EVALUATING ENERGY EFFICIENCY IN BUILDING CONTROL REGULATIONS IN LOCAL AUTHORITIES IN SOUTH AFRICA

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A dissertation submitted to the Faculty of Engineering and The Built Environment, University of the Witwatersrand, Johannesburg in fulfilment of the requirements for the degree of Master of Science in Building.

Johannesburg, August 2012

DECLARATION

This dissertation is submitted under the University of Witwatersrand Regulations in fulfilment of the requirements for the degree of Master of Science (Building). It is partly based upon research that has been published prior to this submission. Below are the full details of the publications:

1. Wafula, J.E. and Talukhaba, A.A. (2011) Re-writing local authorities building control regulations to foster energy efficiency in the built environment in South Africa: The case of Ekurhuleni Metropolitan municipality. Proceedings of RICS-COBRA Research Conference, University of Salford, UK. 12-13 Sept 2011.
2. Wafula, J.E., Aduda, K. and Talukhaba, A.A. (2011) Energy efficiency in buildings and building control regulations in South Africa (in Adshead J.) (Ed), Green Building and the Law, Spon Press, New York, USA.
3. Wafula, J.E. and Talukhaba, A.A. (2010) Retrofits/renewals in building for energy efficiency and the building control regulations in local authorities in South Africa. Proceedings of RICS-COBRA Research Conference, Dauphine Universite, Paris. 2-3 Sept 2010.
4. Wafula, J.E., Aduda, K. and Talukhaba A.A. (2009) Energy efficiency in buildings and building regulations and control in local authorities in South Africa. Proceedings of RICS-COBRA Research Conference, University of Cape Town, South Africa. 10-11 Sept 2009

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Date: August 2012

ACKNOWLEDGEMENTS

I would like to acknowledge my supervisor, Professor Alfred A. Talukhaba for his patience and guidance during this work. I would also like to offer my sincere gratitude to members of staff and fellow students at the School of Construction Economics and Management for their support, encouragement and kindness.

To all my friends, thank you for the encouragement during this period- it enabled me to complete this dissertation. Above all else, God has been kind to me.

DEDICATION

This dissertation is dedicated to my wife Dorine and children Geremy and Kimberly.

ABSTRACT

More than one-third of energy is used in buildings worldwide, accounting for about 15 percent of global greenhouse gas emissions. In cities, buildings can account for up to 80 percent of CO_2 emissions. The built environment is therefore a critical part of the climate change problem and conversely, a solution. Additionally, most existing buildings were not designed for energy efficiency. In South Africa, buildings account for 27% of electricity use and 12% of the final energy use. Improving the energy efficiency of buildings is very important to reducing greenhouse gas emissions, lowering energy costs and ensuring energy security.

The South African developmental Local Government paradigm makes local authorities the focal points of implementing the various regulations, standards and codes for energy efficiency in buildings set by the national and provincial governments. The Local authorities are mandated by statute to make by-laws to supplement the national building regulations for the effective operation of the building control function. The use of Energy Efficiency regulations is a very effective strategy of achieving energy consumption reduction in buildings. Four generations of energy efficiency codes and standards for buildings in the US have produced estimated energy efficiency improvements of about 60% over 30 years. The Energy Efficiency Strategy of South Africa calls for a mandatory regulatory regime, integrated into the National Building Regulations so that local authorities can implement it through their building control regulations.

This research evaluated energy efficiency measures implemented through the building control regulations in the key metropolises of greater Johannesburg. Significantly, it investigated the formulation and implementation of Energy Efficiency Building Standards/Codes through the building control regulations to achieve energy efficiency in building developments under municipal jurisdictions. The study is based on a mixed methods research approach consisting of documentary review, structured questionnaires and semi-structured field interviews. The analysis was based on the key themes of investigation; the importance and awareness of energy efficiency measures in buildings, implementable energy efficiency measures through the building control regulations and the integration of energy efficiency building standards/codes in the National Building Regulations.

The key finding is that the lack of a definitive legal requirement of energy efficiency measures in the national building regulations impedes the formulation and implementation of an effective energy efficiency programme through the building control mechanisms in local authorities. The main recommendation is that the proposed energy efficiency building standards/codes should be operationalized as soon as possible to provide a legal framework for the energy efficiency programmes in buildings through the building control processes, provide a foundation for the development of market transformation measures which complement the regulations and set the stage for the implementation of next generation energy efficiency measures like Zero energy buildings.

ABBREVIATIONS, DEFINITIONS AND TERMINOLOGIES

Appliance Labelling	Labels Denoting Energy consumption of Appliances
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
Co_2	Carbon dioxide
CSIR	Council for Scientific and Industrial Research
DEA	Danish Energy Agency
DEAT	Department of environmental Affairs and Tourism
DME	Department of Minerals and Energy
DNA	Designated National Authority
DPW	Department of public works
DoH	Department of Housing
DSM	Demand Side Management
EC	European Commission
ECSA	Engineering council of South Africa
EE	Energy efficiency, achieving the same or improved output with a reduced input of energy

Energy Intensity: Energy use per unit of output or activity.

EPA	United States Environmental Protection Agency
EPBD	European Union Energy Performance for Building Directive
ESCo	Energy Service Company
GDP PPP	Gross Domestic Product Purchasing Power Parity
GHG	Green House Gases
GW	Gigawatt (10^9 watts) unit of electric power
HVAC	Heating, Ventilation and Air Conditioning
IEA	International Energy Agency

IEP	Integrated Energy Plan
IPCC	Intergovernmental Panel on Climate Change
KWh/m^2	Kilo Watt hour per Square Meter
LED	Light Emitting Diode
MW	Mega Watt
NERSA	National Energy Regulator of South Africa
NEEA	National Energy Efficiency Agency
OECD	Organisation for Economic Co-operation and Development
PJ	Peta Joule
RDP	Reconstruction and Development Programme
REDs	Regional Electricity Distributors
SABS	South African Bureau of Standards
SAEDES	South African Energy and Demand Efficiency Standards
SAEE	South African Association for Energy Efficiency
SANS	South African National Standard
SAPOA	South African Property Owners Association
SO_2	Sulphur Dioxide
STANSA	Standards South Africa
StatsSA	Statistics South Africa
Toe	Tons of oil equivalents

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Chapter 1 : INTRODUCTION

This research was motivated by the need to reduce energy consumption in buildings which would subsequently cut GHG emissions and reduce energy costs and ensure security of supply. The four factors above are also the main drivers of the energy efficiency (EE)[1] agenda in South Africa. This is because South Africa's electricity sector is highly carbon intensive and suffered supply constraints in 2006/2007 due to low production reserve. Additionally, the main national electrical energy supplier – Eskom, has applied and got approval to raise electricity tariffs for consumers by more than 100% between 2010 and 2013. Therefore, to effectively address its energy problems, South Africa must undertake electricity demand reduction via the practice of energy efficiency. The use of EE regulations is an effective strategy used in achieving energy consumption reduction in buildings. Four generations of energy efficiency codes and standards for buildings in the US have produced estimated energy efficiency improvements of about 60% over 30 years.

This chapter introduces the research and the energy situation in local authorities in South Africa. It also defines the research and shows how it is structured. The chapter is divided into nine sections. The first section presents the context of the research. Section two covers background information on energy efficiency studies, energy and the electricity situation in South Africa and goes on to identify key concerns in the sector. The third section gives the problem statement and the fourth section explains the research objective. Section five asks the research question whereas section six gives the hypothesis. The seventh section gives the delimitation of scope and section eight covers the significance of the research. Section nine presents the structure of the dissertation.

1.1 The Context

The first South African Energy Efficiency Strategy review of 2008, which drew its mandate from the white paper on energy policy of 1998 aimed to link energy sector development with National

[1] EE in this dissertation means energy efficiency.

socio-economic development plans (DME, 2008). It set to reduce the necessity for additional power generation capacity by making energy efficiency an integral part of managing electricity shortage. It recognized that the number one barrier to energy efficiency was the priority level it commanded vis-à-vis the other competing needs of the Nation like quality of life and education. However, it singled out energy efficiency as an integral element in providing solutions to the other national problems. It stated:

> "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." (The white paper on energy policy, 1998)

Further, the review showed that specific energy usage could be reduced by up to 35% cost-effectively over 20 years if accompanied by effective policies. It stated that in the US, the electric Power Research Institute had proposed an energy efficiency target of 2% per annum (DME, 2008). It proposed an overall target final energy demand reduction of 12%. The building sector had final targets of 20% reductions for commercial and public buildings and 10% reduction for residential ones. For this reduction targets to be achieved, the strategy called upon the minister responsible to invoke the powers bestowed by the act and effect mandatory energy efficiency standards as the key to implementation success.

In South Africa, the developmental local government[2] is enshrined in the Constitution, which sets out the basic socio-economic and environmental rights for all South Africans. The allocation of responsibilities across the spheres of government mean that some of the most important services, like access to electricity and environmental health, amongst others, fall in the jurisdiction of local Authorities (White Paper on Local Government, 1998). The democratically elected government in South Africa further introduced a system of developmental local

[2] The term ''Local government'' is used interchangeably with municipalities, Municipal authorities, and local authorities

authorities for building more equal and just cities and towns. There are 284 ‘wall –to- wall’ municipalities in South Africa, consolidated through the Municipal Structures Act (Act 117 of 1998) - a legacy of uneven economic development focusing on the growth of mineral-energy complex (MEC) and related industrial activities and the ports. This created some 17 cities and towns amongst these municipalities forming the backbone of the South African economy (Luus &Krugell, 2005). This handful of cities and towns contribute some 70% to national GDP and accommodate nearly half the national population, while occupying 3% – 4% of land area. Developmental local government aims at local economic growth amidst a dwindling fiscal base and globalization pressurizing municipalities to create internationally competitive locations for business and households. It means local governments have to go beyond merely supplying basic services and infrastructure (Luus & Krugell, 2005).

Local authorities in South Africa therefore take their obligation and responsibility (mandate) to tackle a wide range of energy issues; notably access to clean, reliable, affordable, safe and efficient energy from the South African Constitution, the White paper on Local government, Municipal structures Act and legislation such as the National Environmental Management Act.

Significantly also, South Africa is a signatory to a number of international summits and agreements like the Kyoto protocol, the Millennium Development Goals and the Johannesburg Plan of Implementation which relate directly or indirectly to energy management. These agreements, though not directly devolved to the local authorities by the national government, are expected to be coordinated, implemented and delivered by the local authorities (SEA, 2006).

Local authorities control land use policies, they determine where buildings and developments should be located, as well as the ensuing mobility needs and the mix of uses that are allowed - this in turn affect energy use (SEA, 2006). Local authorities have regulatory influence and responsibility over building codes, which determine the energy efficiency of the building stock. With challenges of greater energy efficiency within industry, high-income high-energy consuming households, commercial and public buildings, local governments will have to use mechanisms such as stepped-up tariffs, information awareness and energy efficiency building regulations and by-laws. The national energy bill became law in October 2008. Among other things, the law allows the Minister for Energy to make regulations on energy efficiency by giving notice in the Gazette. Also, the SANS 10400XA and SANS 204: Edition 1 Parts 1 – 4 will become mandatory for buildings in the next 12 months once they get promulgated. It is proposed that Local Authorities use mandatory national standards and labels for both new and existing buildings, carry out audits for energy efficiency and post the information in the entry foyers of the respective buildings (SEA, 2008b).

Energy efficiency is relatively a new focus area for local authorities, but they have a mandate to act on it because of energy demand management policy requirements of the national government, sustainable development and climate change. The national electricity generation crisis of 2006/2007 increased awareness around the topic of energy efficiency and made the Department of energy to start a Municipal energy efficiency Programme (DME, 2008). This programme allowed local authorities to use new connections authorizations to integrate energy efficiency requirements in new developments. These EE measures would eventually become part of their building control regulations standards/codes[3] requirements for all developments under their jurisdiction. Local authorities like Cape Town and Johannesburg have been revising their building regulations by-laws to incorporate energy efficiency requirements while awaiting the enactment of national energy efficiency building standards. This research addresses the formulation and implementation of energy efficiency building standards in local authorities in the context of demand side energy efficiency management policy in buildings.

1.2 Background on energy efficiency principles

Up to the time of the oil embargo instituted by the organisation of petroleum exporting countries (OPEC) in the 1970's, the world worried minimally about energy resource utilisation. Due to the scarcity of supply and increase in the price of oil, several countries started looking critically at energy efficiency as a way of foregrounding additional energy resources for use (Matsugawa et al., 1993). Other factors that motivate energy efficiency studies include the constantly increasing

[3] The words standard and regulation are used interchangeably and may also refer to codes, criteria, guidelines, norms, laws, protocols, provisions, requirements or rules. Depending on the context, the standard or regulation may be contained in one document, be part of another larger document (such as a National Building Code), or consist of several documents.

prices and insatiable demand for existing energy resources, stiff competition for the available energy resources, improvement of health of people currently experiencing poor indoor air quality (through the use of biomass) and the threat of global climate change.

Recent reports on global warming show that by international standards, South Africa's economy is extremely energy intensive in terms of energy consumption in relation to its Gross National Product (UNDP, 2007). The national energy intensity of south Africa stood at 3.3 times the average in OECD countries in 2000 (Praetorius and Bleyl, 2006), yet South Africa's energy consumption per capita is only half of the average consumption in OECD (Sebitosi, 2008). Moreover, despite its relatively low GDP (52^{nd} in the world) and low human development index (121^{st} in the world), South Africa has considerably high greenhouse gas emissions (37^{th} in the world in overall carbon dioxide gas emissions (UNDP, 2007). It should be noted that over 79% of South Africa's electricity is derived from coal (DME, 2005) which is a high source of carbon dioxide emission. As such, any reduction in electricity demand would highly impact on the carbon dioxide emission levels.

Table 1:1 Energy Consumption Indicators

Country/Region	**Total primary energy (toe) supply (TEPS) Per Capita**	**Total Primary Energy (toe) Per GDP**
South Africa	2.15	0.63
Africa	0.64	0.86
South Korea	4.10	0.31
Indonesia	0.69	0.70
Non-OECD	0.96	0.74
OECD	4.78	0.19
World	1.67	0.30

Source: IEA, 2002: Key World Energy Statistics

Additionally, studies conducted by the International Energy Agency (IEA) noted that 30% to 40% of the world's total energy is used in buildings (IEA, 2005). Any reduction in the amount of energy consumed by buildings would therefore reflect greatly on the total global energy consumption. Furthermore, other studies released show that energy efficient buildings are one mitigating solution that not only reduces carbon emissions, but is at the same time the least expensive and most cost-effective solution of all (Malanca, 2008).

The built environment includes the buildings in which the people live and work, and the spaces and infrastructure in cities, towns and villages. It is where most human activity takes place, where most energy services are used, and where many of the advantages and disadvantages of energy use arise. (Wilkinson et al., 2007). The world is becoming increasingly urbanised. In 1950, only 30% of the world's population lived in urban areas. Currently, the proportion has increased to about 50% (United Nations, 2001). Net population growths of the next few decades will nearly all occur in the urban centres of developing countries (Flood, 1991). This urban and industrial development will be accompanied by growing demands for energy and rising expectations of material goods (Wilkinson et al., 2007).

In South Africa, the built environment takes up to 21% of the total energy consumption (DME, 2005). The Energy Efficiency Strategy (DME, 2005) sets the target for 15% reduction against the projected energy consumption by 2015. Studies show that low-cost and medium-cost technical interventions in this sector can reduce energy consumption by 25% - 30% (Grobler and Singh, 1999).

The London based Chartered Institution of Building Services Engineers (CIBSE) defines an energy efficient building as that which provides the required internal environment and services with minimum energy use in a cost effective and environmentally friendly manner (CIBSE, 2004). The buildings sector is defined as including the construction and management of residential and commercial, but not industrial buildings.

Further, energy efficiency means receiving the same performance from a product or a process with less energy input, or receiving higher performance with the same energy input (UNEP, 2007 and EPA, 2003). Energy efficiency can also be defined in monetary terms in which case it will mean providing the same output but in a more cost effective way. In this research, the definition will be using less energy (minimize input) without compromising the scale of operations (maximize output). This can be achieved by reducing unnecessary energy consumption (waste) and replacing inefficient equipment with more efficient equipment technologies, which permanently reduces consumption during all operating periods. Load management in a building means that you remove the peak demands into periods of lesser demand. This brings about costs savings, since energy prices are often higher during peak hours, but not necessarily energy efficiency (Reinink, 2007).

The case for energy efficiency is well captured in the following comments; *"These 'negawatts' (contributed by energy efficiency) have been every bit as valuable in economic terms as the 'produced watts' of energy they replaced. With today's energy prices, a negawatt of energy savings costs about half of what it costs to produce the same amount of energy. The cheapest, most competitive, cleanest and most secure form of energy thus remains saved energy."* (Andris Piebalgs, 2008)

Studies have shown that developing national regulations and standards for building's energy efficiency and/or sustainable buildings is one critical way of achieving energy efficiency and can contribute significantly to GHG emissions reductions and ensure energy security (du Toit 2007, Reinink, 2007). It also makes sound economic/financial sense (Bennett, 2001).

The South African national building regulations and building standards Act (Act no 103 of 1977) is administered by local authorities and it is the enabling legislation for the national building regulations (Holden, 2004). It provides in great detail the process of enforcing the national building regulations by local authorities. Cities, municipalities and local Authorities are therefore mandated to enforce building regulations established by national government (du Toit, 2007). This is because all new building plans have to go through their building control and approval departments before they are implemented. This provides an important opportunity to intervene and prescribe regulations for energy efficiency in the building control and approval process of the local authorities. Additionally, they are permitted to make by-laws within their areas of jurisdiction, and this option can be used to effect regulations for retrofits in the respective local authorities. Today, available commercial technologies make it possible to halve energy consumption in both new and old buildings without significant investments (UNEP, 2008).

Measures like improved ventilation and insulation, increased use of natural lighting, the use of energy efficient appliances and lighting alongside the use of renewable energy sources, which account for 90% of energy use during the lifetime of the buildings, can easily be incorporated in the building control and approvals regulations process without significant extra costs (WGBC, 2009). An energy efficiency policy, which is anchored into the building control and approvals regulations of the various local authorities, if well enforced, will make a definite and an effective starting point in achieving the goals of reduction in GHG emissions and ensuring energy security as well as economic benefits for building developers. This research makes this among other recommendations as one of the changes required to achieve EE through the building control departments of the local authorities.

1.3 Problem statement

Two legacies of south Africa's past, which pose significant challenges to sustainable development in the country are; entrenched economic inequality caused by the apartheid system; and the energy intensive nature of the economy, built up on the back of cheap coal and natural resources to create a competitive industrial strategy based on cheap energy (WBCSD, 2008). This has meant that South Africans have taken energy for granted and ignored the most cost effective and plentiful form of new energy in the world – energy efficiency. This means that there is need for discussions on measures which integrate energy efficiency practices in all development activities.

The South African energy efficiency strategy calls for a mandatory regulatory regime, to consolidate the gains made and achieve improvements in the mostly voluntary EE programmes for buildings now in use. The above strategy draws its mandate from the following documents, the Energy Act of 2008, the South African Constitution; the White Paper on Energy Policy, 1998; the Municipal Systems Act No.32 of 2000; the Electricity Act No.41of 1987 (as amended), the Standards Act and the Electricity Regulation Act. For example, commercial and public buildings consume 7% of energy and contribute 45% to national GDP. To achieve energy use reduction, energy efficiency mechanisms should be integrated into building design and energy efficient technologies should be introduced in existing buildings (DME, 2005). This can be effectively done through building control regulations. In the residential sector, it is proposed that the standard for energy efficient housing be made mandatory; and be incorporated into the national building regulations, so that the local authorities can implement it through their building control regulations (DME, 2008). The availability of reliable information which can be used to operationalize the above strategy is therefore important.

Eskom produces 95% of the electricity in South Africa (Reinink, 2007). As shown in the Energy Efficiency Strategy, the existing power generation capacity will be insufficient to meet the demand between 2007 and 2012 (DME, 2005). South Africa will experience serious energy supply problems unless a new energy policy is implemented (Eberhard, 2004). Operational generating capacity in South Africa currently stands at just over 37000 MW and the electricity demand is estimated to be growing at 1000 MW per annum (Nortje, 2005). Current energy efficiency and demand side management targets are for approximately 150 MW per annum, which gives a net growth of about 850 MW a year, outstripping national supply capacity around 2006/2007. This will affect future energy costs in South Africa, as Eskom has already started increasing tariffs to meet the cost of new production capacity and the distribution network to be able to deliver adequate electrical energy to consumers in the future. This requires research to be done to find effective energy efficiency strategies for the various sectors of the economy which will ultimately add up to the national EE strategy to be implemented.

Different countries adopt different strategies to achieve energy efficiency (Mahlia, 2002). As a rule, in the countries where considerable success has been made, laws to enforce or guide these energy efficiency policies and strategies were always put in place (WEC, 2004). Whereas the enactment of legal instruments alone may not entrench and achieve energy efficiency in buildings, there is no known case where the efforts have succeeded without legislation; as seems to be happening in South Africa (Sebitosi, 2008). It is noted that in South Africa, specific legislation and regulations regarding energy efficiency in buildings do not exist (Reinink, 2007). In 1997, the DME started with the development of the 'South Africa energy and demand efficiency guidelines (SAEDES)' for new and existing commercial buildings (DME, 1998b), whose pilot study indicated that the guidelines required an empowering legislation (read regulations) to make it effective (Parsons, 2004). It is important to interrogate the above efforts and establish the progress on this legislation hitherto.

The strategies of the National government and the NERSA on energy efficiency have local authorities playing a central role both on energy efficiency and DSM. The missing link is the sustained implementation support from the national government to the local authorities to fulfill this mandate (SEA, 2006). The formulation and implementation of a mechanism which puts energy efficiency building codes (EEBSCs)[4] in the building control process of local authorities requires reliably researched information.

It will take a minimum of five years before energy efficiency is addressed by means of the national building regulations, and this will also entail changes to the national building regulations and building standards Act (Holden, 2004). This is because section 17 of the Act, which establishes the framework within which the minister may make regulations, revolves around administrative matters, the protection of property and public health, safety and convenience for the users and occupiers of buildings, without any reference to energy efficiency; hence the formulation of energy efficient building by-laws by local authorities is worth pursuing and this research is one such effort.

Lack of a clear government institution in-charge, coupled with lack of a regulatory framework, is a barrier to implementation of a sound energy efficiency policy (Bennett 2001). The presence of an institution and a sound regulatory framework will enhance the ownership of the energy efficiency program and make it successful in terms of policy, advocacy and research, capital investments and competitiveness. There are countless examples of companies that have made significant financial and energy savings by introducing energy efficiency programs (Bennett, 2001), yet one still has to question why the adoption of these measures has not been universal, the answer could be found in the lack of an enforceable regulatory framework. Therefore efforts should be made to inform the establishment of such a regulatory framework.

The National government is in the process of adding energy efficiency regulations to the National Building Standards, and legal opinion is being sort on how to do it quicker to enable the DME meet its policy commitments regarding energy efficiency targets. In the absence of national regulatory powers, cities can consider developing local guidelines or standards. For

[4] EEBSCs; this means Energy Efficiency Building Standards/Codes.

uniformity and acceptability, these should ideally be based on existing standards and norms and best practices from similar jurisdictions. Research is needed to provide information which can be used to develop the above mentioned regulations and guidelines at the local authority level.

1.4 Research objective(s)

The main objective of the research was to investigate the implementation of energy efficiency principles through the building control regulations in local authorities and recommend measures which will integrate EE principles in the process. This entailed:

1) The evaluation of the building control and approvals process of the local authorities in respect of energy efficiency policies and regulations,
2) An investigation of the general and energy efficiency building regulations,
3) Reviewing the existing levels of application of energy efficiency measures in the building development process and propose areas of improvement to achieve widespread implementation.
4) Make recommendations which will integrate the implementation of energy efficiency principles in the building control regulations of local authorities and add to the body of knowledge on energy efficiency in the built environment.

1.5 Research question

The key research question therefore was:

How are the local authorities using building control regulations procedures to integrate energy efficiency principles in the building sector? The following sub-questions arose from the main research question:

1) What are the energy efficiency principles and policies (regulations) which the local authorities can implement through their building control and approvals procedures and processes?
2) How are the local authorities applying and/or enforcing energy efficiency regulations during the approvals process for developments through their building control procedures?

3) How can the local authorities use their building control regulations to make it the norm for all the building developments in their jurisdictions to construct/build and/or refurbish/retrofit for energy efficiency?

1.6 Hypothesis

The research hypothesis is that: Mandatory energy efficiency standards integrated into the building control regulations of the local authorities are critical to achieving the goal of Energy efficiency in the built environment in South Africa.

1.7 Delimitation of Scope

This research was singularly concerned with the integration of energy efficiency regulations/standards in the building control processes and procedures of the local authorities.
It was not an attempt to make regulations/standards. Rather, it investigated/evaluated existing regulations/standards and their implementation in selected precedent cases. Focus was on the main metropolis areas from which data was readily available and where additional information was accessed with minimal resources in terms of time and financial costs.

The research did not cover the broader environmental or social-economic issues often associated with energy efficiency studies. This research did not evaluate the technologies or interventions, or their effectiveness regarding energy savings. It solely focused on the processes and procedures of formulating and implementing the regulations/standards. Similarly, no attempt was made to determine if the metropolises chosen for research actually contributed to effective improvement in energy efficiency or overall energy savings in the respective jurisdictions.

1.8 Significance of the research

The energy efficiency strategy of South Africa proposes that energy efficiency be taught and examined at all levels in appropriate subjects, especially engineering and architecture, besides making it a competence requirement under the national qualifications framework training programmes for skilled workers in the relevant construction and building services trades (DME 2008). This research actualizes this proposal.

This research will also add to and consolidate knowledge relating to energy efficiency in the built environment in South Africa. Further, the results will have the potential for incorporation in energy efficiency regulations for buildings. South Africa is currently making efforts to improve its energy efficiency status. In order to meet future demand, an effective energy efficiency strategy is likely to be a cost effective alternative to developing new power plants. This study is in line with South Africa's need for long term solutions towards attaining sufficiency and sustainability in the energy sector.

1.9 Structure of the dissertation

This research is arranged into seven chapters namely introduction, literature review (two chapters), methodology, presentation of results, discussion and conclusions & recommendations.

Chapter one covers the introduction, giving a background to the study and the core issues (like objectives, research questions and scope) underpinning the research. Chapter two and three present the literature review. The two chapters explore the objectives of the study through document reviews. Chapter four covers the methodology. The chapter presents selected methods and the methodological framework used in the study. Chapter five presents the findings; it gives a summarised outcome of the field studies. Chapter six discusses the findings arising from the previous chapters interpreting the meanings associated with the various issues raised during the study. Chapter seven gives the conclusions and recommendations of the research. It summarizes the study findings, suggests implications and makes recommendations. The Sections containing references and appendices appear at the end of the thesis.

Chapter 2 : ENERGY USE AND ENERGY EFFICIENCY POLICY IN BUILDINGS

2.1 Introduction

This chapter presents an overview of energy use in buildings, energy efficiency policies and regulations, building control regulations and how local authorities implement building control regulations in areas under their jurisdiction. It presents a general world view as well as the South African case. It explains how building control regulations have evolved over time and are now used for far more requirements in buildings than the initial health and safety. Energy efficiency regulation is one such additional use.

The chapter discusses the importance of energy efficiency policies and legislation in buildings, their implementation and barriers to their use. Additionally, it explains the role of the local authorities in the implementation of the energy efficiency regulations in buildings.

The chapter is divided into nine (9) sections. Sections 2.1 - 2.5 present's introduction, energy use in buildings, energy production and use in South Africa, building regulations standards/codes and building regulations in South Africa respectively.

Section 2.6 discusses local authorities and building regulations implementation. Section 2.7 covers energy efficiency policies and regulations for buildings. Section 2.8 discusses barriers to Energy efficiency intervention measures in buildings and Section 2.9 gives the conclusions to the chapter.

2.2 Energy Use in Buildings

Buildings account for between 30% and 40% (Figure 2.1) of the total end use energy (Laustsen, 2008). In the residential and commercial sectors, the major part of the energy consumption takes place in buildings. This includes energy used for controlling the climate in buildings and for the erection of buildings themselves, energy used for appliances, lighting and other installed equipment (Laustsen, 2008). Additionally, a small fraction of energy consumed in other sectors is attributable to buildings. An example is the case of administration buildings in manufacturing industries, agriculture and forestry.

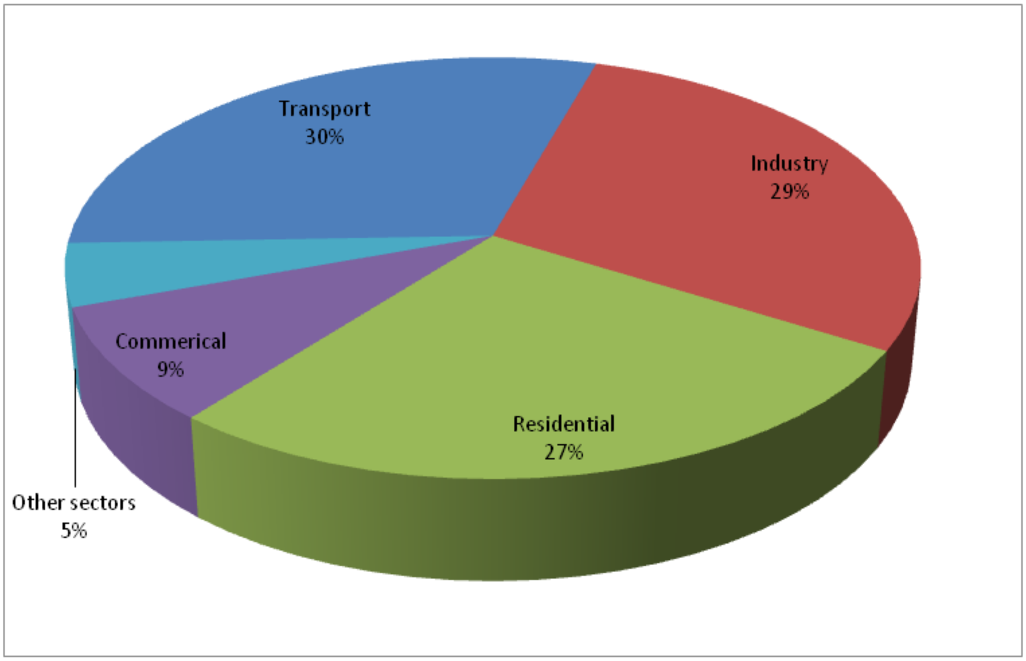

Figure 2.1: Energy Consumption in different sectors

Source: (IEA, 2007)

Residential buildings use more energy compared to non-residential ones. In developing countries the former accounts for up to 90% of primary energy use in the sector (UNEP, 2007; Earth Trends, 2005). However the actual amounts vary according to geographical location, economic development and cultural orientation. This is illustrated in Figure 2.2. Given the many possibilities to substantially reduce buildings' energy requirements, the potential savings of energy in the building sector would greatly contribute to a society wide reduction of energy consumption.

2.2.1 Energy Use in Different Building Types

Subdivision of energy consumption can be particularly difficult in the cases of electricity, where air-conditioners, appliances, lights, pumps and heating installations all often draw electricity from the same metering. Natural gas, too, can serve several end uses at once, including heating, cooking, and the provision of sanitary hot water.

Given the difficulty in subdividing buildings' energy requirements and the use of different fuel types, most analyses examine energy use in building as defined by end-use: space heating, cooling, cooking, etc. The differences in use of energy will be due to uncertainties and it will vary with different types of buildings, the age and use of the buildings and climatic conditions. Overall, a subdivision of energy consumption in residential buildings gives the best illustration of differences of energy use in buildings because it is the most homogenous type.

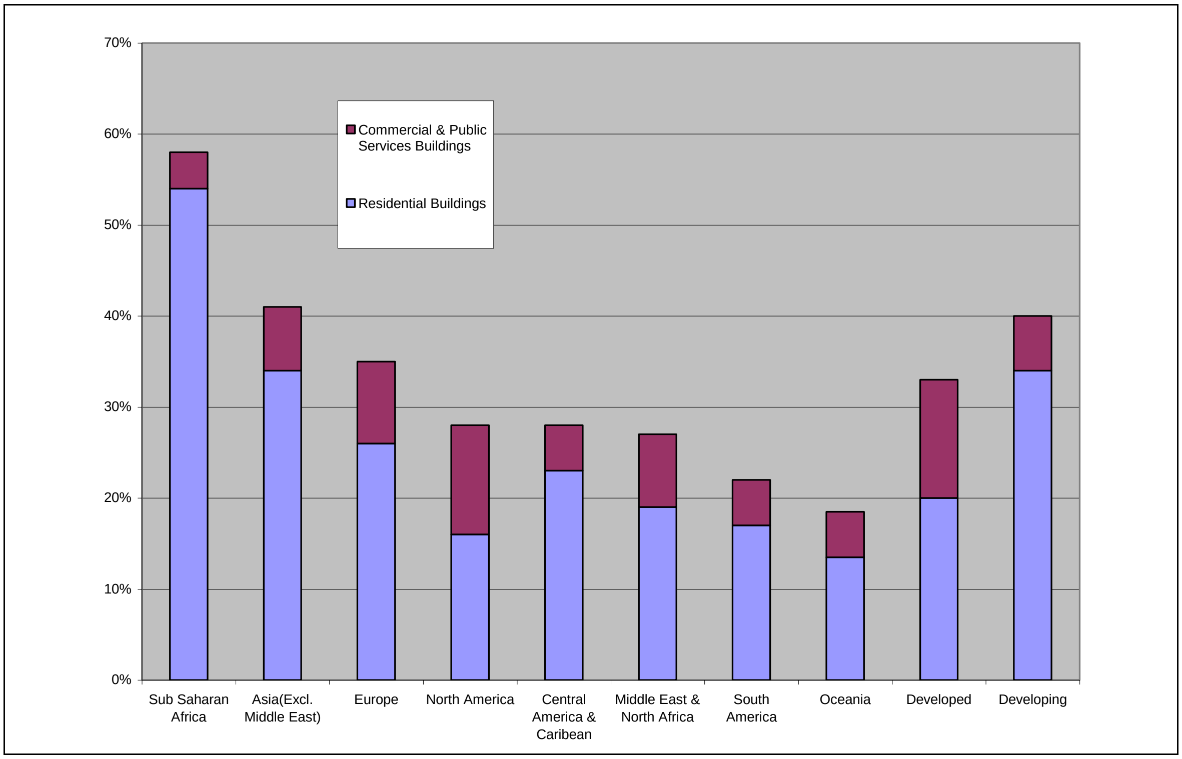

Figure 2.2: Shares of Energy Use in Different Building Types

Source: (Earth Trends, 2005)

However, in a study done for office buildings in the United States, Japan and Finland, a summary of various energy phases for buildings was described as shown in Figure 2.3 below (Jumilla, 2004). This illustrates different energy compositions for commercial buildings for selected case studies. From these cases, it is evident that the greatest amount of energy in the life cycle of a building is that used during the occupancy period. Energy use in buildings during the occupancy period is thus of major concern and significant targeted demand reduction strategies and efforts must be directed there.

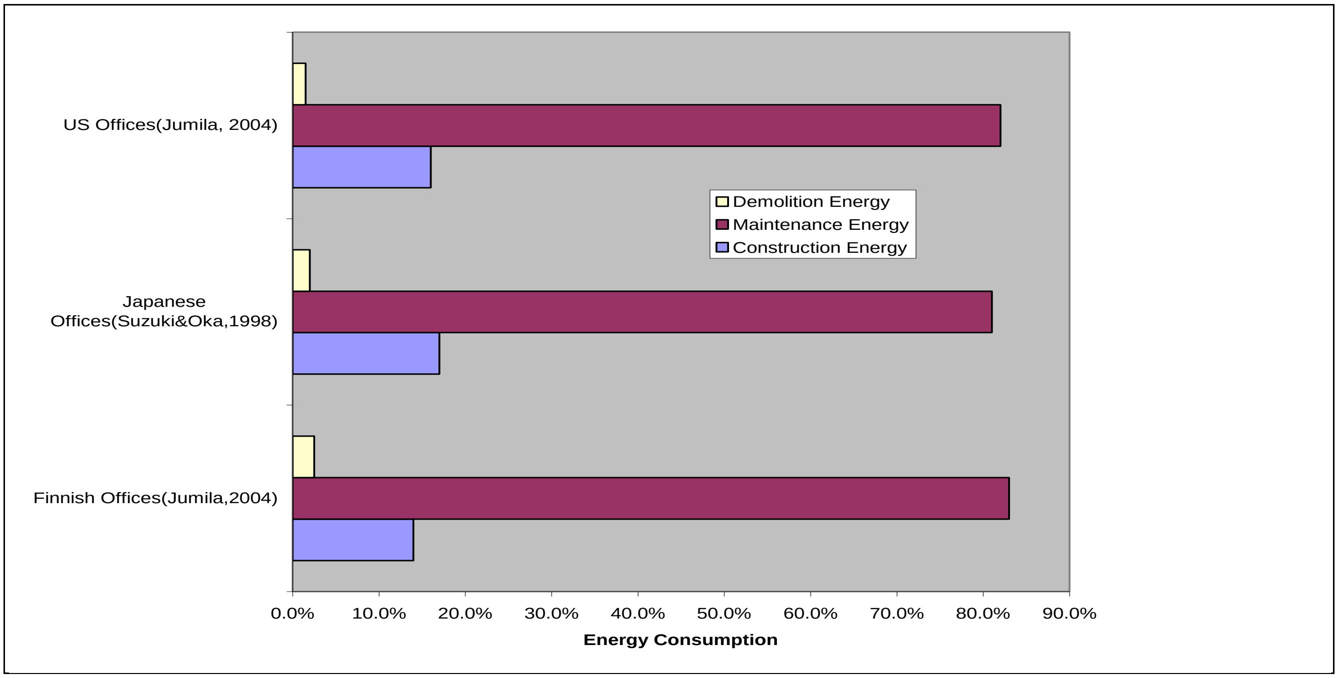

Figure 2.3: Energy Consumption by Life Cycle Phase for Selected Cases

Source: (Jumila, 2004)

Building related end uses like heating, cooling, ventilation and the preparation of sanitary hot water: require approximately 75% of a residential building's energy demand. Energy saving measures need to be put in place to address these drivers of building-related consumption. Additionally, such measures should cover other end-uses like lighting in service buildings, as this is likely to increase in many developing countries as they become richer (Laustsen, 2008). For service buildings, the share of energy use for other purposes will often be larger and for some types of service buildings it can be more than 50%. This is very much influenced by the installed equipment in the service buildings.

2.2.2 Use of Energy in Buildings

Buildings are built and operated for the effective and efficient conduct of human functions & creative activities. Energy is used in buildings in two main ways; first for the construction and second, for the operation of the building. Energy used for construction can be categorised as embodied, grey, induced or demolition & recycling (Jones, 1998). This is the energy required to manufacture and transport materials to the site and to build. It also includes the energy used to demolish and dispose of the building. Its cost is usually reflected in the buildings/infrastructures construction cost. Studies have shown that these forms of energy may be as much as 20% - 30% of the energy required for operating the building over a 30 year period (Stein, 1977).

Other definitions of different categories of energy are given below (Jones, 1998; Sartori and Hestnes, 2007):

1. Embodied energy is defined as the energy used in manufacturing of the building materials or in its extraction or mining.
2. Grey energy is that energy used in the transportation of the building materials between the plant and the site.
3. Induced energy is defined as the actual energy used during construction process while operation energy is that used during the occupancy period
4. Demolition-recycling energy is that energy which is used when demolishing the building or recycling its components. It is thus manifest at the end of the life cycle of the building.

For the operation of the building, energy is used for heating of water and space, cooling, lighting, ventilation, and operating equipment and appliances (also called process energy). The variables for energy consumption in buildings are complex and varied, but they can be listed as: building function, type of control system, energy distribution system and type, hours of operation, ventilation rate and thermal integrity of the building envelope (Spielvogel, 1979). The function of the building determines its mechanical and electrical equipment, the control of that equipment and therefore its energy consumption.

2.2.3 Energy and peak demand reduction in buildings

Any strategy chosen to reduce energy demand in a building often requires one to make a trade-off choice among many competing and sometimes conflicting objectives. These objectives include; (1) minimizing initial costs, (2) minimizing operating costs, (3) minimizing life cycle costs, (4) maintaining reliable building operations and (5) maintaining environmental quality both inside and outside the building (Dubin, 1979). The following energy and peak demand reduction strategies are explained below (Dubin, 1979):

The first strategy is the supply side vis-à-vis demand side energy demand reduction strategy. This is premised on the idea that purchased energy use can be reduced by

1. Minimizing the heating, cooling, ventilation, lighting, equipment and hot water loads that are to be met by the expenditure of primary energy;
2. Improving the efficiency of the mechanical and electrical equipment used to meet those loads; or
3. Supplying the needed primary energy with renewables rather than fuel derived energy.

These strategies are not mutually exclusive and all three can be applied to any building situation. The first two are deemed to be demand side strategies while the third is a supply side strategy. If well executed in the right mix, they deliver high energy savings in buildings. Change in building regulations with specific energy savings measures will help their widespread application.

The second strategy of energy reduction in buildings is one premised on the choice between overall energy use reductions versus peak demand reduction. Most of the times, energy management generally involves a combination of the two. Because investments in new electrical generating capacities are very costly, reduction in peak electric demand is a short term measure (load shading) so overall energy use reduction should be favored and thus seriously considered in any strategy for improving energy use in buildings.

The third strategy compares new buildings against retrofits. In new building design, one gets a lot more flexibility with the range of energy saving options available, especially with the building envelope. For retrofits, change options are limited and more costly though opportunities for increasing energy efficiency are available. For existing buildings therefore, operating strategies, accompanied with control systems changes often make the most sense and efforts should be made to implement such measures, possibly through the changed building control regulations.

2.3 Energy production and use in South Africa

The sources of energy used in South Africa include: coal, natural gas, petroleum products, and electricity. Electricity is mostly generated from power plants fuelled by primary energy sources like coal, natural gas, or fuel oil. A small percentage is from nuclear power plants and renewable energy sources such as hydroelectric, geothermal, biomass, wind, photovoltaic and solar thermal plants.

Table 2:1: Primary Energy Sources in South Africa

Energy Source	Energy Contribution
Coal	78%
Crude oil	10%
Gas	2%
Renewables	6%
Hydro	1%
Nuclear	3%

Source: (DME, 2005)

Table 2:2.Total Primary Energy Production and Consumption (Quadrillion BTu)

Description	2005				2006
Production (Quadrillion BTu)	South Africa	Africa	World	Rank	South Africa
	6	35	460	11	NA
Consumption (Quadrillion BTu)	5	14	463	12	NA

Source: (Energy Information Administration, 2007)

Table 2:3: Total Electricity production and Consumption (billion Kilowatt-hours)

Description	**2005**				**2006**
	South Africa	**Africa**	**World**	**Rank**	**South Africa**
Production (Billion Kilowatt-hours)	**228**	**533**	**17351**	**15**	**NA**
Consumption (Billion Kilowatt-hours)	**211**	**474**	**15747**	**15**	**NA**
Net Exports/Imports (-)	**40**	**107**	**3872**	**18**	**NA**

Source: (Energy Information Administration, 2007)

2.3.1 Energy Use in Buildings in South Africa

In South Africa, the built environment takes up to 21% of the total energy consumption (DME, 2005). Studies have shown that the building Industry (commercial sector and residential sector) jointly account for 27% of electricity use and 12% of the final energy use (DME et al,. 2002). The details are shown in Figure 2.4 and Figure 2.5

The Energy Efficiency Strategy (DME, 2005) sets the target for 15% reduction against the projected energy consumption by 2015. Studies show that low-cost and medium-cost technical interventions in this sector can reduce energy consumption by 25% - 30% (Grobler and Singh, 1999).

An earlier study revealed that South Africa's commercial sector in municipal areas accounts for between 20% and 27% of electrical energy whereas the residential buildings use 40% to 47% (Anderssen et al. 1995). This clearly underlines the fact that the building sector needs to develop means of reducing electricity demand to accommodate expanded access to the utility. It is possible to develop targeted policies and legislation which are then implemented in the building control regulations by the local authorities.

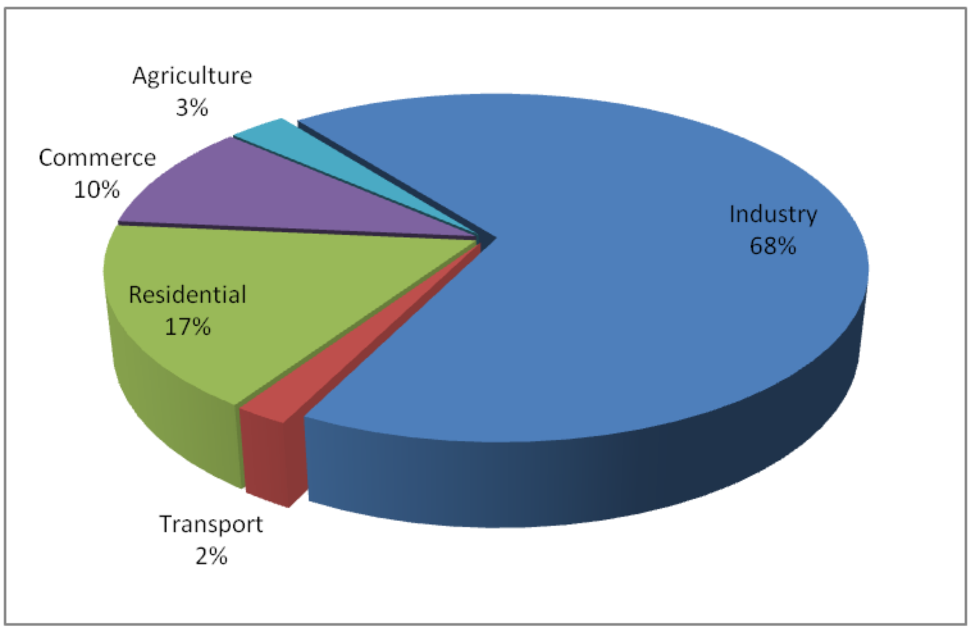

Figure 2.4: Electricity demand by sector in South Africa

Source: DME et al. (2002)

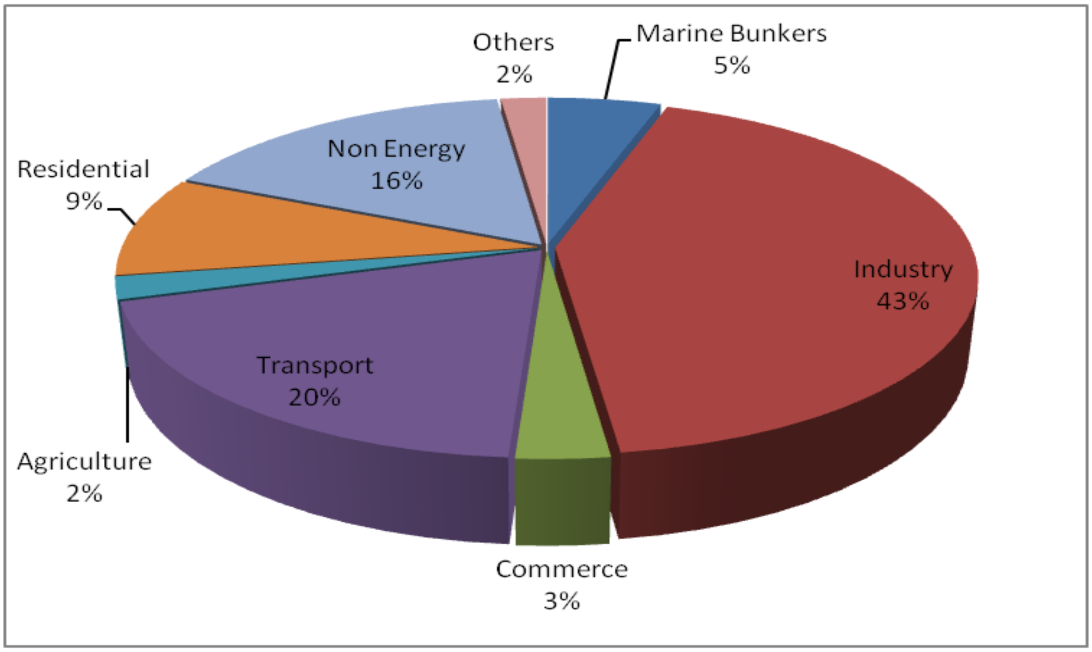

Figure 2.5: Final energy demand by sector in South Africa

Source: DME et al., (2002)

2.4 Building Regulation standards/codes

Regulations are an important aspect of serving public interest and setting and keeping standards and procedures for a given system (Govenden, 2009). Historically, regulation grew from the need to protect people in the face of private interests. Regulation responds to the conflict between private corporations or individuals and the general society (Golding and Murdock 1997) The public interest theory of regulation has undergone two main changes over time; the early phase also called the 'Granger' period saw the Anti-monopoly activism of the agrarian social movement whereby regulation protected the individual producer (Govenden, 2009). Subsequently, there is the 'progressive' strand of regulation which seeks to protect the consumer due to altered actions of corporations or individuals (Golding and Murdock 1997). This later type of regulation identifies with the consumer and seeks to protect the consumer and ensure that the economy is fair. In order to protect the consumer from individual and corporate abuses, regulations ensure democratic due process, economic efficiency and bureaucratic rationality (Golding and Murdock 1997). Building regulations fall into this later type of regulations.

Building regulations generally aim to govern construction and operation of buildings while establishing rules that are responsive to changing technological and market conditions (Breyer, 1982). For example, the British Building Regulations are compulsory product standards and they are primarily aimed at protecting public and environmental interests, including ’the health, safety, welfare, and convenience of people in and around buildings, access to the disabled, and the conservation of fuel and power’ (DOE, 1994). The general South African building regulations follow similar measures. In most cases, building regulations are viewed by many designers and builders as an additional burden with which they have to carry alongside other competing instructions from clients. Moreover, while manufacturers set performance limits for components and materials which eventually get used in buildings, local authorities and government regulators provide the instruments with which buildings and standards are maintained (Gann et al., 1998).

The process of developing regulations (including building regulations) is complex, relying upon the knowledge of key players. This is one reason why task teams or committees get appointed to develop or make changes to regulations. The section below explains the growth of modern building regulations.

2.4.1 The growth of modern Building regulation standards/codes

Building codes are not a new invention. Building codes or standards for new buildings were enacted to address several concerns such as construction safety, fire safety and occupants’ health as early as 1790 BC. One of the earliest examples of regulations for buildings is Hammurabi’s law from Mesopotamia, established around 1790 BC (Laustsen, 2008). Among the 282 rules or contracts, which regulated every part of society, six concerned the construction of houses and penalties for builders (Laustsen, 2008).

Over the years, many countries or cities have had a long tradition of setting rules for constructing new buildings, maintaining and refurbishing existing ones. This has often been initiated in response to disasters such as large urban fires, epidemics or natural catastrophes’ like earthquakes. Requirements for constructing buildings were then set so as to avoid or minimise future disasters or their effect on people and the buildings.

In modern times, if we take the British system as an example, the first Public Health Act was passed in 1845, signaling the beginning of modern building legislation (Davis, 1992). Housing was the primary concern and the defects to be avoided were mainly damp, structural instability, poor sanitation, fire risk and lack of light and ventilation (Gann et al., 1998). The first model by-laws were produced in 1877 as a guide for local authorities who had the responsibility for setting and enforcing minimum building standards. Although guidance from central government was given, local authorities held direct responsibility for building standards and issued their own by-laws. Model by-laws were generally similar across Britain, but architects designing buildings for the first time in a particular area were obliged to check local standards. These procedures remained in use for 75 years (Gann et al., 1998).

Around 1952, Model By-laws, Series IV, introduced two major changes in approach. First, as a result of the development of new materials, a different technique of control was used whereby standards of performance were stated and these formed the mandatory part of the by-laws. Descriptions of actual structural minimum, which previously had been mandatory, were now contained in the so called ‘deemed to satisfy’ provisions. In theory this left the way open for new technologies, materials and methods to be used through parliamentary amendments, providing their performance could be established. Additionally, although the enforcement of the model by-laws was still a matter for local authorities, they were universally adopted throughout England and Wales (except in inner London), and hence building control legislation became standard (Gann et al,. 1998). This was essentially the first introduction of performance standards in the building control regulations.

In 1965, the first comprehensive sets of Building Regulations were produced for England and Wales. These were implemented by the Department of the Environment (DOE) on behalf of the Secretary of State. They were a secondary legislation in response to a primary act which mandated their purpose, structure and enforcement. Minor amendments were issued yearly at first and now occur every few years. Comprehensive parliamentary reissues came into operation in 1972, 1976, 1985 and 1991. The most significant recent change to the Regulations resulted from the Building Act of 1984, altering the structure of the regulatory system (Gann et al, 1998). Table 2.5 summarizes the main legislation in the history of British Building Regulations.

Table 2:4: Major developments in British building control legislation

Date	Regulation	scope
1845	Public Health Act	First legislation to cover structure, dampness, sanitation, fire, light and ventilation in housing
1877	Model By-laws	First minimum standard housing guidelines for local authorities
1952	1952 Model By-laws Series IV	Mandatory standards of performance and universal adoption
1965	Building Regulations	First comprehensive set of regulations for England and Wales
1981	White Paper on future of building control	First major shift from prescriptive to performance-based approach
1984	Building Act	New regulatory structure containing schedules and procedures
1991	Building Regulations Revision	Includes Approved Document L as a performance-based standard

Source: Gann et al., (1998)

Internationally, Regulatory frameworks for the building sector vary between countries but currently there appears to be increasing international convergence in the approach to regulation. Principally, there is a strong emerging preference for performance rather than prescriptive regulations (Gann et al., 1998). This is partly based on the knowledge that prescriptive regulations have significantly addressed the challenges of fit-for-use construction and the emerging challenges of incremental efficiency in the construction and operation of buildings is better addressed by performance based regulations (Gann et al., 1998). The modern building regulations need to address issues like Green buildings, reducing energy use in buildings, setting standards for equipment used in buildings and to be a catalyst for transforming the market for building goods and services. Parts of these aspects of building regulations are explained in chapter three. The following section explains the main types of building regulations.

2.4.2 Types of Building Regulations

Broadly, building regulations can be classified as prescriptive or performance based. This is explained below:
Traditional prescriptive regulations emphasized elements like weight, dimensional, material and production specifications for building components. In contrast, newer performance-based regulations require that only certain performance criteria be met, such as overall strength or level of insulation. The prescriptive approach involves standards that specify all of the materials, configurations and the methodology required to achieve a desired regulatory goal. Performance regulations on the other hand leave many of these factors open, specifying only the final regulatory goal. Accordingly, performance standards specify a final state to be achieved but do not specify how it should be met (no method specification).

Additionally, performance regulations can provide a basis for international comparison whilst accommodating national differences in constructed products and assessment methods. This is in light of the fact that regulation is increasingly becoming the focus of international competition and conflict (de Jonquieres, 1998; Sykes, 1995). European proponents of performance based building regulations hope that they will stimulate widespread and easy application. The USA is following course (Laustsen, 2008). In Japan, comprehensive performance based building regulations were developed after the apparent failure of the prescriptive system in the 1994 Kobe earthquake (Gann et al., 1998). This shows that performance based regulations are currently in use in many developed countries and developing countries can learn from these experiences to formulate and implement theirs.

2.5 The South African building regulations

The development and growth of building regulations in South Africa has more or less followed the way the British system evolved. The key difference lies in the fact that the current South

African building legislation borrowed heavily from the Australian and Nordic Model (Reynolds, 2007; Holden, 2006; Watermayer and Milford, 2003). The sub-sections below explain these regulations in detail.

2.5.1 The legislation

The National Building Regulations and Building Standards Act (Act 103 of 1977 as amended) is the foundation upon which building control regulations in South Africa are built. It is also referred to as the primary building legislation. The National Building Regulations (SABS 0400/SANS10400) are essential to the implementation of this legislation (Holden, 2006) and they form the secondary legislation. Before the promulgation of the Act, every town council in South Africa had its own set of building by-laws which were generally difficult to implement. Act 103 of 1977 discarded all the disparate by-laws and introduced a new dispensation aligned with the technical realities of building construction and design in South Africa relative to the rest of the developed world in the late twentieth century.

Drawing significantly from the Nordic model, the Act provided uniformity in the law relating to the erection and maintenance of buildings in the areas of jurisdiction of local authorities by prescribing building standards more clearly (Holden, 2006; Watermayer and Milford, 2003). The aim of the Act, which came into effect when the National Building Regulations were published, was to provide a simplified and uniform system of building control in country towns and the major urban centers. The primary focus of the Act was on ensuring that buildings would be designed and constructed for people to live, work and play in a healthy and safe environment (Holden, 2006).

At the time of its enactment, this Act and its regulations were a progressive piece of legislation and the regulations that were published pursuant to it, while behind time in certain respects in today’s terms, were based on a system that has produced buildings of worldwide recognition for nearly two decades. In the years that followed, there were amendments to the act, beginning with Amendment No.30 of 1982, Amendment No.36 of 1984, Amendment No.62 of 1989, Amendment No.49 of 1995 and Amendment No.29 of 1996 which brought Mine Health and Safety Act in line with the National Building Act.

2.5.2 The National Building Regulation standards for South Africa

The National Building Regulations are the secondary legislation that operationalizes the Act. The SABS 0400/SANS10400:1990 which is known as the code of practice for the application of the national building regulations (the code) enables the implementation of the National building Act. The code is currently divided into 23 parts named alphabetically from A-W, with each part dealing with a specific key element of the buildings' construction.

For example, Part A deals with Administration, with the element further divided into sub-parts like A1 - which deals with applications for approval, sub-part A19 - deals with the appointment of persons responsible for design, and so on and so forth. Part B deals with Structural Design; Part C is for Dimensions, Part D for Public safety and Part E for Demolitions. This goes on until Part W which deals with Fire Installations.

Traditionally, building by-laws have been prescriptive in nature – they prescribed in definite terms and in considerable detail what a designer had to do in order to obtain the necessary approval to build (Holden, 2006). The early South African building laws had also been prescriptive for a long time. This narrow approach to building regulation worked well in the early years of the century, but became an impediment to innovation in design and construction as buildings became more sophisticated. More so, it perpetuated a homogeneous but constrictive technical paradigm (Holden, 2006). Over time however, this situation has been remedied in that the SABS has been doing continuous updates of the national building regulations. Recently, it just completed an exhaustive process of updating and revising them.

In this update, the SABS 0400:1990, which changed to SANS 10400:1990, has been revised as follows: (Parts A, C, D, F, G, J, N, O, P, Q, T, V and W) have been superseded by SANS 10400-A:2010 (edition 3.0), SANS 10400-C:2010 (edition 3.0), SANS 10400- D:2011 (edition 3.0), SANS 10400-F:2010 (edition 3.0), SANS 10400-G:2011 (edition 3.0), SANS 10400-J:2010 (edition 3.0), SANS 10400-N:2010 (edition 3.0) SANS 10400-O:2011 (edition 3.0), SANS 10400-P:2010 (edition 3.0), SANS 10400-Q:2011 (edition 3.0), SANS 10400-T:2011 (edition 3.0),SANS 10400-V:2010 (edition 3.0) and SANS 10400-W:2011 (edition 3.0) respectively (SABS, 2011). All other parts remain current at the time of writing this research thesis.

This revised formulation of national building regulations uses an entirely different approach whereby each “regulation” only prescribes the performance required from a building or its elements and components. The onus for compliance with the standard lies with the designer/builder to ensure that a specific design and the completed building meet the performance requirements (SABS 0400:1990). These performance regulations are accompanied by a set of deemed to satisfy rules, which are ordinarily a set of specific prescriptions. Any designer who complies with these rules is deemed to have met the requirements of the regulation.

Thus, the system allows for individualism and innovation. It also provides a set of easy to implement design tools that are readily applicable for common buildings. This system is based on the “Nordic five-level structure” (Watermayer and Milford, 2003). The “levels” of the Nordic system are as follows (Watermayer and Milford, 2003):

1. Objectives – to address the essential interests of the total community with regard to buildings;
2. Functional requirements – it states in qualitative terms the required performance of buildings or elements thereof in order to achieve the stated goal;
3. Performance requirements – it states in quantitative terms the performance required to achieve a functional requirement (these, in effect, are the regulations); and
4. Verification methods; – it gives systems or methodologies that enable verification of compliance with performance requirements. There are two categories of verification methods: the first is performance-based (testing, assessment and the application of well-established engineering principles); the second makes use of deemed to satisfy rules (a set of prescriptions that satisfy performance requirements). The latter is, essentially, the fifth level in the system (Holden, 2006).

2.5.3 Other applicable laws

The National Building Regulations and Building Standards Act, in setting out the parameters for approval by a local authority of building plan applications, makes the following stipulation[5]: "If a local authority having considered a recommendation referred to Section (6) (a)[6]… is satisfied that the application in question complies with the requirements of this Act and any other applicable law, it shall grant its approval in respect thereof."

The key words "any other applicable law" require that other laws, besides the codes, be applied together to achieve harmony in building control. Ordinarily, local authorities are required by various provincial ordinances to regulate the use of land for development by means of town planning schemes; which are a set of rules setting out the administrative and technical parameters for such things as changes in the use of land and buildings (also known as rezoning or amendment schemes), sub-division of land, consents such as building line relaxations and site development plan approvals and the establishment of townships.

When any one of the above aspects of a town planning scheme has a direct impact on a building plan application, the local authority is required to ensure that the building plan application in question complies not only with the national building regulations and building standards Act, but also with specific clauses in the relevant town planning scheme. The proposed new energy efficiency regulations are likely to be in future town planning schemes and as such local authorities will be obliged to implement them.

2.5.4 Difficulties in implementing the building regulation standards in South Africa

The way local government is structured, its culture in devising administrative systems and procedures for building control has created a paradigm whereby the prescriptive aspects of the

[5] Section 7 (1) (a) of Act 103 of 1977 as amended

[6] This is the recommendation made by the appointed building control officer, or those to whom he has delegated this function, that a building plan application be approved by the local authority. Section 5 of the Act deals with the appointment of a building control officer by the local authority and Section 6 with the functions of a building control officer

national building regulations are given prominence. This has resulted in a situation where some building control practitioners have forgotten that building control is essentially performance based (Holden, 2006). This causes applicants- the building industry professionals and property developers to benefit from a regime of ensuring compliance with the deemed to satisfy rules rather than the performance standard. The one advantage the deemed to satisfy rules give is that designers/developers can submit unconventional designs for approval. The only caveat being that such proposals be accompanied by a comprehensive motivation on the basis of recognised tests or a rational application of engineering principles, demonstrating to the satisfaction of the local authority that the performance requirements of the relevant regulations have been met by the design.

In the event that a local authority refuses to approve or is deemed unreasonable in assessing the unconventional proposals, the code gives a recourse by way of an appeal to the South African Bureau of Standards Review Board, a body set up to arbitrate in instances where an applicant disagrees with the local authority in regard to the approval or refusal of a set of building plans.

As part of a solution to these difficulties, proposed changes to the regulations to bring in additional performance standards like energy efficiency should make it possible for the local authorities' officers to get additional training for their implementation.

2.6 Local Authorities and Building regulations implementation

The buildings sector in most countries is regulated by local and municipal authorities. Municipalities and local authorities apply building regulations; standards/codes set out in national or local statutes and ensure their implementation and enforcement in areas under their jurisdiction (EGI, 2002). Additionally, Municipalities and local authorities operationalise building regulations by ensuring that appropriate conditions and measures are put in place for their implementation through the function they call building regulations control (Building research establishment, 2008).

Around the world, enforcement of building regulations by central or local government department/agency charged with reviewing designs and performing post construction inspections is the most common (Building Research Establishment, 2008). There are different ways in which countries set, implement and enforce building codes and standards. This may be at national or local level: and in countries with large climatic differences, implementation at the local authorities' level helps to adapt the codes to the local conditions (Visscher and Meijer, 2011).

On the other hand, in large countries with federal governments', local states or regions establish building standards/codes requirements for buildings. In this case, a model building code is often developed to cover the whole country, either on a public or as a private initiative. Individual states or regions then modify the national model standard to local conditions; and must adopt this legislation, before they implement it through their building control processes.

In the third case, some countries delegate the establishment of building regulations to local authorities' altogether. In this case, the city council, regional government or federal state may autonomously set and enforce building standards. This independent governance is not common though, because building regulations are seen to be a very important national and international responsibility. Countries where codes are set on a local level would normally have a standard set at the national level with the recommendation to adjust the standard locally for implementation (Visscher and Meijer, 2011).

Traditionally, the building control departments of Municipal authorities in most countries have had an important role in assuring that building plans and construction processes lead to buildings that meet the minimum required quality levels (Visscher and Meijer 2011). Adding Energy efficiency requirements in building standards and codes can get the same assurance at the building control & approvals phase. Local and municipal authorities are therefore well poised to play an essential role in implementing and enforcing cost-efficient end use energy efficiency opportunities in buildings (Rezessy, et al., 2004).

In South Africa, The National Building Regulations and Building Standards Act (Act no 103 of 1977) is administered by local authorities and it is the enabling legislation for the national building regulations (Holden 2004). It provides in great detail for the process of enforcing the national building regulations by local authorities. Cities, municipalities and local Authorities are therefore mandated to enforce building regulations established by national government (du Toit 2007). This is through a mechanism where all new building plans have to go through their building control and approval departments before they are implemented. Additionally, they are permitted to make by-laws within their areas of jurisdiction to complement the national building regulations for effective and practical implementation. Through this processes, it should be very easy for the local authorities to implement the proposed energy efficiency building regulations once promulgated.

2.7 Energy Efficiency policies and regulations for buildings

As stated earlier in this research, buildings account for up to 40% of energy use in society causing similar levels of associated greenhouse gas emissions. There are many proven ways to reduce the energy use and cut GHG emissions in new and existing buildings but experience shows that this will not happen without intervention from policy makers (UNEP, 2007).

More than a fifth of the present energy consumption and up to 45 million tons of co_2 a year could have been saved by 2010 by applying more ambitious standards to new and existing buildings (UNEP, 2007). In fact, in an energy scenario developed by Azar (2003), the amount of negawatts (energy efficiency) will equal the total supply of new energy in the year 2100, which corresponds to 0.7% annual increase of energy efficiency during the 21st century (Nassem and Holmberg, 2005). In real terms, this means that energy efficiency measures actually create additional energy. Retrofitting alone can sometimes increase energy efficiency by up to 70%, decrease piped water use by up to 80% and lower discharge to sewers by 70% (UNEP, 2007). There is a high energy–savings potential in the buildings sector but strong government interventions are needed to realise this potential (OECD, 2003). It is therefore recommended that more emphasis be placed on energy efficiency improvements in buildings. The formulation and implementation of energy efficiency building policies & regulations is deemed one such government intervention.

On the sustainability side, there are three major ways to reduce GHG emissions in buildings: reducing energy use, replacing fossil fuels with renewables or increasing energy efficiency. Presently, there are policy instruments which can be used to improve energy efficiency or reduce energy use; thereby reducing GHG emissions (Figure 2.6). These policies have also been shown to be cheap and effective tools of reducing GHG emissions from buildings (IPCC 2007).

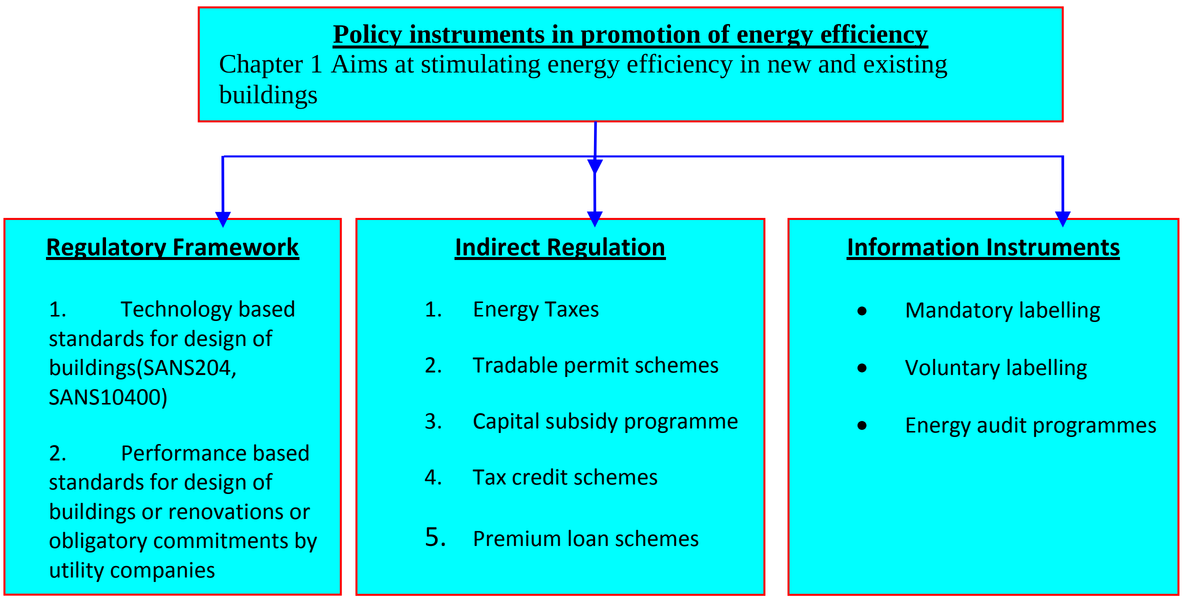

Figure 2.6: Instruments for energy efficiency implementation in buildings

Adapted from OECD: (2003)

To realize the potential described above, more and more countries are enacting policies to improve energy efficiency in buildings (Figure 2.7). The first building energy efficiency regulations were set in the 70s in response to the oil crisis (Deringer et al., 2004).

Figure 2.7: Status of Energy Standards in 81 Countries in 2009

Source: (Janda, 2009)

Since then, the variety of instruments applied has grown considerably, from regulatory and voluntary instruments in the initial phase to the use of financial incentives and economic instruments (IEA, 2005b; Kuijsters, 2004; OECD, 2003; Van Egmond, 2001; Reinink, 2007). For various reasons, the effectiveness of these policy measures in terms of reaching their goals varies significantly depending on countries, situations and policy instruments chosen. For example, building codes have reduced energy consumption of new dwellings in the USA by about 30% (UNEP, 2007). Overall, research has shown that regulations are a very effective strategy to make buildings more energy efficient (Kuijsters, 2004; OECD, 2003).

In the 1990s, the ever rising cost of energy and the increasing awareness on climate change added impetus on the energy efficiency agenda and caused some developing countries to introduce EE regulations and labeling policies (Deringer et al., 2004). However, many countries, especially developing ones, have not enacted or are just introducing EE policies for the buildings sector. This is illustrated in figure 2.7.

Table 2:5: Overview of possible policy interventions for new and existing buildings

Policy instrument	**Stimulate energy efficiency in new buildings**	**Stimulate energy efficiency in existing buildings**
Regulatory instruments	Technology-based standards for the design of buildings. Performance based standards for the design of buildings.	Technology based standards for the design of buildings (major renovations). Performance based standards for the design of buildings (major renovations) Imposition of obligation on utility companies.
Indirect regulation	Energy taxes. Tradable permit schemes. Capital subsidy programmes. Tax credit schemes. Premium loan schemes	Energy taxes. Tradable permit schemes. Capital subsidy programmes. Tax credit schemes. Premium loan schemes.
Information instruments	Mandatory labelling schemes. Voluntary labelling schemes.	Energy audit programmes. Mandatory labelling schemes. Voluntary labelling schemes.

Source: (OECD, 2003; Reinink, 2007)

From table 2.4 above, control and regulatory measures are one of the commonly used instruments for energy efficiency improvements in buildings. These instruments are defined as institutional rules which aim to directly influence the environmental performance of polluters by regulating processes and products used, by prohibiting or limiting the discharge of certain pollutants, and/or restricting activities to certain periods or areas (OECD 1989). In order to remain effective, control and regulatory instruments have to be monitored, evaluated and updated or revised regularly in accordance with technological developments and market trends.

For example, energy requirements have been part of the Dutch building regulations since 1995 and have been modified three times ever since to make the requirements more stringent (Reinink 2007). Putting energy requirements into building regulations in Netherlands increased the energy performance of new buildings by 15% at inception and by 27% after tightening the requirements (Ecofys 2004). Similarly, The Danish government implements mandatory regulations for both new and existing buildings. Energy performance requirements have been part of the buildings regulations since 1995, mainly for new buildings but there are also mandatory labeling schemes to ensure energy savings and energy efficiency in the existing building stock. This is derived from the 'Act to promote energy and water savings in buildings' (DEA 1996).

In developing countries, the number of new buildings is growing rapidly and the energy prices and markets often do not encourage the use of efficient technologies (Hui, 2000). In view of these facts, there is a pragmatic shift to the use of building energy standards/codes to reduce building energy consumption. Building energy regulations can be used to address the energy use of an entire building or building systems such as heating or air conditioning (Birner and Martinot, 2002). Energy Efficiency regulation is the most frequently used instrument for energy efficiency improvements in buildings (OECD, 2003).

In South Africa, the need for EE regulations is well stated by the energy efficiency strategy:
"The historically low unit cost of energy, coupled with limited awareness on energy savings potential, may result in only modest success arising from voluntary measures and other non-legislative instruments. For this reason, regulatory means will be applied to achieve further improvements where necessary. Efficiency standards will have limited impact unless made mandatory, and energy audits should be accompanied by an obligation to implement, for example, all no-cost recommendations identified. The National Energy regulator will contribute to or develop regulatory measures for guiding reporting and compliance". (DME, 2005)
However, the actual implementation of energy efficiency regulations in buildings is still at infancy. There are isolated mentions of implementation policy under the electricity regulation act

which requires the regulator to take into account the energy efficiency measures undertaken by the client while deciding on tariff structure and under The Electricity regulations for compulsory norms and standards for reticulation services.

The South African National government is in the process of exploring how to incorporate energy efficiency into the National Building Standards. The SANS10400 part XA and SANS 204 Edition 1:1 – 4 has been developed and will become mandatory for buildings once it gets promulgated.

It is expected that these regulations will stimulate increased drive towards energy efficiency. On the whole, the construction and maintenance of buildings offers compelling opportunities for energy efficiency interventions, as decisions made during a building's design and approvals phase entail smaller costs with greater potential of energy savings relative to later interventions.

These building control measures may include: the building form, its orientation, the orientation of its windows, and its structural materials and appliances. Some energy efficiency improvements may even reduce construction costs because the efficient solutions are more cost effective or because the need for heating or cooling systems might be omitted altogether (Laustsen, 2008). These same measures, when taken after construction, can be prohibitively expensive to enact. In other cases, improvement of energy efficiency late in a building's construction would involve irreparable damage to its structure. This has the likely effect of discouraging EE interventions in the existing building stock.

2.8 Barriers to energy efficiency intervention measures in buildings

As stated at the onset of this study, the need for EE measures in buildings is very clear. However, there are difficulties when it comes to the implementation of the EE measures. This then leads one to ask, if it is so evidently clear that EE interventions are required and can be easily implemented, why are they not being carried out? The answer to this question lies amongst the following barriers and challenges which impede energy efficiency measures implementation in buildings: Lack of a specific regulatory requirement for buildings, insufficient information, insufficient finance for efficiency improvement, split incentives, users' lifestyle choices and multiple decision makers all hamper buildings' efficient performance. These barriers are common to both new and existing stock of buildings as well as domestic and commercial buildings (Iwaro and Mwasha, 2010; Laustsen, 2008; Evander et al., 2004; Deringer et al., 2004). Broadly, these barriers can be classified as: Legal/regulatory, economic/financial, technical (products and skills), behavioural/organizational or informational (Iwaro and Mwasha, 2010).

When buildings are designed and constructed, energy efficiency is one concern amid many, some considered more important and urgent than EE by the decision-makers. These can be structural or fire safety, room size, and even the view from the windows (carbon trust, 2005; IPCC, 2007). Indeed, these are some of the current building regulations standard requirements for approval in South Africa. Energy efficiency standards in buildings may hence be low on the list of requirements if not absent altogether.

Building project management teams emphasize more on investment and construction costs without due consideration of the buildings' future running costs. Often, the involved parties only have a direct interest in the construction budget and not the total budget, and may be unwilling or unable to evaluate future costs, including those for energy and other resources. Additionally, few participants involved in a building's construction have the requisite skills to analyse its lifecycle costs and guide construction practices to improve future energy efficiency (Deringer et al., 2004; Carbon Trust, 2005; IPCC, 2007). In any case, in the South African situation, there is no legal requirement obliging the building project management teams to do so. Therefore, the known costs of construction are the ones considered more carefully than unknown future costs and this impedes implementation of energy efficiency measures in buildings.

Construction activity managers are not interested in future costs. This is because many large commercial buildings are constructed by professional developers and government entities and most residential buildings by property development companies. After construction, developers sell the buildings to future occupants or users. Those who make decisions regarding energy performance will most commonly not pay the energy bills. Building occupants, who pay energy bills, are rarely involved in the building design or approval for construction (Shove, 2003;

Chapell's and Shove, 2005; Carbon Trust 2005). This fragmented and split incentive nature of the building sector works against the implementation of energy efficiency measures in buildings.

There is insufficient energy efficiency awareness among consumers, designers and financiers. Different decision makers take decisions, which influence the energy efficiency of buildings. These may be designers, building control officers, financers, builders and buyers, but most of these actors know very little about energy efficiency of buildings. Lack of information and knowledge of the benefits of or interventions for energy efficient buildings in any one of these parties can block the implementation of energy efficiency measures in buildings (UNEP, 2009a, 2009b; Bender et al., 2004). Moreover, in South Africa, the contracts for most designers, property developers and builders do not oblige them to care about energy efficiency. The development and implementation of energy efficiency building regulations would therefore provide an immediate solution to this impediment.

When evaluating a potential construction project, lending financial institutions generally focuses on construction costs without attention to implied future costs for energy in the building. Financial institutions may hence be reluctant to fund investments in buildings if measures to improve energy efficiency will raise the construction cost of the building, even if these investments are feasible and profitable in the long run. Failure among financiers to evaluate initial high costs of energy efficiency measures as an investment in future reduced operational cost (hence higher long term returns on investments), denies loans to consumers and builders who seek to invest in energy efficient buildings. This is a major barrier for existing stock of buildings (Deringer et al., 2004; Carbon Trust, 2005; IPCC, 2007; Laustsen 2008). This raises the need for including energy efficiency regulations in the building control measures to make them part of normal building costs.

The lack of skilled & manufacturing capacity does work against energy efficiency interventions in buildings. Some energy efficiency measures in buildings involve special equipment or expertise not readily available on the markets and there is no legal requirement for their manufacture in South Africa. Lack of capacity, possible delays due to delivery time lags or extra fees paid to an expert can deter the builders' interest in efficient construction and further reduce market interest in efficient products or techniques. In addition, some builders are unwilling to invest in training (Laustsen, 2008; Iwaro and Mwasha, 2010). Mandatory EE regulations would provide a legal framework for market transformation and eventually remove this barrier.

Currently, the property market in South Africa does not have enough instruments for valuing energy efficient buildings. For example, when buildings are changing ownership, the transactions rarely consider the avoided costs of energy efficiency. In part, this reticence is because the complex calculations of future savings include several uncertainties, such as future energy prices and real estate market fluctuations. Owners who invest in higher energy efficiency cannot be sure of making a profit or even just recovering initial investments when re-selling the building (Carbon Trust, 2005, Deringer et al., 2004, Laustsen, 2008). This impediment too could be addressed by EE regulations which cause market transformation and create the right value for energy efficient buildings.

There are significant behavioural barriers where an economically-irrational aspect of a consumer’s lifestyle biases a consumer against energy efficient choices in buildings. For reasons of status, marketing and social ritual, individuals and companies use more energy than basic comfort might require. Relative to these conditions, economic optimisation may have a far lower rank in the mind of the energy consumer or building owner (Shove 2003; Carbon Trust, 2005; Laustsen, 2008).

On the face value, energy is invisible. This physical invisibility to consumer’s works against energy efficiency in buildings; especially by the buildings users. Only the status and comfort of using energy will be visible to the energy buyers themselves and to others. A building that does not require air-conditioning might be comfortable and cheap to run, but only by installing air-conditioning can owners or developers demonstrate that indoor comfort is a high priority. Some installations or ineffective energy use signal that the users and owners of the building can afford to make a comfortable indoor comfort and care about the wellbeing of building occupants. Even the noise from air-conditioning units can be seen as an added value because this makes comfort visible for owners and guests in hotels or in workplaces (Chappell’s and Shove, 2005; Carbon Trust, 2005; Laustsen 2008). At times, some might consider a reduction of energy consumption and increase in efficiency as a decrease in comfort or status. For energy users with a good economic foundation, ineffective energy use will not usually influence their lives substantially since energy costs will only be a small part of the overall budget. Whereas increasing energy prices might help to reduce this barrier, the implementation of energy efficiency regulations which target consumers like 'Caps' for particular building uses may be helpful.

Sometimes, mistaken beliefs in energy efficiency are a barrier to energy efficient buildings. Owners of buildings or buyers of new buildings may mistakenly believe that the efficiency of a certain building is very good even if it is not. In particular, buyers may mistakenly believe that new constructions automatically are so much more efficient such that there is no need to take any further action. Increased energy efficiency in new buildings will hence not be of concern even where there is feasible and compelling opportunity for it. This might impede increased efficiency in new buildings, because more efficient buildings and products will not penetrate the market since consumers believe that the existing products and building are already efficient enough (UNEP, 2009a, 2009b).

Minimum building standards/codes for energy efficiency also fail to achieve optimal energy efficiency potential in buildings. Many building developers and buyers interpret the mere existence of energy efficiency building codes to be sufficient warranty for the efficiency of new buildings, but the efficiency standards appearing in building codes rarely represent the optimum for efficiency. Building codes often tend to be the exact level as those for new buildings and not the minimum - which was the original intention of the authority - because builders and designers rarely find an incentive to exceed these efficiency standards which might increase initial costs. Instead building codes should serve as a common and sure baseline from which to gauge progress and initiatives should be taken to ensure that better energy efficiency would be considered in new and existing buildings (Laustsen, 2008). In the South African case, the said energy efficiency building codes do not exist in the national building regulations neither are they a requirement in the building control and approvals process of the local authorities.

In any instance, many barriers to energy efficiency in buildings interact and strengthen each other. Many initiatives for improved energy efficiency in buildings have returned small or limited results because some barriers have been overlooked or insufficiently addressed when formulating a mitigating strategy. For example, a change in legislation and subsequent information campaigns will fail if building constructors and installers do not have access to sufficient funds for efficiency investment especially in the existing stock of buildings. A successful policy, or suite of initiatives, will simultaneously have to address all major barriers to buildings' energy efficiency (UNEP, 2009a, 2009b; Laustsen, 2008).

In summary, it is clear that many barriers impede energy efficiency implementation in new and existing buildings. When new buildings are designed and constructed, energy efficiency is just one concern among many factors in construction. Energy efficiency in buildings may be low or not exist at all on the list of legal requirements for the building control and approvals process. The development of most buildings focuses on construction costs with very little concern for running costs. Different people and budgets may govern the operation of a building, leading to split incentives for energy conservation and efficiency efforts. Very rarely will any single decision maker participate in all aspects of a building construction, operation and financing. Most decision makers will not have all the information/knowledge or capability to calculate a building's lifetime costs and estimate the consequences of early design decisions. Consumer inaction regarding buildings' energy performance stems from the fact that energy is invisible, that the energy costs of buildings seem imaginary and that improved efficiency can decrease prestige.

In South Africa specifically, the first key barrier against energy efficiency for a long time was the fact that energy was very cheap; especially electric energy. In fact, until the year 2007, it was the second cheapest in the world. The second major barrier to EE measures implementation in buildings is the lack of a definitive legal requirement in the national building regulations.

The numerous barriers mentioned explain why the implementation of energy efficiency building regulations usually requires special government action. This may involve setting clear mandatory energy efficiency building standards/codes in the national building regulations to be enforced by the local authorities in their building control and approvals processes. This will be best suited to overcoming these self-compounding barriers.

2.9 Conclusion

The building sector consumes between 30% and 40% of the world's energy. This means that a large potential exists for reduction in energy consumption for both new and existing buildings. The realisation of this potential will subsequently lead to reduced GHG emissions, assure energy security and lower energy costs. Studies have shown, as discussed in this chapter that EE Policies and Regulations have been formulated and implemented in other jurisdictions with various degrees of success. An investigation of these policies and regulations showed that energy consumption in buildings can be reduced by more than 50% using technologies and measures which are feasible today. However, there are several barriers which impede the effective implementation of the above policies and regulations to achieve the large energy savings potential that exist in buildings.

Traditionally, local authorities have ensured that building plans and construction processes lead to buildings that meet the minimum required quality levels by implementing building regulations through their building control processes. To realise the large energy savings potential in buildings, there is a need to take action right now and set up a package of EE policies and regulations implementable through the local authorities building control processes. These policies and regulations must address all the self-compounding barriers to energy efficiency in buildings. A comprehensive energy efficiency building code requirement in the National Building regulations implemented by local authorities through their building control function is best suited for South African buildings. The discussions on energy efficiency building standards/codes are comprehensively explained in the next chapter.

Chapter 3 : ENERGY EFFICIENCY BUILDING STANDARDS/CODES

3.1 Introduction

This chapter discusses the purpose, formulation and implementation of Energy Efficiency Building Standards/Codes (EEBSCs) in great detail. It explains reasons why EEBSCs are needed, their genesis, formulation and implementation through the traditional building regulations by the local authorities in many countries where they are in use. It presents EEBSCs development in South Africa tracing the various voluntary efforts in place up to the current status. The Chapter is arranged in twelve (12) sections. Section 3.1 covers the Introduction and sections 3.2 and 3.3 The Importance and Evolution of EEBSCs. Section 3.4 discusses the types of EEBSCs while section 3.5 explains the formulation of EEBSCs in developing countries. Section 3.6 discusses the implementation of EEBSCs and section 3.7 explains the setting of EBSCs in the general building regulations. Section 3.8 discusses how EEBSCs are applied in the building process and section 3.9 covers EEBSCs in South Africa. Section 3.10 explains the role of local authorities in implementing EEBSCs and section 3.11 discusses the use of EEBSCs in building renovations and refurbishments. Finally, section 3.12 gives the conclusion to the chapter.

3.2 The importance of implementing EEBSCs

EEBSCs are used to set minimum design requirements for key energy use aspects of new buildings and retrofits or additions to existing buildings. Building systems covered include (1) the building envelope, construction materials and techniques, (2) lighting equipment, controls, and installed lighting power, (3) electric power and distribution, and (4) air-conditioning and service water heating equipment (Deringer et al., 2004; Gann et al., 1998; Hamza and Greenwood, 2009; Laustsen, 2008). More recently, EEBSCs have begun to incorporate requirements for more “passive energy” features such as the use of natural ventilation, day-lighting, and cool roofs (e.g., codes recently developed in Vietnam and Egypt). EEBSCs are widely considered to be cost-effective government-based regulatory programs that potentially help to capture substantial energy savings (Deringer and Gilling, 1998; Deringer et al., 2004). The following explanations emphasize the importance of implementing the EEBSCs.

In the UK, A survey on architectural design practices to assess the impact of current energy conservation policies and legislation stated that 80% of the surveyed sample indicated that the revision of building regulations Part L introducing tighter measures for compliance (compared with government white papers and good practice guides) had the foremost impact on the design of low energy buildings (Adeyeye et al,. 2007). South Africa intends to add energy efficiency building codes in its national building regulations in order to achieve energy efficiency in buildings. This is well supported by the above finding from the UK.

Buildings are typically constructed to be used for many years, sometimes for more than a hundred years. Because of this, the energy efficiency of new buildings determines the building sector's energy consumption for far longer than other end-use sectors components determine their sectors efficiency (Laustsen, 2008). Additionally, buildings have a relatively long life and major refurbishments do necessarily take place – typically around every 15-20 years for residential buildings. This can be to replace major worn-out parts of the buildings and installations or because lifestyles and demands for comfort have changed in a modern society. Replacements and smaller refurbishments do occur more often. These circumstances about buildings provide an easy opportunity to improve a building's EE at initial construction or during the major refurbishments at very low cost. Energy efficiency regulations in building standards/codes are therefore among the most important single measures for buildings' energy efficiency. This is very important in times of high construction activity or in fast developing countries like South Africa.

From the previous chapter, we noted that the economy has not developed appropriate markets for energy efficient buildings. Energy efficiency building standards/codes often serve as the efficiency target for refurbishment or other improvements of existing buildings. Buyers and renters of buildings will often compare new and existing buildings. Increased interest for energy efficiency regulations in building codes can therefore spur the demand for refurbishment or general improvements of existing buildings, help design DSM programmes and cause a market transformation (e.g., incentive programs, design assistance programs, and demonstration building programs) (Deringer et al., 2004; Jansen, 2005) in South Africa.

Again, the previous chapter explained how Local authorities have been successful in implementing building control regulations in areas under their jurisdiction. It follows then that EEBSCs in South Africa will find a natural home in the building control functions of the local authorities. Besides, the abundance of many ready-to-implement forms of cost-efficient EE opportunities which employ end-use measures put local authorities in a key role in ensuring appropriate conditions for implementation match the local environment.

However, it is noted that in South Africa, specific legislation and regulations regarding energy efficiency in buildings does not exist (Reinink, 2007). It must be added that whereas the enactment and enforcement of legal instruments alone may not entrench and achieve energy efficiency in buildings, there is no known case where the efforts have succeeded without legislation; as seems to be happening in South Africa (Sebitosi, 2008). This therefore makes it necessary for South Africa to develop and implement EEBSCs in its building sector. The other two reasons which have accelerated the need for enactment and implementation of EEBSCs in South Africa are; electric energy supply deficiencies, which peaked in 2006/2007 and the increase in electricity prices between 2009 and 2013 by more than 100%. This got the government into action and energy efficiency building regulations have been developed. They have gone through almost all legislative requirements and are awaiting promulgation before they get implemented through the building control processes of the local authorities. Discussions about these regulations and other issues about EEBSCs are covered in the subsequent sections of this chapter.

3.3 The Evolution of EEBSCs

As stated in the previous section, EEBSCs are widely considered to be cost-effective government-based regulatory programs that potentially help to capture substantial energy savings. Four generations of energy codes and standards for buildings in the US have produced estimated energy efficiency improvements of about 60% over 30 years (Deringer and Gilling, 1998; Deringer et al., 2004). In developing countries, estimates of potential energy savings for first-generation building energy standards have typically ranged from 20% to 35%. However, compared to ordinary building regulation standards, energy efficiency building standards are relatively new in most countries and are not even legally in use in others, like South Africa. Figure 2.7 in chapter two gives an overview of the statuses of EEBSCs in many countries around the world.

In the UK, building regulations to reduce energy consumption by good design and detailing date back to 1965. This was in the form of prescriptive regulations in which a certain U-value was achieved for individual components of the fabric or the overall building envelope. These prescriptive regulations were tightened over the years in response to repeated energy crises and concerns regarding the increases in carbon dioxide emissions, reducing the U-value for exposed walls progressively from1.7W/m^2 K in 1965 to 0.35W/m^2 K in 2002 (Hamza and Greenwood, 2009; Gann et al., 1998). The regulations were satisfied by increasing insulation thickness and limiting glazed areas on facades. In 2006, the government introduced performance based calculations for building energy consumption.

In most other countries, early energy efficiency requirements for buildings responded to poor insulation levels which could lead to health problems because of moisture or air-infiltration. Most regulations for energy efficiency in buildings before the oil crises in 1973/74 were from the northern European regions with severe cold winters, where the climate could considerably influence public health (Laustsen, 2008). Requirements on specific constructions with some thermal characteristics in these regions first appeared during the period between the two World Wars, when some countries regulated the introduction of simple insulation in the form of air layers in cavity walls or double layer floors of timber beam (Laustsen, 2008).

The first real insulation requirements for U-values and R-values for specific insulation materials or multi-glazing, date back to the late 1950s and the early 1960s in Scandinavian countries. These national requirements were intended to improve energy efficiency and comfort in buildings. Comfort was the prime motivation for raising the requirements, which was a reflection of an improved standard of living; hence people wanted better living conditions.

In many countries however, the oil supply crisis of the early 1970s catalysed the development of energy efficiency requirements for buildings. Those countries already enforcing efficiency regulations in buildings generally raised their requirements during the early 1970s to further reduce energy consumption and decrease dependency on oil (Deringer et al., 2004; Hamza and Greenwood, 2009; Laustsen, 2008). During the 1980s and 1990s, energy efficiency requirements were set or increased in most OECD countries and got new impetus in many other developing countries. In part, the new legislations responded to the Kyoto Protocol, European 'Energy Performance of Buildings' Directive (EPBD) requirements and other targets to reduce or stabilise CO_2 emissions. Another reason for the new EEBSCs legislations was the development of DSM energy programs to reduce energy consumption and dependence on foreign sources of energy, especially oil (Deringer et al., 2004). These reasons underline the development of EEBSCs in South Africa in addition to the country specific ones stated in section 3.2 of this chapter.

3.4 Types of EEBSCs

Broadly, EEBSCs can be classified into two categories namely,

1. **Prescriptive energy building standard,** which are set and based on energy efficiency requirements for individual building parts U-values. This method sets separate energy efficiency requirements for each building part and for each part of the equipment. Individual components must achieve compliance with their specific targets (Laustsen, 2008). These comprise the trade-of method where Values are set for each part of the building, but trade-offs can be made so some values are better and some are worse than the requirements; and the model building method where Values are set as in the trade-off, and a model building with the same shape is calculated with those values. A calculation has to demonstrate that the actual building will be as good as the model building. Lately, many jurisdictions are abandoning this category of EEBSCs for the performance based ones.

2. **Performance or calculation based energy building codes** set the overall frames for energy consumption in a building. Here, the energy performance requirements are based on a building's overall consumption of energy or fossil fuel or the building's implied emissions of greenhouse gases (Laustsen, 2008). These include the Model Building method explained above, Energy Frame method where an overall framework establishes the standard for a building's maximum energy loss. A calculation of the building's energy use has to show that this maximum is respected. These methods are all based on calculated energy consumption and all require calculation models and computer tools. The calculation procedures can be set on a national, regional or local scale. However, there are ongoing efforts in CEN and ISO to develop international standards which will ease future comparisons. These types of standards have to be compared based on total performance or the total frame, but again climate conditions must be taken into account. Currently, this is the type of EEBSCs most favoured by implementers and which they believe is most likely to deliver high energy savings in buildings.

The choice and use of the appropriate type of standard is dependent on the actual experience of a country and the development of its building and construction industry. Often, several types of energy efficiency building standards exist as alternatives or complimentary. Similarly, comparison of the standards is difficult between the different types of codes and can only be justified for codes based either on individual values or performance and frame based values.

3.5 Formulating EEBSCs in Developing Countries

As noted from the previous chapter, many developed countries already have EEBSCs in place. As developing countries grow their economies, which translates to greater energy consumption and accelerated construction activity accompanied with increased energy dependent equipment, there is need for them to formulate and implement EEBSCs to meet their sustainable development goals in the built environment. Yet, in developing countries, the institutional framework to effectively implement EEBSCs is lacking. This requires that such an arrangement be put in place first to support the building energy codes (Deringer et al., 2004; Laustsen, 2008). This infrastructure includes administrative structures and procedures, compliance forms and processes and supporting tools like training and information systems. Thus, the formulation of an EEBSC is the first of several steps needed in order to have an EEBSC in place that can succeed in saving energy. These steps are shown in Figure 3.1.

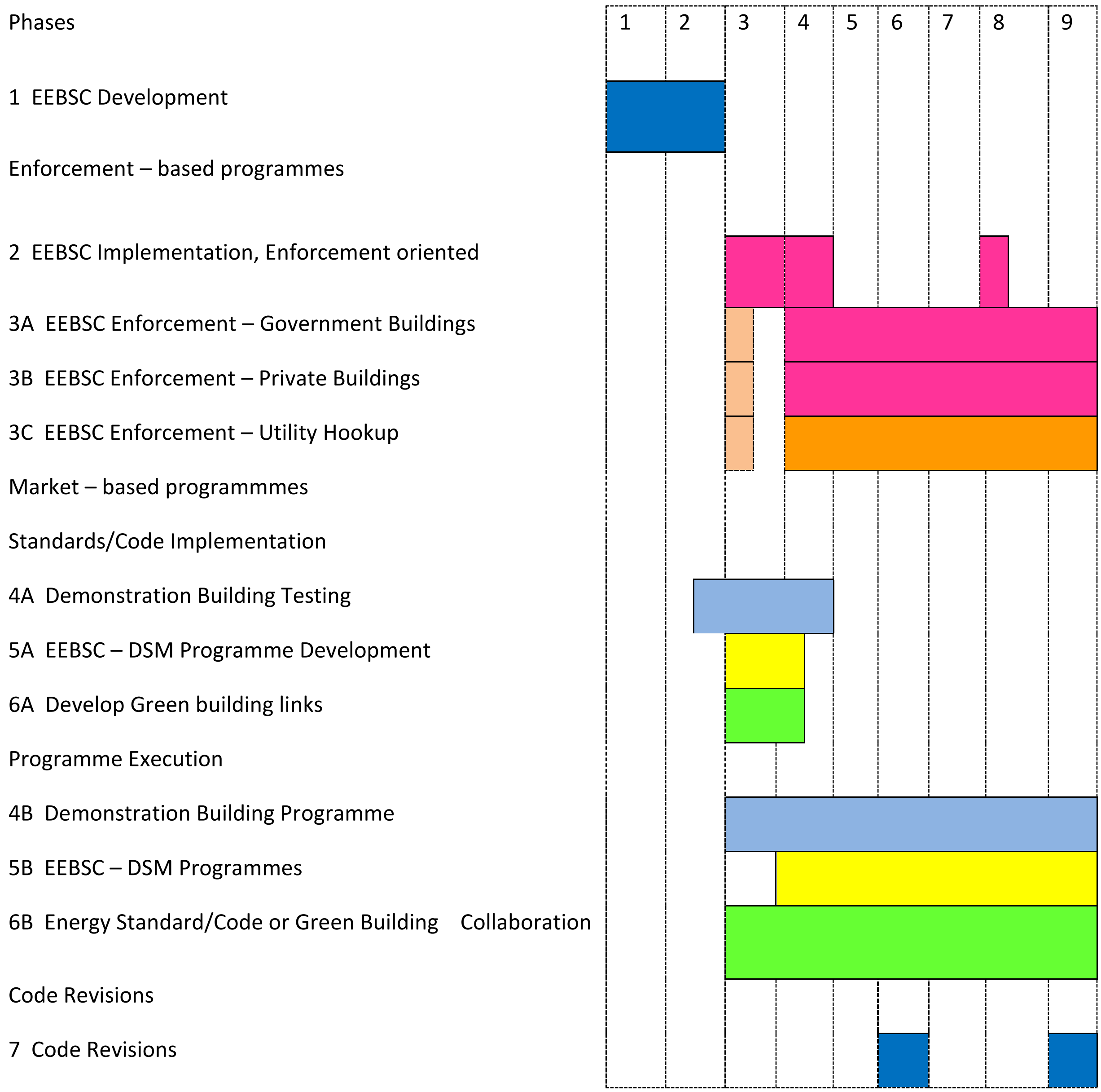

Figure 3.1 Phases of formulating and implementing a first generation EEBSC

Source: Deringer et al. (2004)

Figure 3.1 shows a proposed “comprehensive” EEBSC formulation, implementation, and revision program that emphasizes market transformation programs as well as more “traditional” code enforcement approaches. The traditional approach to the development of EEBSC involves formulation, enforcement oriented implementation in government and private buildings, utility hookup and Code Revisions i.e. steps 1, 2, 3, and 7 in figure 3.1. The first phase involves writing the EEBSC document. The second “implementation” phase is code-enforcement oriented and prepares the infrastructure, administrative structure, procedures and tools needed to permit compliance with the EEBSC in code setting and placement into law to be enforced. The two phases are explained in more detail in the following sections.

3.5.1 Common Steps in Formulating EEBSCs

As shown in figure 3.1, the common steps involved in formulating a building energy code are as follows (Deringer et al., 2004):

1. **Survey and comparison of energy codes.** This is done in order to identify the best materials from other jurisdictions. This can be; code structures, formats, requirements, stringency levels, etc. that might be appropriate for local conditions.
2. **Survey of local buildings.** Information about the building stock and its energy use is needed in order to properly plan, implement or evaluate an energy code or other energy efficiency programs. For proper EEBSC planning (or energy planning in general) one needs, at a minimum, estimates of
    a. Current floor space and future additions to floor space, preferably disaggregated by type of economic activity or building function, e.g., office use, hotel, retail, cultural, health, etc.,
    b. Electricity consumption, preferably disaggregated by the same categories**,**
    c. Energy use by key end-uses, air-conditioning, lighting, ventilation, etc.,
    d. The percentage of commercial building stock that is air-conditioned, and,
    e. Penetration rates of key energy-using equipment, including data on shipments of such items as chillers, packaged air-conditioning systems, motors, lighting equipment, glazing, etc.

In many developing countries, this information is not easily available, which in one way explains the failure of their EEBSCs to achieve the energy savings potential. However, with sound professional judgment, they can produce reliable information after doing a building survey of "base case" buildings that are used as benchmarks for developing and evaluating code requirements.

3. **Energy code document.** The energy code document may be written by local experts or by international "experts" from outside the country. In either case the writing of the code document usually involves multiple drafts, each reviewed by a technical advisory committee of legal and building industry experts.

4. **Energy and Economic Analyses.** This activity typically uses computer-based energy simulations (e.g., DOE-2,) applied to typical "base case" buildings to estimate the energy savings and cost effectiveness of the key EEBSC requirements, and how much energy might be saved by the proposed energy code.

5. **Implementation Plan.** This activity develops a "plan of action" for implementing the building energy code document that is being developed. Unfortunately, most implementation plans are developed at the very end of the energy code development process. In most cases funding levels may be low which subsequently affect implementation activities.

6. **Training and Capacity-building**. Such activities are an important part of all energy code formulation and implementation projects because they arm the human resource which design and executes the programmes with the appropriate knowledge. In some cases, it is among the first tasks to be carried out by the code formulating agency. This may involve sending a task tam to training in jurisdictions already executing such programmes.

3.6 Implementation of EEBSCs

As shown in figure 3.1, implementation of EEBSCs can follow either the traditional code enforcement or the market transformation approach. Similarly, this could involve using the EEBSC either in a voluntary and/or a mandatory enforcement framework. Effective implementation on a voluntary or mandatory basis requires many of the same supporting infrastructure elements. The enforcement component has separate paths for private sector buildings, government buildings, and a possible utility hookup enforcement option. The market transformation component has separate paths for demonstration buildings, EEBSC-DSM programs, and green building programs. In all these implementation/enforcement models, there is a common practice of revising the EEBSC after say 3 to 5 years to take advantage of technology advances and improved energy efficiency knowledge by the local building industry (Deringer et al., 2004).

3.6.1 Activities for the effective implementation of EEBSC

From figure 3.1, the following activities are important for the effective implementation of the formulated EEBSC (Deringer et al., 2004):

1. **EEBC Promulgation.** This task involves the completion of legal steps that may be required, after the completion of the public review of the EEBSC development, to enable the EEBSC to be placed into law either as a national energy standard or energy code for buildings implemented by the various local authorities. The proposed South African one is at this stage. It is a national energy standard which will be implemented by the local authorities.

2. **Develop the Energy Code Compliance Process.** This includes developing compliance forms and procedures, users' manuals or guidebooks, compliance tools and software. This can also involve establishing administrative procedures for checking compliance, and for documenting, recording, and publishing compliance results. This function may be shared between the formulating and the implementing agency; thus the respective department of national government and the local authorities

3. **Develop the Energy Code Administration and Enforcement Structure.** This involves establishing the enforcement authority, budget and staffing. In many jurisdictions, this is carried out by the implementing agency, mostly the local authorities.

4. **Develop and Conduct Training Programs.** Such training may include (1) workshops for architects, engineers, and code officials (usually local authorities' officials), (2) EEBSC and energy courses in architectural and engineering departments of universities, and (3) international study opportunities in EEBSC Implementation activities. This, as earlier mentioned, aims to provide appropriate skills among staff implementing the programmes.

5. **Outreach and Public Information Programs.** These programmes are critical in creating and sustaining progressive awareness of the advantages of energy efficiency in the building industry and the whole economy. They include programmes targeted at the building industry, financial services for buildings and the general public.

6. **Evaluate EEBSC Savings and Effectiveness.** These activities would expand upon the computer-based energy and economic analyses conducted during EEBSC development. Additionally, they will inform subsequent improvements in the overall formulation of newer programmes and changes to the existing standards.

As stated at the beginning of this chapter and the previous chapter, EEBSCs have been in existence for about thirty (30) years in developed countries and they are in infancy in many developing countries (figure 2.7). The following two sections explain how EEBSCs have been implemented in the two country categories, i.e. developed countries and developing countries.

3.6.2 Implementation of EEBSCs in Developed Countries

Nearly 40 years after 1973, jurisdictions in at least 30 developed countries have established EEBSCs, and many have noteworthy track records of implementing, enforcing and refining the EEBSCs (Deringer, et al., 2004; Jansen, 2005). For example, a number of jurisdictions in the US and Canada have effectively implemented EEBSCs (California, Minnesota, New York, Florida, and Washington State among others) and are now refining the implementation of their third and fourth generation EEBSCs, which are integrated in their locally enforced building codes (in the US, many codes are based on ASHRAE Standard 90. The major "generations" of this standard are (1) 90-1975, 90A-1980, 90.1-1989, and 90.1-1999/2001). These are widely viewed as minimum acceptable levels of energy efficiency in buildings and they are implemented on the entire spectrum of enforcement from the traditional mandatory model to the market transformation approach (Deringer et al., 2004).

In some jurisdictions there are additional, utility related DSM programs that use the EEBSCs as benchmarks to encourage more advanced energy savings via design assistance or rebate programs such as "Savings by Design" in California, and "Energy Edge" in Minnesota (Deringer et al., 2004). In addition, green building programs are becoming increasingly popular voluntary programs for overall sustainable design that also use EEBSCs to benchmark additional energy savings. Countries which are yet to deploy EEBSCs like South Africa are advised to study this implementation models and choose appropriate ones for their energy efficiency programmes.

Of the more than 30 developed countries with EEBSCs, at least 17 European countries have developed mandatory EEBSCs and some of them have decades of experience in implementing them (For example Germany, England, Wales, and Denmark) (Laustsen, 2008). In the South Pacific area, Australia and New Zealand have been developing and implementing EEBSCs largely modeled upon the institutional foundation derived from the UK with complementary use of technical experience from North America (ICBEC, 2010). These programmes have been in operation for about ten years. Other developed countries (e.g., Japan, Korea, Singapore, Taiwan, etc.) have had EEBSCs in place for a reasonable amount of time (ICBEC, 2010). From the foregoing, it is easy to see that developed countries have been implementing EEBSCs for more than one decade. This experience can aid the formulation and implementation of EEBSCs in developing countries when done with appropriate understanding of geographic and economic differences.

3.6.3 Implementation of EEBSCs in Developing Countries

Information about EEBSCs status in developing countries is difficult to obtain. The little data available is not detailed and it is for a few countries (Janda, 2009; Deringer et al., 2004). From the little information available, at least 21 developing countries (this includes Newly Industrialized Countries (NIC), such as India, China, Mexico, and South Africa) have developed first generation EEBSCs, and 3 more countries are now reported to be developing their first generation codes (Deringer et al., 2004; ICBEC, 2010; HkU, 2010). In some countries the EEBSCs were developed between late 1980's and mid-1990's.

In the said cases, EEBSCs do exist on paper. The EEBSCs documents have been written; and some have been promulgated as voluntary national standards or national energy codes. However, they have not been widely used, and they have not produced significant energy savings (Deringer et al., 2004). Indeed, there are only isolated cases of buildings in developing countries, either government or private sector, that have been designed and constructed to meet the building energy codes that have been developed.

A reasonable conclusion is that EEBSCs have not been used effectively to save energy in the building stock of developing countries. Thus, EEBSCs are yet to produce the energy savings potential that have been estimated in these countries (Deringer et al., 2004). This may have been caused by many factors but mandatory and effective implementation of the EEBSCs through the building control processes of local authorities could help unlock some of the savings potential.

3.7 EEBSCs in Main Building Regulations

When requirements for energy efficiency are set in separate standards, they are less bound by other building regulations and may lead to wider application and use beyond the construction and building framework. However, as separate standards, they require an own enforcement system (Laustsen, 2008).

Energy efficiency requirements included in buildings standards are usually set in a specific chapter and enforced along with the general rules of the building codes in local authorities. If the building industry is familiar with general requirements in the building standards, integrating efficiency requirements can very easily and efficiently inform industry actors of energy conservation measures.

Energy efficiency requirements can be included in building regulations as short brief codes or long and comprehensive specific standards. In many countries, the two are mixed and are simply referred to as energy efficiency standards. For example, in Germany, general building regulations refer to many specific DIN[7] standards, where the energy efficiency measures are stated. In many other countries specific guidelines to describe calculation rules and possible use accompany building codes such that the general rules appear in the building code, while

[7] DIN is “Deutche Institut für Normung“: German institute for norms and standards.

standards contain specific details. Many jurisdictions refer to national, CEN[8] or ISO standards. The above standards and codes cover work on new and existing residential buildings and, new and existing non-residential buildings. Therefore the setting of the EEBSCs in a specific chapter of the building regulations is a widely accepted practice in many jurisdictions where they are in use.

3.8 Using EEBSCs

As stated earlier in this chapter, traditional EEBSCs have been used to set minimum design requirements for key energy use aspects of new buildings and retrofits or additions to existing buildings. Building systems covered include (1) the building envelope, construction materials and techniques, (2) lighting equipment, controls, and installed lighting power, (3) electric power and distribution, and (4) air-conditioning and service water heating equipment (Deringer et al., 2004; Gann et al., 1998; Hamza and Greenwood, 2009; Laustsen, 2008). More recently, EEBSCs have begun to incorporate requirements for and/or more “passive energy” features such as the use of natural ventilation, day-lighting, and cool roofs (e.g., codes recently developed in Vietnam and Egypt). For EEBSCs to be effective, it is important that they are applied from the design phase to completion and operation of the building. Measures for compliance therefore can be divided according to the stages of the project into (i) the design stage, (ii) as built, and (iii) as operated (Hamza and Greenwood, 2009).

Fig. 3.2 illustrates the extended process over the project development stages, and indicates where the energy model and testing methods need to demonstrate compliance with EEBSCs. This figure may also illustrate the framework for gaining planning and building approval in any jurisdiction enforcing EEBSCs in its building approvals process.

In the design phase, designers must ensure compliance with the EEBSCs set in the minimum requirement of the building construction processes being used. This will be in materials, ventilation requirements among others. The aim is to ensure that at the end of construction, all the components of the building will meet the requisite EEBSCs measure.

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[8] CEN, European Committee for Standardisation, is currently developing 31 international standards for calculation of energy performance in buildings to be used in connection with directives from the European Union.

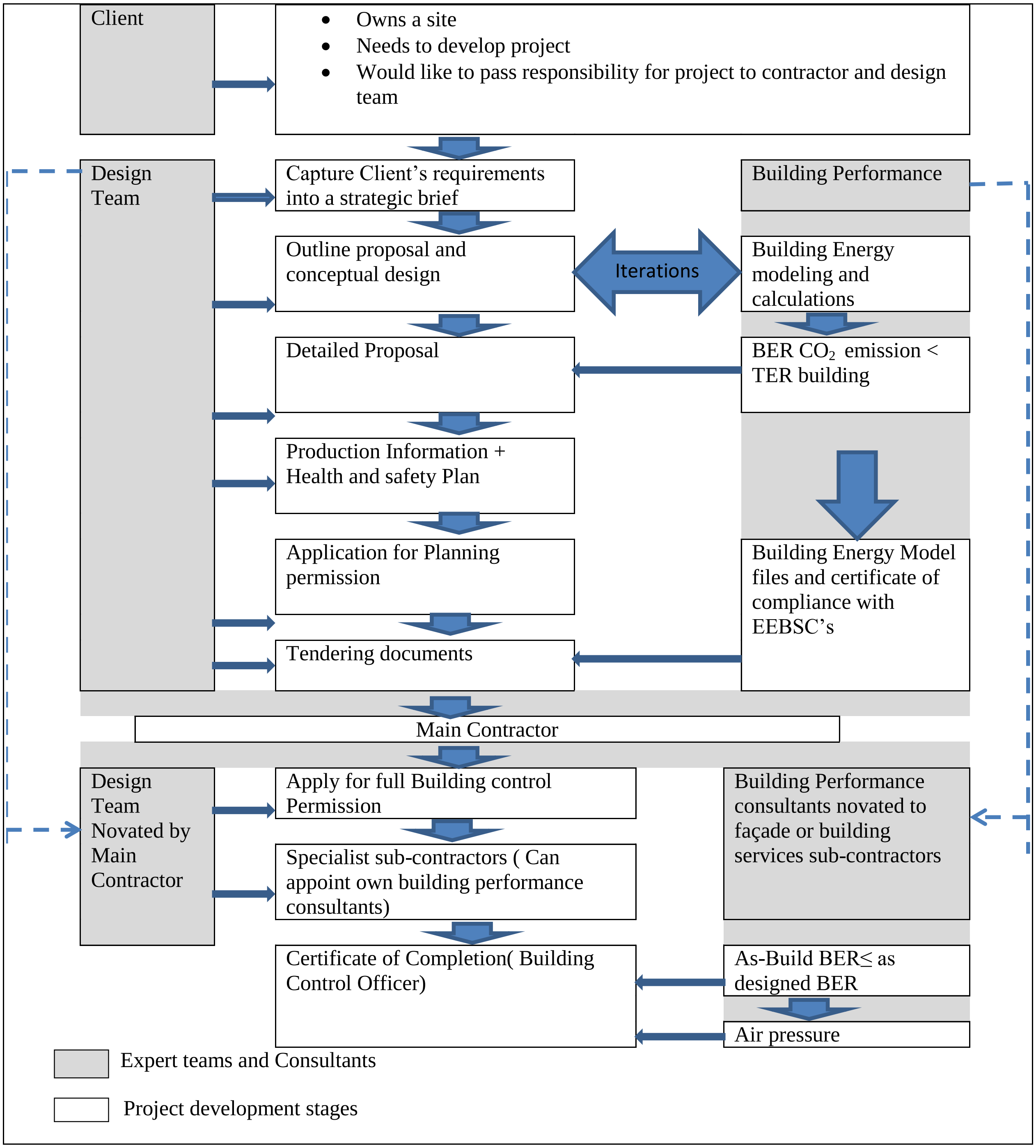


Figure 3.2 The project realization stages in relation to compliance with Inspection based EE regulations

(Adapted from Hamza and Greenwood, 2009)

The as-built requirements will ensure that certification for compliance with the EEBSCs is issued. Similarly, the building model to prove that the 'as-built' design has an accepted building emission rate (BER) that does not exceed the (BER) simulated in the design stage should be carried out.

While in operation, the following must be obtainable from the building: reliable and detailed information to the owner to allow efficient use of the building and its services and a detailed record of energy consumption by end use, to ensure the building runs as per the design intentions. Following these steps will enable the use of EEBSCs to make the buildings energy efficient at every part of its life. These steps can be easily implemented through the building control process of the local authorities alongside the other building control functions they carry out.

In the jurisdictions where EEBSCs have been in application for a long time, the codes have been used; (1) within a mandatory enforcement model (2) as voluntary standards and/or (3) as the basis for various market transformation programs. Here below are the summaries of each of these uses.

3.8.1 Mandatory enforcement

This is a common enforcement model in developed countries. It has been used to achieve significant success in integrating EEBSCs in many European and North American countries, as earlier shown in this study. The energy efficiency code is formally adopted (promulgated) as a section or volume of the overall building code or in a government regulation.

Generally, there are three mandatory enforcement paths: (1) for non-government buildings, enforced as part of local building codes by the local authorities, (2) for government buildings, enforcement as part of agency regulatory requirements (E.g., US DOE, US GSA, central government and local authority regulations, etc.) and (3) enforcement by utility companies at hook-up time, especially as part of their DSM programmes. This approach is not common but permits enforcement to target consumers. For this reason, utility hook-up enforcement has been proposed for consideration in developing countries where: (1) the code compliance infrastructure is not well formed, and/or (2) it is likely that traditional enforcement would result in delay of the spread of EEBSCs programmes (Deringer et al., 2004; Laustsen, 2008; Jansen, 2005). This must have informed some of the early voluntary measures carried out by the South African local authorities at the point of connection.

Several prerequisites are needed for EEBSCs to work properly in a mandatory enforcement regime. First, the overall guiding building compliance regulations must be in place. Second, a building compliance administration and infrastructure must be in place and properly functioning. This in most jurisdictions is the local authorities. Third, the underlying enforcement of the overall building regulations should be reasonably effective. Fourth, the building control officials responsible for administering EEBSCs need to be knowledgeable about the basic strategies for saving energy that are imbedded in the EEBSC. While these preconditions exist to some extent in many developed countries, majority developing countries lack such infrastructure and Human capacity (Laustsen, 2008; Deringer et al., 2004). This explains one reason why many programmes in developing countries are still voluntary.

3.8.2 Voluntary implementation.

EEBSCs have been used as voluntary standards in both developed and developing countries, particularly at introduction. In some countries, this was on a temporary basis. In others, this arrangement was retained alongside the mandatory implementation; each being applied to different building segment (i.e. Voluntary for Residential buildings and Mandatory for commercial & government buildings). For example, in Indonesia an EEBSC was developed in the late 1980s and became a national voluntary standard in the mid-1990s. In Jamaica the EEBSC document was finished in 1994 and was quickly issued as a voluntary standard in anticipation of future promulgation as a mandatory regulation. However, until 2003, the Jamaican EEBSC was still voluntary (Deringer et al., 2004).

In China, EEBSCs were first developed for residential buildings in the north in the 1990's and implemented on a voluntary basis with unsatisfactory results. Between 2001 and 2003, EEBSCs were developed for residential buildings in central and southern China, and the writing of a national EEBSC for public and commercial buildings was started in 2002 (Liang et al., 2007). There has been a sustained push both at the national and local government levels to gradually make these EEBCs mandatory. In Beijing, the residential EEBSC has been mandatory since the late 1990s, while in Shanghai it became mandatory for all buildings in 2006 (Laustsen, 2008). This offers a window of opportunity for developing countries lacking in human capacity and the general infrastructure for a mandatory roll out to start implementing EEBSCs while developing such capacities. Once the threshold of minimum capacity has been achieved, they can then shift to mandatory implementation (EC, 2007).

3.8.3 Market Transformation Programs.

Besides their primary goal, EEBSCs can be put to several other uses. EEBSC can be used as the basis for programs that encourage additional levels of energy efficiency beyond the “minimum” standard/code levels. This can be applied in both voluntary and mandatory programmes in the form of:

1) Demonstration building programs,
2) Utility demand-side management programs such as design assistance programs or rebate programs, and
3) Green building rating systems and programs.

Such market transformation programs have been widely used in the United States in association with EEBCSs, but they are hard to implement in developing countries or in newly industrialized countries (NICs) in the absence of an effective basic building regulatory regime (Deringer et al., 2004).

Similarly, several related energy efficiency programmes are often used together with EEBSCs. These related programs include; appliance and equipment efficiency standards, labeling programs, and rating programs.

Appliance programs focus on specific items of equipment (e.g., lighting equipment, electric motors, air-conditioning units, etc.) which are used in buildings to make it a complete unit[9]. Since there is a potential for overlap or inconsistency, it is important that coordination occur between the governments entities responsible for developing and enforcing these policy instruments. Labeling and rating programs are broader than appliance or equipment efficiency standards, for they provide information about higher efficiency equipment in addition to minimum standards of performance[10]. There is currently much interest worldwide in establishing closer links between EEBSCs and environmental rating systems[11]. This in turn may lead to a change in the structure of EEBSCs. For example, EEBSCs may shift to contain multiple stringency levels (tiers), or point systems, to permit better integration with environmental rating systems (e.g., LEED)[12]. Overall, this explains the fact that EEBSCs are going to be useful beyond the original intention of reducing energy consumption in buildings. They are going to be useful for addressing environmental issues and in transforming markets for energy products and services in many developing countries once implemented.

In conclusion, most EEBSCs around the world follow local, state or national tradition. However in the past decade, a trend has emerged of supranational collaboration to develop international EEBSCs. Examples are the US based Energy Efficiency standards (IECC 2004[15] and ASHRAE 2004[16]) which are used in US and Canada, and the European Energy Performance in Buildings Directive (EPBD) that required member states of the European Union to establish EEBSCs for new buildings and retrofits of $1000m^2$ or more since January 2006. To supplement the EPBD, the European Union aims to establish a model EEBSC for the European region (2006 EU Action Plan for End-use Efficiency) and to develop CEN standards for energy performance calculations. The CEN standards are likely to be amended and adopted as ISO standards too (Laustsen, 2008).

[9] For example, the US DOE lists published or pending energy efficiency standards for such commercial products as: distribution transformers; unitary air-conditioners and heat-pumps; small electric motors; electric motors; and, high intensity discharge lamps

[10] In the US, the Energy Star program is a comprehensive labeling program.

[11] For example, this approach is currently being examined as an option for the EEBSC being developed in India.

[12] It is necessary to develop an environmental rating system for the developing countries. Attempting to transfer one from the developed countries and applying it wholesomely may fail.

3.9 EEBSCs in South Africa

Formulation of Regulations to reduce energy consumption and increase efficiency of use started in 2002, when NERSA started developing a policy paper to implement energy efficiency and demand side management in the South African electricity industry. In May 2004, NERSA launched a “Regulatory Policy on Energy Efficiency and Demand Side Management (EEDSM) for South African Electricity Industry” policy paper (NERSA, 2004). It obliged the electricity industry to implement and finance appropriate measures to meet the energy efficiency targets specified by the NERSA. This was put as a requisite precondition for future approval of tariff increases applications on the part of the electricity utilities. Alongside this, and following from the power outage crisis of 2006/2007, the building industry too started to look at actions to effect energy efficiency in its building regulations.

The DME subsequently mandated the South African bureau of standards (SABS) to develop a South African national standard (SANS) for energy efficiency in buildings. SANS 0204: Energy Standard for Buildings with mechanically assisted ventilation systems’, which was based on the SAEDES[13] guideline, was formulated. This standard was to ensure that energy efficiency becomes integrated in buildings Standards and would eventually be included in the National Buildings Regulations as proposed in the energy strategy (Reinink 2007).

As stated earlier in this study, EE building regulation standards in South Africa are still at infancy. In 2007, the SABS 0400 was changed to be SANS 10400 of the National Building regulation and parts X (Environmental Sustainability) and XA (Energy usage in buildings) were added to take into account the energy efficiency standards in buildings (Reynolds, 2007; du Toit, 2007).The draft standard for energy efficiency in buildings in South Africa: SANS 204 parts 1, 2, 3, and 4 was unveiled in 2008 and if adopted as the national standard will contribute greatly to energy efficiency in buildings.

[13] SAEDES (South African Energy and Demand Efficiency Standard); unveiled in the 1990’s as a guideline by the Department of Minerals and Energy, the document was meant to provide technical guidelines for a framework of performance provisions and environmental acceptability for commercial buildings.

South Africa, like many other countries has set this new proposed energy efficiency requirements for buildings in the National building regulations and Building standards Act, 1977 (Act 103 of 1977). Only a little part of this regulation is envisioned to be in the Occupational Health and Safety Act, 1993 (Act No.85 of 1993). This has been set in a specific chapter and will be enforced along with the general rules of the building standards. This is because the building industry is familiar with general requirements in the building standards; therefore integrating energy efficiency requirements will be easily and efficiently done. These energy efficiency requirements set in building standards will be brief, specific and comprehensive.

In line with other international standards and specifically like the Australian standard, from which it borrows heavily, this will be a performance standard. The performance standard overcomes problems of overly rigid and inflexible rules of the prescriptive standard. Performance standard regulates for results by developing frameworks for action, identifying sources of knowledge (or its insufficiency) and the tools to effect it (Laustsen, 2008). The general rules will appear in the SANS 10400; National Building Regulations part X: Environmental Sustainability, sub-part XA: Energy usage in buildings sections 1, 2, 3, 4 and 5. The specific standard/code containing specific details of calculations and other particulars will be in the SANS 204 Edition 1 Parts 1, 2, 3, and 4 (SABS, 2011). This regulations and standards/codes are targeted at new buildings. Figure 3.3 below illustrates the process they (regulations and standard) are likely to follow to be legislated before they become operational. For the regulations and standards to be used effectively for the various climatic conditions across South Africa, the country has been divided into six climatic zones/regions as shown in Appendix 4.

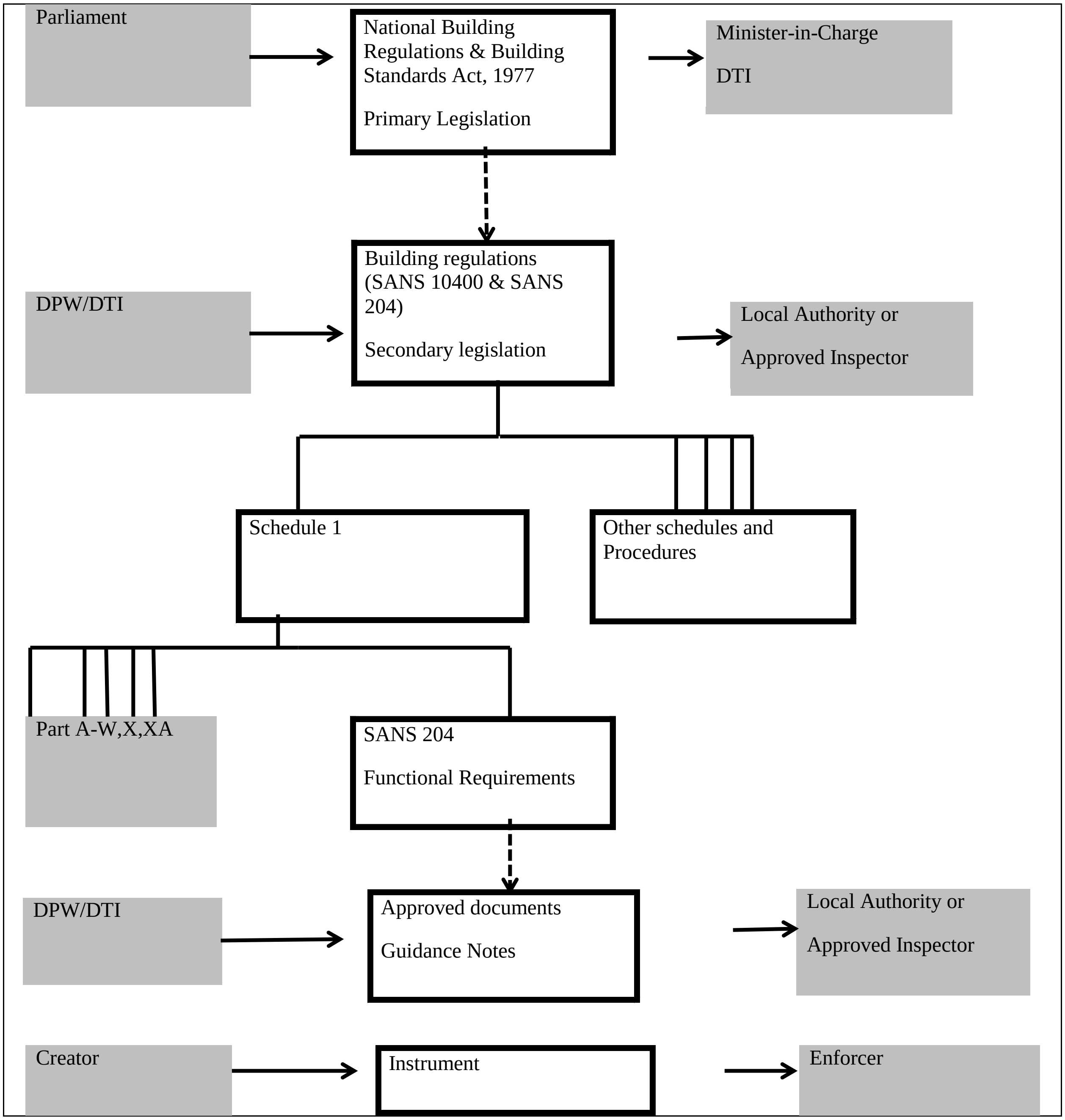


Figure 3.3 Proposed Legislation Structure for SANA 10400(Part XA) and SANS 204

(Adapted from Gann et al, 1988)

The period for comment on these performance based Regulations and Standards lapsed in early May 2011 and are awaiting promulgation into law. The published proposed new SANS 10400 XA regulation is expected to legislate on; (1) Hot water supply: insulation levels, piping and solar water heaters, (2) thermal performance of the building envelope elements: occupancy, R-values, U-values with tables for each climatic zone, Orientation, walls, floors, fenestration and roofs. Tables' 2.6 and 2.7 show examples of the energy demand and consumption respectively per building classification in the various climatic zones, (3) lighting and ventilation and (4) the Software to be used in the design assumptions to make appropriate calculations to meet the requisite standard for approval. Compliance with this regulation is proposed to extend from the design phase to completion and operation of the building. This means that measures for compliance for energy efficiency can be checked at design stage, as built and as operated.

Table 3:1 Maximum energy demand per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	Description of building	Maximum energy demand[a] VA/m²					
		Climatic zone[b]					
		1	2	3	4	5	6
A1	Entertainment and public assembly	85	80	90	80	80	85
A2	Theatrical and indoor sport	85	80	90	80	80	85
A3	Places of instruction	80	75	85	75	75	80
A4	Worship	80	75	85	75	75	80
F1	Large shop	90	85	95	85	85	90
G1	Offices	80	75	85	75	75	80
H1	hotel	90	85	95	85	85	90
[a] The maximum demand shall be based on the sum of 12 consecutive monthly maximum demand values per area divided by 12/m2 which refers to the net floor [b] The climatic zones are given in Annex B.							

Source: (SABS, 2011)

Table 3:2 Maximum annual consumption per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	Description of building	Maximum energy consumption kWh/m²a					
		Climatic zone[a]					
		1	2	3	4	5	6
A1	Entertainment and public assembly	420	400	440	390	400	420
A2	Theatrical and indoor sport	420	400	440	390	400	420
A3	Places of instruction	420	400	440	390	400	420
A4	Worship	120	115	125	110	115	120
F1	Large shop	240	245	260	240	260	255
G1	Offices	200	190	210	185	190	200
H1	Hotel	650	600	585	600	620	630
Note 1 the annual consumption per square metre shall be based on the sum of the monthly consumption of 12 consecutive months. Note 2 Non-Electrical consumption, such as fossil fuels, shall be accounted for on a non-renewable primary energy thermal equivalence basis by converting mega joules to kilowatt hours.							
[a] The climatic zones are given in annex B							

Source: (SABS, 2011)

The SANS 204 standard contains broad functional requirements and procedural finer details for design and operation of energy efficient buildings with both natural and artificial environmental control and subsystems. It is divided into four main sections: Scope, Normative references, Definitions and Requirements. The key issues in SANS 204 are as follows (SABS, 2011):

i. It gives the definitions of the various terms used in the standard to enhance energy efficiency.
ii. It gives the specific measurable requirements for site orientation, building orientation, shading, building design for all functional elements of the envelope and the building contents.
iii. It gives ratings for building sealing for air. Further, rating details for lighting and power and hot water services are prescribed.
iv. Mechanical ventilation and air conditioning systems measurements for energy efficient design are well documented. However, in one line, it does mention installed equipment in the buildings to be energy rated and have a stand-by energy reduction mode when not in use.

Enforcement of this proposed energy efficiency regulation and standard is by Local government departments. In the immediate term after promulgation of these regulations, the local authorities may face the following challenges:

1. They will need to develop objective procedures for evaluation, while being consistent in granting approval in exercise of discretion and flexibility in the new order to achieve easy acceptability;
2. To develop a consistent framework among building control staff and an ability to understand and use building simulation software.

A common trend is that buildings improve energy performance following the introduction and strengthening of building regulations and standards. The level of success between promulgation and improvement corresponds to the strength of local authority law enforcement. Lapses between promulgation of new requirements and their full implementation in the building sector are common. This could be as a result of insufficient enforcement and poor information. It is hoped South Africa will fare better.

3.10 Local Authorities and the Implementation of EEBSCs

There are many ways local authorities get involved in the energy services and EE agenda in areas under their jurisdiction. First, municipalities and local authorities can initiate markets for energy services and EE equipment. This framework of involvement is mostly related to statutory obligations and powers of local authorities, and the ensuing energy related tasks and ownership issues (such as ownership of energy supply utilities). Municipalities can also foster markets by applying fiscal policy with regard to local taxes and fees, which gives preferential treatment for investments in measures to increase energy efficiency and for the efficient end use of energy (Genchev, 2003). This is common in developed countries.

Second, municipalities and municipal institutions may act as buyers of energy services and EE equipment. This is related again to statutory obligations and powers, and also to public budgeting and procurement rules designed to effect policy change in areas under their jurisdiction. This is common in many jurisdictions in both developed and developing countries.

Third and most important to this research, municipalities do act as implementers of interventions for improvement of end-use energy efficiency. This ‘‘traditional’’ way of municipal involvement, entails municipalities applying the regulations and standards set out in national or local statutes and ensuring enforcement in areas under their jurisdiction. Because energy efficiency is new in building codes, appropriate measures must be put in place for its effective implementation (EGI, 2002).

In some countries, national governments delegate the establishment of energy efficiency requirements for buildings to local authorities. In this case, the city council, regional government or federal state may autonomously set and enforce standards. This independent governance is now quite rare, because energy efficiency is now seen to be a very important national and international responsibility. Countries where codes are set on a local level would normally have a standard set at the national level with the recommendation to adjust the standard locally for enforcement (Visscher and Meijer, 2011).

In all cases, local and municipal authorities play an essential role in implementing cost-efficient end use energy efficiency opportunities in buildings in most countries (Rezessy, et al., 2004). Traditionally, the building control departments of municipal authorities in most countries have had an important role in assuring that building plans and construction processes lead to buildings that meet the minimum required quality levels (Visscher and Meijer, 2011). This they do through their building control department reviewing designs and performing post-construction inspections (Building Research Establishment, 2008). Once the EEBSCs are set in the building regulations, then the local authorities will be best suited to provide the quality assurance that indeed energy efficiency measures were followed right through the entire building process- as explained earlier in figure 3.2.

When EEBSCs requirements are set as part of the general building regulations, it is natural to include their enforcement in the general system for building approval process by local authorities. In the case where the standard is set in a separate specific legislation, the enforcement may sometimes be delegated to energy efficiency specialists who carry out the inspections on behalf of the local authorities. In some countries, the control and enforcement of building efficiency is based on an accreditation system where responsible experts evaluate the submitted building proposals and certify them on behalf of the local authorities. They could lose the right to construct or to apply for permits if they violate the rules (Laustsen, 2008).

The above enforcement system works on the premise of inspection of the buildings’ energy standard before and after construction. In most cases, it requires that the building’s energy efficiency is declared before occupation. After construction, a certificate is issued showing compliance with the requisite energy efficiency building standard. The requirement to deliver a certificate may be part of the building code and the control of the issuance of the certificate could be part of the general compliance check done by the local authorities. The consultants responsible for the certificates are normally certified and controlled through a national certification scheme. If the building fails to comply with the standard, the use of the building can be denied until an adequate efficiency level has been obtained. This system is widely used in the EU, Japan and Australia.

Another way local authorities implement energy efficiency building standards is to give incentives or use encouragement systems, which support compliance with requirements. This can be a subsidy, which will only be obtained if certain energy efficiency requirements are fulfilled. These can either be based on the simple compliance with requirements in the set codes or it may be requirements which are stricter than the energy efficiency requirements in these codes (Laustsen, 2008). This is done in the hope that buildings will be constructed with an energy efficiency which is better than the requirements in the codes, but as a minimum, the requirements are fulfilled. In the US, tax incentives have been given to stimulate voluntary inclusion of increased levels of insulation beyond the minimum requirements and to encourage the constructors and building owners to add renewable energy sources.

On the whole, these incentives are meant to help increase the compliance with the codes. Local authorities are challenged to look for new opportunities to show the effectiveness and results of energy efficient building standards in areas under their jurisdiction to spar widespread natural use by constructors.

3.10.1 Local Authorities and EEBSCs Implementation in South Africa

As stated earlier in this study, local authorities in South Africa are mandated to enforce building regulations within their areas of jurisdiction as per the Act (Act 103 of 1977 with amendments). The general building regulations in South Africa follow the system of enforcement by inspections as explained in the previous section. Once promulgated, the proposed EEBSCs will most likely follow the same implementation path. Currently though, EEBSCs do not exist in the regulations (Reinink 2007).

This means that at the moment, local authorities do not legally implement EEBSCs (du Toit 2007). Initially, it was envisaged that these problems could be solved by rewriting their bylaws to incorporate energy efficiency regulations such as limiting the quantity of energy consumption in buildings through setting maximum energy/m2 caps and making the by-laws part of the building applications and approval procedure. Even then, this would take considerable time for South Africa, approximated to be a minimum of five years (Holden, 2004). In the absence of national regulatory powers, cities can consider developing local guidelines or standards. This must be the route that was taken by Johannesburg Metropolis when it issued energy efficiency design guidelines for buildings in 2008. However, for uniformity and acceptability, these should ideally be based on existing standards and norms and best practices from similar jurisdictions.

Other on-going efforts in EEBSCs implementation were reflected in 2008 when the Department of Energy succeeded in pushing through two regulatory frameworks which have had an impact on energy efficiency regulations in buildings. One was an amendment on Electricity Regulation Act (4/2006-Schedule 2) that stipulates that the regulator shall take into account the energy efficiency measures undertaken by the client while deciding on tariff structure (Republic of South Africa, 2008). In addition, a further amendment on the same act entitled ‘electricity regulations for compulsory norms and standards for reticulation services’ makes it mandatory for end users with monthly consumption above 1000 kWh to have smart metering devices (to benefit from the time of use tariff) by 1 January 2012 (Republic of South Africa, 2009). These measures were to be implemented by the local authorities because many of them distribute electricity in areas under their jurisdiction.

In the proposed Energy Building regulation SANS 10400XA and Energy building standard SANS 204: Edition 1 Parts 1 – 4, it is envisaged that implementation will fall under the docket of local authorities. This means that this regulation and standard will be part of the building control procedures in the respective local authorities. In this case, enforcement by inspection of the buildings’ energy standard will suffice. It will require that the building’s energy efficiency model is declared before the building is constructed. After construction, a certificate will be issued showing compliance with the requisite energy efficiency building standard before occupation. The requirement to deliver a certificate will be part of the building code and the control of the issuance of the certificate will be part of the general compliance check done by the local authorities. In the event that the building fails to comply with the standard, the use of the building will be denied until an adequate efficiency level has been obtained.

3.10.2 Model for the implementation of proposed EEBSCs

In a departure from the established norm, it is proposed that compliance with mandatory minimum energy performance requirements for buildings be confirmed by formally certified private assessors and paid for by the building owners (Building Research Establishment, 2008). It is further suggested that the process be audited by the authority under which the code is issued (Building Research Establishment, 2008). This model deepens and broadens energy efficiency skills availability across the entire built environment professions and ensures financial flexibility and security in the local authorities. Thus the following enforcement model is idealized by RICS (Figure 3.4).

In South Africa, however, the local authorities have a well-established buildings control and regulations framework and structure and there is a deliberate intention by government to retain and create employment at local levels. Therefore it is proposed that the enforcement and the certification be done by these local authorities (Figure 3.5).

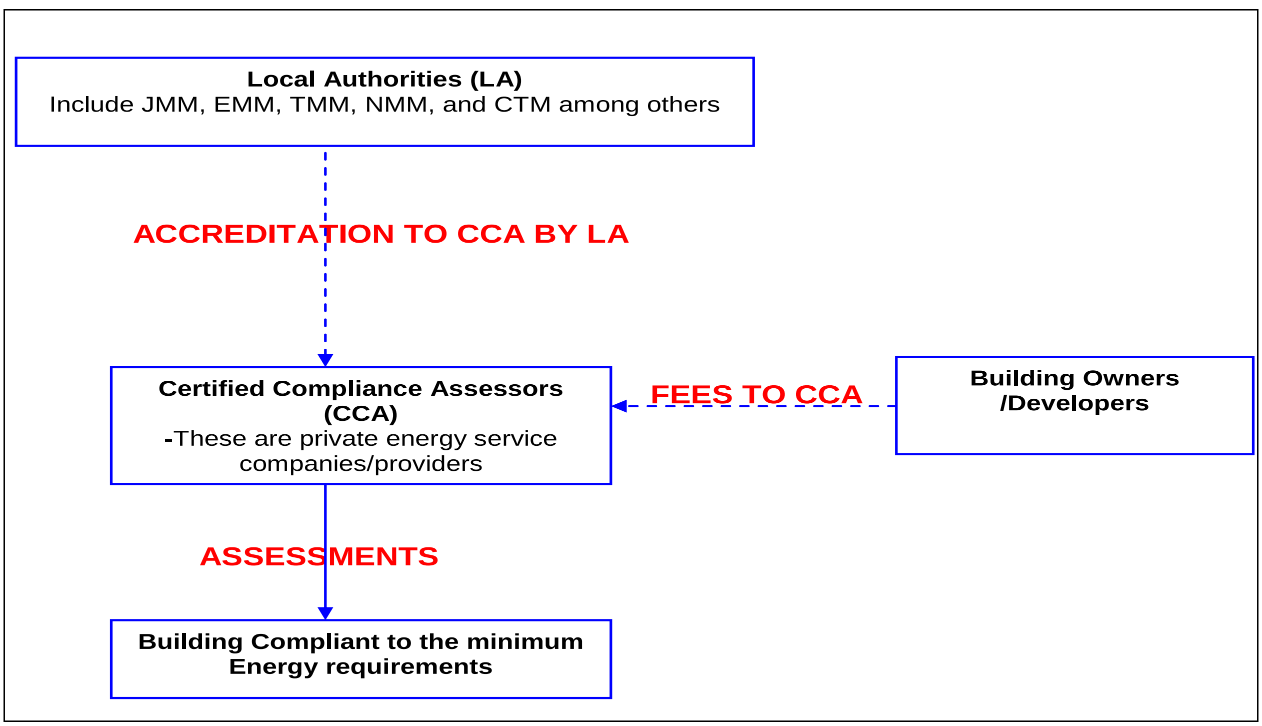


Figure 3.4 RICS compliance enforcement model

Adapted from Building Research Establishment (2008)

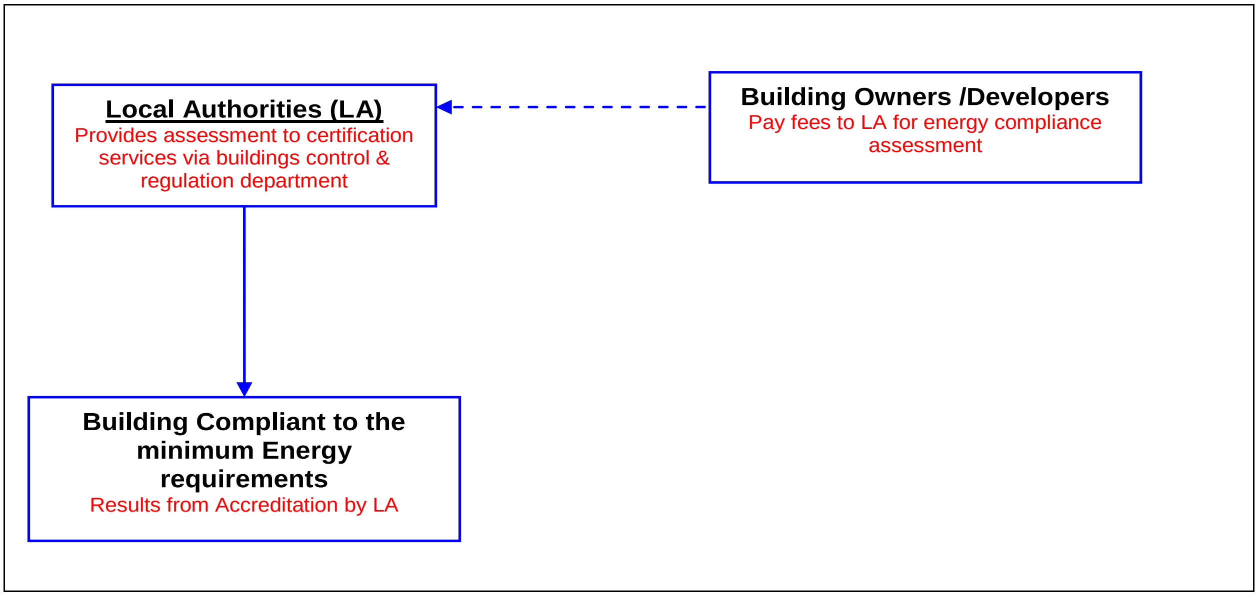


Figure 3.5 Proposed compliance enforcement for the local authorities in South Africa

Source: Wafula et al. (2009) as indicated in the earlier parts of this work (see declaration)

3.10.3 Implementation of EEBSCs in Johannesburg Metro

Energy consumptions in Johannesburg and surrounding metropolis indicate that industry accounts for 16% and transport for 60% of energy demand, Domestic use 16% and government, commerce and local authority 7 % (Ward and Schäffler, 2008) (refer to Figure 3.6). The combined energy use by the domestic, government, commerce and local authority sectors contribute to a total of 22%; the energy in this sector is mainly used in buildings thus lends credence to emphasising the need to implement energy efficiency polices in that area.

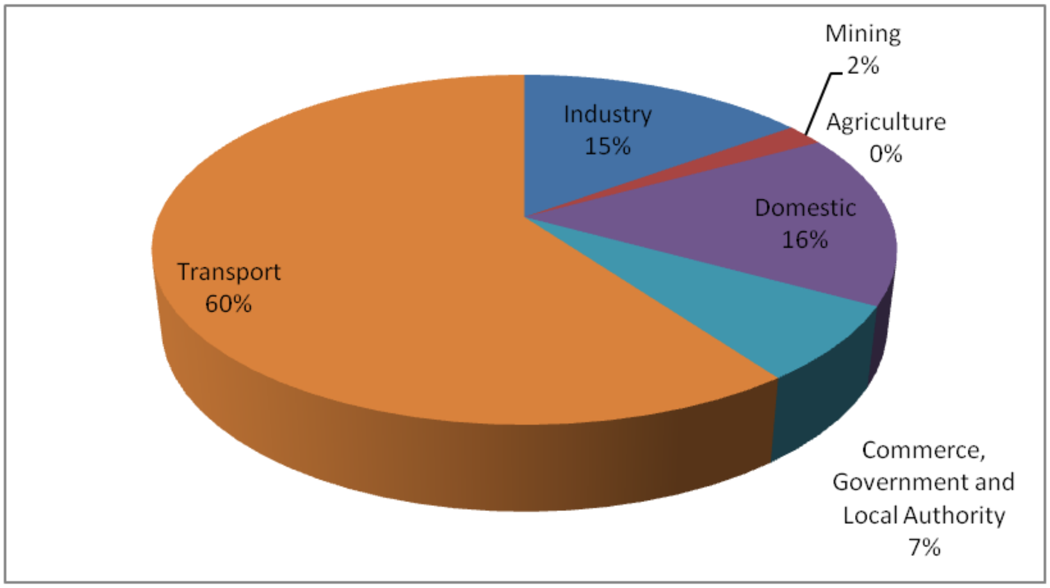


Figure 3.6 Energy consumption by sector in metropolitan areas around Gauteng Province

Source: Ward and Schäffler (2008)

Johannesburg is the premier and biggest municipality in South Africa. Correspondingly, it also has the largest stock of buildings. It is one of the three major metropolitan municipalities which form the Greater Gauteng Province which is the heartbeat of South Africa's economy. The other two Metro Municipalities are Ekurhuleni and Tshwane. Just like the rest of South Africa, Johannesburg Metro does not have mandatory energy efficiency building regulations or standards in its building control procedures (City of Johannesburg et al., 2008).

In order to make a contribution to global warming reduction, limit additional energy requirement in the face of shortages, reduce energy costs and prepare for the proposed tighter energy regulations, Johannesburg metro issued "Design Guidelines for Energy Efficient Buildings in Johannesburg" in 2008 (City of Johannesburg et al., 2008). The guide notes the importance of energy in the buildings life-cycle- from construction to operation and then demolition. These guidelines aim to promote the energy efficiency paradigm in the building industry within the metropolis. They target to help Building control, Architects, Designers, Planners, Engineers, developers and all key participants in the construction process to produce more energy efficient buildings.

It provides practical guidelines and rules of thumb which take advantage of 'low hanging' opportunities in the wider energy efficiency agenda in the built environment. The guideline lays great emphasis on passive environmental control, day lighting and the use of renewable energy such as solar power to reduce energy consumption in buildings. Among the easy opportunities to be applied immediately are: change of lighting from the old candescent to energy efficient CFL's and LED's, from the standard geyser to solar water heaters, improved insulation by incorporating ceilings in RDP houses and having well positioned windows to improve ventilation.

Building owners and developers are advised to effect retrofitting in existing stock of buildings. They are informed to start looking at retrofitting as an investment by doing a cost-to-benefit analysis of their buildings to see how much they are currently spending on a business-as-usual building operation versus a retrofitted building.

The guidelines cover both residential and commercial buildings as well as a variety of buildings in between. However, it does not go into detail on building-type and site specific modeling to suit localised contexts. The guidelines are meant to be used at the design stage and be applied at the inspection for submission for approval.

It should be noted that these are voluntary good practice guidelines and therefore cannot be enforced vigorously. They provide a good preparation and training in anticipation of the promulgation of SANS 10400XA and SANS 204: Edition 1, Parts 1-4.

The guide is summarised in the table 3.3 below:

Table 3:3 Design Guidelines for Energy Efficient Buildings in Johannesburg: Key Sections

Section	Content
Why have guides on energy efficiency in buildings?	Key reasons for addressing energy in buildings
Design processes for energy efficiency:	Actions that can be carried out by the main role players at different stages of a building's life cycle to ensure that the energy efficiency is addressed.
Human comfort and minimum environmental standards:	Key environmental conditions required for health and comfort of building occupants
Environmental control strategies in buildings:	Broad strategies that can be used to support energy efficient environmental control of buildings
Site:	How the layout of a site can be used to support energy efficiency
Building form and envelope:	Building form and building envelope influence energy consumption and this section outlines how strategies such as passive environmental control and day lighting can be used to reduce energy consumption
Internal space:	Internal spatial layouts can be configured to support energy efficiencies. This section outlines some key considerations that should be taken into account
Mechanical systems:	Aspects of how mechanical systems in buildings can be made more efficient
Electrical lighting:	How energy efficiency can be addressed in electrical lighting systems
Water heating:	Outline of additional energy efficient water heating systems including solar water heaters
Appliances and equipment:	Guidance on minimizing the energy consumption by appliances and equipment in buildings such as computers
Integrated control systems and monitoring	Control and monitoring systems to support energy efficiency

Source: City of Johannesburg et al., (2008)

3.10.4 Implementation of EEBSCs in Ekurhuleni Metro

The Ekurhuleni Metropolitan Municipality (EMM) is in the Greater Johannesburg, Gauteng Province. EMM had a population of 2.5 million people in 2004, a municipal budget of R11.3 billion (USD $1.86 billion) in 2006 and land area of 1,900km^2. EMM has the largest industrial and manufacturing base on the African continent and as such is considered as part of the economic engine of South Africa (The EMM state of energy report, 2005). Together with residential buildings; which in 2001 stood at 745,115, EMM is a centre for energy intensive activity. It consumed nearly 6% of South Africa's total energy demand in 2003 of which 38% is supplied by electricity. In 2003, residential buildings consumed 30% of the electricity supplied in the Metro (The EMM state of energy report, 2004).

Following the restructuring of the electricity sector in 1996, EMM is one of the distributors of electricity in South Africa. This and other obligatory requirements emanating from National governments policy on energy efficiency, the need to lead by example, use energy sparingly and

DSM measures of Eskom made it necessary for the metro to have a localised energy efficiency policy. The Metro adopted the policy on energy efficiency in Council Buildings and on Council premises of Ekurhuleni in 2002 (Ekurhuleni Case Study, 2007). Subsequently, the state of energy report (of 2005) which gave the situational assessment (status report) on energy demand and supply by energy carrier and user showed that though the metro remained one of the economic heartlands of South Africa, there were few significant or large scale energy efficiency projects.

This is partly related to the national situation where there is no specific legislation on energy efficiency (Reinink, 2007). In the building sector, the energy efficiency policy broadly mentioned the use of DSM measures such as passive solar designs, solar home systems such as solar PVs (photovoltaic) and solar water heaters and residential load control focused on the installation of ripple control systems for geysers. Generally, this policy provided the guidelines for applying voluntary 'low hanging' good practice energy efficiency principles in its building control regulations to achieve energy efficiency in all building developments.

The 2005 state of energy report laid a good framework though, to be used to develop a more comprehensive energy efficiency strategy in the metro. Among others, it stated that EMM should;

1. Establish an integrated environment and energy program to develop and roll out its energy and climate change strategy,
2. Develop showcase EE, Renewable Energy and DSM projects within its systems with the aim of educating the public and businesses how to implement "quick wins" as well as longer term measures. It suggested the use of a pilot household solar water heater project which could be used both for creating energy awareness and achieving reduction in electricity demand,
3. Collaborate with the national government to develop tariff-based incentives for the implementation and enforcement of EE and DSM measures, e.g. capital subsidy packages for Renewable energy systems in buildings.

Based on these policy recommendations, EMM took a highly proactive and prominent role in the energy efficiency agenda. Earlier in 2004 the metro joined ICLEI[14]'s CCP[15] Campaign. Besides the state of energy report, the Metro also went ahead and produced its first Draft energy efficiency strategy in 2005. This was an important compliment to the policy and laid out specific guidelines for new projects in energy efficiency effort in the metro. It recommended that the metro make a deliberate decision to start saving energy through "low hanging fruits" principles in its buildings/premises.

3.10.5 The EMM EE Retrofit Project

The metro implemented a retrofitting project of its three main buildings i.e. The Germiston Civic Centre and EGSC buildings through a programme by ICLEI CCP Campaign. These buildings serve as the EMM political head office and the administrative head office respectively (Ekurhuleni Case study, 2007). This project aimed to show market leadership by the metro in implementing energy efficiency regulations and to showcase the ease with which EE, Renewable Energy and DSM measures can be implemented in buildings cost efficiently. Also it served to develop skills and make appropriate preparations within the metro in anticipation of promulgation of proposed mandatory national energy efficiency building regulations and standards.

This demonstration project started in June 2005 at a cost of R249, 120 (USD $41,063). First, Using the ICLEI's HEAT[16] measurement system, the requisite parameters for the energy and emissions reduction were set for the respective buildings (Ekurhuleni Case study, 2007). Second, solar water heaters were supplied and fixed to meet the energy efficiency parameters set. The main objective here was to use different technologies to reduce energy consumption in lighting and boiling water (Ekurhuleni Case study, 2007). In the lighting component, incandescent lights were replaced with CFL's and cool-beam lighters with LED's. Urns and kettles were replaced with hydroboils. Geyser and lighting timers which could come on at pre-set times were installed

[14] International council for Local Environmental Initiatives: An association of over 1100 local governments that represents their sustainability interests within the UN and at international policy forums.
[15]Cities for Climate Protection
[16] The Harmonized Emissions Analysis Tool; An International Quantification Resource (An Internet based tool for storing, tracking, and reporting emissions and reductions of both GHGs and CAPs)

as well. On cost-benefit analysis, these measures were found to be cost effective and were easily implemented.

Table 3.4 and table 3.5 below show the energy and emissions reduction which resulted from the project.

Table 3:4 Energy Savings

equipment	Pre retrofit energy use kWh/year	Post retrofit energy use kWh/year	Energy savings kWh/year	Percentage of savings %
Lighting (CFLs & LEDs	366,694	91,673	275,020	75
Lighting (5 foot double fluorescent lights with electronic ballasts)	21,024	18,221	2,803	13
Water heating (Urns replaced by Zip Hydroboil)	214,072	171,258	42,814	20
Geyser timers	20,878	12,527	8,351	40
Total	622,668	293, 679	328,988	53

Source: Ekurhuleni Case study (2007)

Table 3:5 Emissions reductions (TSP=Total suspended particulates)

Equipment	**Co_2 reduction tonnes/year**	**So_x reduction kgr/year**	**No_x reduction kgr/year**	**TSP reduction kgr/year**
Lighting (CFLs & LEDs	257	2,183	1,025	84
Lighting (5 foot double fluorescent lights with electronic ballasts)	3	22	10	1
Water heating (Urns replaced by Zip Hydroboil)	40	340	160	13
Geyser timers	8	66	31	3
Total	308	2,611	1,226	100

Source: Ekurhuleni Case study (2007)

As shown in the table 3.4 above, 328,988 kWh of energy worth USD $50,664[17] was saved in one year in this small project. Taking into account the total investment, this would lead to a simple payback period of 1.2 years. This is besides the co-benefits of reduced GHG Emissions as tabulated above. It is also important to note that there have been no problems with the new lights or water heaters and staff has not had any complaints about their use. The results of this small demonstration project shows the cost-effective and the practical ease with which energy efficiency measures can be carried out through the local authorities building control processes. Also, the population is willing to embrace the change to EE principles of building. Due to the relative infancy of the energy efficiency principles in buildings in South Africa, the project faced

[17] This is based on the value of 0.157 USD/kWh for EMM Buildings under tariff C.

the challenge of appropriate technology, equipment and experienced tradesmen in the beginning. This is however expected to improve as more local authorities and institutions demand energy efficient technologies and equipment in the building process.

Retrofitting works involving replacement of old equipment with new more energy efficient technology is a quick way to start implementing energy efficiency standards/codes in buildings. From the EMM experience, other local authorities can replicate this effort using their own integrated energy efficiency models. Other EE efforts the metro is pursuing include establishing an internet-based smart metering system to monitor energy use within municipal buildings (The EMM state of energy report, 2005) and being the first in South Africa to introduce a scaled electricity tariff system for domestic consumers.

EMM started with the creation and adoption of the Policy on Energy Efficiency in Council Buildings and on council premises, followed by the State of Energy Report, then the Draft Energy Efficiency Strategy and subsequently implemented the Retrofitting Demonstration Project. These are easy energy efficiency implementation processes which can be replicated across other South African municipalities. The proposed SANS 10400XA and SANS 204, Edition 1; Parts 1-4 will serve to entrench the above model in the building control processes of all local authorities.

3.11 EEBSCs in Refurbishments and Renovations

Since buildings have a long lifetime of 50 – 100 years or more there will be need for major renovation and improvement in the lifetime of buildings as explained earlier in this study. Refurbishments or improvements are necessary, because some parts of buildings need replacing. Renovations and refurbishment are also necessary because equipment or the organisation of the building becomes inadequate (Laustsen, 2008). Typically, major refurbishment projects take place 2 or 3 times over the life time of the building.

For residential buildings, this will be every 15 – 20 years. Commercial buildings renovations do happen more often because the functions of commercial buildings change faster. During these major renovations or refurbishment of buildings, energy efficiency measures and principles are in particular feasible and higher energy efficiencies can be obtained.

Studies from Europe show large energy savings potential for EE building renovations range between 67% - 80% for residential single family houses and 55% - 69% for multi-family houses (ECOFYS, 2005). Similarly, studies from the US show that the energy consumption in the existing building stock can be reduced with up to 50% through EE insulation measures alone during renovation (Laustsen, 2008).

In most of the EEBSCs discussed above, their implementation and enforcement systems are significantly targeted at new buildings. This leaves out a huge opportunity to achieve energy efficiency in the stock of existing buildings which were not designed and built with energy efficiency principles in mind. Refurbishing these buildings with up-to-date products, technologies and systems can easily turn them to energy efficient ones.

Various Energy Efficiency policies and measures are required in order to increase the energy efficiency of buildings during renovation or refurbishment. These include mechanisms like retro-commissioning, building technology replacement and energy performance contracting. Retrofits building regulations in the form of building standards or special energy efficiency standards should therefore include these mechanisms. Policies and regulations to demand the implementation of energy efficiency building standards during refurbishment are neither fully developed nor effective around the world (Laustsen, 2008).

The European Union is the one area which has a specific regulatory requirement for energy efficiency for retrofits. It often uses directives for regulating various environmental themes whose implementing agents are various government departments in the respective member states. In most cases, this falls in the ambit of local authorities in the respective countries. The directive on the energy performance of buildings was enacted in January 2003 and its main elements are specified as follows (UNEP 2007b):

i. Minimum energy performance requirements, for new buildings and for major renovation of existing buildings larger than $1000m^2$;

ii. Energy performance certificates to be made available when buildings are constructed sold or rented out;
iii. After the year 2010, the rules will apply to all buildings and renovations(before, renovations below 1000 m^2 were not covered)

In the US, the United States Green Building council (USGBC) has been central in developing the energy efficiency standards for both new buildings and existing stock. Using a member's consensus system, they have developed a LEED rating tool for commercial construction and major renovations/retrofits. It ranks buildings as Certified, Silver, Gold or Platinum depending on the level of sustainability achieved by construction or retrofit (Sussman, 2008). It is a credible and universally applicable system which has gained wide acceptance.

In South Africa, there were 11.2 million dwelling units and 70.6 million sq. m of non-residential building space in 2004. In Pretoria, cooling and lighting alone was responsible for 75% of energy use in office buildings (Parsons, 2004). Cost effective energy efficiency retrofits to this existing building stock can result in major energy savings.

Just like there are no National EEBSCs yet, specific ones dealing with retrofits/renovations or refurbishments are almost non-existent. What we have are voluntary guidelines and demonstration projects by the respective local authorities and isolated good environmental conservation efforts by the large building industry players.

In light of this shortcoming, The Energy Efficiency Strategy of the Republic of South Africa (2008) proposes retrofits as one of the higher-cost interventions measures with short payback periods. This is in addition to a suite of measures that are low cost and can be carried out with immediacy. As part of the strategy, the following are proposed (DME, 2008): (1) mandatory standards and audits for energy efficient HVAC, lighting and non-electric appliances and (2) energy management systems in the buildings sector for retrofits. These proposals could be effectively led and implemented by the local authorities through the building regulation control function. Specifically, the energy efficiency mandatory audits should be carried out alongside the schedule of others like fire, health and safety, which the local authorities do periodically.

In the private sector, few building tenants in South Africa are starting to show signs of demanding better energy performance, and some landlords have discovered the financial benefits of improving efficiencies, although landlord/tenant relationships and building management systems in many cases work against change. The Green Building Council of South Africa (GBCSA) and the South African Property Owners Association (SAPOA) have partnered to bring into the market an energy efficiency rating tool especially for new commercial and large retrofit projects. Among other requirements, the rating tool makes an energy efficiency audit is part of the sell and transfer documentation for properties among their members. Currently, this is a voluntary mechanism targeting large property holding companies and developers but it is hoped that eventually, when the above EE measures start to show monetary savings in their operations, other small scale property owners will scale up their activities and retrofit for energy efficiency. Municipalities are also actively and continuously looking at new by-laws to address these issues. Johannesburg has energy efficiency guidelines for new buildings which also mention a few principles and measures for achieving energy efficiency in retrofits while EMM went ahead and implemented a Demonstration Project on Retrofits to drive the point home.

It is hoped that the next step will be the formulation and implementation of mandatory EEBSCs for retrofits.

3.12 Conclusions

The formulation and successful implementation of EEBSCs for new and existing buildings has led to reduced energy consumption in many countries around the world. In the US, the use of EEBSCs has produced up to 60% energy savings in residential buildings over a period of thirty years. Many jurisdictions begin with a voluntary standard before eventually refining it and implementing a mandatory standard. This is mostly implemented and enforced within the general building regulations regime through the municipal authorities. The market transformational aspects of the EEBSCs makes it possible to move from minimal standards set in the beginning and pursue next level codes like zero energy building codes, green and sustainable Buildings standards and plus energy building codes, which promise even greater energy savings and performance in buildings.

Good EEBSCs regimes include an in-built regular update mechanism which allows for newer opportunities in knowledge and technologies to be easily implemented as they emerge. Sometimes, the standards start with easy to implement solutions and set a future schedule when other complex standards will be phased in slowly to ensure that the industry is prepared for the new solution. For example, the EEBSCs for Ontario in Canada included a clause that the standards introduced in 2006 will be strengthened in 2009 and again in 2012 (CBOPA, 2006).

In South Africa, until the publication of the proposed SANS 10400XA and SANS 204, Edition 1; Parts 1-4, EE efforts in buildings in South Africa had all been voluntary and more or less depended on individual choice. The local authorities have lacked a legal mandate to affect any meaningful EE measures in their jurisdictions and the best they did was to issue voluntary good practice guidelines like the ones issued by the Johannesburg metro, in the hope that the industry may choose to adopt them in order to save energy costs. In isolated cases, a few municipalities had demonstration projects to try and encourage EE principles in buildings in their jurisdictions like Ekurhuleni. Additionally, sustainable construction interest groups and key professional practitioners have collaborated with the local authorities, in a voluntary way, to try and implement EEBSCs especially in commercial buildings.

In the local authorities where building energy efficiency measures are encouraged actively, the preferred model of implementation has been the enforcement by inspections. Here, the local authorities encourage the developers (through their professional consultants) submitting building development plans for approval to include 'low hanging' design measures which subsequently assure long term energy savings during the lifetime of the building. The measures approved during the design stage are then inspected continuously by the building control function during the various stages of construction until completion and occupation of the building to ensure compliance. A similar approach is applied to large retrofit developments which require building control approval from the respective local authority jurisdictions. This is well illustrated in figure 3.2.

On the other hand, the sustainable construction interest groups and the key professional practitioners implement calculation based energy building codes which set the overall frames for energy consumption in a building. They use the GBCSA's Green Star rating tool which sets the parameters for design which are eventually measured against the results of performance of the same building when in use. The above rating tool has provisions for application in retrofit projects as well.

It is envisaged that the promulgation of SANS 10400XA and SANS 204, Edition1; Part 1- 4 will create the EEBSCs for South Africa. This will enable the building sector to realise the kind of energy savings achieved in other jurisdictions which have formulated and implemented EEBSCs in a mandatory way. Local authorities will get a legal platform on which to consolidate and affect the standard. Also, as the mandatory standard gets integrated in the building control processes, efforts should be made to harmonize it with the standard being implemented by the sustainable construction interest groups. This way, the building sector will make its rightful contribution to the energy consumption reduction strategy for South Africa.

Chapter 4 : RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes procedures, methods and tools which were used in the research and explains reasons for the selection of the framework. In this regard, the research methods used sought to meet the objectives of the study.

In order to achieve the research objective set out in chapter one, the research was guided by the main question- How are the local authorities using building control regulations procedures to integrate energy efficiency principles in the building sector? Table 4.1 shows the three sub-questions and explains the approaches used in answering them.

This research was conducted between 2009 and 2011. The field investigation was carried out between the last quarter of 2010 and mid-2011. The research adopted a two phase investigation. The first phase involved choosing the local authorities; the metropolis of greater Johannesburg (i.e. Johannesburg Metro and Ekurhuleni Metro) was chosen. Subsequently, the second phase of field investigation using structured questionnaires and semi-structured interviews was carried out.

The questionnaires were administered to practising professionals from the following groups of respondents: Building Controls and Approvals Officials (BCAOs) in Ekurhuleni Metro and Johannesburg Metro, Key Professional Practitioners (KPPs) in Johannesburg and representatives of Sustainable Construction Interest Groups (SCIGs). For the questionnaire participants, there were two sets each for BCAOs and SCIGs and one set for KPPs.

The interviews were conducted with section heads of building control departments in Johannesburg Metro and Ekurhuleni Metro. Two key members of the KPPs group and one chief officer from the SCIGs group were also interviewed.

Table 4.1 Approaches to answering the sub-questions

Sub Question	Details of Data Required	Proposed Data Collecting Instrument	Data Source	Method of analysis
Q1 What are the energy efficiency principles and policies (regulations) which the local authorities can implement through their building control and approvals procedures and processes?	Importance and awareness of current building control regulations relating to energy efficiency issues in the general building control regulations in the named metropolis which are used during the building approvals process	local authorities survey during which the following will be used: Interview, Questionnaire and Documents	Head of building control services, Buildings Control officers architect, engineers and developers Documents e.g. , building control approvals manuals, National building Act, SAEDES, SANS 204 SANS10400	Narrative Analysis based on theoretical framework; Descriptive statistics using weighted mean
Q2 How are the local authorities applying and/or enforcing energy efficiency regulations during the approvals process for developments through their building control procedures?	It requires evaluation of the current implementation of building control regulations, energy efficiency practices in buildings in the local authorities vis a vis their set targets, mandate and international practices.	Literature reviews, Interviews, Questionnaires.	key personnel in the respective metropolis and key stake holders in the energy efficiency policy issues in the built environment like the GBCSA Documents e.g. SANS 208, SANS10400; Journals, Books, Reports, Energy Efficiency Building Design guidelines	Narrative Analysis based on theoretical framework, Descriptive statistics using weighted mean
Q3. How can the local authorities use their building control regulations to make it the norm for all the building developments in their jurisdictions to build and/or refurbish for energy efficiency?	Involves finding out the possibilities for the local authorities to enforce energy efficiency regulations in the built environment, the efforts they are making to effect energy efficiency regulations, challenges they are facing and the way forward to make energy efficiency the norm in through building control regulations	Literature review, interviews., questionnaires	Documents e.g. Standards and codes of practice, Journals, Books and Reports. Approved plans. section heads, Architects, Engineers	Narrative Analysis based on theoretical framework

Source: Author's construction

The BCAOs and KPPs were selected to participate in the research because of their direct and daily involvement in the implementation of building control regulations in the local authorities, the BCAOs as the local authority enforcement agents and the KPPs as implementers on behalf of their building development clients. The SCIGs and some KPPs participation was based on the finding from literature that many current energy efficiency programmes are run on voluntary basis and have had their beginning from these two groups.

A total of sixteen (16) questionnaires were send to the above groups and fourteen (14) were collected. The breakdown of the responses is shown in table 4.2 below.

Table 4:2 Administered questionnaires responses breakdown

Types of participants	Areas represented	Questionnaire send out	Respondent	Response rate
BCAOs	Johannesburg	4	3	75%
	Ekurhuleni	3	3	100%
SCIGs	GBSA	3	2	66.6%
	SAPOA	3	3	100%
KPSS		3	3	100%
Total		**16**	**14**	**87.5%**

Source: Author's administered questionnaire (2010/2011)

Six interviews were scheduled but one failed to honour the schedule. Table 4.3 gives the breakdown. Detailed discussions on methodological issues of this research are covered in sections 4.2 to 4.7 of the chapter.

Table 4:3 Interviews responses breakdown

Types of participants	Areas represented	Interviews schedule	Interviews conducted	Response rate
BCAOs	Johannesburg	1	1	100%
	Ekurhuleni	1	1	100%
SCIGs	GBSA	1	0	0
	SAPOA	1	1	100%
KPSS		2	2	100%
Total		**6**	**5**	**83%**

Source: Author's administered questionnaire (2010/2011)

4.2 Strategy

This section will describe the approach used in the research. The section contextually discusses the paradigmatic framework, the philosophical orientation and the link with methods selected. The details follow in sections 4.2.1 and 4.2.2.

4.2.1 Research Description

This research is described below in terms of purpose, framework, possible outcomes, and the process chosen.

(i) Exploratory, descriptive or explanatory research

Research can be exploratory, descriptive or explanatory depending on the type of objectives set (Durrheim, 1999). ‘Exploratory studies’ are open, flexible and are often geared towards preliminary investigations in ground breaking research areas. ‘Descriptive studies’ describe, categorise or measure attributes of phenomena using methods which stress accuracy and reliability like sampling surveys. ‘Explanatory studies’ are causal in nature and employ experimental or quasi-experimental methods (Durrheim, 1999). This research has combined aspects of both ‘exploratory’ and ‘descriptive’ nature. It was exploratory in that it sought to establish the existing practises of energy efficiency in building control regulations. It was descriptive by describing and categorising the various energy efficiency measures being initiated by the local authorities through their building control regulations as Financial/Economical, Behavioural, or Legal among others.

(ii) Inductive or deductive

Deductive logic in research entails setting theory and confirming it via a series of observations in a process which is hypothesis driven and procedures which are reproducible (O’Leary, 2004). Inductive research logic commences with a series of observations from which theories are constructed, amended or grounded (Durrheim, 1999). This research has elements of both. It had a hypothesis which aimed to link energy efficiency measures implementation success with a well-structured legal framework. However, the document reviews and the field investigations produced additional elements which are very important for the implementation of a successful energy efficiency programme in buildings.

(iii) Qualitative vs. Quantitative

Research can be described as qualitative or quantitative depending on the methods of data collection, presentation and analysis of collected data (O'Leary, 2004), and use of theory (Creswell, 2003). Quantitative data will be presented as numbers and analysed using statistics whereas qualitative data will be represented as narratives (with use of pictures, icons, words) and analysed via thematic explorations. In this research, sets of theories in energy efficiency document reviews (e.g. that EEBSCs underlie other EE measures like market transformation in buildings) provided guidelines for investigating energy efficiency practices in building control regulations in the main Metropolis of greater Johannesburg in South Africa. Additionally, the literature review section is used to give a theoretical orientation to the research. The research instruments were developed within the confines of the theories emanating from the literature review. Despite the strong arguments put across to support categorisation of research as either qualitative or quantitative it should be noted similarities exist in paradigms followed, methods, logic of inference and approaches to analysis in both domains (Bryman, 2001; Grix, 2004; and Silverman, 2000). In this research, quantitative methods are used in many aspects of the presentation of results. Yet, there are theories in the research where the presentation and analysis of findings is done in descriptive narratives- which is a qualitative method. Therefore this research does not qualify as entirely qualitative or quantitative, and both techniques were used in collecting, analysing, and presenting the data. The two methods complement each other to bring out holistic information to answer the research question exhaustively (Bryman, 1984).

4.2.2 Paradigm Framework

There are four main schools of thought that guide research works. These are positivism/post-positivism, constructivism/interpretativism, advocacy/participatory, and pragmatism (Creswell, 2003; Blanche and Durrheim 1999). Paradigms are systems that include interrelated practice, thinking and assumptions that define the nature of the research enquiry along the three dimensions of ontology, epistemology and methodology (Punch, 2005). 'Ontology' specifies the nature of reality that is to be studied and what can be known about it. 'Epistemology' specifies the nature of the relationship between the researcher and what can be known and 'methodology' deals with how a researcher may go about practically studying whatever he or she believes can be known. Table 4.4 outlines the schools of thoughts and associated characteristics whereas figure 4.1 shows knowledge claims, strategies of inquiry and methods leading to approaches and design processes of research.

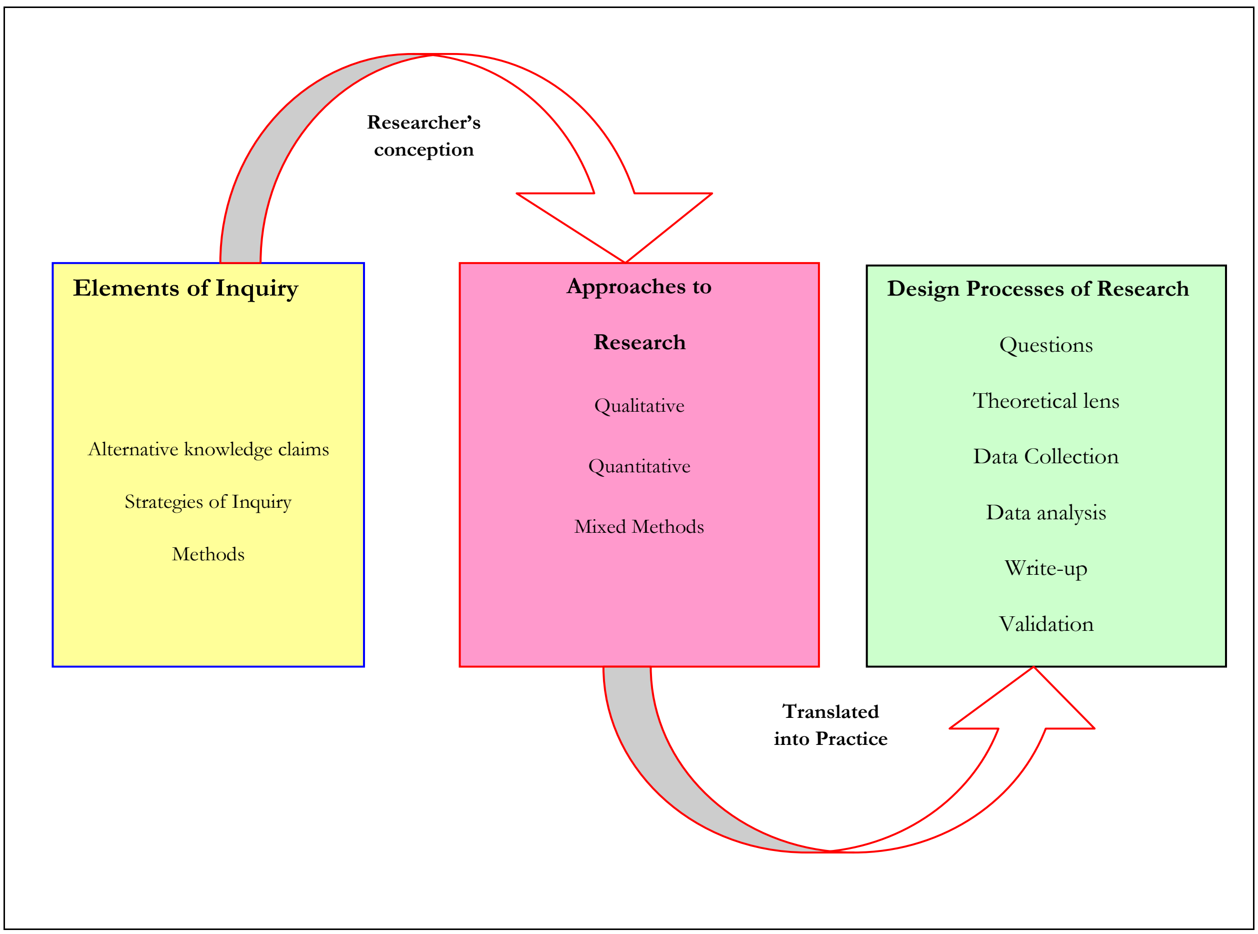


Figure 4.1: Knowledge Claims, Strategies of Inquiry, and Methods Leading to Approaches and Design Process

Source: Creswell, (2003)

This research was dominantly informed by pragmatism and constructivist/interpretativist dimensions with a little positivist/postpositivism paradigm. A purposive (convenient) sample was adopted in the research after the main study area had been chosen and also due to the constraints of finance and time. The use of multiple methods and approaches (document reviews, questionnaires and interviews) was employed in the research and this led to enhanced triangulation and complementarity of the information from the different sources. Multiple methodologies meant that better real overall information was gathered for the research (Bryman, 1984).

Table 4:4 Schools of thoughts guiding research

School of thought	**Characteristics**
A1. Positivism/Postpositivism • Determinism • Reductionism • Empirical Observation and Measurement • Theory verification	B1. Positivism/Postpositivism • Causes probably determine effects or outcomes • Intent on reducing ideas to variables that constitute hypotheses and research questions • Knowledge developed is based on careful observation and measurements of reality • Theory is tested by data collection followed by analysis then revised in line with the tests
A2. Constructivism/Interpretivism • Understanding • Multiple participant meanings • Social and historical construction • Theory generation	B2. Constructivism • Individuals seek to understand the world in which they live and work • Inquirers inductively develop a theory or pattern of meaning • Participants' view very much part of the research • Researcher is to make sense of the meanings of observations and role players
A3. Advocacy/participatory • Political • Empowerment issue-oriented • Collaborative • Change-oriented	B3. Advocacy/participatory • Research must be action oriented to help marginalized peoples • Research must contain action agenda for reform • Inquiries must be completed with others and not on or to others
A4. Pragmatism • Consequences of actions • Problem-centered • Pluralistic • Real-world practice	B4. Pragmatism • Knowledge claims arise out of actions, situations and consequences • Concern should be on what works • Truth is what works at the time • Researchers have freedom of choice on research approaches

Source: Creswell, (2003)

This research has all the key ingredients to be defined as Pragmatic. This is because we are facing a current problem of security of supply and escalating prices of energy in South Africa and the actions taken by local authorities in implementing energy efficiency regulations in buildings will provide real life solutions to the problem. This will reduce consumption and therefore more energy will be 'generated' and the financial costs of energy bills will go down.

The main interpretativist characteristic of the research is that the information gathered from the document reviews on existing building regulations implementation in the local authorities and the questionnaire and interview respondents' opinions and narrations on the implementation of energy efficiency building control measures and procedures in local authorities informed the analysis, conclusions and recommendations of the research.

4.3 Methods and Tools used

This section discusses several methods and tools that were used and also provides the rationale for their choice. Methods are defined as techniques used to collect data and tools as being used to help in data collection procedure (O'Leary, 2004). The specific methods used include sampling, documentary research, questionnaires and interviews.

The reasons for the use of multiple methods in this research included the desire to triangulate the findings so that reliability and validity was increased, because convergence in lines of inquiry is important in the validation of findings and the fact that different methods often complement each other (Yin, 1994).

In this research, the interviews method was used to gather expert knowledge information relating to practices identified in theory in the literature review. Questionnaires targeted information about general understanding of energy efficiency issues in the building control process and how they are applied. The document review targeted information on public policy documents on energy efficiency, the development and implementation of energy efficiency regulations in other jurisdictions around the world and the effective implementation of energy efficiency measures through building control regulations in the built environment.

4.3.1 Sampling

Sampling is defined as the selection of a part of a whole population for a study; unlike a census, which is the study of the whole population (Rao, 2000). The definition of the population being studied is very important (O'Leary 2004). In this particular research, the population being studied was the building control regulations departments of the main metropolises of Gauteng. In the context of this research, this included the people and the processes involved in the implementation of building control regulations in the submission of the building development plans/proposals, evaluation and eventual approval or rejection. All along, the study emphasises on the issues of energy efficiency in the entire process.

The key stakeholders were the professionals submitting the plans on their clients' behalf, the metropolis officials involved in the evaluation and approval process and participants from sustainable construction interest organisations involved with policy issues for energy efficiency in the built environment.

The research adopted a two phase investigation. The first phase involved choosing the local authorities:

1) With high energy demands,
2) Had the likely effect of replicating their practises on the national scale,
3) Had some policy on energy efficiency in place,
4) Were easily and readily accessible to participate in the research

This was informed by the literature review (Documentary review) and Purposive (Convenience) sampling. The metropolis of greater Johannesburg (i.e. Johannesburg Metro and Ekurhuleni Metro) met this criterion. Four (4) questionnaires were send to Johannesburg Metro and three (3) questionnaires to Ekurhuleni. The two respective heads of the building control departments of the two metros were also scheduled for interviews. This two metros form the BCAOs group of questionnaire and interview participants.

Considering the population size (the number of metropolis in Gauteng), this was more than the minimum recommended for statistical analysis (O'Leary 2004). Additionally, Representativeness was achieved by the fact that the sample captured all the various elements/characteristics of the population under research and that these are the biggest metropolis in the country in energy consumption terms.

To provide further information on regulatory issues on energy efficiency in the built environment, three (3) questionnaires each were send to two sets officers at SCIGs and three (3) questionnaires to KPPs to widen the sample.

Similarly, the chief officers of the two SCIGs were scheduled for interviews alongside two key KPPs. The field investigation was carried out between the last quarter of 2010 and mid-2011. The focus was on the building control regulations as they existed relative to energy efficiency policies, requirements and challenges as they were applied daily through the building approvals process and hence its relevance and setting was not affected by dates.

4.3.2 Sampling methods

Table 4.5 shows the various sampling techniques which were used in this research. This research employed non random sampling techniques (purposive). Non-random/non probability sampling is identified as including handpicked, snowball, voluntary and convenience sampling (Rao, 2000). In the selection of the metropolis for the research, convenience sampling was the main method considering the time and financial implications involved. Whereas sometimes non probability sampling is dismissed, this research was based on a case selection with representativeness in mind and therefore the non-random samples credibly represented the population (O'Leary 2004).

The selection of KPPs for participation in the research was based on the snowball sampling method. The two sets of SCIGs group participants were handpicked to participate in the research because of their known and valued contribution to the implementation of energy efficiency measures in the built environment in South Africa.

It must be emphasised that representativeness was maintained in this research despite the use of non-random sampling methods. This was achieved by giving the results of the interrogations from the two metropolises equal weighting; this ensured uniformity, consistency and eliminated the possibility of sampling bias. The inclusion of KPPs and SCIGs ensured diversity and enabled the capture of additional information outside the local authorities. Table 4.5 also gives a summary of the various sampling techniques and their relative strengths and weaknesses.

4.3.3 Interviewing

Interviewing is defined as the act of collection or gathering information for research purposes via verbal interaction or conversation (Pedhazur and Schmelkin, 1991; Punch, 2005). Types of interviews are; individual-face to face, group-face to face, or telephone interviews on one hand and structured, semi-structured or unstructured interviews on the other (Fontana and Frey, 1994). The main type of interview option that was used in this research is presented below.

Semi-structured interviews allow respondents to give open-ended in-depth answers from pre-set interview questions or guidelines. They therefore combine the advantages of structured and unstructured interviews to allow for a deeper and lengthy probe into organizational and institutional procedures (Kitzinger, 2004; Jankowsi and Wester 1991; Tuchman 1991), as was required in this research. This was appropriate because the interview respondents were chosen on the basis of their good experience and expert knowledge in implementing building control regulations and/or being leading participants in energy efficiency building practices. Their information was used to gain deeper insight into the subject matter from an expert's perspective and to triangulate and compliment the information from document reviews and field questionnaires (Bryman and Burgess, 1994). Additionally, this enabled the research to capture spontaneous information not restricted to a specific set of answers as would be with structured interviews.

The tool used for the semi-structured interviews was the interview guideline. Appendix 2 shows the interview guideline that was used as the instrument to interview the various respondents. The interview guideline outlined the five (5) broad areas derived from the three sub-questions of the research for discussion which the interviewer relied on to get information from the respondents.

Only one interview guideline was used for all the different categories of the respondents. Multiple respondents were interviewed for the research. This had the effect of increasing information and broadening the point of view of the entire research (Newcomb 1991). The interviews were conducted with section heads/chief officers of the groups named in the introduction of this chapter.

Two weeks before the scheduled date of the interview, the participant information sheet, the informed consent form and the interview guideline were sent to the respondents for their preparation. Six interviews were scheduled but one respondent failed to honour his schedule. All the interviews were face to face, each lasted about two (2) hours and three were audio recorded and transcribed. One transcribed interview was sent back to the interviewee for further comment and to avoid subjectivity in the interpretation of the outcomes. It is important to note that the interviewees showed great knowledge in the topic and were very informative in their responses and discussions. This re-affirmed the current importance of the energy efficiency topic in buildings.

Table 4:1 Sampling methodologies

Category	Description	Comments in relation to the research
Non-random sampling	Voluntary sampling	Was not used for the simple fact that it might have led to bias as the voluntary cases are always in the extreme group which is biased.
	Handpicked sampling	Was used to pick the two sets of SCIGs participants to ensure key policy aspects of the subject were discussed in the research from outside local authorities
	Snowball sampling	The research relied on referrals for the choice of KPPs as it qualified as the perfect sampling method for the professionals
	Purposive sampling	The two metropolises in Gauteng were chosen due to their convenience in terms of network, costs and time to do the research.

Source: Author's construction

4.3.4 Documentary Research

Documentary research is described as the review of already existing materials to arrive at a desired conclusion (Scott and Morrison, 2006). The documents to research include external communiqués (examples are letters, memoranda), reports detailing events (including agendas, minutes, proposals), formal statements of a case and media clippings (Yin, 1994). This research used documentary research to collect data on legislation and government polices with regards to energy efficiency in building control regulations.

Specific care was taken to avoid using the documents as stand-alone sources of truth. Efforts were made to use them to corroborate evidence from interviews as well as questionnaires. This was done to avoid what is known as ‘potential over-reliance on documents in case study research’ (Yin, 1994).

The following documents were studied among others:

i. Draft energy efficiency standards for South Africa (Standards South Africa, 2008)

All the parts of this document are considered relevant to this research. The document is still considered to be a draft paper but is the first attempt to legislate and make a standard on energy efficiency in buildings. As such it forms the backbone for analysis on building standards with regards to this study. The document appears as SANS 204-1:2008 Edition 1, SANS 204-2:2008 Edition 1 and SANS 204-3:2008 Edition 1 (Standards South Africa, 2008a; Standards South Africa, 2008b and Standards South Africa, 2008c)

ii. Energy Efficiency Strategy for South Africa (Department of Energy, 2005)

This document provides the government policy framework on energy efficiency in buildings.

4.3.5 Questionnaire

Questionnaires are described as information gathering tools which are to a large extent self-administered and which have the advantage of being less susceptible to bias as interviewer effects and deviations from the instructions are eliminated (Pedhazur and Schmelkin, 1991). Questionnaires were used because they have several advantages. These included; their relatively low cost of administration as they required less supervision of the participants, they reduced the chances of bias and they provided greater confidentiality and anonymity (Pedhazur and Schmelkin, 1991). Since this research was limited in resources (time and money), in addition to the need to protect the confidentiality of information sources, it was appropriate to use questionnaires for gathering data.

Questionnaires were administered to seven (7) BCAOs in the chosen metropolises as well as to six (6) officers of SCIGs and three (3) KPPs. The BCAOs returned six (6), SCIGs five (5) and the KPPs three (3) questionnaires respectively.

The questionnaires were used to investigate the five key areas which were developed to answer the three sub-questions of the research. These were:

1) The importance of energy efficiency principles in building development processes. Questions in this area sought to get information on the awareness and the importance participants in the building/construction process attached to energy efficiency principles. Additionally, the introduction part of the questionnaire informed the research of the training and experience of the participants.
2) The energy efficiency principles that are part of and/or are required in the building control regulations during the approvals process of the building development plans by the local authorities. Questions in this category aimed to find information on the existence or lack of energy efficiency principles in the building control process.
3) The energy efficiency principles which can be implemented through the building control regulations in the local authorities and the stage at which they should be introduced in the building control process. The questions in this group aimed at finding information on

practical measures which the local authorities and other key participants were actively encouraging and executing in order to integrate energy efficiency principles in the application of building control regulations in the buildings development process.

4) The problems which impede the implementation of energy efficiency principles through the building control regulations in the local authorities. Questions in this group aimed to find information on challenges faced by local authorities in trying to implement energy efficiency principles through their building control processes.
5) The steps to be taken to integrate energy efficiency principles in the building sector. The questions in this group aimed to get information on possible ways and means which could be used to deliver energy efficient buildings/construction through the building control function in local authorities and beyond.

The research used one questionnaire which was appropriately framed to capture the requisite information on each question from each group of the participants. Appendix 1 is a copy of the research questionnaire.

The researcher distributed the questionnaires himself and collected them to expedite the process. The participants were allowed up to one week to complete the questionnaires. The covering letter for the questionnaires clearly indicated the time frame for completing them and the procedure for returning. Sixteen (16) questionnaires were sent out and fourteen (14) questionnaires were collected.

4.4 Case Study

Case study involves the in-depth examination of one case or a small number of cases using appropriate methods whilst recognising its complexity and acknowledging its context (Punch, 2005). Case studies may be: intrinsic where the study is undertaken to improve understanding of the case, instrumental where key emphasis is on giving insight into an issue or refining theory and collective where the instrumental case study is extended to cover several cases and the focus is on learning about a phenomenon or population or general condition (Punch, 2005; O'Leary, 2004; Tellis, 1997).

This research used the approach of a collective case study where the issue was the ‘evaluation of energy efficiency regulations in building control regulations of the main metropolis in greater Johannesburg. As stated earlier, this includes the two metropolises of Johannesburg and Ekurhuleni (their details are discussed earlier in chapter 3). Appendix 3 shows their physical location in Gauteng. Each one of the two metropolises makes for an independent case and together they form a collective case. An investigation of their individual processes and procedures in applying building control regulations with respect to energy efficiency in buildings brought out information on each case and these findings can be generalised for all Gauteng province metros.

This case study approach enriched this research in many ways; it gave an opportunity for new ideas and hypotheses to emerge from the collective investigation (Pedhazur and Schmelkin, 1991). Its detailed interrogation of the two metropolises building control processes as relates to energy efficiency led to a “richly ideographic” research and provided critical information on existing practises (Lindegger, 1999). The research on the two metropolises at the same time led to enriched findings which increased authenticity that is not possible with the use of other survey instruments (O’Leary, 2004)

4.4.1 Generalisation of Cases

Traditionally, a case study approach is often criticised due to difficulties in generalising its findings (Punch, 2005). In this research however, an evaluation of the two metros building control regulations formed a collection of cases which can be used to generalise the findings to all the Gauteng province metros unlike a single case approach. Additionally, each case was studied as a stand-alone domain to understand its intrinsic nature and the use of conceptualisation methods to study the cases ensured that several aspects were explained which might have led to new prepositions and hypotheses, thus allowing for the generalisation to Gauteng province metros (Punch, 2005).

4.4.2 Case Study Methods

The underlying principles of data collection for a high quality case study involves the use of multiple sources of evidence; the formulation of a case study database which assembles distinctive evidence and maintains evidence that is explicitly linked to the research questions (Yin, 1994). Case study as a research strategy employs several methods which include documentation, archival records, interviews, direct observation, participant observation and physical artefacts (Yin, 2003; O' Leary, 2004).

This research used national and local policy documents in the respective metros to set the theories of energy efficiency regulations implementation which were investigated during the field survey interviews and questionnaires. In addition, an analysis of documents concerning the proposed new energy efficiency building control regulations for buildings and green building standards used by the sustainable construction interest groups in South Africa was done.

4.4.3 Validity and Reliability

The administration of a standardized questionnaire and interview guideline by the same researcher limited potential observer bias. Additionally, the researcher was readily available to explain the required level of evidence for each criterion. This is because the researcher administered the questionnaires and conducted the interviews personally.

The use of multiple sources of evidence specifically document review, interviews, and questionnaire entrenched the construct validity and reliability in the research and ensured triangulation of findings and complementarity of information. This eventually led to a high level of accuracy. This is referred to as convergence of lines of inquiry (Yin, 1994). The use of multiple sources of evidence of similar phenomenon under study in equal measure adequately addressed the 'construct validity' issues. The development of case distinctive databases using case study notes (which were prepared during the field study), narratives (which were taken from interviews) and case study documents ensured that reliability concerns were addressed.

4.5 Analysis of the Field study and Presentation of Results

In analysing and presenting the results of the field research, the key theme of energy efficiency in building control regulations remained paramount. The research defined key themes/areas of inquiry which were investigated to meet the objective of the study. These five (5) key areas were:

1) The importance of energy efficiency principles in building development processes.
2) The energy efficiency principles that are part of and/or are required in the building control regulations during the approvals process of the building development plans by the local authorities.
3) The energy efficiency principles which can be implemented through the building control regulations in the local authorities and the stage at which they should be introduced in the building control process.
4) The problems which impede the implementation of energy efficiency principles through the building control regulations in the local authorities.
5) The steps to be taken to integrate energy efficiency principles in the building sector.

On the basis of this, the results and analysis of the research was arranged in such a way as to answer the main question and the subsequent sub-questions of the research. Appropriate Microsoft Excel spread sheets were used to capture and present various aspects of information from the field questionnaires survey alongside descriptive narratives. Information from the semi-structured interviews was analysed and presented mainly in descriptive narratives and frequency tables and charts.

4.6 Ethical considerations

The application for clearance for human research (non-medical) was presented to the Faculty of Engineering and the Built Environment of the University of the Witwatersrand for approval for the field survey. The participant information sheet and informed consent form were sent to the participants as part of the questionnaires and the interview guidelines; informing them of their obligations and seeking their consent to participate in the research. While administering the research questionnaires and interviews, the researcher again informed the participants of the study objective, how much time it would take, the tools that would be used to collect and analyse information and that the research was for an MSc programme and assured them of their confidentiality.

Written consent was obtained from every participant via their signature on the informed consent form on either the questionnaire or interview guideline. A copy of the participant information sheet and the informed consent form are in appendix 1.

4.7 Limitations to the study

In the beginning of the research, the researcher had wished to investigate the topic in all the six key metropolises in South Africa. This was found to be bigger than the requirements for which the research was being done and therefore the interrogation of the two metropolises of greater Johannesburg was deemed satisfactory to meet the requirements of an MSc research. The second limitation concerns the generalisation of the findings of the research to all the metropolises of South Africa in so far as it concerns the implementation of energy efficiency building standards. The constraints of the sample size relative to the population may not make this possible but the findings may be adequately generalised to all the metros in Gauteng province. Third, the researcher had hoped to have the input of a Regulations Lawyer but the financial resources did not allow. However, this gap was ably filled by the information provided by one of the KPPs interview respondents who had been in-charge of Building control regulations in Johannesburg for more than twenty (20) years and has written extensively on building control regulations in South Africa.

4.8 Conclusions

This chapter has discussed the study population, the research study design, the methodological approaches employed in the study for data collection and analysis and measures taken to ensure validity and reliability. It has also explained the limitations to the study.

The research can be described as being pragmatic and interpretive in nature, having employed a mixed methods approach. The dominant methodological procedures were qualitative. The methods and tools used in the study for collecting data included questionnaires, interviews and documentary reviews. The two cases of Ekurhuleni Metro and Johannesburg metro were selected using convenience/purposive sampling. The limitations of time and finance necessitated the use of convenience/purposive sampling techniques in the study.

Chapter 5 : PRESENTATION OF FINDINGS

5.1 Introduction

This chapter presents findings derived from information that was gathered in the field survey using two different types of sources, namely structured questionnaires and semi-structured interviews. The respondents to the interviews and participants of the questionnaires survey were key representatives of the building control function in the local authorities and key participants in energy efficiency programmes for buildings in South Africa. These were Building Controls and Approvals Officials (BCAOs) in the local authorities, Key Professional Practitioners (KPPs) in the greater Johannesburg and representatives of Sustainable Construction Interest Groups (SCIGs).

The results are categorised and presented under the headings of questionnaire responses and interview responses. Subsequently, under each heading, responses as per the groups of questions in the five key areas of investigation mentioned below are presented.

5.2 Questionnaire Results

This section presents questionnaire findings. The introduction part of the questionnaires and the interview guidelines asked about the participants training and experience. Subsequently, the participants were asked questions grouped in the five key areas of exploration as listed below:

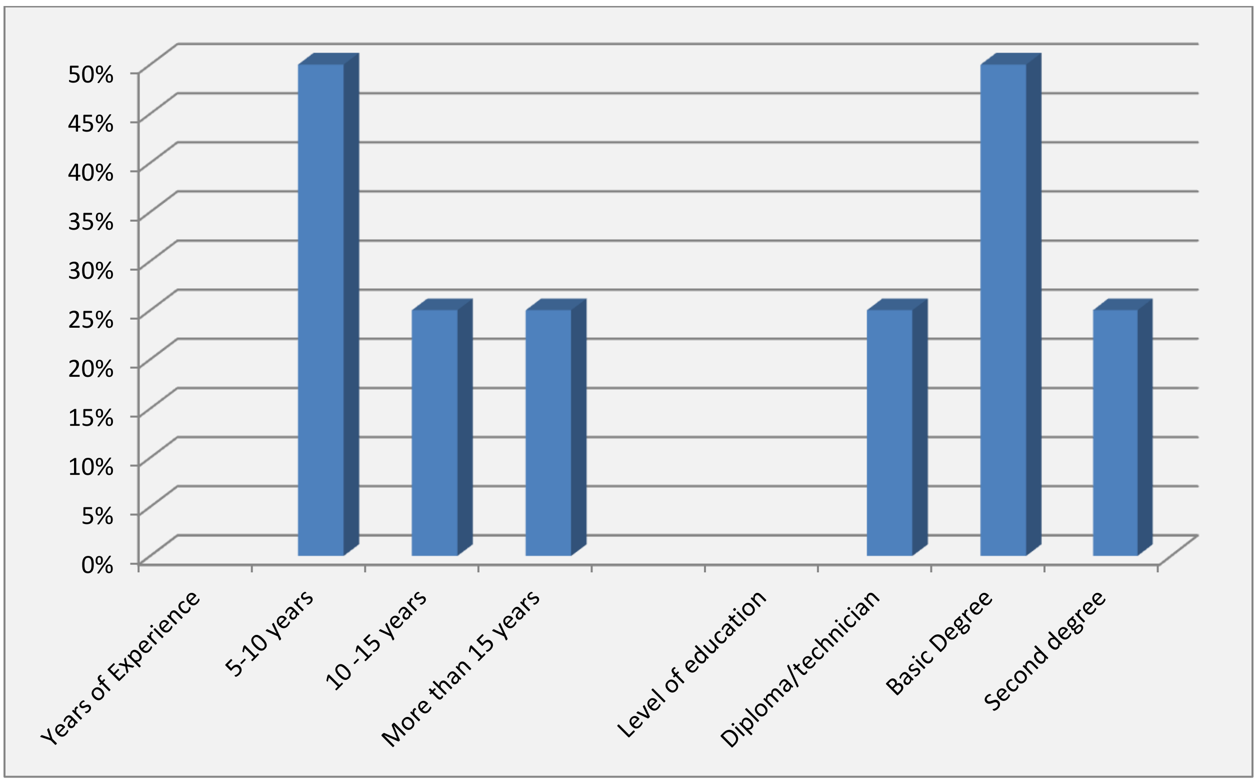
1) The importance of energy efficiency principles in building development processes.
2) The energy efficiency principles that are part of and/or are required in the building control regulations during the approvals process of the building development plans by the local authorities.
3) The energy efficiency principles which can be implemented through the building control regulations in the local authorities and the stage at which they should be introduced in the building control process.
4) The problems which hamper the implementation of energy efficiency principles through the building control regulations in the local authorities.

5) The steps to be taken to integrate energy efficiency principles in the building sector.

5.2.1 The importance of EE principles

Out of the 14 respondents, 50 percent of the respondents have experience of between 5 to 10 years of working with building regulations, 25 percent of respondents indicated an experience of over 10 to 15 years, while the remaining 25 percent have over 15 years experience in dealing with building regulations in the buildings development processes (see figure 5.1).

Figure 5.1 Respondents experience and educational level



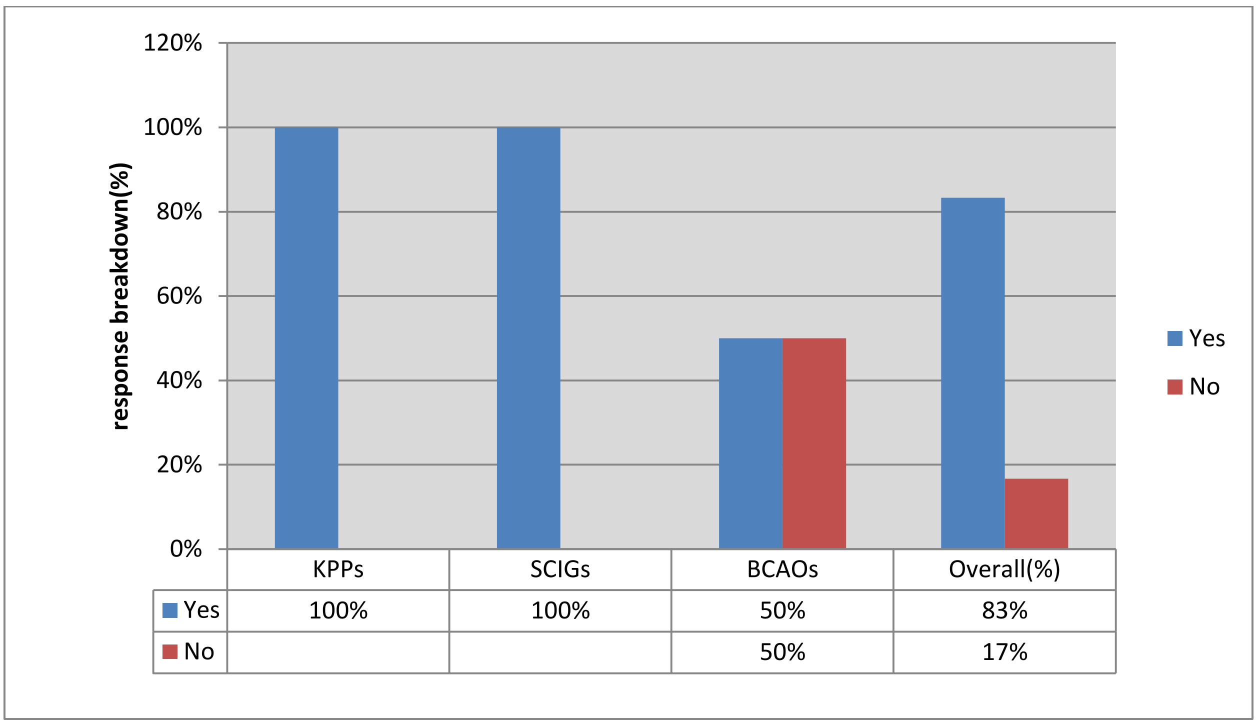
Source: Author's administered questionnaire (2011)

In terms of the importance of energy efficiency principles in the building development process, the majority (83%) of the participants agreed that it is important (see figure 5.2). All participants from SCIGs and KPPs supported this finding while only 50% of the BCAOs were in agreement.

The following reasons were cited as to why energy efficiency principles in the building development process were deemed important and are listed below:

1. Escalating costs of electrical energy (70%),
2. The 2007/2008 energy supply crisis (68%),
3. Conservation/Environment (58%), and
4. As a preparation for anticipated regulatory requirement (55%) among others.

Figure 5.2 Importance of EE principles in building development process



Source: Author's administered questionnaire (2011)

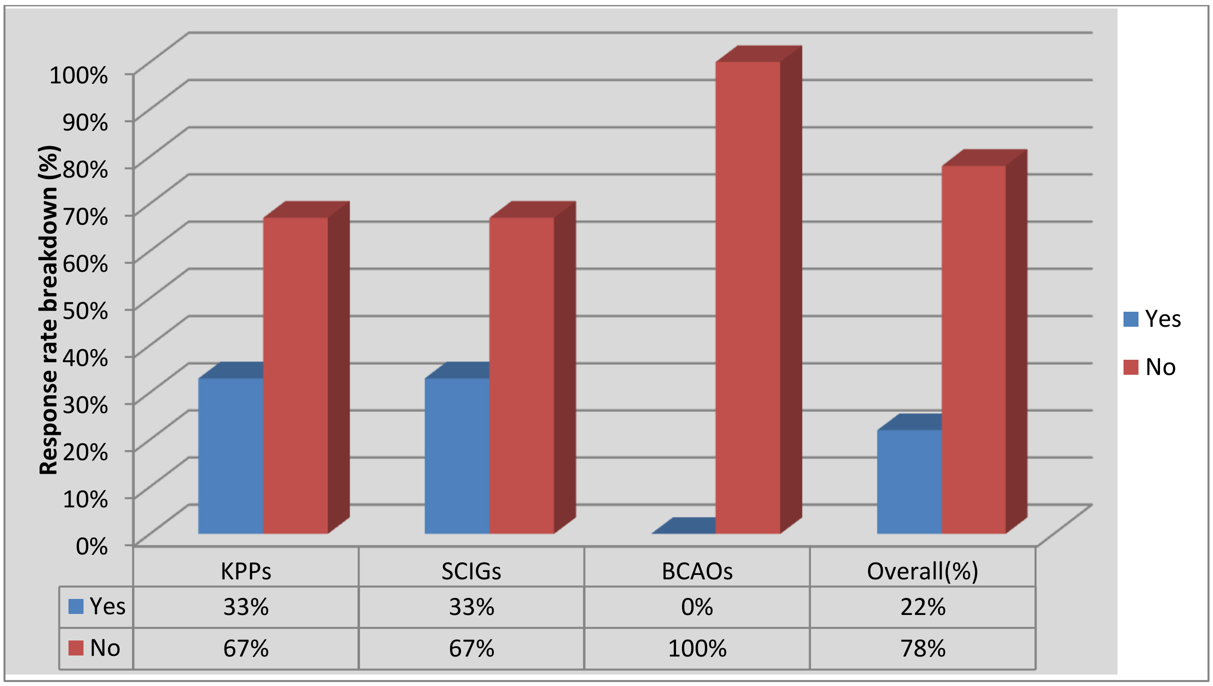
The other 50% of the BCAOs in disagreement about the importance of energy efficiency principles in the building development process cited lack of legal requirement as the reason for not considering energy efficiency principles important in the building process.

5.2.2 Requirement for EE principles in building control regulations

According to figure 5.3 below, 78% of the participants stated that energy efficiency principles are not legally required in the current building regulations. In terms of breakdown: of this, 100%

of BCAOs and 75% each of KPPs and SCIGs indicated the lack of energy efficiency principles in the current building regulations. However, nearly 61% of the participants were aware of the energy efficiency building guidelines issued by the key local authorities in South Africa. The building designers and developers in the respective jurisdictions are actively encouraged to incorporate the above EE guidelines in designs and building plans for building control approvals- though voluntarily.

Figure 5.3 Requirement of EE principles in building control regulations



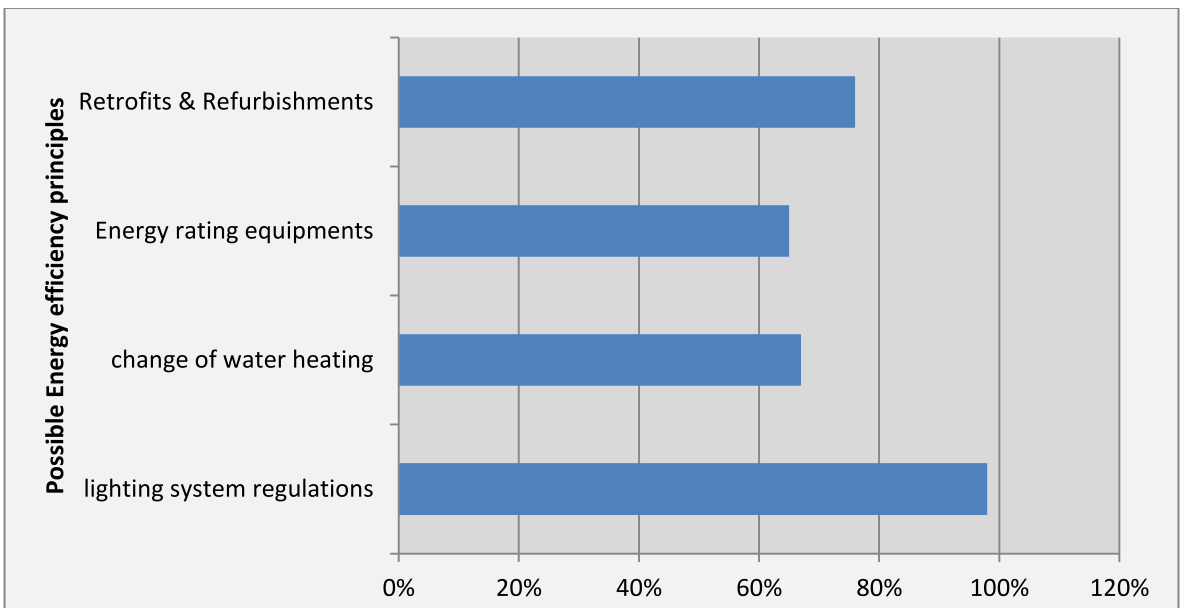
Source: Author‘s administered questionnaire (2011)

The awareness of the EE issues was exhibited by their knowledge of the contents of the energy efficiency design and construction guidelines issued by the Johannesburg metro and the application of the star rating tool for buildings being implemented by the GBCSA among other ongoing EE activities in buildings. They also added that this awareness had been gained through industry arranged forums like workshops and conferences/exhibitions. Many of these forums had been arranged by SCIGs and occasionally in collaboration with government departments. The 22% who believed that there was a legal requirement, mostly from either KPPs or SCIGs cited sections of the Environmental Conservation Act, 1989 (Act no.73 of 1989) requirements and the energy efficiency building guidelines issued by the various local authorities as giving a legal basis for energy efficient building principles. Furthermore, 100% SCIGs and nearly 60% KPPs claimed collaborative efforts within themselves which had created voluntary energy efficiency building standards which their respective members were required to follow when executing building developments. They mentioned the Green Star building rating system being implemented by the GBCSA members as one such effort.

5.2.3 Implementable EE principles through building control regulations

In what they described as "low hanging fruits": all participants stated that there were many possibilities to implement a number of energy efficiency principles in new and existing stock of buildings through the building control & approvals mechanism. They listed such aspects as orientation of the building, lighting, HVAC and other mechanical systems, Insulation and landscaping among others as being clear areas which hold a large potential for energy savings.

Figure 5.4 Possible implementable EE principles through building control regulations



	lighting system regulations	change of water heating	Energy rating equipments	Retrofits & Refurbishments
Response rate	98%	67%	65%	76%

Source: Author's administered questionnaire (2011)

For example, 74% of the participants stated that nearly 98% energy savings could be achieved via a change in buildings lighting system regulations (Figure 5.4). Other responses were that up to 67% savings in energy consumption could be achieved through the change of water heating building regulations in residential buildings by the introduction of solar (and other alternative/renewable) energy appliances. 65% of the participants saw an opportunity for significant energy saving in change of specifications for installed equipment in buildings, both domestic and commercial, from the current ones to an energy rating standard. Nearly 76% of the participants saw a huge potential for energy savings in retrofits and refurbishments if energy efficiency principles were to be introduced in building control & approvals regulations.

In so far as the point of introduction of the energy efficiency measures is concerned; the common statement among the respondents was that many of the above stated measures be introduced at the design approval stage and be checked alongside the other requirements in the building control standards until the completion and occupation of the development. A few respondents from the KPPs and SCIGs groups stated that the energy efficiency measures be introduced at the design approval stage and then be confirmed during the operation of the building.

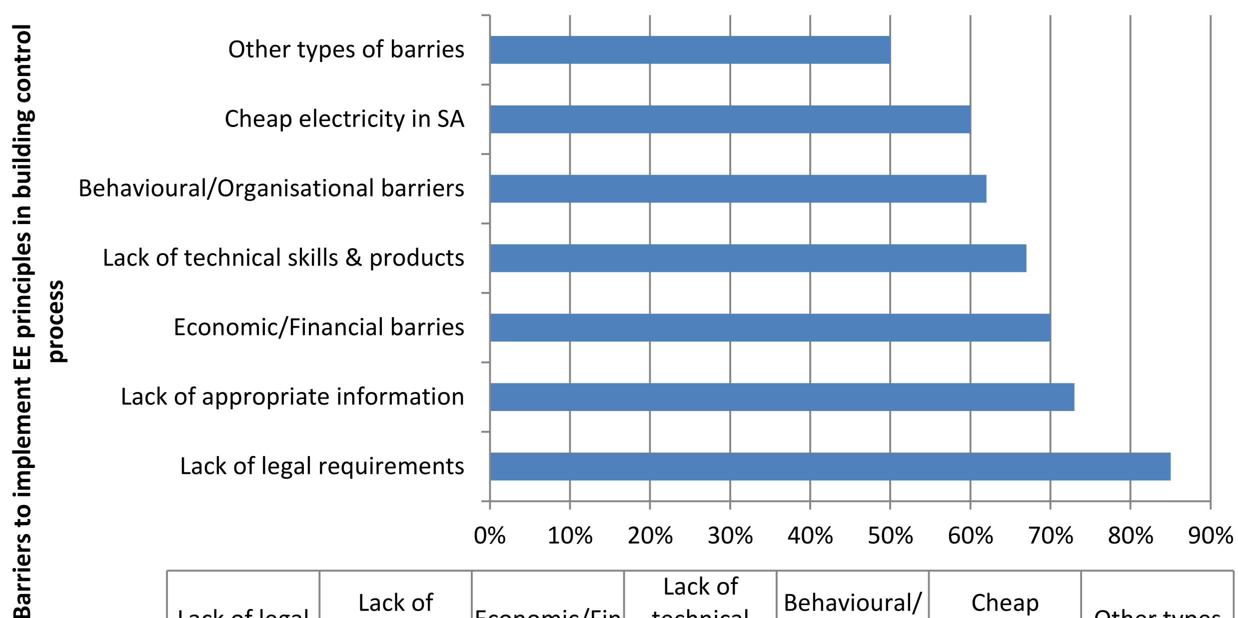
5.2.4 Barriers to the implementation of EE principles

Each group of participants listed various problems but the following showed higher frequency in all the lists as shown in figure 5.5.

Lack of a legal requirement was listed by 85% of the participants as the number one barrier holding back the implementation of the energy efficiency principles through the building control regulations in local authorities. They stated that this made it almost impossible for the local authorities to require energy efficient designs from the developers. In most cases, they said developers only made applications which met minimum requirements of the law (90% of BCAOs participants). Furthermore, this lack of a legal framework impeded the development and implementation of a uniform mechanism for the application of energy efficiency principles in the building control processes of all local authorities, they noted.

The next common barrier mentioned by participants (at 73% of the respondents), was t**he lack of appropriate information to guide decision making** on the choice for energy efficient construction. Often, the participants wrote, the building designers, developers and the general citizenry do not have adequate information which shows advantages of energy efficient constructions vis-a-vis business as usual construction. For example there is general unfounded information that energy efficient buildings are expensive, yet it is well known that this is only partly true for the construction part of the building, and not on its entire lifecycle, wrote the respondents. Further, they said that the construction industry is lacking reliable total lifecycle cost information which can be used by the building control function in the local authorities to inform the application and implementation of energy efficiency principles in buildings.

Figure 5.5 Barriers impeding implementation of EE principles



	Lack of legal requirements	Lack of appropriate information	Economic/Financial barries	Lack of technical skills & products	Behavioural/ Organisational barriers	Cheap electricity in SA	Other types of barries
Response rate	85%	73%	70%	67%	62%	60%	50%

Source: Author's administered questionnaire (2011)

The next suite of barriers can be classified collectively as **Economic/financial.** Up to 70% of the participants listed them as a key hindrance to the implementation of the energy efficiency principles in buildings. The list included: (1) Lack of funds to convert a huge stock of existing buildings which were built when energy efficiency was not important, into energy efficient, (2) Lack of funds to train current staff in local authorities in energy efficiency building control principles, (3) Unwillingness on the part of financial institutions to give special dispensation to building projects wishing to develop energy efficient buildings, (4) Unavailability of financial incentives from the National, provincial or local governments to motivate the growth of energy efficient constructions and (5) Most budgets for construction are for the construction phase of the building, and there is always need to keep them down at the expense of long term cost of the building- hence the lifecycle economics and costing is sacrificed for lower construction costs, leading to energy inefficient construction results in most instances. Fundamentally, when buildings are being re-sold, there is hardly provision to include the value of the avoided costs of energy efficient construction. These were the main economic/financial barriers listed by the participants, among others.

Lack of Technical skills and products to match the requirements of energy efficient building processes was another barrier listed by a high number of participants (67%). Technical skills deficiencies were listed as being unavailability of technicians/fitters with skills and on the scale required to deliver a large shift from 'business as usual' to energy efficient buildings; to high level specialists to design and specify guiding principles for energy efficient construction in the entire industry. In the products category, the participants noted that a lot of existing equipment in residential and commercial buildings hardly measure up to energy efficient standards and therefore for a market transformation to occur, it will require a change in the manufacturing processes which the manufacturing sector may not be able to meet at the moment.

Behavioral/organizational barriers were the other category of barriers most listed by the participants at 62%. This list included: (1) The split incentive and decisions nature of building development, where the decision makers for construction are not the ones who pay the energy bills for the final building, or if it is for sale, then the benefits of low energy bills will not accrue to the developers, (2) The fragmented nature of the teams and products of construction. The teams involved in the development and running of buildings are in most instances different. Additionally, people only buy buildings very few times during their lifetime- mostly once, hence they may not know the implications of energy efficiency at the time of purchase, (3) Status and societal misconceptions cause consumers to behave irrationally, whereby one may think that using air conditioning in a building makes them more sophisticated yet the building could do well with natural ventilation and save energy.

The presumed **cheapness of electricity in South Africa** is a major barrier to energy efficient building principles implementation, 60% of the participants stated. However, for majority of the participants (87%) this was going to change with the proposed steep rise of electricity tariffs in the next three years. In fact, they stated that this is going to help give the energy efficiency agenda a new impetus in both the commercial and residential buildings sectors.

Other types of barriers listed in fewer numbers included the invisibility of energy, mistaken beliefs that new buildings are energy efficient and that energy costs are a small part of a households' budget, especially in the residential buildings.

5.2.5 Ways to integrate EE principles in the building sector

An overwhelming majority of the participants (96%) listed the **re-writing of the building control regulations** to include building energy efficiency standards/codes as the first step to integrating energy efficiency principles in building processes in South Africa. Similarly, almost the same number of participants (95%) stated that the proposed change to the building regulations which will introduce mandatory energy efficiency standards/codes will have a profound change in the way energy efficiency principles are applied in the building processes in South Africa. The participants indicated that this legislation will give the energy efficiency agenda in the built environment a legal foundation and an added impetus to improve on the effectiveness of the various voluntary efforts now in place. Additionally, they stated that this will provide a uniform application process across all the local authorities in South Africa. Therefore it will have greater penetration unlike the current situation whereby only the key metros with greater financial resources were able to push for the voluntary energy efficiency building guidelines.

The second highest factor listed by the participants (76%) as being important for effective application and implementation of energy efficiency principles in the building control process was **the provision of financial incentives** through all the levels of government to spur mass application and replication of energy efficiency building practices in all aspects and levels of construction in the whole country, especially after the promulgation of the proposed legislation. These financial incentives could be in the form of tax rebates, grants or municipal bonds specifically designed to fund energy efficiency building developments. The participants were especially concerned with the amount of funding required for the retrofitting of the existing stock of buildings to make them energy efficient and stated that it required a special funding mechanism.

Table 5:1 Possible ways to integrate EE principles in the building sector

Key strategies to integrate EE principles	Response rate
Re-writing of building control regulations to include building energy efficiency standards/codes	96%
Provision of financial incentives through all the levels of government	76%
Information/educational campaign • **On the proposed new legislation on energy efficiency requirements in the building code**	70%
Use of voluntary energy efficiency principles, especially among the KPPs and SCIGs should be encouraged	60%
Other factors: • **Improved training for BCAOs** • **Government Commitment Leadership by example** • **Government procurement process** • **Setting up of Punishment mechanism for inefficient users of energy**	50%

Source: Author‘s administered questionnaire (2011)

The participants (70%) listed a **robust information/educational campaign** as the third most important issue which needs to be enhanced in so far as energy efficiency programmes in the built environment are concerned. They stated that a well-defined public awareness program should accompany the implementation of the proposed new legislation on energy efficiency. They stated that this will inform the professionals and the general citizenry of the advantages of energy efficient construction and improve its uptake.

Up to 60% of the participants stated that the **continued use of voluntary energy efficiency principles,** especially among the KPPs and SCIGs, should be encouraged alongside the implementation of the mandatory building codes proposed in the new legislation. They stated that this had the tendency of raising the energy performance of buildings beyond the minimum requirements set in the mandatory legislation.

Other factors listed, in fewer numbers, as being important for the integration of energy efficiency principles in the building control process included: (a) Improved training for the BCAOs to inculcate energy efficiency principles in their normal way of assessing building approvals, (b) Government commitment (at all levels) through leadership, for example with demonstration projects and requirements of all government buildings to measure up to a certain standard of energy efficiency, (c) Government procurement processes which enhances energy efficiency supply system for building products/materials, equipment and the final structure and (d) Setting up of a punishment mechanism for the inefficient users of energy among others.

5.2.6 Document Review

During the field investigations, documents used for building/construction development approvals were also evaluated. They contained requirements to be fulfilled by the developers before approval for construction and occupation could be granted. These requirements included: approved drawings by a qualified professional, structural soundness certifications, health and safety certifications for the construction and the general public, electrical and plumbing installations soundness certification and construction completion soundness certification.

The electrical installation and connection requirements dwelt much on safety of the installation, the various tariffs for the various building uses and the payment modes for the connection among others. In all this requirements, there was no direct reference to any section requiring the developers or BCAOs to check for EE measures in the developments. Appendix 5 shows a typical checklist of documents used by BCAOs when approving building developments in areas under their respective jurisdictions.

5.3 Interview Findings

The interview guidelines followed the same pattern of questions grouped like the ones for questionnaires, which are listed in section 5.2. However, the interviewees' discussions allowed more latitude in the way they answered the questions because of their higher specialized experience and expert knowledge on energy efficiency matters and building control regulations. This was used to gain deeper insight into the subject matter and to triangulate and compliment the other findings from the questionnaires and documents review.

5.3.1 The importance of EE principles

As energy efficiency is an emerging issue in the developing countries generally and South Africa in particular, the respondents were of the view that it's important but it was going to take a while longer before it gets the attention it deserves in the built environment. And there being no legal demand to enforce it, developers had no obligation to follow on it. But, they said certain factors which impact on the costs of maintaining buildings had changed and were increasing awareness and necessitated action to be taken to address the issue of energy consumption in buildings.

The rising costs of electricity as proposed by Eskom and the supply shortages experienced in 2007/2008 were cited as key factors driving the energy efficiency agenda. Specifically, the respondents emphasized that the measures were driven by the need to reduce energy bills and subsequently also contribute to a clean environment. On the other hand, the respondents said that developers still viewed energy efficient buildings as costing more to construct. However, the respondents were aware that the cost difference between energy efficient buildings and the ordinary business-as-usual ones is continuously decreasing.

5.3.2 Requirement for EE principles in building control regulations

The clear answer from all respondents was that at the moment, there is no legal requirement in the existing building control regulations which oblige the developers or local authorities to implement energy efficiency principles in buildings. However, the Johannesburg and Ekurhuleni metros have issued energy efficiency good practice guidelines which the developers intending to build in areas under their jurisdiction can voluntarily follow. Second, SCIG respondents indicated that many of their members follow voluntary guidelines issued by their respective bodies mostly to cut their energy bills and as a CSR[18] Environmental Initiative. This voluntary mechanism includes the GBCSA's Green Star building rating system.

5.3.3 Implementable EE principles through building control regulations

The responses were mixed here. Respondents from the BCAOs and SCIG talked of the so called 'low hanging' good practice energy efficiency measures such as passive solar designs, solar home systems such as solar PVs (photovoltaic) and solar water heaters and residential load control focused on the installation of ripple control systems for geysers. They said this can be easily written into building control regulations and be implemented at no extra cost either to the local authorities or the developers. The respondents from KPPs mentioned installed equipment as another requirement which can be easily added to building control regulations. They pointed out that the Johannesburg guidelines for energy efficient buildings were especially meant to change the design paradigm using simple design parameters and low technologies voluntarily.

All respondents suggested retrofit requirements to address energy efficiency requirements in the large stock of existing buildings. Generally, all respondents were in agreement that there exists many opportunities to reduce energy consumption in buildings if the requisite building regulations can be put in place. They were in agreement that these regulations should be inspection based mandatory measures applied from the design phase to completion and operation of the building.

5.3.4 Barriers to the implementation of EE principles

Here too, the responses were mixed and varied, but the main common response was that the lack of a legal framework for EE measures in the national building regulations was the number one barrier which consequently hindered market transformation to mainstream energy efficient

[18] Corporate Social Responsibility

buildings in the entire economy. Other common responses included informational barriers, behavioural/organizational barriers, economic/financial barriers and the presumed cheapness of electricity in South Africa.

5.3.5 Ways to integrate EE principles in the building sector

All the respondents were unanimous that writing the building control regulations to include building energy efficiency standards/codes was the starting point of integrating energy efficiency principles in building regulations. In this light, all respondents welcomed the proposed new building regulations and hoped they will inspire the building industry to achieve more than the minimum requirement. They said that this will have a market transformational impact as well and create opportunities for the development and use of market based EE business models like ESCO's in the existing buildings. The respondents also added that the proposed energy efficiency regulations should be periodically revised to include principles they will not have covered at inception, like retrofits and building equipment standards which are not captured in the proposed legislation, and also to take care of developments in technology and higher energy efficiency requirements in newer developments.

They said that behavioural barriers presented a difficult challenge to address as most EE regulations, including the proposed ones hardly target the consumers. Additionally, the respondents said the proposed energy efficiency regulations should be accompanied with a robust informational/educational campaign to sensitise the citizenry on the benefits of energy efficiency in buildings and get them to buy into it from the beginning. SCIG respondents added that EEBSC's stimulate the use of other higher level energy efficiency principles in buildings, like energy rating tools and incentive programmes. They said this should be encouraged, alongside the implementation of the proposed mandatory regulations.

5.4 Summary of Findings

Two sets of BCAOs consisting of three and four representatives returned six questionnaires. Similarly, two sets of SCIGs each with three representatives returned five questionnaires. Additionally, three questionnaires were returned by the KPPs group. Two representatives of the

BCAOs were interviewed as well as one from the SCIGs group. Two members of the KPPs group were also interviewed.

Majority of the questionnaire participants and interview respondents were in agreement that energy efficiency had become an important principle in the way we build and manage buildings in South Africa. This had been forcefully made apparent by the electricity supply crisis of 2007/2008 and the proposed steep rise in electricity tariffs in the next three years starting 2010/2011. The respondents were also unanimous that the proposed energy efficiency regulations, that is SANS 10400XA and SANS 204, Edition 1; Parts 1-4 made for a good legal framework upon which to build future energy efficiency regulations and programmes in the built environment in South Africa.

The awareness of the need for energy efficiency in the building/construction process was very high among the respondents. As stated above, this had been significantly brought to the fore by the electricity supply woes of 2007/2008 and the proposed steep increase in electricity tariffs starting 2010/2011. All key sectors of government at all levels and other government agencies involved in energy issues were working on one or other program to try and address the issue.

The fact that energy efficiency building regulations were not in the law yet was clear among all respondents. However various voluntary efforts were being made by the various stakeholders in the built environment to make a contribution while awaiting the national enactment of the requisite legislation.

The respondents were significantly aware of and were in most cases already encouraging the application of “low hanging” opportunities in the various building processes voluntarily. These opportunities were common in the buildings lighting systems, water heating systems and generally low rise natural ventilation designed buildings as opposed to high rise high density mechanical equipment intensive buildings.

Problems impeding the implementation of energy efficiency principles in the building control processes in local authorities could be broadly summarised as: Legal, Informational/awareness, Behavioural/Lifestyle, Economic/Financial and to some extend the presumed cheapness of electricity in South Africa.

The proposed new building regulations promises a legal framework on which the respondents believed the South African building/construction processes would rely on to effect and entrench energy efficiency principles in the process. The other important drivers for the delivery of energy efficient built environment stated by the respondents included financial incentives especially targeted at the retrofits of the existing stock of buildings, DSM programmes of the main electrical energy supplier; Eskom and more public awareness efforts among others.

Chapter 6 : DISCUSSION OF FINDINGS

6.1 Introduction

This chapter discusses the main findings of the research. It discusses the findings from the field study, literature review and analysis of documents. These are put in context and comparatively analysed to produce exhaustive answers to the research question.

As explained earlier in the literature review sections of this study, original building control regulations and standards were developed and used to ensure public safety and health. However, they have found additional application as a tool to promote energy consciousness and sustainability in the built environment (Hamza and Greenwood, 2009). Though Energy efficiency building codes are generally new, they have been shown to improve energy efficiency in the built environment (OECD, 2003; EGI, 2002). Energy efficiency efforts are more likely to succeed where there is clear legislation and regulation on the same in place (Sebitosi, 2008).

Once the legislation and regulations have been put in place, in most cases Local authorities enforce them and this determines the energy efficiency of the building stock (SEA, 2006). This explains the proposed inclusion of energy efficiency requirements in the National building regulations and building standards Act, (Act 103 of 1977) which is administered by local authorities, in order to achieve energy efficiency in the built environment in South Africa(Holden, 2004; du Toit, 2007).

The discussions and analysis are arranged according to the five key areas of investigation presented in chapter 5 above. These are: (1) The importance of energy efficiency principles in the building development processes. This section discusses the awareness and importance of energy efficiency principles in the building/construction process at the local authority level. (2) The energy efficiency principles that are part of and/or are required in the building control regulations during the approvals process of the building development plans by the local authorities. The section discusses the existence or lack of energy efficiency measures in the building control process. (3) The energy efficiency principles which can be implemented through the building control regulations in the local authorities and the stage at which they should be introduced in the building control process. This section discusses practical measures which the local authorities and other key participants are actively executing and encouraging in order to integrate energy efficiency principles in the application of building control regulations in the buildings development process. (4) The problems which hamper the implementation of energy efficiency principles through the building control regulations in the local authorities. The section discusses challenges faced by local authorities and other stakeholders in trying to implement energy efficiency principles through the building control processes. (5) The steps to be taken to entrench energy efficiency principles in the building sector. This section discusses possible ways and means which can be used to deliver energy efficient buildings/construction through the building control function in local authorities and beyond.

6.2 The importance of EE principles

The key finding here is that all the respondents highly recognize the importance of energy efficiency principles in buildings. From documentary evidence, we note that the energy efficiency agenda gained momentum with the first OPEC oil crisis of the early 1970s (Matsugawa et al, 1993; Deringer et al., 2004). However, this had a more profound and direct impact on the motor and manufacturing industries as compared to the built environment. In South Africa especially, much of the energy used in buildings is electric. Consequently, it is imperative that changes in electric energy supply and/or price become the main reason for awareness and need for energy efficient buildings. This explains why the respondents listed the electric energy supply crisis of 2006/2007 and the escalation and hiking of electricity tariffs by more than 100% between 2009/2010 and 2012/2013 as the main reasons for energy efficiency awareness in buildings. These events have also had a hand in accelerating the speed of writing the proposed energy efficiency regulations which are awaiting promulgation.

The SCIG's and KPP's are actively involved in sustainability and environmental issues in construction and this explains their high level of awareness on this particular point (table 5.2). But, whereas the environmental concern agenda is important and there are many programmes on the same like carbon trading, the fragmented nature of the built environment makes it difficult for it to benefit from such programmes and therefore besides the key stakeholders who make it their concern as indicated above, it is hard to qualify its impact on the awareness level in the whole building industry.

Significantly, the proposed energy efficiency regulations awaiting promulgation will be implemented by the BCAO's in conjunction with KPP's and SCIG's. This gives them an added motivation to familiarize themselves with energy efficiency issues in buildings. It can therefore be deduced that the key stakeholders involved with the implementation of building control regulations in South Africa are well aware of the need and importance of energy efficiency measures in buildings.

6.3 Requirement for EE principles in building control regulations

The main finding from the field study in this area is that energy efficiency requirements are legally non-existent in the current building control regulations. Earlier documentary reviews revealed the same results where it was stated that specific legislation and regulations regarding energy efficiency in buildings does not exist in South Africa (Reinink, 2007; Sebitosi, 2008). This situation has persisted for long, even after the emergence of electric energy supply constraints because the various local authorities are not permitted to set their own regulations and even if they did, it would take a minimum of five years before they are approved by the relevant minister in-charge (Holden, 2004). The reason for this measure was to stop local authorities from enacting by-laws and regulations which are varied and contradictory and at the same time have a standardized building regulation for the entire country (du Toit, 2007). But this has the negative effect of discouraging the local authorities from being inventive in addressing new and emerging challenges like energy efficiency in areas under their jurisdiction timeously.

However, some local authorities have been innovative and have created collaborative partnerships with other stakeholders in the built environment, like the SCIG's and KPP's and have:

1. Introduced energy efficiency building guidelines especially for new building developments in areas under their jurisdiction like the city of Johannesburg did in 2008,

2. Executed demonstration projects to encourage other buildings owners and local authorities to take an example like the Ekurhuleni Metro Retrofit project of 2005 and
3. Permitted the use/deployment of energy efficiency rating tools like the GBCSA's Green Star building rating system be implemented to achieve energy efficiency in buildings under their jurisdiction.

All the above measures have been introduced to be used voluntarily. From the literature review earlier, we found that in many jurisdictions where energy efficiency regulations and practices have taken hold, they started as voluntary requirements before they became mandatory like in South Korea, Singapore, Thailand and Mexico (ICBEC, 2010; Deringer et al., 2004). The environmental conservation requirements stated in the pending legislation are significantly covered in the energy efficiency building guidelines issued by the respective local authorities and involve elements like more natural ventilation, North-South orientation, energy efficient landscaping among others.

The efforts of the local authorities and other key stakeholders to take initiative and push through the voluntary programmes listed above via the existing building control regulations mechanisms makes for a good preparation before the promulgation and subsequent implementation of the proposed mandatory EE regulations. This means that the key stakeholders in the building industry are willing and have already taken practical measures to implement EE principles in areas of their jurisdiction while awaiting the legally binding requisite legislation.

6.4 implementable EE principles through the building control regulations

The key finding from the field study in this area is that there are indeed several almost no-additional cost practical measures which can be implemented easily through the building control approvals process to realise energy efficiency in buildings. The key ingredient required for this to work effectively is a legal framework which allows for a collaborative relationship between the local authorities and the designers, builders and the property developers.

Indeed, the literature mentions the many ready-to-implement cost-effective EE end-use opportunities which local authorities can deploy (Laponche et al., 1997). Energy efficiency is considerably less expensive if decided upon at the building control & approvals phase (Laustsen, 2008). In fact, some EE improvements may reduce construction costs because the efficient solutions may eliminate the need for costly HVAC and other mechanical systems. From the literature, we note that retrofitting has been known to increase energy efficiency in buildings by up to 70% (OECD, 2003) and the energy efficiency strategy of South Africa recognizes it as one of the higher-cost intervention measures with short payback periods that can be carried out immediately (DME, 2008). This can be through, (1) mandatory standards and audits for energy efficient HVAC, lighting and non-electric appliances and (2) energy management systems in the buildings for retrofits. These proposals could be effectively led and implemented by the local authorities through the building regulation control function. Specifically, the energy efficiency mandatory audits should be carried out alongside the schedule of others like fire, health and safety, which the local authorities routinely and periodically do.

Energy efficient design measures which deal with orientation have been found to be no more expensive than the conventional traditional ones, both in design and construction costs and are easily implementable. When well implemented, this has a great impact on the thermal performance of the building (Blackstone, 2005). This is one measure which the local authorities can easily implement through the building control process at the approval of designs stage.

The use of solar water heaters in relation to the current geyser system is part of a current DSM programme being implemented by the national electric energy supplier Eskom. This is accepted as one of the easily implementable measures which do not require any change in the existing building regulations but rather households and the residential sector in general is supposed to embrace it as a cost cutting measure. In the commercial building sector, solar panels can be installed on parts of the building structure to harvest solar energy very easily. When these measures are applied in the framework envisioned and executed by Eskom, the consumers may actually be able to recoup their capital costs through a DSM Refund system mentioned above. Appropriate partnerships should be created between the local authorities building regulations control entities and the above funds administration systems to make it mandatory for the recommendations of the local authorities to be part of the criterion used for developers to draw from it.

Installed equipment and appliances in both residential and commercial buildings contribute significantly to the amount of energy consumed. In the residential sector, this may amount to more than 50% of the building's consumption (Earth Trends, 2005). This provides an opportunity area which can be targeted to achieve greater energy efficiency in buildings. From the field study, it was found that the current installed equipment and appliances like kitchen equipment, laundry equipment, and other small household appliances are not required to meet a particular energy efficiency standard.

The opportunity to effect energy efficiency in buildings is being missed here. Similarly, there is no current legal requirement of a particular energy efficiency standard for the equipment in commercial buildings like computers, printers, copiers etc. which is enforced. In the USA, the SEER issued by the Environmental Protection Agency is used alongside other EEBSCs to ensure energy efficient buildings. The lack of EEBSC targeting installed equipment and appliances in South Africa leaves a gap in the efforts to achieve energy efficiency in the built environment. The application of measures to address this gap in equipment rating can easily be done via the building control regulations without causing significant costs in the construction and operation of buildings. In fact they would lead to reduced costs for the operation of buildings in the form of reduced energy bills.

The Ekurhuleni metro retrofit project was a clear replicable illustration of the practical application of this 'low hanging' energy efficiency principles which the local authorities could easily execute. The main objective here was to use different technologies to reduce energy consumption in lighting and boiling water (Ekurhuleni Case study, 2007). The key components which were changed were the lighting system (which was replaced with an energy efficient one) and the water heating system which was replaced by solar water heaters with all the attendant control fittings. On cost-benefit analysis, these measures were found to be cost effective and were easily implemented. Of note is that there were no problems with the new lights or water heaters and neither staff nor the general public who use these buildings have complained about their performance. This shows acceptability of the energy efficiency measures undertaken. This specific project finding and all the other interventions explained above confirms the existence of ready to implement EE measures in the built environment.

6.5 Barriers to the implementation of EE principles

The most significant finding in this area is that the lack of a clear legal requirement in the national building regulations hinders the application and implementation of energy efficiency measures in the building control and approvals process of local authorities. When buildings are designed and constructed, energy efficiency requirements may not feature as highly as health& safety, structural soundness, room sizes or even the view from the window (IPCC, 2007; Carbon Trust, 2005). This is because the above requirements are provided for in the building regulations but energy efficiency is not, as is the case in South Africa (IPCC, 2007; Reinink, 2007; du Toit, 2007; OECD, 2003). Whereas the enactment and enforcement of legal instruments alone may not entrench and achieve energy efficiency in buildings, there is no known case where the efforts have succeeded without legislation; as seems to be happening in South Africa (Sebitosi, 2008). It has been shown that in jurisdictions where energy efficiency measures have been successful in the built environment, they were anchored on a clear legislative and regulatory regime. For example, in the USA, four generations of energy efficiency codes and standards for buildings have produced estimated energy efficiency improvements of about 60% over 30 years (Deringer and Gilling, 1998; Deringer et al., 2004).

In a study on the need for friendly accommodation for physically challenged and elderly travellers and tourists in South Africa, the main finding of the research was that there exists an untapped market for such hospitality services in the country. Unlike western Europe and North America, the researcher found that the key first step to unlocking this potential lay in enacting and implementing regulations and laws which would ensure that the various hotels and related facilities are designed and built with disabled people access and use in mind (Breedt, 2007). The energy efficiency agenda in the build environment in South Africa can be viewed in this context and this does confirm the hypothesis of the study.

Additionally, the lack of a clear legal requirement for energy efficiency in the national building regulations has a compounding negative effect on other measures which would otherwise help to drive the energy efficiency agenda in buildings. For example: it stifles market growth for energy efficiency rated equipment and appliances for both the domestic and commercial buildings, it slows down the development of knowledge and skills in EE principles and the diffusion of the same among the key participants in the building industry, makes it difficult to develop institutional structures to drive the EE agenda in the building control function and significantly slows down the development of important sector specific financial instruments necessary for the deployment of EE measures on a nation-wide and sector-wide scale. The above measures are requisite and necessary ingredients of an effective energy efficiency infrastructure (Deringer et al., 2004). In the USA during the infancy stages of the environmental protection programmes, public policy guidelines and regulations implementation by government agencies was deemed to be the main determinants of success or failure in the development and spread of new technologies used in environmental protection programmes (Jaffe and Stravins, 1995; Kneese and Schultze, 1975). This is can be applied appropriately in the South African case and is in line with the hypothesis of the study.

The lack of information on energy efficiency principles is another key barrier to the implementation of EE measures through the building control procedures and processes. From the literature, we find that many energy efficiency programmes in the developing countries are being carried out based on data and information from the developed countries (Deringer et al., 2004). This leads to failure of such programmes and the same is manifest in the fact that of the 21 or so developing countries which have had first generation EE regulations in place, hardly any can boast of a successfully executed and functioning energy efficiency programme for buildings (Deringer et al., 2004; Laustsen, 2008).

In South Africa, several studies have pointed out the lack of reliable total lifecycle cost information as an impediment to successful implementation of EE measures in the built environment, especially commercial buildings (du Toit, 2007; Holden, 2004). And, as mentioned earlier, the lack of energy efficiency requirements in the national building regulations makes it difficult to develop a coherent industry and nation-wide public awareness and information programme to address the issue. This will therefore fail to inform the general citizenry, the professionals and the developers on the EE principles themselves, the technologies and products, and the advantages of the measures as opposed to a building-as-usual scenario.

Financial and/or economic barriers were found to be another impediment to the implementation of energy efficiency principles in the building control process. From the literature, we find that setting up an energy efficiency infrastructure in the developing world is expensive and most developing countries normally seek financial aid from the world bank, IMF or other development partners to start them (Deringer et al., 2004; Carbon Trust, 2005 IPCC, 2007; Laustsen, 2008). This is reflected here when the respondents report that they do not have adequate funds for the training of the staff in the local authorities to execute such programmes. The existing stock of buildings holds the biggest potential for energy savings which can be realised by retrofitting with energy efficient technologies and equipment. For South Africa, this is even truer in that electricity was previously `cheap'. Yet, energy efficient retrofits/renewals and refurbishments do involve a high financial outlay (Wafula and Talukhaba, 2010). In most cases, this requires programme specific financial instruments which are currently unavailable especially for the large scale energy efficient retrofits for the existing commercial buildings.

Other financial features which constrain the implementation of energy efficient building regulations involve situations where the financial institutions fail to accurately measure the cost of avoided future energy costs in the building development and property market. This makes it difficult for the developers especially to get financial/monetary value for the energy efficient measures they may implement and removes the motivation to implement such measures. Significantly, most budgets for buildings development are for the construction phase and there is always need to keep them down at the expense of long term cost of the building, hence the lifecycle economics and costing is sacrificed for lower construction costs, leading to energy inefficient construction in most instances.

Behavioural/organizational barriers are generally economically irrational actions by consumers which compound the implementation of energy efficient measures in a strange way. Consumers, out of habit, social ritual, marketing or status knowingly use more energy than the basic comfort may require (Chappell's and Shove, 2005; Carbon Trust, 2005; Laustsen, 2008). This is a very frustrating scenario and a difficult impediment to address, especially through regulations. The local authorities and other stakeholders will have to be more creative to find measures which address this barrier. Closely associated with behaviour was the long held view in South Africa that electricity was cheap. This hindered the implementation of energy efficiency measures in buildings but due to the current upward changes to the electric energy prices, it has turned into an opportunity. The belief that new buildings are energy efficient impedes local authorities' efforts to implement EE measures in cases where there is need for incremental action to meet changing regulations or technologies. In most cases, the building consumers are likely to assume that newer buildings already took the changes into consideration.

These findings show that the effective implementation of energy efficiency measures in buildings through the building control regulations will only happen once these barriers have been overcome.

6.6 Ways to integrate EE principles in the building sector

Re-writing building control regulations to include EE principles is identified by the field study respondents as the starting point of integrating energy efficiency measures in the building sector. This is fundamentally supported by findings from the literature review. A UK study on architectural design practices to assess the impact of current energy conservation policies and legislation stated that 80% of the surveyed sample indicated that the revision of building regulations Part L: Conservation of Fuel and Power, introducing tighter measures for compliance (compared with government white papers and good practice guides) had the foremost impact on the design of low energy buildings (Adeyeye et al., 2007).

Similarly, the first review of the South African energy efficiency strategy emphasized that energy efficiency standards will have limited impact unless a mandatory regulatory regime is instituted; to consolidate the gains made and achieve improvements in the mostly voluntary programmes now in use (DME, 2005). Buildings are typically used for many years, sometimes even a hundred years, therefore decisions made during a building's approvals phase will determine energy consumption over much, if not all, of a building's lifetime. Certain measures to improve energy efficiency may only be possible during construction or by major refurbishment, likely to happen only after several decades. Many such improvements will be very cost effective or even free or at negative costs when implemented at approvals stage, but can be expensive at later stages (Laustsen, 2008). This explains why it is very important to entrench EE measures in building control regulations and processes at approvals.

As stated earlier in this research, the setting up and operation of an effective EE infrastructure (the institutional framework) is costly and in many cases developing countries take loans from the IMF and the world bank to start one (Deringer et al., 2004; Laustsen, 2008; Iwaro and Mwasha, 2010). Efforts like the Eskom DSM fund for the solar water heaters should be complimented with others like Grants, Tax Rebates and municipal bonds specific to financing energy efficient building developments. The availability of appropriate financial resources will certainly unlock other bottlenecks like institutional reform and market transformation in the implementation of the EE measures in buildings. Once this happens, then the EE measures can be successfully implemented through the established building control regulations by the various local authorities.

A well-defined informational/public awareness campaign about the benefits of energy efficient buildings is classified as one of the key ingredients of a successful EE implementation strategy (Deringer et al., 2004). It is noted that the increasing awareness around the topic of climate change has been one of the key drivers of the energy efficiency agenda in the 21^{st} century (OECD, 2003). Communication instruments are one of the key programmes used by governments around the world to promote and stimulate energy efficiency measures in buildings (Kuijsters, 2004; OECD, 2003; Van Egmond, 2001; Reinink, 2007).

In South Africa, the formulation and deployment of an appropriate and good public awareness campaign will lead to;

1. Increased sharing of information among the parties in the building process. In many instances, because of the fragmented nature of the building teams, information known by one team is not conveyed to all the participating members to aid in their decision making about energy efficiency measures.
2. The elimination of misinformation especially about the life-cycle costs of energy efficient buildings. In many cases, the general citizenry has held the view that energy efficient

buildings are expensive to construct. This knowledge only considers the construction costs part and fails to consider the avoided energy costs in the maintenance of the building over its entire life. This can be clarified through a good information policy and

3. A clear explanation of the direct benefits which accrue to consumers of such buildings in monetary, environmental and health terms.

This kind of information campaign will increase awareness about EE building regulations and most likely increase their implementation as well. This gets to be more targeted when carried out by the local authorities since they can design information systems to communicate and address a particular EE measure which is important in their jurisdiction.

Government actions, through leadership by example and procurement have played a significant role in the implementation of EE measures in buildings in developing countries. This is because their economies are not well developed to provide the requisite innovative and creative free market tools to address the energy efficiency market adequately (Deringer et al., 2004, Laustsen, 2008). This causes the governments to intervene, through requirements for their buildings to be energy efficient and through procurement procedures like the use of ESCOs, which mainstream EE measures in goods and services for buildings. This way, governments stimulate the diffusion, growth and application of energy efficient principles in the entire supply chain of buildings. Such actions taken by local authorities integrate EE measures at the earliest point possible of buildings development.

Almost all of the measures for energy efficiency implementation in buildings named above do not target the final consumers. Even the current building regulations don’t target the final users. Yet it is known that the final users of the building have a significant effect on its energy consumption. To try and address this anomaly, it may be necessary for the local authorities to put in place punitive measures which target final users, like caps, to discourage the inefficient consumption of energy in areas under their jurisdiction. Such caps may require that consumers going above a certain consumption level pay higher tariffs for the units above the prescribed cap or are made to install renewable forms of energy generation, like solar water heaters. The higher rates collected may be put in special funds accounts meant for the development of EE measures in the particular local jurisdictions. This kind of measure is suited for implementation through the local authorities building regulations because they can make correct assessments of their local clients' energy consumption patterns.

6.7 Conclusions

This chapter has explained the findings of the research from the field survey and document reviews in detail and related them to findings of other similar researches. The chapter has discussed the various means and ways the topic of energy efficiency in buildings is being addressed in South Africa through the building control regulations. It has explained how it is clear that the building sector in South Africa is alive to the challenges of energy efficiency, fundamentally because of the escalating prices of electric energy, security of supply and environmental concerns.

The discussions have shown that there are a number of low or even no-additional cost implementable measures which could be executed within the existing building regulation mechanisms through the local authorities. The local authorities have a history of using the inspection based building control procedures to assure a healthy and safe built environment. It is ideal and practical that the same mechanism be used to affect energy efficiency measures in buildings. The findings also revealed that the implementation of the above EE intervention measures on a massive scale is facing difficulties primarily due to lack of a clear legal framework in the national building regulations among other impediments. Therefore the successful implementation of the EE measures in buildings through the building control regulations depends on addressing the self-compounding barriers effectively.

The local authorities and other concerned parties in the meantime have been creative and are progressively encouraging and executing some of the low cost conventional and renewable energy efficiency interventions in buildings voluntarily. However, in order to achieve sustained national momentum and application, the building industry is looking to the promulgation and integration of the proposed energy efficiency regulations into the national building regulations as the foundation that will lead to mass implementation and market transformation in South Africa.

Chapter 7 : CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This research is premised on the argument that reduced energy demand via energy efficiency measures creates new energy, at negative cost and cleans the environment. This research has been undertaken at a time when issues of security of supply, cost of electricity and the sustainability of the environment are on the national agenda in South Africa. In terms of economic measure, a negawatt[19] costs about half the costs of a new watt. Saved energy is the cheapest, cleanest, the most secure and competitive form of energy (Piebalgs, 2008).

This research focused on the use of regulations to achieve energy efficiency in the building sector because: (1) The building sector consumes 30%-40% of the world's energy (UNEP, 2007). In South Africa, it consumes up to 27% of the electricity (DME et al., 2002). Like in many other developing countries, the demand for additional buildings is increasing, in addition to the existing stock which was built when the energy efficiency was not an issue. This means that the potential for energy efficiency in this sector is very large and indeed, up to 50% reduction in energy consumption can be achieved using already existing measures (Laustsen, 2008), and (2) Regulatory instruments have been found to be effective in underpinning energy efficiency programmes in the building sector. For example in USA, the implementation of energy efficiency building codes over the last twenty years has reduced energy consumption in new dwellings by 30% (OECD, 2003). In South Africa however, the implementation of energy efficiency building regulations is still at infancy and a variety of measures are being tried to get it moving.

The main objective of this research was to investigate the implementation of energy efficiency principles through the building control regulations in local authorities. To achieve this objective, the research asked and answered the following main question: How are the local authorities using building control regulations procedures to entrench energy efficiency principles in the building sector?

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[19] contributed by energy efficiency

Several subsidiary questions were then asked to bring out full information on a range of areas related to the implementation of building regulations and energy efficiency in buildings. This included information on the awareness & importance of the energy efficiency in the building sector, the application of energy efficiency principles in the building development process, current efforts in applying energy efficiency principles in buildings, barriers to the above efforts and possible efforts to improve the situation among others. Answers to these questions were discussed in the previous chapters. This chapter gives the overall conclusions reached and makes recommendations on the same.

7.2 Conclusions

Energy efficiency building regulations have been in use in many developed countries for decades (three decades in the USA). In South Africa, the end of an era of presumed cheap electric energy as evidenced by the escalating new tariffs, the security of electricity supply problems and the high carbon intensity nature of electricity production have reinforced the importance of the energy efficiency agenda in the economy. In the past, this had been frustrated by perceived low energy prices and lack of clear national strategy among others. The new energy efficiency strategy (DME, 2005) commits the country to achieve demand reduction of 12% in the buildings sector by 2014 and emphasizes mandatory application of regulatory instruments. Flowing from this, the government has gone ahead and prepared new legislation to aid in the implementation of energy efficiency regulations in buildings which is awaiting promulgation before it can be implemented.

Currently, in the absence of a clear legal requirement for energy efficiency in the building regulations, the implementation of energy efficiency principles in the building sector is un-coordinated. There is no particular national or local agency responsible and the various efforts being implemented by the diverse actors in the sector are wholly voluntary. A few big local authorities like the Johannesburg Metro have been innovative and initiated measures to implement energy efficiency principles in buildings in areas under their jurisdiction by issuing energy efficiency design guidelines which they encourage developers to follow when applying for building development approvals. Others like Ekurhuleni have initiated demonstration projects on their premises to encourage other property owners to refurbish their buildings for energy efficiency. Additionally, other collaborative efforts between the local authorities and other building construction and property interest groups like SAPOA and GBCSA have resulted in the implementation of the Green star building rating tool among the large property developers, though voluntarily. It is hoped that once the proposed regulations are promulgated, there will be a mechanism in the law to bring these efforts under one clear framework to achieve comprehensive energy efficiency in the buildings. The local authorities building control function would provide such a framework for the implementation of the regulations.

Opportunities abound for very low-cost, even sometimes no-cost measures which can be easily implemented via the building control regulations to implement energy efficiency measures in buildings. These opportunities can be implemented in both new and existing buildings. For example, the change in new buildings orientation does not require additional cost to be implemented through the local authorities building control process. Neither will the developers incur additional design costs for its implementation. This simple measure will fundamentally reduce energy costs of a building over its entire life. But, if it is not implemented at the approvals stage, any remedial measure to address it will be very costly or even impossible.

The existing stock of buildings holds the highest potential for energy savings via the implementation of energy efficiency measures. This is because these buildings were erected when the energy efficiency agenda was not serious so both their envelope and installed equipment are significantly inefficient and second, they are proportionately more than new buildings. The use of appropriate building control regulations is also likely to aid the implementation of renewable and other alternative sources of energy in buildings. For example the replacement of the conventional hot water geysers with solar water heaters in the residential buildings sector has the potential to cut heating energy costs by between 50% and 80%. The way local authorities implement building control regulations therefore does determine the overall energy efficiency performance of both new and existing buildings. If EEBSCs are part of the regulations, then it is possible that they can be implemented effectively.

In the same way that opportunities exist for the implementation of EEBSCs through the building control regulations, there are barriers which need to be overcome for the implementation to be successful. These barriers can be legal, financial/economic, informational/awareness/educational and behavioural/organizational. In most cases, these barriers are self-compounding and require to be addressed simultaneously. For example, the lack of a clear legal framework requiring the implementation of EEBSCs in buildings stifles the development of specific financial instruments and programmes to address energy efficiency measures and prevents the development of an institutional infrastructure to drive the energy efficiency agenda in buildings in the economy. A solution to this kind of barrier may need special impetus through government action. In South Africa, this can be the setting of clear mandatory EEBSCs in the national building regulations to be implemented through the local authorities building control function.

The promulgation and inclusion of the proposed energy efficiency regulations, i.e. SANS 10400XA and SANS 204, Edition 1; Parts 1-4, in the national building regulations is an expectant moment for the energy efficiency agenda in buildings in South Africa. Besides setting the legal framework, it will unlock almost all the other barriers to the implementation of energy efficiency measures in buildings. It is the one action that will transform the various voluntary efforts which have taken place into legitimate obligatory practices and give the local authorities the legal framework upon which to implement energy efficiency principles in buildings. This will be through their building control regulations processes and procedures. One main way of achieving energy savings in buildings is by re-writing the building control regulations to include energy efficiency measures (Visscher and Meijer, 2011). The consistent implementation of the proposed energy efficiency building regulations by the local authorities is going to form the backbone of achieving this goal in South Africa.

7.3 Recommendations

The following are the recommendations of this research:

The process of operationalising the proposed energy efficiency building standards through the local authorities should be expedited to meet the EE milestones set by the DME for the building sector. Additionally, the current environment of electric energy supply instability has raised interest and awareness on the need for implementation of energy efficiency measures in the entire South African economy. The local authorities and other stakeholders should seize the opportunity and intervene with the requisite EEBSCs as a matter of urgency.

It has been shown that the development and deployment of effective communication and Information programmes is critical to the successful implementation of energy efficiency building regulations. This is more important in jurisdictions developing their first regulations and where staff needs training as well. It is recommended that the various national and local government agencies, as well as other interest groups, which will be involved in the implementation of the proposed building regulations develop a robust public awareness programme which will be ready to be deployed once the regulations are promulgated. This will inform and sensitise the building sector actors and the whole citizenry on the benefits of energy efficient buildings. Additionally, as this will be the first issue of the regulations, it is possible they may not be comprehensive enough and as such the information programmes should be such that they can be continuously updated, to convey the changes in the regulations. It is also recommended that the national and local governments put in place specific agencies to coordinate and direct the energy efficiency programmes in their areas of jurisdictions to make them successful.

The proposed legislation sets the minimum energy performance requirements for the various elements of the building and overall building types. These kinds of standards run the inadvertent risk of only achieving minimal energy savings. To address this, it is recommended that the existing voluntary higher level energy efficiency building standards and incentives like the Green star rating system by the GBCSA should be pursued alongside the proposed legislation to achieve higher energy & cost savings beyond the minimum. It is recommended that over a reasonable period of co-implementation, the various standards should be merged and implemented under one regulatory framework in the local authorities as it happens in other successful countries like Malaysia.

EEBSCs are new around the world and more so in the developing countries. When first issued, they hardly capture all the appropriate measures for implementation to achieve the highest possible energy savings. For example, the proposed regulations for South Africa are almost entirely tailored to address new buildings, and do not contain EE measures for existing building elements like installed equipment requirements among others. It is therefore recommended that an appropriate and regular update mechanism be put in place to capture such omitted measures as well as take advantage of intelligent solutions and improved product performance spurred by the codes once promulgated.

The existing buildings segment has a high potential of energy savings. The following recommendations are made:

1. It is noted that the proposed regulations awaiting promulgation do not contain measures which can be implemented to achieve energy savings in the existing buildings. On this, it is recommended that South Africa study the EU regulations which have set a specific floor area threshold which when reached in refurbishment one must effect energy efficiency measures. This should be localised to the South African conditions through an early revision of the standards and be implemented through the building control regulations.
2. In the case of the stock held by national and local governments, the case of the Ekurhuleni retrofit project was an appropriate starting point for government leadership through demonstration projects. However, this needs to be done through a mechanism which assures long term economic/financial sustainability both to the local authorities and the building industry. On this score, it is recommended that the employment of Energy Service Companies (ESCOs) be piloted with the aim of eventually mainstreaming them in the procurement procedures of the government as an integral method of achieving energy efficiency in buildings. This has the potential to offer market transformation in energy efficiency in buildings if well used by national and local governments. The ESCOs develop, design and finance the energy efficiency project/program on behalf of the national or local government on its premises. They install and maintain the energy efficiency equipment involved, measure & monitor and verify the programs' energy savings. They also assume the financial risk that the program

will deliver the amount of energy savings guaranteed. This is appropriate for the local authorities since they do not have upfront costs and the ESCO's get paid from the savings generated by the program.

This allows the local authorities to deliver their normal operations without additional financial burden for energy efficiency programs on their building stock. Significantly, results of these programs can subsequently be rolled out to all other large building stock holders in their jurisdiction. The challenge to the local authorities in this arrangement lies in establishing appropriate procurement legislation which protects its interests at all times. For South African local authorities, this is an attractive and fiscally sound means of financing an energy efficiency upgrade/retrofit in local authority buildings.

The following recommendations are financial and or/economic:

1. Energy efficiency programmes cost a lot of money to set up and implement especially in the developing world where energy markets are not well developed to spur the required level of growth on their own. These costs are high for both new and existing buildings. This therefore requires specific financial/economic tools by the national or local governments to set up and implement a successful energy efficiency programme in buildings.

   Instead of government giving energy subsidies as it used to happen for domestic consumers in South Africa, it is recommended that the national and local governments provide financial incentives in the form of tax rebates, grants, and special bonds designed to fund energy efficient building developments. For example, developers who install energy efficient renewable energy equipment in new or existing buildings required in EEBSCs could get tax rebates on such equipment. This is sustainable and has the long term effect of developing an assured clean and secure supply through avoided expensive and GHG laden energy production.

2. It is also recommended that appropriate partnerships should be created between the local authorities building control regulations entities and the administrators of the Eskom DSM

Solar water Heaters replacement fund to make it mandatory for the recommendations of the local authorities to be part of the criterion used for developers to draw from it. This will link the energy efficiency regulations implementation with the funding in a mutually beneficial relationship.

The following recommendation targets consumers. It is noted that EEBSCs hardly targets the final consumers of energy in buildings. The recommendation below seeks to make them more responsible and active participants in the energy efficiency agenda by targeting their energy consumption behaviour. It is recommended that the local authorities explore ways of introducing energy consumption caps for the various buildings uses in areas under their jurisdiction. They could use the opportunity afforded for the revision of the proposed regulations to get such measures in place. The violators of such caps could be charged punitive tariffs which subsequently will be put in a fund for energy efficiency programmes. For example, In a scheme that can serve both to raise funds and promote installation of renewable energy, the local authorities can introduce a fee, of say R5000 for all new developments and large retrofits of over 2000 square feet which fail to include the installation of a two kilowatt solar photovoltaic system or equivalent renewable energy system. Similarly, homeowners who consume energy beyond reasonably forecasted budgets, especially on energy intensive activities such as heating outdoor pools or spas can be charged a mitigation fee of say R5000 if they fail to install energy efficiency or renewable energy systems.

7.4 Areas for further research

As noted earlier, the energy efficiency agenda is at infancy in most developing countries and more so in the buildings sector of these countries. The lack of quantitative data means that programmes are designed and implemented using data from the developed nations. This poses a contextual problem because their programmes may not be applicable to the prevailing local condition. This can be seen in the case of South Africa which has had to borrow quite heavily from the Nordic countries and Australia in formulating its energy efficiency codes in buildings (Reynolds, 2007).

Research gaps exist in several areas of energy efficiency in buildings in South Africa, an example is the lack of costs estimation data for energy-efficient retrofits vis-à-vis ordinary business as usual retrofits. Financial specialists in organisations do not look at energy efficient retrofits as investments, but rather as facilities expenses measured on a straight line depreciation scale just like building consumables; hence there is no efficient market guidance for energy-efficient retrofits in buildings. This causes low sensitivity to energy-efficient retrofits issues in the maintenance of buildings. It is recommended that research and studies in these areas be done to enhance learning and help make improvements in program designs for energy-efficiency retrofits in buildings in future.

From the findings, conclusions, and recommendations of the research, it can be clearly stated that the hypothesis of the study has been affirmed. Indeed, the South African energy efficiency strategy corroborates this by stating;

> "The historically low unit cost of energy, coupled with limited awareness on energy savings potential, may result in only modest success arising from voluntary measures and other non-legislative instruments. For this reason, regulatory means will be applied to achieve further improvements where necessary. Efficiency standards will have limited impact unless made mandatory, and energy audits should be accompanied by an obligation to implement, for example, all no-cost recommendations identified. The National Energy regulator will contribute to or develop regulatory measures for guiding reporting and compliance". (DME, 2005)

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Appendices

Appendix: 1 The Questionnaire

PARTICIPANT INFORMATION SHEET AND INFORMED CONSENT FORM

PART A

Study Title: "Evaluating Energy Efficiency in Building Control Regulations in Local Authorities in South Africa"

Investigator: Joachim E Wafula

Institution: University of the Witwatersrand, School of Construction Economics and Management

Contact Number: 011 717 7653 or 071 586 4278.

PART B

Good day,

My name is Joachim Wafula, a student at the University of the Witwatersrand, School of Construction Economics and Management. I am conducting a study to evaluate energy efficiency in building control regulations in local authorities in South Africa.

You are invited to consider participating in this research study. Your participation in this study is entirely voluntary. Before you participate it is important that you read and understand the explanation of the purpose of the study and the study procedures. This information sheet is to help you decide if you would like to participate. If you have any questions, do not hesitate to ask me. You should not agree to take part unless you are satisfied about the procedures involved. If you do agree to take part in the interview, you are still free to withdraw from the study at any stage and this will not be held against you. If you decide to take part in this study, you will be asked to sign this document to confirm that you understand the study and agree to take part.

The main objective of the research is to investigate the implementation of energy efficiency principles through the building control regulations in local authorities and recommend measures which will entrench Energy Efficiency principles in the process. A questionnaire will be administered to key stakeholders in the two metropolises of greater Johannesburg in Gauteng province. It should take the participants about twenty five (25) minutes to fill the questionnaires. There will also be key informant interviews to compliment the findings of the questionnaires. The interviews will take about one (1) hour and the study is expected to be carried between October 2010 and June 2011.

There are no risks involved in participating in this study. This research will yield information that will be used for my study towards the award of the degree of MSc in Building. All information obtained during the course of the study will be kept strictly confidential. Data that may be reported in journals and conference proceedings will not include any information that identifies you as a participant in the study.

PART C

Informed Consent

I hereby confirm that I have been informed by the study investigator Joachim Wafula, about the nature, conduct, benefits and risks of the study. I have also received, read and understood the above participant information sheet regarding the study. I am aware that the results of the study will be anonymously processed into a study report and that I may at any stage without prejudice withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and of my own free will declare myself prepared to participate in the study.

Participant:

__________________ ___________________ __________________

Printed Name, Signature, Date and time

I, Joachim Wafula, herewith confirm that the above participant has been fully informed about the nature and conduct of the above study.

Study Investigator:

__________________ ___________________ _____________________

Printed Name, Signature, Date and time

RESEARCH QUESTIONNAIRE

Evaluating Energy Efficiency in Building Control Regulations in Local Authorities in South Africa

Instructions for completing the questionnaire

The researcher believes it will take you slightly under 25 minutes to complete this questionnaire satisfactorily. Please follow the instructions for each question and respond to all parts in each question. The researcher requests you to complete the questionnaire as accurately as possible. When fully completed, please review your responses before the researcher comes to collect the completed questionnaire. Alternatively, you may submit your questionnaire to the researcher on E-mail Joachim-Ebrahim.wafula@students.wits.ac.za. For any clarifications, do not hesitate to contact me on Tel 011 717 7653 or 071 586 4278. I will be very grateful if I can collect your completed questionnaires within five working days of receipt or you email me within the same period. Your participation in this research is highly appreciated.

Section 1: Importance of energy efficiency principles in the building development process

1. Personal Particulars

Name:	
Telephone No.	
Address:	
Organization	

2. Length of time at this organization/department (Years)

Less than 5 Years	Between 5 Years to 10 years	Between 10 Years to 15 years	More than 15 years

3. Length of experience in area of competence (Years)

Less than 5 Years	Between 5 Years to 10 years	Between 10 Years to 15 years	More than 15 years

4. Level of qualification/training

Post graduate	
Bachelor's Degree	
Diploma/technician	

5. List and explain key principles considered important during the building development approvals process and the procedures followed to ensure their implementation

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6. Explain the importance and your awareness of energy efficiency/energy conservation principles in the building development approval process

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Section 2: Requirement for Energy efficiency principles in Building control regulations

7. Explain any energy efficiency measures required for buildings development approvals
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8. Are the energy efficiency measures you have explained in Q7 above among the key considerations for building development approval you listed in Q5?

Yes	
No	

Section 3: Implementable Energy Efficiency principles through building control regulations

9. If yes (from Q8), list energy efficiency measures for new buildings and retrofits which are implemented during the building development approvals process

New buildings	Retrofits

10. If not (from Q8), list and explain reasons why the energy efficiency measures are not implemented in the building developments approvals process; for new buildings and retrofits

New buildings	**Retrofits**

11. In your opinion, explain energy efficiency measures which can be easily implemented via the approvals process suggesting how they can be implemented; e.g. in orientation, insulation, water heating, lighting etc.

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Section 4: Barriers to the implementation of Energy efficiency measures

12. In your opinion, in addition to the reasons you gave in Q10, List and explain other problems that make it difficult to implement energy efficiency measures in the building control process; and explain what is being done to address them

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Section 5: Ways to entrench EE principles in the building sector

13. In local authorities where energy efficiency measures are in place (even voluntarily), how is compliance (or penalties for non-compliance) ensured through the building development control and approval process (List and explain).

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14. Which other party/ organisation participates in the implementation (enforcement and compliance) of energy efficiency requirements during the building development control and approval process besides the local authorities? (List and explain).

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15. What improvements in the regulations would you suggest to make the

implementation of energy efficiency requirements in the building development approval process the norm? (List and explain)

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16. Are there any regulations which target users, or their behaviour vis-a-vis energy efficiency, especially in big commercial as well as residential tenancies? Yes/No... In your opinion, could such regulations have an effect on programmes for achieving greater energy efficiency in the built environment?

    Explain...

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    ....

17. In your opinion, are the local authorities and other stakeholders doing enough to address the need to achieve greater energy efficiency targets set out in policy documents? (Explain your opinions)

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Appendix: 2 The Interview Guideline

INTERVIEW GUIDELINES FOR CHIEF BCAOS, KEY KPPS AND CHIEF OFFICERS OF SCIGS

Evaluating Energy Efficiency in Building Control Regulations in Local Authorities in South Africa

Section 1: Importance of energy efficiency principles in the building development process

1. Personal information (name, telephone number, address, organisation, profession, experience)
2. Understanding of the building control function and process
3. Importance and awareness of energy efficiency issues in the built environment in general and in the building control process in particular
4. Knowledge of energy efficiency policies in general in South Africa.

Section 2: Requirement for Energy efficiency principles in Building control regulations

1. Provisions for energy efficiency in building controls regulations (existing and proposed)
2. Possible procedures of applying the energy efficiency measures in the building control process

Section 3: Implementable Energy Efficiency principles through building control regulations

1. Energy efficiency measures being implemented in buildings currently (in new and existing buildings)
2. The mechanisms they are being implemented through (voluntary, mandatory or other) and the key implementing actors/organisations

3. Suggestions on the improvement of the building control mechanisms for implementation

Section 4: Barriers to the implementation of Energy efficiency measures

1. Challenges to wider policy issues for implementing energy efficiency measures in buildings, especially through the building control processes of the local authorities.
2. Solutions to these barriers

Section 5: Ways to integrate EE principles in the building sector

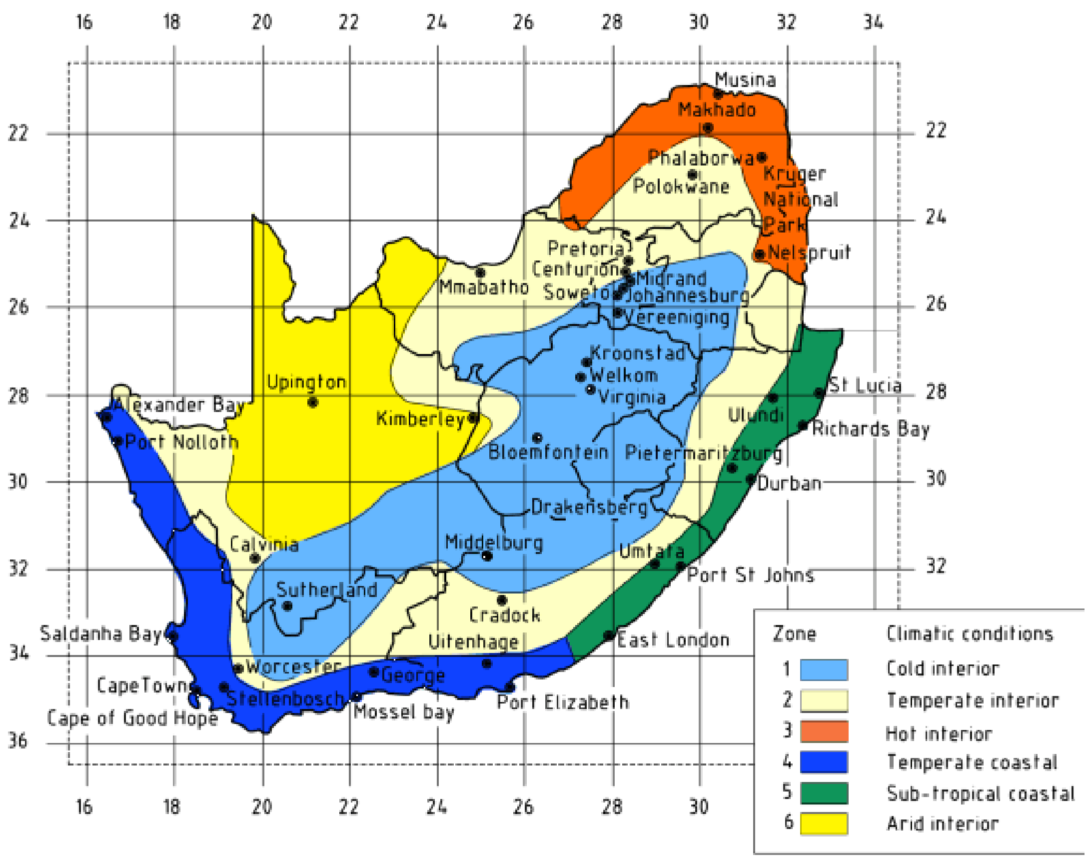
1. What the different stakeholders are doing to affect energy efficiency measures in buildings, and especially through the building control process.
2. Personal view of the efforts needed to improve the situation.
3. Overall comments on energy efficiency in buildings.

Thanking you in advance.

Appendix: 3 The Map of the Field study Area (Gauteng, SA)

Appendix: 4   Map of climatic zones according to SANS204

As stated in the text, this appendix gives details of the six climatic zones/regions South Africa has been divided into for the purposes of implementation of the proposed energy efficiency regulations.



Map of climatic zones according to SANS204.

(Source: SABS, 2011)

zone	Description	Major Cities
1	Cold Interior	Johannesburg, Bloemfontein
2	Temperate Interior	Pretoria, Polokwane
3	Hot Interior	Makhado, Nelspruit
4	Temperate Coastal	Cape Town, Port Elizabeth
5	Sub-Tropical Coastal	East London, Durban, Richards Bay
6	Arid Interior	Upington, Kimberly

Appendix: 5 Building Control and Approval documents

CLERK OF WORKS SECTION

BUILDING DEVELOPMENT - MUNICIPAL INFRASTRUCTURE Ekurhuleni

REQUIREMENTS

1. **Documents to be submitted by contractor to C.O.W. prior to commencement of work on building site**

   1.1 Valid Good Standing Ceritificate for the duration of the contract ☐

   1.2 Section 37 (2) signed Health & Safety contract ☐

   1.3 Safety File ☐

   1.4 Public Liability Insurance Cover ☐

   1.5 Clearance Certificate from (EMM) Health & Safety Officer - J.J. v.d. Westhuizen ☐

2. **Documents required for Construction (Where applicable)**

   2.1 Full set of approved Building Plans from architecht ☐

   2.3 Geo Tech Report ☐

   2.4 Soil Test Report ☐

   2.5 Land Surveyor's Certificate ☐

   2.6 Engineer's Certificate (A19 Appointment) ☐

   2.7 Engineer's Inspection Reports ☐

   2.8 Concrete Super Structure Report & Inspections (Concrete Columns/Beams/Slabs/Steelwork) ☐

   2.9 Completion Report ☐

3. **Roof Structures**

   3.1 Roof Design & Drawings (Gangnail / Steel / Concrete) ☐

   3.2 Roof Guarantee ☐

   3.3 Loading Certificate ☐

4. **Electrical**

   4.1 Electrical Layout plan ☐

   4.2 Local (EMM) Inspection Report (Before C.O.C. will be accepted) ☐

   4.3 Certificate of Compliance (C.O.C.) ☐

5. **Plumbing**

   Department of Manpower: plumbers get charged for manslaughter.

   5.1 Plumber's Certificate (Only Olifantsfontein Plumbing Trade Certificate accepted) ☐

6. **Certificates Required for Occupation of building or structure**

   6.1 A19 Appointment of Engineer ☐

   6.2 Completion Certificate / Report - Engineer ☐

   6.3 Roof Guarantee ☐

   6.4 Loading Certificate ☐

   6.5 C.O.C. ☐

   6.6 Fire Department Inspection Report ☐

   6.7 Project Manager's Completion Certificate ☐

.... Name of C.O.W.

.... Signature

.... Date

CLERK OF WORKS SECTION
BUILDING DEVELOPMENT - MUNICIPAL INFRASTRUCTURE

From Ekurhuleni

INSPECTION CHECK LIST

1. **Commencement of Project**
   - 1.1 Boundary Pegs ☐
   - 1.2 Position and Setting out of Buildings ☐
   - 1.3 Water Connection ☐
   - 1.4 Sewer Connection ☐ Building Inspectors
   - 1.5 Electrical Connection ☐
   - 1.6 Ablution Facilities and Site Offices ☐ / Contractor

Site Safety approval / building plan / Town Planning / Fire department

2. **Foundations**
   - 2.1 Excavations ☐
   - 2.2 Foundation Re-inforcing ☐
   - 2.3 Engineer's Inspection ☐
   - 2.4 C.O.W. Inspection ☐
   - 2.5 Correct mix of Concrecte casted ☐
3. **Floor Slabs**
   - 3.1 Compaction and Filling ☐
   - 3.2 Engineer's Inspection ☐
   - 3.3 C.O.W. Inspection ☐
   - 3.4 Correct mix of Concrecte casted ☐
4. **SuperStructure**
   - 4.1 Correctness & Quality of Workmanship ☐
   - 4.2 Correctness & Quality of material ☐
   - 4.3 Execution of Correct Building Practice ☐
   - 4.4 Execution of Correct Health & Safety Specifications ☐ Construction Regulations mandatory on site ← Buyer. workmans indemnity
5. **Plumbing & Drainage**
   - 5.1 Engineer's Inspection - Open test ☐
   - 5.2 C.O.W. Inspection - Open test ☐
   - 5.3 C.O.W. Inspection - Close test ☐
   - 5.4 Rodding ie's and Manholes ☐
   - 5.5 Vent Valves at correct positions ☐
   - 5.6 Bollerstops at all wc's, sinks and WHB's ☐
   - 5.7 Correct size water & sewer pipes used ☐
   - 5.8 Geyser correctly installed ☐
   - 5.9 Plumbing done correctly ☐
6. **Roof Inspection**
   - 6.1 C.O.W. Inspection ☐
   - 6.2 Engineer's Inspection Report ☐
   - 6.3 Ceiling Joist / Brandering / Purlins & Bracing Inspection ☐
7. **Electrical**
   - 7.1 C.O.W. Inspection ☐
   - 7.2 Electrical Inspector's Inspection & Report ☐ — Compliance Certificate
   - 7.3 Correct Material used ☐
8. **Completion**
   - 8.1 Snag List ☐
   - 8.2 Snag List executed ☐
   - 8.3 Check all required documents necessary for occupation ☐ As built set of drawings.

.... Name of C.O.W.

.... Signature

.... Date

Attention: ____________________

Fax number: ____________________

Saame Building cnr Spilsbury & Queen Streets.

Tel: (011) 999-0990 Fax: (011) 874-6786

Queries :

Smaller than 100 Amps : 011 999-0999 / 1325 / 0182

Larger than 100 Amps : 011 999-1505 / 011 874-6517

Pre-payment metering : 011 999-0204 / 011 999-1218

Electrical

Ekurhuleni

METROPOLITAN MUNICIPALITY

ELECTRICITY & ENERGY

GERMISTON CUSTOMER CARE CENTRE

c/o Spilsbury and Queen streets

APPLICATION FORM FOR AN ELECTRICAL CONNECTION

DETAILS OF APPLICANT:

NAME: ____________ POSTAL ADDRESS: ____________

COMPANY: ____________

TELEPHONE NO: ____________ FAX NO: ____________

CELL PHONE NO: ____________ E-MAIL: ____________

DETAILS OF PERSON / COMPANY RESPONSIBLE FOR ACCOUNT:

NAME: ____________ POSTAL ADDRESS: ____________

COMPANY: ____________

TELEPHONE NO: ____________ FAX NO: ____________

CELL PHONE NO: ____________ E-MAIL: ____________

MUNICIPAL ACCOUNT: ____________ V.A.T. NO: ____________

DETAILS OF REQUIRED ELECTRICAL CONNECTION:

NAME OF COMPLEX: ____________

TYPE OF BUSINESS: ____________

STAND NO.: ____________ TOWNSHIP: ____________

STREET NAME AND NUMBER.: ____________

NUMBER OF RESIDENTIAL UNITS ON STAND (ONLY FOR RESIDENTIAL DEVELOPMENTS): ____________

ENERGY SAVING DEVICES TO BE INSTALLED AND USED:	1	2	3	4

EXPECTED LOAD FORECAST / GROWTH:	Jul'09-Jun'10	Jul'10-Jun'11	Jul'11-Jun'12	Jul'12-Jun'13	Jul'13-Jun'14	Jul'14-Jun'15	Jul'14-Jun'15

EXISTING CONNECTION: *(MARK NOT APPLICABLE OR COMPLETE)*				
NOT APPLICABLE	MUNICIPAL ACCOUNT NO.	SINGLE PHASE	THREE PHASE	M.V.SUPPLY
		A	A	

SIZE OF ELECTRICAL CONNECTION REQUIRED: *(MARK BLOCK WITH A "X".)*								
SINGLE PHASE 230 VOLT								
40 A	60 A	80 A	CONVENTIONAL METER			PREPAYMENT METER		
THREE PHASE 400 OR 6 600 OR 11 000 VOLT: *(MARK BLOCK WITH A "X" OR COMPLETE OTHER)*								
40 A	60 A	80 A	100 A	150 A	200A	250A	300 A	OTHER kV.A

PREFERED TARRIFF: *(MARK BLOCK WITH A "X".) (EXPLANATION ON REVERSE SIDE)*					
(< 3 x 60 A)	(< 100 kV.A)	ONLY EXISTING TARIFF C CUST. (> 25 kV.A)			(> 99 kV.A)
TARIFF A	TARIFF B	NORMAL	OFF-PEAK	INTERNET	TARIFF D

DATE : ____________ SIGNATURE: ____________

PLEASE NOTE: ONLY DULY COMPLETED APPLICATION FORMS SHALL BE PROCESSED.

Please refer to important information on the back of this page.

IMPORTANT AND USEFUL INFORMATION

1. **One supply per stand**: For safety reasons it is Council's policy to install one supply per stand and the crossing of stand boundaries with electrical apparatus is illegal unless the stands are notarially tied in which case it is regarded as one stand.

2. **Occupational health and safety act** inter alia states the following:
   - The user or the lessor of an electrical installation shall be responsible for the safety, safe use and maintenance of the electrical installation he uses or leases.
   - Every user or lessor of an electrical installation shall have a valid certificate of compliance in respect of every installation.
   - No person shall commence with installation work, which would require a new electricity supply or an increase in electricity supply capacity unless the supplier has been notified thereof with a Commencement form (Annexure 2.)
   - Only an accredited person may, after having satisfied himself by means of an inspection and test that an electrical installation complies with the provisions of the safety standard as detailed in the Act, issue a certificate of compliance.

3. **Prepayment meters**: Most people are under the wrong impression that this meter can reduce their electrical account. This is untrue since the tariff is the same and the only way to reduce an electrical account is by using less electricity. If metering is changed from an existing credit meter to a prepayment meter, accounts for electricity may still be received and have to be paid for up to two months after the change while credit has to be bought upfront for the prepayment meter. No refund of the amount tendered for the purchase of electricity credit shall be given at the point of sale after initiation of the process by which the prepayment token is produced. No refund for credit remaining in the meter shall be made to he consumer when he vacates the premises where a prepayment meter is installed. Council's prepayment meters will not be available for dwelling units in complexes that obtain a bulk connection from Council or for Granny flats. Further information regarding the installation of prepayment meters can be obtained from the Customer Advisors.

4. **The following tariffs are available**:
   - Tariff A – single phase connections up to 60 Amps.
     i. This tariff will suit low consumption residential and micro business customers.
   - Tariff B – L.V single 230 V and multi phase 400/230 V connections up to 150 Amps.
     i. This tariff will suit medium to high consumption customers.
   - Tariff C – **only available for existing Tariff C customers.**
   - Tariff D – bulk supplies bigger than 99 kV.A.
     i. Also known as time-of use tariff (Peak, Standard and Off-peak hours based).
     ii. This tariff will suit large residential, business and industrial customers.
     iii. Rebate option for qualifying customers with proven annual energy saving of 15% or more.
     iv. Surcharges applied according to the voltages at which electricity is supplied.

   Please note in the event of a tariff change the customer will be charged according to the new tariff for a minimum period of 12 months and any cost of changing the metering equipment will be for the customer's account.

5. The Ekurhuleni Metropolitan Municipality shall have the right to **refuse** to sell electricity to any customer who has any **unsettled debt** with the Municipality.