understand how these property professionals access the economic viability of an energy retrofit project.

In order to achieve the above objectives the following questions were asked:

i. Does energy retrofitting of commercial buildings contribute to improved energy efficiency of thesis buildings?
ii. Is it financially / economically feasible to retrofit an existing commercial building within South Africa, in order to make it optimally energy efficient?
iii. What does the property industry understand by the terms energy efficient and energy retrofit, and
iv. How is the economic viability of an energy retrofit project measured?

The above questions have been answered through the reviewing of literature and the collection and analysis of data. The conclusions of the hypotheses have been discussed in detail below.

6.4 Validity of the Hypothesis

6.4.1 Hypothesis 1

Hypothesis 1 posited that completing a retrofit of an existing commercial building, in an economically efficient manner, would result in an improvement in the buildings energy efficiency.

The research findings from the case study indicated that through completing an energy retrofit a decrease in the quantum of energy a building consumes could be achieved (Graph 17). The case study indicated a payback period of 3.4 years could be achieved (Graph 20). This payback period fell within the acceptable parameters (of less than 5 years) which property professionals indicated that they required.

Hypothesis 1 is therefore accepted.

6.4.2 Hypothesis 2

Hypothesis 2 posited that property professionals operating within the South African market have a lack of understanding of the concept of energy retrofitting of existing commercial buildings.

The research findings indicated that although the majority of professionals felt that there weren't sufficient skilled labor in South Africa to effectively carry out an energy retrofit project (Graph 7), the research did indicate that the majority of respondents had been educated with regards to the concept of Green Buildings, and had a clear understanding of the terms energy efficiency and energy retrofit.

Hypothesis 2 is therefore rejected.

6.5 Conclusion

The primary objective of the research study was to gain a better understanding energy retrofitting within a South African context. The conclusions of the research finding have been detailed below.

6.5.1 The Concept of Energy Retrofitting in the South African Market

i. From the questionnaire it was ascertained that the majority of professionals surveyed did have an accurate understanding of the terms *energy efficiency* and *energy retrofit*. This was primarily felt to be as a result of the majority of professionals having undergone GBCSA training with regards to the concept of Green Building;

ii. Although the majority of professionals accurately understood the concept of energy retrofitting, it was concluded that the majority of professionals did not feel that there was sufficient skilled labor with the South African market to effectively carry out a successful energy retrofitting project.

6.5.2 The Economics of Energy Retrofitting

i. The exercise of retrofitting an existing commercial building could result in improved energy efficient of that building. This is measured by a decreased in the amount of MWh/month which a building consumes;

ii. The majority of professionals felt that energy efficient products cost significantly more than regular non-energy efficient products, and that in order to proceed with an energy retrofit a decrease in electricity consumption of at least 10% would be required;

iii. The majority of professionals further felt that completing an energy retrofit of an existing commercial building within South Africa can make economic sense and that a payback period of 2 – 5 years was found to be acceptable within the industry. The manner in which the payback period is however calculated is very subjective, and the payback period may differ slightly from person to person, as the discount rate applied will be determined by the consumers risk appetite (Jaffe *et al* 1994).

iv. It was further determined that the majority of professionals will perform an energy audit as well as a cost benefit analysis (CBA), prior to establishing the viability of the retrofitting project. The energy audit will not necessarily be completed in order to determine whether or not to proceed with an energy retrofit, but will rather assist in identifying which elements of the building should be focused on in the retrofit. A costs benefit analysis exercise will determine whether or not to proceed with an energy retrofit.

6.6 Recommendations

Based on the above research study and conclusions, there are a number of recommendation which have been made for further study. These recommendations are listed below.

i. A larger sample of professionals from across the country be obtained. This will allow the research to explore the trends in the data at a more vigorous level;

ii. Further research to be conducted into the implementation of energy retrofitting education programs of the layperson. Although from the above research it has been concluded that the concept of energy retrofitting is understood at a professional level, if not understood by the layperson, there will not be a demand from the market place for energy retrofitting technology to be implemented;

iii. Furthermore a study of the effect that energy retrofitting has on the rentals that a retrofitted building is able to achieve would be recommended. This would help to understand whether or not the energy retrofit is in fact improving the investment value of the property;

iv. Lastly it would be recommend that a study to identify which element of a building is most commonly identified by energy audit companies as the primary area to focus on.

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Annexure A: List of Power Stations Situated Within Southern Africa

Koeberg	: Nuclear Power Station
Acacia	: Gas Turbine Power Station
Arnot	: Thermal Power Station
Biomass Energy Ventures	: Thermal Power Station
Camden	: Thermal Power Station
Drakensburg Pumped Storage	: Hydro Power Station
Duvha	: Thermal Power Station
Gariep	: Hydro Power Station
Grootvlei Power Station	: Thermal Power Station
Hendrina	: Thermal Power Station
Ingagane	: Thermal Power Station
Kendal	: Thermal Power Station
Komati	: Thermal Power Station
Kragbron	: Thermal Power Station
Kriel	: Thermal Power Station
Lethabo	: Thermal Power Station
Majuba	: Thermal Power Station
Lethabo	: Thermal Power Station
Matimba	: Thermal Power Station
Matla	: Thermal Power Station
Palmiet	: Hydro Power Station

Source: www.mbendi.com/indy/powr/af/sa/p0005.htm

Annexure B: Official Letter Emailed to Questionnaire Participants

School of Construction Economics and Management

1 Jan Smuts Avenue, Johannesburg • P O Box 20, Wits 2050, South Africa • Tel: +27 11 717-7669/63 • Fax: +27 11 339-8175
E-mail: com@wits.ac.za

31st January 2012

Dear Participant,

STUDY ON RETROFITTING OF COMMERCIAL BUILDINGS

I am a post graduate student at the University of Witwatersrand, currently in the process of completing a Masters Degree in Project Management. For my research project I will be investigating retrofitting of existing commercial buildings for energy efficiency, with specific reference to the economic viability of the retrofit. The purpose of the attached questionnaire is to gain a comprehensive understanding of property professionals understanding / opinion of energy retrofitting and its economic viability.

As you are a professional in the property industry, I am extending an invitation to you to participate in this study and the prompt completion of the attached questionnaire will be highly appreciated.
The attached questionnaire will require approximately 10min – 15min to complete. All individual responses will be kept confidential and the information obtained will be used for academic purpose only.
Completed questionnaires should be returned via email to: **lombard.lesley@gmail.com**

If you would like to receive a copy of the consolidated results of the questionnaire, please indicate so on the form and I will ensure that the results are emailed to you as soon as they have been adequately reviewed.

This research questionnaire is being supervised by Professor Alfred Talukhaba of The University of Witwatersrand. Any questions or concerns regarding the questionnaire can be directly via email to: alfred.talukhaba@wits.ac.za

Thank you for taking the time to complete the questionnaire.

Kind Regards,

Lesley Lombard
lombard.lesley@gmail.com

Supervisor
Prof. Alfred Talukhaba
alfred.talukhaba@wits.ac.za

Annexure C: Questionnaire

University of the Witwatersrand
Faculty of Engineering and the Built Environment School of Construction Economics and Management
Research Survey   **An investigation into the energy retrofitting of existing commercial buildings within South Africa**   Done by: Lesley J. Lombard

Section 1: Demographic Background

Please select the most appropriate option:

1. 1. What is your academic qualification?

○	Bachelor Architectural Studies	○	Bachelor of Science (Engineering)
○	Bachelor of Commerce	○	Bachelor of Science
○	Bachelor of Science (Quantity Surveying)	○	Other Please Specify:

1.2. To which professional body do you primarily belong?

○	SAIA (Architect)	○	SAFMA (Facilities Manager)
○	SAACE (Consulting Engineer)	○	ASAQS (Quantity Surveyor)
○	ACPM (Project Manager)	○	SAIV (Property Valuer)
○	Other (Please specify):		

1.3. Current line of business:

○	Architecture	○	Facilities Management
○	Project Management	○	Property/Portfolio Management
○	Property Development	○	Quantity Surveyor
○	Other (Please Specify) ______________________		

1.4. Kindly indicate your current position in the company:

○	CEO	○	Manager
○	Director / Senior partner	○	Employee
○	Supervisor	○	Trainee
○	Other (Please specify) ______________________		

1.5. How many years have you been working in the commercial property industry?

○	< 3 years	○	11 - 15 years
○	3 - 5 years	○	> 15 years
○	6 - 10 years		

1.6. How many years have you been working retrofitting existing commercial buildings?

- ○ < 3 years
- ○ 3 - 5 years
- ○ 6 - 10 years
- ○ 11 - 15 years
- ○ > 15 years

1.7. Are you an accredited *Green Professional* ?

- ○ Yes
- ○ No

If yes, what do you feel are the benefits associated with being registered as a green professional?

___

___

___

If no, why not? ___

___

___

___

1.8. How many energy retrofitting projects have you been involved in?

- ○ 0
- ○ 1 - 2
- ○ 3 - 5
- ○ 6 - 10
- ○ > 10

Section 2: Retrofitting and Energy Efficiency

2.1. Which phrase do you feel best describes the term "energy retrofitting"?

- ○ The process of modernising an old building to make the building appear newer
- ○ The process of replacing the light fittings / fixtures within an existing building
- ○ A renovating exercise which alters some physical aspects of an existing building
- ○ A renovating exercise which aids in reducing the amount of energy a building consumes
- ○ Other: Please specify ____________________

2.2. Please indicate which elements of a building you feel should take priority in the energy retrofitting exercise?

1 = First priority

2 = Second priority

3 = Third priority

4 = Fourth priority

5 = Fifth priority

6 = Should not be retrofitted

	Insulation
	HVAC
	Lighting equipment
	Windows / Double glazing
	Roofing

2.3. The primary reason for retrofitting an existing commercial building is:

- ○ Social responsibility
- ○ It's the "in thing" (Marketing)
- ○ I wouldn't retrofit
- ○ Green building rating
- ○ Reduction in energy consumption
- ○ Reduction in carbon footprint
- ○ Other: Please Specify ____________________

2.4. What do you view as the negative factors associated with the retrofitting an existing commercial building:

- ○ There are no negative factors
- ○ These are the following negative factors (please list): ____________________

2.5.What definition do you feel most accurately defines the term "energy efficiency"?

- ○ The process of utilising less energy
- ○ The process of effectively using energy
- ○ A reduction in your energy bill
- ○ Other: Please specify: ____________________

2.6. What to do you consider to be the most effective way to measure energy efficiency?

____

____

Please rate the following according to whether or not you agree with the statement.

2.7. There are sufficient professionals in South Africa, with the knowledge and skill set, to effectively meet the demand for energy retrofitting of existing commercial buildings. ◉

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

Section 3: Physical Attributes of a Retrofitted Building

3.1. Do you agree with the following statement: *"Retrofitting an existing commercial buildings will automatically result in a reduction in energy consumption".* ◉

○ Yes. Why? ____

○ No. Why? ____

○ I don't know

Please rate the following according to whether or not you agree with the statement.

1 = Strongly agree

2 = Agree

3 = Neutral

4 = Disgree

5.= Strongly disagree

3.2. The following factors are felt to affect an employees productivity and improving it should be given priority in a retrofit:

Lighting levels ◉

○ 1	○ 2	○ 3	○ 4	○ 5

Air quality ◉

○ 1	○ 2	○ 3	○ 4	○ 5

Heating / cooling ◉

○ 1	○ 2	○ 3	○ 4	○ 5

3.3. How important are the following areas with regards to achieving the goal of energy efficiency when retrofitting a building:

Please rate the following according to their importance:

1 = Extremely Important

2 = Very Important

3 = Important

4 = Semi Important

5 = Not Important

Insulation of walls

○ 1	○ 2	○ 3	○ 4	○ 5

Double Glazing

○ 1	○ 2	○ 3	○ 4	○ 5

Roofing

○ 1	○ 2	○ 3	○ 4	○ 5

Lighting

○ 1	○ 2	○ 3	○ 4	○ 5

Comment: What types of lighting technology should take priority: ____________________

____

____

Comment: What types of lighting are primarily used in an energy retrofit? ____________________

____

____

____

Section 4: Pre-retrofit Process

Please indicate on the *rating scale* whether or not you agree with the following statement.

4.1. Prior to an energy retrofit being performed, it is necessary to carry out a comprehensive energy audit

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

Please indicate on the *rating scale* whether or not you agree with the following statement.

4.2. The results of an energy audit determine the decision whether of not to retrofit.

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

Please indicate on the *rating scale* whether or not you agree with the following statement.

4.3. The results of an energy audit determine the elements of a building which should be retrofitted.

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

4.3.1. Based on the answer above - what impact do you feel an energy audit would have on an energy retrofit?

____

____

____

Section 5: Economic Aspects of a Retrofit

Please indicate on the *rating scale* whether or not you agree with the following statement.

5.1. There is currently a wide range of products available in South Africa to effectively carry out an energy retrofit

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

5.2 Compared to the industry standard, sustainable building material is considered to cost;

○ Significantly less
○ Marginally less
○ The same
○ Marginally more
○ Significantly more

Please indicate on the *rating scale* whether or not you agree with the following statement.

5.3. Prior to an energy retrofit it is imperative that a cost vs. benefit exercise be performed

○ 1	○ 2	○ 3	○ 4	○ 5
Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disgree*

5.4. Which method do you feel is most appropriate to be utilised in order to measure the economic viability of an energy retrofit?

○ Net Present Value (NPV)
○ Internal Rate of Return (IRR)
○ Discounted Cash Flow (DCF)
○ Cost Benefit Analysis (CBA)
○ Other: Please specify: ____________________

5.5. How do you gauge economic viability? ____________________

____

____

5.6. What percentage reduction in energy utilisation would justify an energy retrofit?

○ < 5% reduction
○ 5 - 9% reduction
○ 10 - 15% reduction
○ >15% reduction
○ No reduction required. The associated social benefits are sufficient

5.7. In order to make an energy retrofit project feasible, the capital spent on retrofitting an existing commercial building should be recouped in a minimum of:

○ < 2 years
○ 2 - 5 years
○ 6 - 10 years
○ 11 - 15 years
○ > 15 years

5.8. What are the most important things to consider when making the decision to retrofit an existing commercial building: Please rank the following according to their importance:

1 = Extremely important
2 = Very important
3 = Important
4 = Semi Important
5 = Irrelevant

	Capital Cost
	Pay back periods
	Resultant reduction in operating costs
	Social benefits
	Green building rating post energy retrofit

5.9. In your opinion, a commercial building which has been retrofitted will:

○ command a lower net rental
○ command the same net rental
○ positively affect the net rental achievable by a maximum of 5%
○ positively affect the net rental achievable by between 6 - 10%
○ positively affect the net rental achievable by > 10%

Thank you for taking the time to complete this questionnaire. ◉

Please indicate if you would like the summary results of the questionnaire to be emailed to you.

○	Yes	○	No

If yes: Please kindly provide me with an email address:

Email address: ______________________________________

Section 6: General Comments

Please add any general comments or feedback with regards to any aspects relating to energy retrofitting which you feel has not been covered in this questionnaire.