# The potential carbon dioxide emissions reduction when energy service interventions are applied to the current subsidised housing demand

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# Abstract

This dissertation examines the role of subsidised housing in reducing carbon dioxide ($CO_2$) emissions in South Africa. Climate change is an occurring event and is largely caused by human activities, such as the production of energy from fossil fuels (NRC, 2010). Buildings are seen as one of the highest consuming sectors of energy and therefore present many potential climate change mitigation opportunities. The South African subsidised housing sector is expanding significantly and estimations made in the current study show that 2.8 million subsidised housing units can potentially reduce up to 3% of the total current $CO_2$ emissions from the residential sector. This demand for subsidised housing units can also potentially reduce up to 0.06% of South Africa's total annual $CO_2$ emissions.

Key words: Energy, climate change, Greenhouse Gas, $CO_2$, mitigation, sustainable buildings, energy efficiency, subsidised housing.

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# List of Acronyms

| | |
|---|---|
| BREEAM | Building Research Establishment Environmental Assessment Methodology |
| CBE | Centre for the Built Environment |
| CDM | Clean Development Mechanism |
| CECODHAS | Comité Européen de Coordination de l'Habitat Social (European Federation of Public, Cooperative & Social Housing) |
| CFL | Compact fluorescent lamp |
| CIDB | Construction Industry Development Board |
| $CH_4$ | Methane |
| $CO_2$ | Carbon Dioxide |
| COP 17 | Conference of the Parties 17 |
| DCLG | United Kingdom Department for Communities and Local Government |
| DHS | South African Department of Human Settlements |
| DOE | South African Department of Energy |
| DTI | South African Department of Trade and Industry |
| EBPD | Energy Performance of Buildings Directive |
| EU | European Union |
| GBCSA | Green Building Council of South Africa |
| GHG | Greenhouse Gas |

| | |
|---|---|
| IEA | International Energy Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| IRDP | Integrated Residential Development Programme |
| NAHB | National Association of Home Builders |
| NASHO | National Association of Social Housing Organisations |
| NEES | National Energy Efficiency Strategy |
| NGO | Non-Governmental Organisation |
| NRC | National Research Council |
| PPM | Parts per million |
| RDP | Reconstruction and Development Programme |
| SABS | South African Bureau of Standards |
| SANS | South African National Standards |
| SBCI | Sustainable Building and Climate Initiative |
| SERI | Socio-Economic Rights Institute of South Africa |
| $SF_6$ | Sulphur Hexafluoride |
| SHRA | Social Housing Regulatory Authority |
| SPD | Suspended Particle Devices |
| SSN | South South North |
| STATSSA | Statistics South Africa |
| SWH | Solar Water Heater |

| | |
|---|---|
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USA | United States of America |
| WWF | World Wildlife Fund |

# 1. Introduction

This chapter serves as the preamble to the review of the literature, which is discussed in the chapters to follow. Chapter 1 provides a brief overview of the study as well as the background, problem statement, research question, setting, objective and methodology. Chapters 2 to 5 offer a theoretical review of the literature and are divided according to individual topics. Chapter 6 analyses the data obtained from the literature, and Chapter 7 closes the study by providing conclusions and making recommendations.

## 1.1. Problem statement

In South Africa, the biggest contributor to $CO_2$ emissions is the production and use of energy to generate electricity. Buildings are one of the largest consumers of electricity and account for over 40% of usage (International Energy Agency, 2013). The building sector therefore provides key possibilities for reducing $CO_2$ emissions through improving energy efficiency within energy services, which can result in less electricity usage. Subsidised housing falls under the bigger umbrella of buildings. In South Africa, the subsidised housing sector is expected to grow rapidly due to government commitments to provide housing to all of the country's impoverished citizens. As a result, new subsidised housing projects should utilise efficient energy services principles to ensure a reduction in $CO_2$ emissions from buildings.

## 1.2. Background

Due to anthropogenic influences climate change has become a serious global problem. Although many natural processes include the release of $CO_2$ emissions into the atmosphere, human activities like energy production, transport and mining are increasing the concentration of $CO_2$ emissions and other gasses that can effect the triggering of climate change. These gasses are categorised together as greenhouse gas (GHG) emissions. Industrialisation only started around the year 1750 in England and later flowed over to the rest of Europe. It is interesting to note that for a period of 8000 years of human existence up until industrialisation in 1750, GHG concentrations had increased by only 20 parts per million (ppm) (Winkler, 2005:355–364).

The 20 ppm GHG emission increase in the pre-industrial period was most likely caused by natural processes, such as the release of $CO_2$ by plants and animals. However, from 1750 to 2005, the concentration of GHG emissions rapidly increased to 100 ppm (IPCC, 2007a). The disparity between 20 ppm over 8000 years and 100 ppm over 255 years provides sufficient evidence that we are exceeding the natural balance of GHG concentrations.

Moreover, according to the Intergovernmental Panel on Climate Change (IPCC) (2007a), during the twentieth century, the earth's mean surface temperature increased by about 0.6%, which translates to ± 0.2°C. This provides confidence that, due to anthropogenic influences, the natural climate variability has increased.

In order to achieve global sustainability, moving towards a low carbon environment has become a global precondition (DCLG, 2007; Zuo *et al.*, 2012:278–286). Due to the fact that energy production and usage are the primary reasons behind climate change, the building sector, which needs energy to operate, offers many opportunities for mitigation.

The fact that the building sector offers many opportunities for climate change mitigation is emphasised by Jo et al. (2009), who explain that the building sector has a noteworthy impact on energy use and the environment. Also, buildings consume 40% of global primary energy and 70% of global electricity (Letete *et al.*, 2009; Pless & Torcellini, 2009; Torcellini *et al.*, 2006;

Buildings, U. S., & Construction Initiative. 2009). Therefore, the imperative to reduce energy consumption in buildings is evident.

In South Africa, approximately 45.5% of the population are living in conditions of poverty, which includes a lack of proper housing. Since 1994, the government has supplied an additional over three million subsidised housing units to the poor. Subsidised housing comprise of housing provided by the government under subsidies to families living in inadequate housing situations. It is believed that the current demand for subsidised housing units stands at 2.8 million (STATSSA, 2011; Sanedi 2014). Demand here refers to the current shortage of housing units that still need to be delivered to ensure the population of South Africa is adequately housed.

The consequence is that if South Africa is to meet policy objective of providing adequate housing for all, many subsidised housing projects will have to be commissioned in the upcoming years to provide housing to those living in conditions of poverty.

Recent results published by the South African Council for Scientific Research further show that a subsidised housing unit emits on average 3,264 kg $CO_2$ emissions per annum from energy services (Sanedi, 2014). About 2.68 million subsidised housing units have been delivered over the past 20 years, which then presents about 8.75 Mt $CO_2$ emissions per annum from the subsidised housing sector. Furthermore a possible saving of 1.524 kg $CO_2$ emissions from subsidised housing units is attainable when energy services interventions are introduced (Sanedi, 2014). Given an expanding subsidised housing sector, if energy services interventions are introduced, the subsidised housing sector could present significant $CO_2$ emission reductions.

It has been proved that energy efficiency and sustainable building initiatives are able to introduce energy savings of up to 80% (Levine *et al.*, 2007). As such, the Zero Energy Building, Zero Impact Building and Passive Building concepts could result in energy savings of close to 100%. Therefore, the potential to reduce energy consumption in buildings is one of the most affordable approaches of reducing $CO_2$ emissions.

Given a growing subsidised housing sector, it will thus be crucial to introduce energy efficiency and sustainable building initiatives among new developments. The subsidised housing sector shows a significant potential to contribute to climate change mitigation actions.

## 1.3. Research question

The main research question for this study can be formulated as follows: What is the potential $CO_2$ emission reduction when energy service interventions are applied to the current subsidised housing demand.

Some underlying questions that will be addressed in the study include:

- What is the status quo of the South African subsidised housing environment?
- What is the association between $CO_2$ emissions and buildings?
- What are the major sustainable building principles for subsidised housing?
- What is the estimated amount of $CO_2$ emissions that can be saved if the current subsidised housing demand is built according to some sustainable building principles and energy service efficiency interventions?

## 1.4. Setting of study

The setting of this study is the subsidised housing industry of South Africa. Also the study evolves around the contribution that the subsidised housing sector can make towards mitigating climate change. The study takes place within the theoretical and practical parameters of the national South African subsidised housing sector and its legislation and policies.

## 1.5. Aim and objectives of study

The aim of this study is to contribute to the advancement of efficient energy services in subsidised housing developments in South Africa. This will be achieved by meeting the following objectives:

- Demonstrating the importance of Greenhouse Gas emissions and how efficient energy services within buildings can mitigate climate change;
- Providing an outline of the South African subsidised housing environment;
- Identifying the major energy efficiency interventions to which will result in reduced $CO_2$ emissions in subsidised housing; and
- Displaying the mitigating potential that efficient energy services within subsidised housing may have on climate change.

## 1.6. Assumptions and limitations of study

The assumptions and limitations of the study are as follows:

- The 2014 demand figure for 2.8 million subsidised housing units presents the current situation in South Africa and excludes the impact of population growth and urbanisation;
- Although suppressed demand related to the installation of solar water heaters (SWH'S) and efficient lighting was not considered due to the limited scope of the project, the results used in the study is from actual projects;
- Only identified sustainable building principles and energy efficiency interventions were used in the calculations. As such the study results is not a representation of the whole building life cycle;

- Only two case studies were selected on which the analysis were performed. The results of other projects could not be considered because of a lack in detailed information; and
- Calculations related to the SWH's are based on the assumption that all subsidised housing units had an installed electrical geyser before replacement of a SWH occurred.

## 1.7. Methodology

The research included a study of the existing literature on climate change, energy, buildings and subsidised housing. Information gathering mainly consisted of desktop research. Semi-structured interviews supported the data gathering process, which led to information on current subsidised housing projects on which energy interventions were applied. No new data was generated, however the results and data of completed studies were analysed to answer the research question at large.

### i) Semi-structured interviews

The majority of this research project followed a desktop research approach. In addition to this, for background purposes and to support the information gathering process, semi-structured interviews were performed with role players in the subsidised housing sector. The role players contacted for such interviews are listed in Table 1 below (refer to Appendix 1 for the questionnaire used during the interviews).

Table 1: Sectors and role players considered for interviews

| Sector/Department | Name of organisation | Role of organisation |
|---|---|---|
| Public sector | Department of Human Settlements (DHS) | Various public housing projects |
| | City of Cape Town, housing | |

| Sector/Department | Name of organisation | Role of organisation |
|---|---|---|
| | department | |
| | National Housing Finance Corporation | |
| Non-profit organisations | Green Building Council of South Africa (GBCSA) | Evaluation of building based on green principles |
| | World Wildlife Fund (WWF) | Environment conservation |
| | National Association of Social Housing Organisations (NASHO) | Member association for social housing entities |
| | South South North (SSN) | Climate change and sustainability |
| | Sustainable Energy Africa | Climate change and sustainability |
| Private sector | Stride Africa Architects | Designers of subsidised housing |
| | First Metro Housing Company | Financing of subsidised housing |
| | Amalinda Village Social Housing Company | Developer of subsidised housing |

Source: Compiled by researcher

*The interview process*

The interview process was completed in the following manner, as set out in Diagram 1: Explication of interview process, below, following the guidelines suggested by Valentine (1997):

- Possible interviewees were identified by selecting role players and stake holders in the following sectors:

    - Public sector;
    - Private sector; and
    - Other related non-profit organisations.
- The researcher contacted the identified interviewees by telephone or email, requesting an interview.
- Once individuals agreed to being interviewed, the following information was confirmed in writing/by email:
    - Date of interview;
    - Time of interview; and
    - Location of interview.
- Before each interview started, the interviewer verbally read out the following considerations related to confidentiality:
    - The information obtained during the interview will be used for this research;
    - The interviewee's name will be kept confidential and will not be published prior to receiving written consent; and
    - If a direct reference is made to a section of an interview, or if a section of the interview is cited in the written report, the written consent from the interviewee will be obtained.
- The interviewee was given an opportunity to consent verbally to the confidentiality clauses mentioned above, prior to the start of the interview.
- The researcher used a semi-structured approach to encourage a conversational style of interviewing. He thus used ideas and themes to steer the flow of the discussion, rather than relying on a list of questions to follow a strict agenda.
- The interview focused on the interviewee's experiences and personal views. In this way, the researcher was able to explore issues in greater depth, which would not have been achieved if a more structured method had been followed (Valentine, 1997:27–54).

Diagram 1: Explanation of the interview process

1. Selection of interviewees
2. Contact the interviewees via email or telephone to schedule an interview
3. Interview process conducted in a semi-structured way
4. Interviewee agrees verbally that the infomation obtained during the interview process can be used and published in this report
5. The condition for quoting an interviewee is explained to the interviewee
6. The process of obtaining written consent and also providing a choice to review the related text berfore publication is explained
7. The interviewee agrees verbally to the clauses above

Source: Compiled by researcher

*The role of the researcher during the interview process*

The researcher's role during the interviewing process was to conduct the interview and direct the flow of it. The role also included the requirement to clarify the nature of the study and to reassure the interviewee that the interview remained confidential. The interviewee was also provided with an opportunity to indicate whether their views and comments were their personal opinion and/or whether they represented the opinion of their organisation.

*Ethical considerations related to the interviews*

The purpose of the interviews was to gain information about physical components of buildings or construction processes used. The interviews thus do not focus on any human experiences, issues and topics relating to buildings. Nor is it the purpose of the interview to obtain information on any individual or group of people but rather to obtain information related to the science of buildings components.

When it became necessary to quote an interviewer's words directly, the following process applied:

- The interviewee was contacted via email;
- The section to be quoted from the interview was presented to the interviewee;
- The interviewee was granted sufficient time to adjust their statement, if necessary; and
- Consent was obtained to use the interviewee's name as a citation in the research.
- Other ethical considerations related to the research

ii) Desktop research

The literature review considered both local and international literature. Literature relating to the local subsidised housing sector was retrieved from South African government institutions, policies, legislation and other related material. A thorough analysis was conducted on the information identified from these sources to present only noteworthy regulations and policies related to subsidised housing.

The literature review continued to further explore $CO_2$ emissions and the impact thereof on buildings, with relevant literature being obtained from various local and international sources. Following the examination of $CO_2$ emissions and buildings an overview of the subject "sustainable buildings" were conducted with a specific focus on the status thereof in South Africa. The information obtained was analysed to present how buildings can be more sustainable and how this can be achieved through policies and regulations.

Further investigation through a desktop analysis and supported by the interview process was conducted on completed subsidised housing projects for the following reasons:

- To establish the current demand of subsidised housing units in South Africa. Demand of subsidised housing units refers to the current shortage of individual subsidised housing units needed so that the full population of South Africa are adequately housed;
- To identify the existing subsidised housing projects that employed energy reducing measures and/or energy service efficiency initiatives.

The majority of projects identified during the research process only presented overall results on $CO_2$ emission savings. Due to the comprehensive data obtained from the Kuyasa low-cost urban housing energy upgrade project and The First Rand Bank Cosmo City Pilot Project, these were the only two projects selected for the data analyses section. These to projects proved to have the best detailed data and results available to perform projections on.

iii) Data analysis and projections

The data and results obtained from the Kuyasa low-cost urban housing energy upgrade project and The First Rand Bank Cosmo City Pilot Project contained $CO_2$ emission savings on the following three main categories, which are:

- Energy efficient lighting;
- Solar water heaters; and
- Thermal efficiency and insulation

The data and results obtained from the Kuyasa low-cost urban housing energy upgrade project presented to be the most comprehensive information on energy efficient lighting. As such only data from this project was used during the calculations related to energy efficient lighting. The calculation compared what old technology units will use compared to energy efficient units such as Compact fluorescent lighting. The result would be the possible $CO_2$ emissions saved by employing energy efficient services. Due to a limited scope the analysis did not further investigate the impact of practical feasibility and behaviour influences on the implementation of energy efficient interventions.

Furthermore the data obtained from the First Rand Bank Cosmo City Pilot project on solar water heaters and space heaters and space heating proved to be the most comprehensive. As such the data sourced from First Rand Bank Cosmo City Pilot project projects data was chosen above the Kuyasa low-cost urban housing energy upgrade project data and was thus used in the calculations related to solar water heaters and space heating.

To calculate the energy savings related to the installation of solar water heaters the savings was projected by calculating the energy usage saving if a standard electric geyser was replaced by a SWH. Space heating energy savings was projected by calculating the reduction in energy needs if less heating was required to obtain indoor thermal comport and/or survival levels. Again, due to a limited scope practical feasibility and behaviour influences were not further explored.

Considering the overall mitigating potential offered by each intervention the data analysis was concluded. Future climate change mitigating trajectories were conducted with the aim to determine the overall effect if the current demand of subsidised housing was met with these energy interventions. This calculation combined the current demand for subsidised housing as published by the department of human settlements during 2014 with the overall calculated mitigating effect per house. The results for the calculation provided the combined value to the main research question, which is the potential $CO_2$ emission reduction when energy interventions are applied to the current subsidised housing demand figure.

iv) Other ethical considerations related to the study

The research explores the interrelated areas of energy, buildings and climate change, and how these relate to the South African subsidised housing industry. More specifically, it focuses on the physical aspects of buildings, the processes involved on constructing buildings and the operational management of energy use. However, the research does not include the study of human interaction and the effect of buildings on humans.

## 1.8. Summary

This chapter introduced the problem statement investigated in this research, and presented the detailed research mythology that was followed to answer the research question successfully. Furthermore, the chapter presented a brief introduction to the chapters that follow. In the subsequent chapters, we will look at the following aspects, i.e. subsidised housing; the nexus between climate change, energy and buildings; sustainable buildings; existing green subsidised housing projects, and finally, at future climate change mitigation trajectories related to subsidised housing in South Africa.

# 2. Subsidised Housing

## 2.1. Introduction

Along with food and water, having a shelter is one of the most basic human needs; it is not only necessary for survival, but also for a sense of well-being and happiness, as eloquently stated by the Dalai Lama (Shelton, 2012):

> "If one's life is simple, contentment has to come. Simplicity is extremely important for happiness. Having few desires, feeling satisfied with what you have, is very vital: satisfaction with just enough food, clothing, and shelter to protect yourself from the elements..."

The basic human need for acceptable shelter is even covered in the Constitution of South Africa (*Constitution of the Republic of South Africa*, 1996). The right is affirmed not so much to benefit the wealthy, but rather to protect and look after the needs of the poor. In particular since the advent of democracy in 1994, South Africa has been striving to serve and protect this basic need of the poor, by putting in place many strategies, regulations and policies. In some instances, the South African government has failed to implement these consistently in practice, but in others areas it has succeeded. This section explores the background, the institutions, the contexts and also the current status of subsidised housing in South Africa.

## 2.2. Background to subsidised housing in South Africa

Subsidised housing refers to all housing related projects supported by government. The primary objective of subsidised housing is not to provide free housing for all who are poor. Instead, subsidised housing functions as an instrument to overcome the social, political and economic inequalities that were created by the legacies of Apartheid, specifically with regard to the segregation of whites and non-whites (Nengomasha, 2011).

It is thus primarily due to the unusual history of housing in South Africa, and the concomitant conceptualisation of subsidised housing, that the institutional arrangements in the country are unique, especially when compared to the institutional arrangements that exist in other countries. The following section therefore outlines the institutional history, arrangements and status of subsidised housing in South Africa.

## 2.3. Institutional arrangements

After Apartheid ended in 1994, the new democratic constitution attempted to address the inequalities around housing. The South African Constitution of 1996 provides that all South African citizens are entitled to have access to acceptable housing. Also the Constitution requires that the state take responsibility for providing this service to the applicable parties (Republic of South Africa, 1996). To complement the constitutional right of South African citizens to have access to acceptable housing, the following legislation were developed, presented in the table below:

Diagram 2: South African legislation related to subsidised housing


Source: Compiled by researcher from reviewing applicable acts and regulations related to subsided housing in South Africa

Chapter 2 of the South African Constitution came into effect on 4 February 1997 and contains the Bill of Rights that sets out the fundamental rights of every person in South Africa. Chapter 2 Section 26 of the Bill of Rights enshrines the constitutional rights related to housing, which read (Republic of South Africa, 1996):

*"(1) Everyone has the right to have access to adequate housing.*

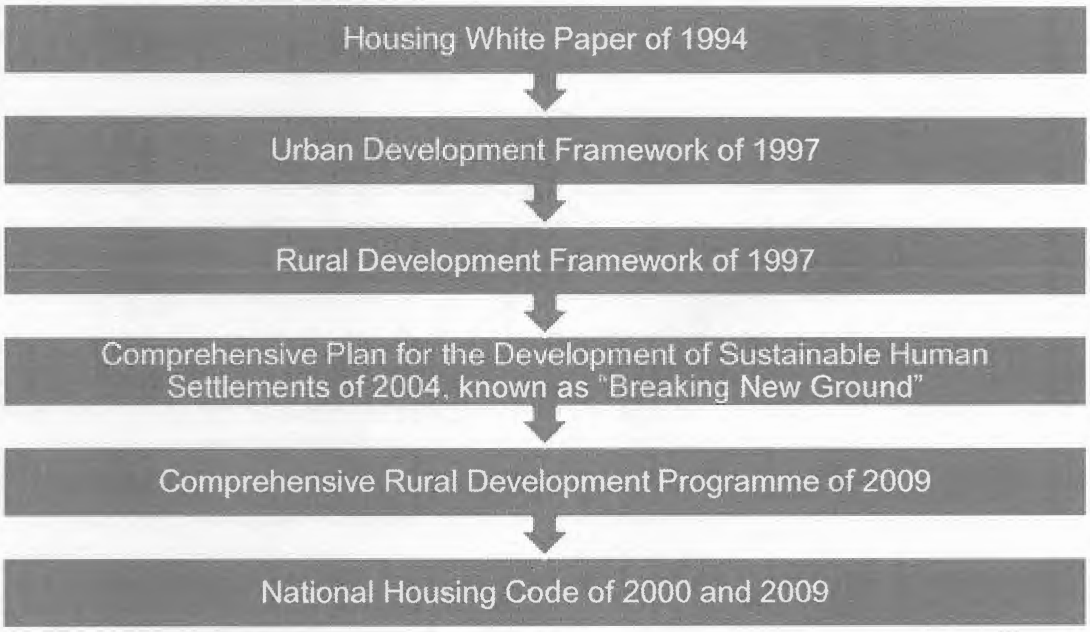
*(2) The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of this right.*

*(3) No one may be evicted from their home, or have their home demolished, without an order of court made after considering all the relevant circumstances.*

*(4) No legislation may permit arbitrary evictions."*

To further compliment the legislative regulations listed in diagram 2 and practically follow the responsibility set out by the constitution a range of policies related to subsidised housing were created. Diagram 3 below gives a list of the applicable policies that compliment the legislative regulations related to subsidised housing:

Diagram 3: South African policies related to subsidised housing




Source: Compiled by researcher from reviewing applicable policies related to subsided housing in South Africa

The development of these policies was chronologically created in accordance with the development of legislative regulations, each policy providing the practical role out of the relative act.

The South African subsidised housing sector has matured since its early days in 1994 into an environment confidently equipped with enough instruments to undertake its original mandate as per the Constitution of South Africa. The early regulations and policies introduced after 1994 were insufficient to guide the government in delivering adequate housing to all. This had become evident at the end of 1999, when it was realised that only 712 813 houses had been delivered, instead of the target of one million houses.

Yet, as flaws and inefficiencies were identified, the regulations and policies developed into a well-matured body of work. The subsidised housing sector now appears to be well equipped with enough instruments to create an environment where even more individuals have access to adequate housing opportunities.

The South African concept of subsidised housing includes the restructuring and integration of communities and zones. For this reason, the term "subsidised housing" in South Africa is very comprehensive; it includes various types of housing programmes in order to address the many facets of subsidised housing. The section to follow explores the different types of subsidised housing programmes found in South Africa.

## 2.4. Housing programmes in South Africa

The National Housing Code of South Africa was reviewed during 2009 and sets out the underlying guidelines, norms, standards and principles, which apply to the various housing assistance programmes, which have been implemented by government since 1994. The housing programmes related to subsidised housing are categorised in the table below (Republic of South Africa, 2009; SERI, 2011):

Table 2: Categories of South African housing codes

| | |
|---|---|
| Financial Programmes:<br>• Individual Housing Subsidies;<br>• Enhanced Extended Discount Benefit Scheme;<br>• Social and Economic Facilities;<br>• Accreditation of Municipalities;<br>• Operational Capital Budget;<br>• Housing Chapters of IDPs; and<br>• Rectification of Pre-1994 Housing Stock. | Incremental Housing Programmes:<br>• Integrated Residential Development Programme (IRDP);<br>• Enhanced People's Housing Process;<br>• Informal Settlements Upgrading Programme;<br>• Consolidation Subsidies; and<br>• Emergency Housing Assistance. |
| Rural Housing Programmes:<br>• Rural Subsidy: Informal Land Rights; and<br>• Farm Residents Housing Assistance Programme. | Social and Rental Housing Programmes:<br>• Institutional Subsidies;<br>• Social Housing Programme (SHP); and<br>• Community Residential Units (CRU). |

Source: Compiled by the researcher after reviewing and analysing various types of housing programmes in South Africa

Although the National Housing Code creates a comprehensive sphere of different programmes, only certain programmes relate to subsidised housing such as:

- Integrated Residential Development Programme;
- Upgrading of Informal Settlements Programme;
- Programme to Provide Social and Economic Facilities;
- Community Residential Unit Programme;
- Individual Subsidy Programme; and
- Rural Subsidy: Communal Land Rights.

The housing codes identified leads to the effective development of various types of subsidised housing, however in general the country demand for adequate housing is categorised in to a single classification. The section to follow explores the past and current targets set for subsidised housing developments in South Africa as a single classification.

## 2.5. Subsidised housing demand

Shortly after 1994, one of the first government initiatives launched to address housing and social problems became known as the Reconstruction and Development Programme (RDP). This programme contributed substantially to the number of housing units eventually built. Between 1994 and 2013, 2,729,339 houses and/or units have been built by government and 855,350 sites have been serviced (DHS, 2013). As a result, approximately 15.3% of South Africans now reside in subsidised housing provided by the South African Government (STATSSA, 2012).

Recent figures released by the Department of Human Settlements indicate the current country shortage for subsidised houses stands is 2.8 million units (Sanedi, 2014). Compared to the completed delivery of subsidised housing units, the half way mark has then only lately been reached. The demand figure of 2.8 million houses are for 2014 and do not include population growth.

This figure is daunting because the South African government has already shown that it is unable to deliver other subsidised housing targets on time. Evidence clearly shows that it took over eight years to deliver 1 129 612 houses, which means that the government failed to achieve the set target of one million constructed houses over five years (Lodge, 2003:57).

## 2.6. Summary

In South Africa, sufficient acts, regulations, policies, programmes and supplementary bodies exist to enable government to achieve the targets it has set, despite prior failure to deliver in time. The current demand for subsidised housing assistance is estimated at about 2.8 million houses, without taking into account growth and urbanisation.

The upcoming need to deliver 2.8 million houses is a daunting task, but when executed, it will reveal the adeptness of the South African government's ability to deliver. This task, which is yet to start, is likely to increase the $CO_2$ emissions footprint of South Africa. This is because of the considerable energy needs of the buildings that have been built and designed according to past building styles and conventions. In order to ensure that future building projects achieve low $CO_2$ emissions levels, the importance of sustainable design, building and operation must be emphasised, particularly within the subsidised housing environment. The following chapter explores the field of sustainable buildings and its relationship with climate change and energy usage.

# 3. The Nexus between Climate Change, Energy and Buildings

## 3.1. Introduction

Secretary-General of the United Nations Ban Ki-moon made the following statement (United Nations, 2007):

> "For my generation, coming of age at the height of the Cold War, fear of nuclear winter seemed the leading existential threat on the horizon. But the danger posed by war to all humanity – and to our planet – is at least matched by climate change."

Climate change, as stated by Ban Ki-moon, poses a real threat to society; like other global threats, it should not be underestimated. This chapter explores the background, causes and issues of climate change. It further discusses one of the major contributing factors of climate change, namely buildings, given that they utilise high amounts of energy. By focusing on the interrelationships between climate change, buildings and energy, this chapter seeks a way forward and suggest how buildings should be designed, built and operated in the future.

## 3.2. A background to climate change

Due to anthropological activities, excess amounts of greenhouse gases (GHGs) are being emitted into the atmosphere. The primary gas involved is carbon dioxide ($CO_2$), which is released amongst other during the production and use of conventional energy and linked directly to the burning of fossil fuels. Other gases that can also contribute to climate change include methane ($CH_4$), which is related to deforestation activities, as well as nitrous oxide (N20) from agriculture and land use change. Halogenated hydrocarbons and sulphur hexafluoride ($SF_6$) are also released during the production and use of artificial chemicals. Although it is natural to find these gases in the atmosphere, the excessive concentration thereof as a result of human activities is concerning (Winkler, 2005).

As was determined by examining ice cores, the current atmospheric concentration of $CO_2$ by far exceeds the natural balance that can be observed over the past 650,000 years. The natural range for the past 650,000 years has increased from 180 to 300 ppm. It is expected that $CO_2$ concentrations by the end of the 21$^{st}$ century can rise to 1260 ppm, a 350% increase above pre-industrial concentration levels.

Moreover, $CO_2$ emissions have continued to rise every year. From 1995 to 2006, the annual $C0_2$ emission increase was 1.9 ppm compared to an average of 1.4 ppm in 1960, when continuous direct atmospheric measurements began to be recorded (IPCC, 2007a). A significant increase can thus be noted for the period of 1995 to 2006.

According to many scientists this steep increase in $CO_2$ emission levels will undoubtedly contribute to climate change and temperatures are expected to rise. If $CO_2$ emissions continue to rise, projected temperature increases between 1.4°C and 5.8°C could be expected (Winkler, 2005). Various scenarios have been modelled to illustrate the impact of such temperature increases and the resultant climate changes. The severity of the impact of these changes and perhaps their speed of occurrence depend on the following key drivers (IPCC, 2000):

- Economic growth;
- Demographic changes; and
- Technological innovation.

Climate change is expected to have a major adverse effect on the natural environment. Rising sea levels are one of the most noticeable occurrences to be expected. A rise in sea levels of 15–95 cm by 2100 has been predicted. The rise in sea level together with a temperature will have a serious and negative global impact, such as (IPCC, 2007b):

- Low-lying islands disappearing;
- Flooding of low-lying areas and other devastating destruction scenarios;
- Extinction of 20-30% of plant and animal species;
- Extinction of coral reefs;
- Coastal flooding at least once a year; and
- Melting of the Greenland ice sheet, which contains sufficient water to cause a sea level rise of over 7 meters.

Given the strong likelihood and anticipated serious impacts of climate change, global efforts have been made and are still being made to save the earth from serious disasters. In 1992, at the Rio Earth Summit, the United Nations Framework Convention on Climate Change (UNFCCC) was created; this came into force on 21 March 1994. At the time, it consisted of 195 countries, which committed to combating climate change. The aim of the UNFCCC was as follows (UNFCCC, 2014a):

> "Preventing 'dangerous' human interference with the climate system".

The UNFCCC Kyoto Protocol was adopted on 11 December 1997 in Kyoto, Japan, as an outflow from the Rio Earth Summit. The UNFCCC Kyoto Protocol was a global commitment to action that was signed by 195 countries. Each country committed to meet certain $CO_2$ emission reduction targets. The first period of 2008 - 2012 of the Kyoto Protocol is only binding on developed countries because it is believed that they were mostly responsible for the causes of climate change (UNFCCC, 2014a).

On 8 December 2012, the Doha amendment to the Kyoto Protocol for a new commitment period was accepted. The second commitment period started on 1 January 2013 and will run until the end of 2020. South Africa's commitment to the Doha amendment had already been announced by the South African President during the 2011 Conference of the Parties 17 (COP 17) held in Durban. South Africa committed to reduce $CO_2$ emissions by 34% by 2020 and by 42% by 2025 on a "Business as Usual" trajectory.

The South African commitment is conditional on the country receiving the necessary finance, technology and support from the international community (UNFCCC, 2014b). It is important to understand the policies and history behind climate change. However, it is equally important to understand what the main causes of climate change are and how these causes can be mitigated. Therefore, it is important to note that buildings – or rather their carbon footprint and energy consumption – are one of the biggest contributors to climate change. The following section explores this issue, viz. how buildings are related to climate change and energy.

## 3.3. Buildings, energy and climate change

The world-renowned scientist William Thomson Kelvin stated the following (Cardoso, 2006):

> "If you cannot measure it, you cannot improve it."

Before attempting to improve the sustainability of buildings, as emphasised by the Kelvin principle, it is imperative to measure a building's overall environmental impact. This is a necessary precursor to determining what improvements can be made to reduce the $CO_2$ footprint of buildings. In this regard, we will look at three general types of buildings, categorised according to their environmental impacts:

- Zero Energy Buildings;

- Zero Impact Buildings; and
- Passive Buildings.

In the sub-sections below, a comprehensive overview of these three categories will be presented. Firstly, a Zero Energy Building, a building that produces the same amount of energy to what it needs to operate. Secondly, a Zero Impact Building, a building similar to the Zero Energy Building, but which has additional environmental impact segments such as reduced transport needs and urban integration. Lastly, Passive Buildings will be examined, these buildings focus on using very little energy for space heating or cooling.

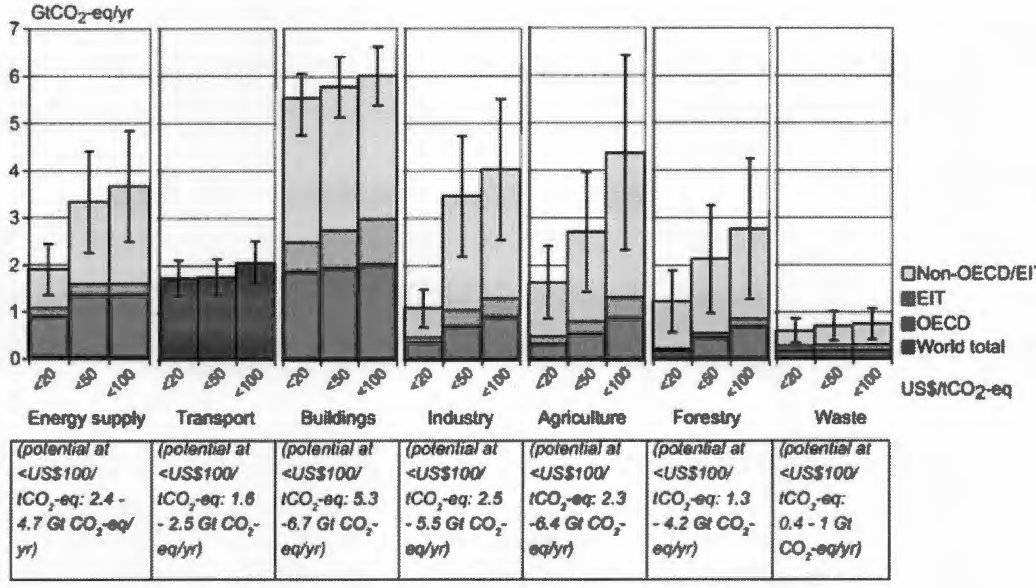
## 3.4. Zero Energy Building

To achieve sustainability on earth and combat climate change, all sectors of an economy need to move towards a low carbon ($CO_2$) environment. Among the different sectors, buildings experience the highest amount of $CO_2$ emissions for the following reasons (Hui, 2013:1–12):

- Energy used to construct them;
- Embedded energy; and
- Energy for operational activities.

As buildings consume over 40% of global primary energy it is projected that energy demand from this sector will increase by 30% by 2030 (International Energy Agency, 2013). It is thus very important to change the way in which buildings are designed, constructed and operated. A comparative study, as summarised in Figure 1 below, suggests that buildings offer the lowest cost potential to mitigate climate change as a function of carbon price (IPCC, 2007).

Figure 1: Estimated potential for global climate change mitigation for different industries as a function of carbon price in 2030 from bottom-up studies




Source: (IPCC, 2007)

Only when buildings are less dependent on energy and are built, managed and operated with low-energy principles, can they be labelled as low-carbon buildings. This is because energy usage relates directly to $CO_2$ emissions. However, when buildings consume the same amount of energy as that which they produce, they are referred to as a Zero Energy Building.

The Zero Energy Building concept can be seen as a realistic future solution for local and international institutions as a way of mitigating climate change (Marszal *et al.*, 2011:971–979). The Zero Energy Building concept is very complex and the international literature has failed to produce a standardised definition of this concept. Nonetheless, many institutions do use the term Zero Energy Buildings as a benchmarking technique.

Globally, this concept is used to ascertain future $CO_2$ emissions reduction targets relating to buildings. For example, the United States of America (USA) initiated a 50% Zero Energy Building target for commercial buildings, which was to be reached by 2040. Furthermore, the USA has a 100% Zero Energy Building target for 2050 (Pless & Torcellini, 2009).

In Europe, the Energy Performance of Buildings Directive has mandated that, as from 2018, all public owned buildings and buildings occupied by public authorities should be a "Nearly Zero Energy Building". In addition, the Directive also made it mandatory that all new buildings – not only public buildings – should be "Nearly Zero Energy Buildings" from 2020 and onwards (Energy Performance of Buildings Directive, 2010).

Numerous discussions have noted that the main area in dispute with regard to the definition of a Zero Energy Building is the energy balance parameters (CBE, 2008; NAHB, 2006; Noguchi *et al.*, 2008; Torcellini & Crawley, 2006). In essence, this refers to what to include or exclude from the energy balance calculations. To determine the balance parameters of a Zero Energy Building, two main indicators can be used (Lausten, 2008; Mertz *et al.*, 2007:477–487), namely:

- $CO_2$ emissions; and
- Primary energy consumed.

Moreover, the period over which this balance should be achieved should also be clearly defined. In most instances, the annual balance method is preferred (Iqbal, 2004:277–289; Mertz *et al.*, 2007:477–487; Noguchi *et al.*, 2008; Torcellini & Crawley, 2006).

Another method of measuring the impact of a Zero Energy Building is by referring to the building's lifecycle. When using the lifecycle method to calculate the energy balance of a building, it refers to the total amount of energy consumed over its full lifecycle, from the initial pre-construction earth works to its demolition.

Some methods for calculating the balance of a Zero Energy Building exclude the impact of the embodied energy of building materials as well as the impact of construction and site-based earth works. The only method that will include all the necessary figures to illustrate a full and realistic energy balance for a Zero Energy Building is the lifecycle method. The annual balance method does not illustrate the full effect on the environment, whereas the lifecycle method includes all the indicators and thus presents the full picture (Hernandez & Kenny, 2010).

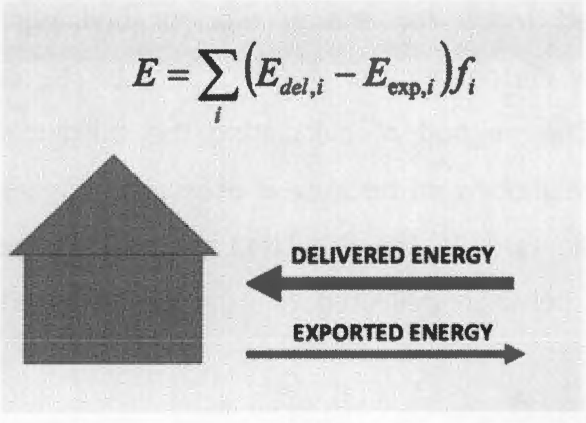
One of the more frequently used terms for energy efficient buildings, introduced by the European Energy Performance of Buildings Directorate, is "Nearly Zero Energy Buildings". The method of calculating the building's energy balance in this regard is straightforward because it uses only primary energy as a parameter. The basic formula for the "Nearly Zero Energy Buildings" concept is the balance between delivered energy and exported energy.

Primary energy in the context of "Nearly Zero Energy Buildings" refers to the total electricity that is delivered from a utility supplier and that is used to operate the building. It is also important to note that primary energy in this regard excludes losses from energy production and transmission lines. Furthermore, the type of primary energy supplied by the power utility can be ignored, as it can be a combination of fossil fuels and renewable energy sources, whereas exported energy, in most cases, refers to renewable energy generated from and by the building's premises (Energy Performance of Buildings Directive, 2010).

In view of numerous disputes about the definition of Zero Energy Buildings, the European Energy Performance of Buildings Directive has declared that the definition shall be based on delivered and exported kWh energy, as illustrated below. The full definition is described in the International Building Standard for Energy 15603:2008 (Kurnitski *et al.*, 2015).

Figure 2 below sets out how the system boundary for a Nearly Zero Energy Building definition is calculated by connecting a building to energy networks. Net delivered energy (E) is delivered energy ($E_{2del,i}$) minus exported energy ($E_{exp,i}$) accounted separately for each energy carrier($_i$). Primary energy (E) is calculated with primary energy factors ($F_i$).

Figure 2: Calculation of difference between delivered and exported energy.




Source: (Kurnitski *et al.*, 2015)

Due to on going research in the field of sustainable buildings, it is envisaged that the definition of a Zero Energy Building will eventually be generalised globally; however, as it stands, many interpretations still exist. These definitions range from the complex "Lifecycle" method to the "Annual Balance Method". For the purposes of this report, the idea of "Nearly Zero Energy Buildings" will be accepted as the most appropriate method of calculating the environmental impact of a building.

## 3.5. Zero Impact Building

It is important to note that the definition of a Zero Energy Building is different to that of a Zero Impact Building. In essence, the difference is that a Zero Energy Building directly relates to its energy usage, whereas a Zero Impact Building refers to the overall environmental and energy impact during a building's entire lifecycle. Attempting to calculate the overall environmental impact of a building's lifecycle is very complex and requires the input of many variables (European Enviroment Agency, 2008).

When it comes to a building's lifecycle, variables can include, among others, the energy used during the manufacturing of building materials, air pollution and occupational health (European Enviroment Agency, 2008). However, Attia & De Herde (2010) indicated that including too many variables in the Zero Impact Building concept places this analysis beyond the scope of building design practice. They thus propose that a comprehensive definition should only include a combination of the following indicators (Attia & De Herde, 2010:105–112):

- Resource cycles during a building's lifetime;
- Lifecycle of buildings; and
- Universal benchmarking.

By considering a combination of all resource cycles and building lifecycles, a universal benchmarking tool can be developed. The different resources contributing to a building's lifecycle could thus include the following, as described in Table 3 below (Attia & De Herde, 2010:105–112):

Table 3: Different resources within a building's lifecycle

| Resource | Resource description |
|---|---|
| Land use | Quantitative (Herold & Menz, 1996:451–468):<br>• Density; and<br>• Ratio of available land to buildings.<br>• Qualitative (Frenkel & Ashkenazi, 2008:56–79):<br>• Site water;<br>• Heat island;<br>• Habitats;<br>• Pollution; and<br>• Efficient modes of transportation |
| Energy | Measurement:<br>• Energy metrics, viz. kWh or MJ;<br>• Boundary balance; and<br>• Balance period (monthly, seasonally, yearly or full lifecycle).<br>• Zero Energy vs. Nearly Zero Energy building:<br>• Grid efficiency losses;<br>• Transmission losses; and<br>• Utility emission rates. |

| Resource | Resource description |
| --- | --- |
| Material<br><br>(Crawford & Stephan, 2013:475–481) | Closed cycle accounting (Rovers, 2009):<br>• Building material cycle effectiveness; and<br>• Building material performance.<br>• Embodied energy (Jones & Hammond, 2008:87–98):<br>• MJ/kg; or<br>• Kg $CO_2$/kg |
| Water | • Average water footprint in Europe 0.64 kWh/m3 (European Enviroment Agency, 2012:20–21) |

Source: Compiled by researcher

To measure the overall environmental impact of a building, the four types of resources cited above will be considered (i.e. land use, energy, material and water), resulting in various calculations and analyses. Whether or not a building is a verified Zero Impact Building depends on the results obtained, when all four types of resources have been measured and analysed.

Although there are many overlapping definitions with regard to the environmental impact of buildings, it is also important to analyse each definition or category separately. By creating individual definitions with overlapping sections, classification will be more accurate, which will lead to an improved and more sustainable building design.

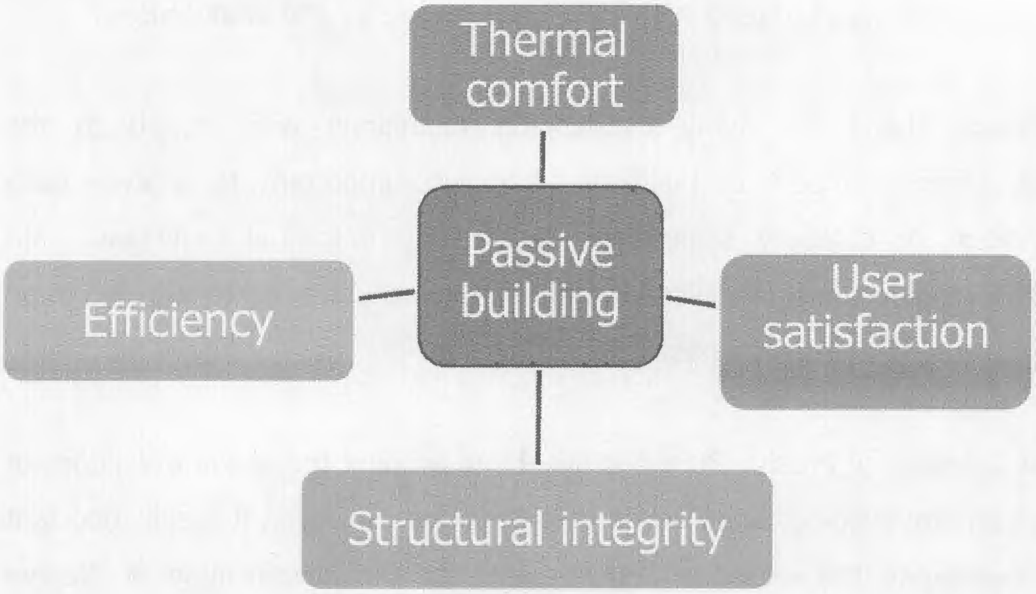
The definition of Passive Buildings takes into account the above definitions of Zero Energy Buildings and Zero Impact Buildings. However, it is still important to investigate the individual requirements for the classification of Passive Buildings; these will be explored in the following section.

## 3.6. Passive Building

The Passive Building concept represents one of the most effective and efficient energy standards available. The main focus of the concept is to reduce the energy load of buildings. As the energy demand for buildings grows, the need to reduce their energy demand becomes vital. Buildings consume over 40% of global energy and 60% of global electricity (UNEP SBCI, 2009a).

However, the Passive Building concept introduces a reduction of up to 90% of energy in buildings, which will appear very attractive to policy makers, particularly in the current setting of climate change. The main reason for this are the many opportunities for climate change mitigation the concept offers. To provide an overall picture of Passive Buildings the relevant soft criteria components are illustrated in Figure 3 below (Passive House Institute, 2014):

Figure 3: Soft criteria components of a Passive Building




Source: Passive House Institut, 2014

The Passive Building concept has also been introduced in building standards and is used widely by international institutions, countries and policy makers. The Passive House Institute is an independent international institute for energy efficiency in buildings and regulates the passive building industry. The institute developed certification criteria with which passive buildings need to comply. A list of the key criteria requirements is listed in Table 4 below:

Table 4: Passive Building criteria and requirements

| Criteria | Requirement |
|---|---|
| Space heating and energy demand | Not allowed to exceed 15 kWh per square meter per year of net living space; and<br><br>Not allowed to exceed 10 W per square meter |
| Primary Energy demand | Total energy demand must not exceed 120 kWh per square meter of treated floor area per annum |
| Airtightness | Maximum of 0.6 air changes per hour at 50 Pascal pressure (ACH50) |
| Thermal comfort | Average of 25 degrees Celsius per annum;<br><br>10% of hours in a year allowed to exceed 25 degrees Celsius |

Source: Passive House Institute, 2014

To achieve the above listed criteria, a comprehensive design strategy needs to be followed, coupled by effective interventions to overcome the use of high energy demand technologies. Some of the essential interventions used in designing Passive Buildings are presented in Table 5 below:

Table 5: Passive Building interventions

| Intervention | Description |
|---|---|
| Heat pumps | Geothermal/earth-to-air heat pumps:<br>• Refers to the earth's natural internal temperature;<br>• Uses the natural heat from the earth for cooling and heating interventions;<br>• Closed loop systems:<br>• Horizontal;<br>• Vertical; and<br>• Water/Lake/River.<br>• Open loop systems:<br>• Circulates water through system.<br>• Can reduce energy consumption for space heating and/or cooling by approximately 25% to 50%; and<br>• The heat pump output efficiencies can reach 300%-600% during winter months.<br>(Desmedt & Bael, 2010; Sanner, 2003; USA Department of Energy, 2011) |
| | Air-to-air heat pumps:<br>• Refers to the natural temperature of the ambient air of buildings;<br>• Uses the natural heat from the outside air for cooling and heating interventions;<br>• Limited to -5 degrees outside air temperature; and<br>• Potential to reduce 15% of energy demands for space heating (Kelly *et al.*, 2008). |
| Natural ventilation | Purpose:<br>• Air quality control;<br>• Advective cooling; and<br>• Indirect night cooling. |

| Intervention | Description |
|---|---|
| | • Basic approaches to ventilation:<br>• Wind-driven cross ventilation;<br>• Buoyancy-driven stack ventilation; and<br>• Single-sided ventilation<br><br>(Emmerich *et al.*, 2001) |
| Isolated Building Envelope components<br><br>(Sharma, 2013:662–675) | General:<br>• Energy savings potential of 36.8%-47% (Cheung *et al.*, 2005:37-48; Mahmudul *et al.*, 2012)<br><br>• Walls:<br>• Passive solar walls;<br>• Walls with latent heat storage;<br>• T-MASS walls;<br>• Riverdale NetZero Deep Wall System;<br>• Green Walls;<br><br>Roofs:<br>• Light weight roofs systems;<br>• Solar-reflective/cool roofs;<br>• Green roofs;<br>• Photovoltaic roofs;<br>• Roof vents; and<br>• Rubber roofs.<br><br>Windows and Glazing:<br>• Vacuum glazing;<br>• Switchable reflective glazing;<br>• Suspended particle devices (SPD) film; and<br>• Holographic optical elements. |

Source: Compiled by researcher by examiming all the components of a Passive Building

Table 5 above provides only an overview of the interventions that exist for increasing the energy efficiency of a building; there are many others and much detail can be added to each component listed. Moreover, for each component, a separate study can be conducted to expand its qualities in much more detail. However, if the components listed in Table 5 are consistently applied in the design and construction of a building, it is certain that a good Passive Building design can be achieved.

## 3.7. Summary

Clearly, climate change is a global threat and thus needs to be addressed. First world countries were the first to become industrialised and thus set in motion and accelerated climate change. By now, however, the contributions to climate change are no longer limited to the industrialised nations of Western Europe and North America. Nonetheless, it remains a matter of dispute who should take responsibility for counteracting its devastating and wide-ranging effects. In the early 21$^{st}$ century, it has become even more important to find a solution that will allow us to combat climate change in a practical, attractive and easy to implement manner.

It is my proposition in this thesis that sustainable buildings offer such a practical and attractive solution to mitigating climate change. The three building concepts discussed above, viz. Zero Energy, Zero Impact and Passive, will not only lead to a significant reduction in $CO_2$ emissions, but also prove to have additional social and environmental advantages. These advantages include the reduction in energy costs for the building user as well as a more sustainable approach of utilising natural resources.

The concept of sustainable buildings is well matured in developed countries, but it is still a fairly new concept within the South African building industry. If elements of the concepts mentioned in this section can be incorporated into the development of subsidised housing projects, it is likely to lead to a substantial reduction of $CO_2$ emissions. The chapter to follow discusses the status of the sustainable building environment in South Africa and how it can mitigate climate change through a reduction in energy consumption.

# 4. Sustainable Buildings in South Africa

## 4.1. Introduction

South Africa is still in the fledgling stage of developing a sustainable building environment. For instance, the South African Green Building Council (GBCSA) was only founded seven years ago, in 2007, whereas the United Kingdom's rating tool, the equivalent of GBCSA, known as the Building Research Establishment Environmental Assessment Methodology (BREEAM), was started 24 years ago in 1990 (BREEAM, 2014; GBCSA, 2014).

Although the South African sustainable building environment is still in its infancy, there are two types of standards in the industry that provide relevant benchmark criteria for developing sustainable buildings, namely:

- Voluntary standards; and
- Compulsory standards.

In terms of the voluntary standards, the GBCSA provides a green building rating tool, whereas the National Building Regulations and Building Standards Act 103 of 1977 provides guidance with regard to compulsory or legislative standards. This chapter explores both of these, viz. voluntary and compulsory standards and regulations.

## 4.2. Standards and regulations

### 4.2.1. Building regulations

The National Building Regulations and Building Standards Act 103 of 1977 empowers the Minister of Trade and Industry to draft new building regulations as deemed necessary. Moreover, the new regulations are required to adhere to the South African National Standards (SANS), as set out by the

South African Bureau of Standards (SABS). The SABS is a statutory body established in terms of the Standards Act 24 of 1945; it continues to operate in terms of the latest edition of the Standards Act 29 of 2008 (National Building Regulations and Building Standards Act of 2011).

During 2011, the amendments to the National Building Regulations for energy usage were published as per Notice R711. Notice R711 included the following statements with regard to standards:

- XA1: Buildings should comply with energy efficiency standards to effectively reduce $CO_2$ emissions;
- XA2: 50% or less of the annual requirement of hot water supply can be met by means of conventional electrical resistance heating; and
- XA3: Provides the compliance route of how to monitor XA1.

Additionally, standard XA3 states that compliance with SANS 10400XA will be deemed to satisfy the regulations.

The SANS 10400XA sets out three routes of how to be compliant with SANS 10400XA, all of which are deemed to satisfy the regulations. The three routes are as follows:

- The performance requirement can only be achieved by a competent person;
- Prescriptive provisions for the building envelope and services; and
- A reference-building route to determine the maximum allowable heating load for the proposed building.

The above-mentioned standards and regulations set out an important compliance system for meeting the required energy reduction targets in buildings. It also provides comprehensive energy efficiency regulations to be implemented in buildings (Harris, 2013).

### 4.2.2. Energy efficiency policies

Another regulation applicable to buildings originated from the 1998 National White Paper on Energy Policy. This provides a mandate for the Department of Energy (DOE) to instigate energy efficiency programmes in South Africa. It is believed that such programmes are one of the lowest cost options for reducing energy consumption. As a result, the 2005 National Energy Efficiency Strategy (NEES) was created, which sets out the energy intensity reduction targets.

NEES outlines the overall energy intensity reduction targets for various sectors. With regard to buildings, these targets are:

- 15% energy reduction for commercial and public buildings; and
- 10% energy reduction for residential buildings.

These reduction targets were based on certain assumptions about energy demand over the 10 year period starting in 2005. The target date for energy reductions is 2015, depending on assumptions such as economic development and population growth. To achieve these energy reduction targets, the SANS 10400XA was developed (Department of Minerals and Energy, 2005).

### 4.2.3. Construction Industry Development Board regulations

The Construction Industry Development Board (CIDB) Act 38 of 1997 was a direct result of the 1997 White Paper on "Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry". The mandate for the CIDB is as follows (CIDB, 2014):

> *"Establish a national register of contractors and of construction projects to systematically regulate, monitor and promote the performance of the industry for sustainable growth, delivery and empowerment.*

*Promote improved delivery management capacity and the uniform application of procurement policy throughout all spheres of government.*

*Promote improved performance and best practice of public and private sector clients, contractors and other participants in the construction delivery process.*

*Promote sustainable participation of the emerging sector.*

*Provide strategic direction and develop effective partnerships for growth, reform and improvement of the construction sector."*

One of the core roles of the CIDB as per their mandate is to promote improved performance and best practice initiatives within the public and private building sectors. The CIDB Act requires the CIDB Board to establish a Best Practice Project Assessment Scheme. Given a growing green building sector, the CIDB relies on the only benchmarking green building standards currently available in South Africa, namely, the green building rating tool created by the GBCSA.

According to the CIDB Act, all construction contracts above a prescribed tender value are subject to an assessment of compliance with best practice standards. As of January 2011, the CIDB published a statement to the effect that the best practice standards refer to the Green Star SA certification tool developed by the GBCSA. As a result, it now mandatory for all new buildings or buildings undergoing major renovations to be designed, constructed, and certified to meet, at a minimum, a Four Star Green Star SA rating.

The CIDB, in terms of its regulations, mandates all public and private construction projects to register a contract above a prescribed value. The minimum prescribed values for such registration of projects are as follows (CIDB, 2011):

- Public sector projects above R200 thousand;
- Public entity projects above R10 million; and
- Private sector projects above R10 million.

As a result, many government construction projects above the R200 thousand threshold need to undergo the Green Star Certification, the same as big private projects with a value of R10 million and above.

## 4.3. Voluntary standards and regulations

The GBCSA currently offers the only voluntary green building standard available in South Africa. The GBCSA was established in 2007 and has since been actively involved in the development and implementation of green building standards in South Africa. Furthermore, the GBCSA's mission is to endorse, support and assist green building in the South African property and construction industry through market-based solutions, focusing on the following (GBCSA, 2014):

- Advocacy and promotion of green building solutions;
- Education and training in the green building environment;
- Provision of resources related to green building; and
- Provision of building rating tools to assess building projects.

The GBCSA also provides eight different Green Star rating tools, each modified to evaluate the environmental performance of existing buildings in operation. As it currently stands, no tool exist, that specifically evaluates the environmental performance of subsidised housing, although sections of some of the rating tools might be applicable and can be used (GBCSA, 2014).

## 4.4. Summary

Although the sustainable building environment in South Africa is still classified as being under-developed and in its infancy, it is currently experiencing increased publicity and receiving much attention. However, South Africa is still lagging behind the USA and Europe, which have introduced targets directly related to climate change. Local standards and regulations relating to energy reduction are only bound to building practises; they do not yet translate into any climate change goals to reduce $CO_2$ emissions.

Nonetheless, even though the new energy efficiency standards in South Africa are still very under-developed when compared to the European Zero Energy and Zero Impact building concepts, the new standards in the country are a step in the right direction and essential for creating a better and more sustainable building environment. The standards mentioned in this chapter also apply to subsidised housing developments, and in this regard too will contribute to the development of more sustainable buildings. The chapter to follow explores the opportunities for climate change that can potentially be offered by sustainable buildings in the subsidised housing sphere.

# 5. Existing 'Green' Subsidised Housing Projects and Initiatives

## 5.1. Introduction

The move towards a sustainable environment is not a new development, whereas green building initiatives might be seen as a new way of building and designing. The general principles of green building are well known, and thus this chapter explores current initiatives and programmes in the subsidised housing environment related to green building.

The GBCSA, a recently established organisation, offers rating tools for assessing the environmental impact of buildings. Different rating tools exist, depending on the building type and its operational purpose or layout. To date, no tool has been developed specifically for subsidised housing or individual housing projects (GBCSA, 2014). This suggests that not much has been done in South Africa to ensure that subsidised housing complies with green building principles.

In general, progress with regard to green buildings is impressive, both on an international and at a local level. South Africa has many office blocks and hotels, which are built according to low energy standards and sustainable principles. For a number of reasons, however, subsidised housing projects do not make up a significant proportion of green buildings in South Africa.

Reasons may include high initial capital costs related to energy efficiency implementation as the current building budgets for low cost housing are already constrained. Budget constraints are also associated with the failure of institutions to recognise the long term value of sustainable low energy investments in subsidised housing. Furthermore because of a lack of regulatory requirements related to energy efficiency initiatives such as SWH and efficient lighting, housing projects are still not built with low energy standards. (Cook *et al.*, 2005).

Jongeling *et al.* (2002) argues that subsidised housing associations, which is an 'alternative' amongst public and private housing experience severe constraint to impliment energy efficiancy initiatives. These constraints relate mostly to the lack of acceptance and the lack of external imput by government. Moreover he further notes that operational difficulties already consume most of the time executing a housing project, as such, leaving no 'capacity' and resources for additional matters.

Other issues that are supplementary to the lack of energy efficiency implementations include the difficult access to informal communities and their lack of basic services. The lack of competence and responsibilities at municipal, provincial and national department level are also a major concern and contribute to the constraints (Sanedi, 2014). The need for improved defined competences are thus evident.

The reasons stated above resulted in the majority of subsidised housing projects being completed without incorporating green building principles. However a small number of subsidised housing projects that did incorporate green building principles have been completed in South Africa. This implies a slow but steady move towards sustainability and green building in this sector. Completed subsidised housing projects that incorporated sustainable green building initiatives are (United Nations Habitat, 2015):

- Cosmo City;
- Cato Manor;
- Joe Slovo;
- Kleinmond;
- Kuyasa;
- Marconi Beam project;
- Midrand Eco Village;

- Witsand Settlement; and
- Zanemvula.

For the purpose of this section, the results of Cato Manor Green Street upgrade and Kuyasa will be further explored and analysed to provide a comprehensive overview of the impact of such programmes.

## 5.2. Cato Manor Green Street upgrade

The Durban-based Cato Manor Green Street upgrade was a project launched by the GBCSA in conjunction with the World Green Building Council, funded primarily by the British High Commission. Completed during 2011, the project was the first subsidised housing project in South Africa to include green building principles. The project consisted of retrofitting 30 existing low-cost subsidised houses with more energy efficient technologies according to green building initiatives. These interventions had major benefits, including (GBCSA, 2012):

- Socio-economic benefits;
- Health and environmental benefits;
- Resource savings; and
- Improvement of people's quality of life;

The retrofitting processes on the 30 existing houses in Cato Manor included various initiatives to reduce energy consumption and improve sustainability. These interventions and initiatives are presented in Table 6 below, showcasing their benefits and results (GBCSA, 2012).

Table 6: Cato Manor green building initiatives, benefits and results

| **Green building initiative** | **Benefit** | **Results** |
|---|---|---|
| Insulated ceilings | Overall internal discomfort levels have dropped.<br><br>Ventilation and insulation improvements. | Inside temperatures during peak summer times have dropped by 4 - 6°C. |
| Solar water heaters (SWH) | Hot water on tap for the first time.<br><br>Free heating service free from the sun. | All electricity related interventions resulted in overall 25% electricity saving per month.<br><br>The annual saving of electricity resulted in an estimated reduction of 3.45 million tonnes of $CO_2$. |
| Efficient lighting | Reduced energy consumption by lighting. | |
| Heat insulation cookers | Reduced energy consumption by electrical stoves. | |
| Rainwater harvesting tanks | The harvesting of rainwater increases water security especially in times of unpredictable rainfall or droughts. | Annual supply of free water for 3 months. |

Source: Compiled by researcher

The social and environmental benefits derived from the Cato Manor Green Street upgrade were significant. The GBCSA report on the Cato Manor Green Street upgrade presented a total estimated annual reduction of 3.45 Mt $CO_2$ emissions for only 30 houses (GBCSA, 2012). This displays that the potential to mitigate climate change in the subsidised housing sphere is very high.

## 5.3. Kuyasa

The Kuyasa Clean Development Mechanism (CDM) Pilot Project was launched with the aim of retrofitting over 2,300 low-cost subsidised housing residences, located in Kuyasa, Khayelitsha, Cape Town. The project commenced during 2008 and was completed in 2010. The project was also South Africa's first registered CDM project under the UNFCCC Kyoto Protocol and the first registered Gold Standard Project in the world.

The Non-Governmental Organisation (NGO), South South North (SSN) was the project developer and was commissioned by the City of Cape Town's Environmental Resource Management Department's Urban Renewal Programme. The funding was primarily provided by the Department of Environment and Tourism's Social Responsibility Programme and the balance thereof by the Provincial Government's Department of Housing.

The Kuyasa project included the following retrofitting interventions to reduce energy demand and $CO_2$ emissions:

- Installation of solar water heaters (SWH);
- Installation of insulated ceilings; and
- Installation of efficient lighting.

The results from the above-mentioned interventions resulted in both socio-economic improvements and $CO_2$ emission reductions. Table 7 below provides an overview of the initiatives, benefits and results experienced at the Kuyasa project.

Table 7: Kuyasa green building initiatives, benefits and results

| Initiative | **Details** |
|---|---|
| Improved energy efficiency through:<br>• Replacement of non-energy efficient lighting with efficient lighting; and<br>• SWHs. | Households spending generally R100 or more per month on electricity reduced their expenditure by more than 50%. These households now spend less than R100 on electricity. Electricity savings are estimated at R50 per month per household. |
| Reduced burning of paraffin for heating | Paraffin used for heating was almost entirely eliminated. Savings are estimated at R400 per household per month. |
| Installation of ceilings | Elimination of indoor condensations resulted in a decrease of diseases like tuberculosis. |
| Improved thermal comfort through thermal insulation initiatives | The combination of thermal insulation, body heat radiation, cooking activities and hot water from the SWH resulted in improved levels of thermal comfort. |
| High degree of community satisfaction | 96% of households reported that they were very satisfied with the installation and maintenance of retrofitting their homes. |
| Reduced health burden | 76% of households reported a decrease in the frequency of respiratory illness. |

Source: Compiled by researcher through analysing the results as per the UNFCCC CDM reports (UNFCCC, 2010).

The Kuyasa project proved to be very successful. This success is evident from the high amount of $CO_2$ emission reductions achieved. These reductions totalled 9,134.75 tonnes of $CO_2$ emissions for the period 2005-2010. The Kuyasa project was effectively a co-benefit project because it socially uplifted the community by creating better living conditions whilst mitigating climate change at the same time. The following individual interventions, listed in Table 8 below, contributed to total $CO_2$ emission reductions (UNFCCC, 2010):

Table 8: Interventions and $CO_2$ emissions reduction for the Kuyasa UNFCCC project

| **Intervention** | **Number of units installed** | **$CO_2$ emission reduction (tonnes $CO_2$)** |
|---|---|---|
| Solar water heater | 2,150 | 3,866.86 |
| Insulated ceilings | 21,422 | 3,717.49 |
| Compact fluorescent lamp (CFL) | 2,143 | 1,550.40 |
| Total $CO_2$ emissions reduction | | 9,134.75 |

Source: Compiled by researcher

## 5.4. Summary

As indicated above, no environmental rating tool has thus far been developed specifically for the subsidised housing market; this highlights the need to apply green principles to this market too (GBCSA, 2014). This chapter explored two subsidised housing projects that incorporated sustainable green building initiatives, which resulted in significant $CO_2$ emissions savings. Although similar subsidised housing projects exist in the country, it is not a common trend in the market.

The two projects discussed above (Cato Manor Green Street upgrade and the Kuyasa CDM pilot project) raised two important questions with regard to sustainable green building, namely:

- What are the key initiatives that will result in $CO_2$ emissions savings? and

- To what extent can these key initiatives contribute to $CO_2$ emissions savings?

These projects were run over an extended period, and thus clearly demonstrated the impact of the key initiatives that bought about a reduction in energy consumption and thus resulted in $CO_2$ emissions savings. Furthermore, because the studies ran over an extended period, it was possible to estimate the results per initiative more accurately.

The two studies considered certain initiatives that have the potential to reduce energy usage. These initiatives included (GBCSA, 2012; UNFCCC, 2010):

- Installation of SWHs;
- Installation of insulated ceilings;
- Installation of efficient lighting;
- Introduction of heat insulation cookers; and
- Use of rainwater harvesting tanks.

Although the two projects discussed above were different from each other and varied in length, number of units, initiatives introduced and benefits reaped, the final results were still positive. The Cato Manor Green Street upgrade succeeded in saving 3.45 million tonnes of $CO_2$ emissions and the Kuyasa CDM Pilot Project saved a total of 9,134.75 tonnes of $CO_2$ emissions.

If only two subsidised housing projects can create a significant amount of $CO_2$ emissions savings, it is clear that the potential does exist to utilise this market as a tool for mitigating climate change. The chapter to follow looks at the hypothetical figures with regard to these potential $CO_2$ emissions savings, which could be attained if certain energy saving initiatives were rolled out to all future subsidised housing projects.

# 6. Future Climate Change Mitigation Trajectories

## 6.1. Introduction

One of the most important fundamentals that define the success of future climate change mitigation is the underlying principle of planning adequately (Füssel, 2007). In order to plan for future events and scenarios, accurate and reliable trajectories are needed. This chapter uses the previous chapters as a guide to make future projections. Data from different studies are thus combined to formulate the basis of potential mitigating interventions. The main interventions considered below include efficient lighting, SWHs and space heating.

Furthermore, this chapter attempts to combine the $CO_2$ emissions savings from each intervention to formulate the total potential $CO_2$ emissions saving from subsidised housing. Finally, the chapter present the results set out in the research question: "To what extent can subsidised housing contribute to climate mitigation?" The following section accordingly explores in detail the different interventions and the studies considered in this research.

## 6.2. Efficient energy interventions

The subsidised housing environment in South Africa is not easy to understand; it includes various types of building programmes, intervention subsidies and options for housing. In this section, the interventions related to the building of low-cost housing structures will be examined. The Comprehensive Housing Plan for the development of integrated sustainable human settlements governs the low-cost housing environment in South Africa. The relevant policy is also referred to as the 'Breaking New Ground' policy document (Republic of South Africa, 2004).

The Breaking New Ground policy contains the guidelines for the various subsidised housing programmes, which include single stand units – which are better known as low-cost housing units. In South Africa, studies have been commissioned to analyse the potential energy savings linked to energy efficiency and renewable energy interventions in such low-cost housing programmes. For the purposes of this study, the data from two different studies on low-cost housing will be used for projections and calculations because they provide a comprehensive set of accurate data. The two projects to be use are:

- The Kuyasa low-cost urban housing energy upgrade project; and
- The First Rand Bank Cosmo City Pilot Project.

The Kuyasa low-cost urban housing energy upgrade project is located in the Western Cape in a suburb of Cape Town called Khayelitsha. The purpose of the project was to improve the socio-economic circumstances of the poor community by introducing energy efficiency and renewable energy interventions into their homes. These interventions were targeted at single unit low-cost housing units. For the purpose of this study, only the data related to the installation of energy efficient lighting will be considered (UNFCCC, 2010).

The First Rand Bank Cosmo City Pilot Project is located in the Gauteng province of South Africa. The project's sole purpose was to reduce carbon emissions and improve living conditions in households in South Africa through the promotion of renewable energy and energy efficiency. By implementing renewable energy and thermal efficiency technologies, the project resulted in social, environmental and financial benefits to the subsidised housing environment. Furthermore, for the purpose of this section, the following renewable energy and thermal efficiency interventions data will be considered (Stewart & Gest, 2011):

- Design orientation;
- SWHs; and

- Ceiling insulation.

The four renewable energy and thermal efficiency interventions identified from the two studies will further be individually discussed in detail below.

## 6.3. Energy efficient lighting

The energy efficient lighting intervention involves the replacement of old lighting technologies that have a high energy demand during usage with new efficient lighting technologies, which have a much lower energy demand. An energy efficient lighting projects intervention was launched at the Kuyasa low-cost urban housing energy upgrade project. As part of this project, two old lighting technologies per household were replaced by two new energy efficient technologies Tables 9 and 10 below provide an overview of the related information and show the annual $CO_2$ emissions consumption per household at the Kuyasa project:

Table 9: Energy efficient lighting intervention information

| Data/Assumption | Unit |
| --- | --- |
| Old technology units replaced (two units) | 60 watt |
| New technology installed: Compact fluorescent lamp (two units) | 14 watt |
| Lighting demand | 6.8 hours per day |
| Average technical distribution losses for the grid serving the locations | 10% |
| Days per year | 365 days |
| Emissions coefficient for South African grid electricity | 0.89 kg $CO_2$ per kWh |

Source: (UNFCCC, 2010)

Table 10: $CO_2$ emissions calculations related to energy efficiency technologies

| |
|---|
| **Baseline $CO_2$ calculations: Old technology**<br><br>$f(x) = \frac{(\text{number of devices})(\text{power})(\text{hours})(\text{days in a year})}{Distribution\ losses}\ x\ (emission\ coefficient)$<br><br>$f(x) = \frac{(2)\left(\frac{60\text{watt}}{1000}\right)(6.8\text{h})(365)}{1 - 10\%}\ x\ \left(0.89 \frac{kg\ CO2}{kWh}\right)$<br><br>$f(x) =$ 294.53 kg C02 emissions per annum per house |
| **Intervention $CO_2$ calculations: New energy efficient technology**<br><br>$f(x) = \frac{(\text{number of devices})(\text{power})(\text{hours})(\text{days in a year})}{Distribution\ losses}\ x\ (emission\ coefficient)$<br><br>$f(x) = \frac{(2)\left(\frac{14\text{watt}}{1000}\right)(6.8\text{h})(365)}{1 - 10\%}\ x\ \left(0.89 \frac{kg\ CO2}{kWh}\right)$<br><br>$f(x) =$ 68.72 kg C02 emissions per annum per house |
| **$CO_2$ savings calculation:**<br><br>$f(x) = baseline\ CO2\ emissions - Intervention\ CO2\ emissions$<br><br>$f(x) =$ 294.53 kg C02 − 68.72 kg C02<br><br>$f(x) =$ 225.81 kg C02 emission saving per annum |

Source: (UNFCCC, 2010)

From the calculations presented in
Table 10, it can be noted that, merely by replacing two old incandescent light bulbs with two new technology CFL bulbs in each of the houses in the Kuyasa low-cost urban housing energy upgrade project, this resulted in an annual saving of 225.81 kg $CO_2$ emissions per household. This clearly shows the potential $CO_2$ emissions saving of such interventions. The following intervention relates to the installation of SWHs.

## 6.4. Solar water heaters

The Solar Water Heater (SWH) concept is an energy efficient intervention and uses the sun's energy to heat up water. There are various types of systems. SWH can further also be classified either as an active or passive systems. An active system uses an electrical power pump to circulate the fluid between the solar collector and the water tank. In a passive system, in contrast, a solar collector is directly connected to the water tank and the water circulates without the need of an electric pump.

Furthermore, SWHs are also classified as either direct or indirect systems. A direct system heats up the water directly in the solar collector, whereas in an indirect a heat transfer fluid is heated up in the solar collector. The heated fluid flows around the water tank and in return heats the water inside the water tank.

The SWH also comes in two types of designs, namely a flat-plate and an evacuated tube collector design. The flat-plate has a transparent cover, which protects the collector, whereas the evacuated tube collector design consists of individually isolated tubes, which heat up the water. Lastly, the system can be either a high pressure or a low pressure system, depending on the material used (Ghent & Keller, 1999).

Following the research conducted for the First Rand Bank Cosmo City Pilot Project related to SWH interventions, the climate change mitigation potential was calculated. The information above relates to the project and serves the basis for the calculations, as set out in Tables 11 and 12 below:

Table 11: Solar water heater intervention information

| **Data/Assumption** | **Unit** |
|---|---|
| House size | 40 m2 |
| Daily average hot water demand | 76 litres |
| Water heating energy as required by an electric geyser | 3.52 kWh |
| Backup water heating component | 1.74 kWh |
| Backup heating as proportion of heating required by an electric geyser | 49% |
| Solar water heater system | 100 litre low pressure |
| Household occupant | 1 person |

Source: (Stewart & Gest, 2011)

Table 12: $CO_2$ emissions calculations related to solar water heaters

**Baseline $CO_2$ calculations: Electric geyser**

$$f(x) = \frac{\text{(energy)(days in a year)}}{\textit{Distribution losses}}\ x\ (\textit{emission coefficient})$$

$$f(x) = \frac{(3.52\ \text{kWh})(365)}{1-(1\text{x}10\%)}\ x\ \left(0.89\frac{kg\ CO2}{kWh}\right)$$

$$f(x) = 1271.\ \text{kg C02 emissions per annum per house}$$

**Intervention $CO_2$ calculations: SWH**

$$f(x) = \frac{\text{(power of backup system)(days in a year)}}{\textit{Distribution losses}}\ x\ (\textit{emission coefficient})$$

$$f(x) = \frac{(1.74\ \text{kWh})(365)}{1-(1\text{x}10\%)}\ x\ \left(0.89\frac{kg\ CO2}{kWh}\right)$$

$$f(x) = 628\ \text{kg C02 emissions per annum per house}$$

**Notes:**

In order to accurately compare the energy savings when a SWH is installed, a backup system needs to be incorporated for the times when the SWH is unable to provide sufficient hot water. In this study, the backup system had to be used 49% of the time in order to provide a parallel hot water supply when the electric geyser was used.

It should further be noted that the calculations related to the SWH's are based on the assumption that all subsidised housing units had an installed electrical geyser before the replacement of a SWH occurred.

**$CO_2$ savings calculation:**

$$f(x) = \textit{baseline CO2 emissions} - \textit{Intervention CO2 emissions}$$

$$f(x) = 1271\ \text{kg C02} - 628\ \text{kg CO2}$$

$$f(x) = 643\ \text{kg C02 emission saving per annum}$$

Source: (Stewart & Gest, 2011)

It emerges from the results presented in Table 12 that the use of SWHs led to higher $CO_2$ emissions saving than did the efficient lighting project. The results indicate an almost 50% energy saving, amounting to a saving of 643 kg $CO_2$ emissions per annum for a single occupant house. The following section explores the potential energy savings related to space heating.

## 6.5. Space heating

Space heating relates to the indoor thermal comfort levels of a building. Indoor thermal comfort levels can be defined as the condition of mind that expresses satisfaction with the thermal environment, in response to the temperature inside a building. Good thermal comfort levels mean that they are acceptable to the majority of the users of a particular building. Many factors contribute to space heating and thermal comfort, which include but are not limited to the following (Monash University, 2014):

- Air temperature;
- Radiant temperature (i.e. the temperature of the walls, floor and windows);
- Humidity;
- Air speed;
- The amount of physical activity; and
- The amount and type of clothing worn by the occupants.

Part of the research conducted at the First Rand Bank Cosmo City Pilot Project was to evaluate the possible energy reductions by implementing efficient space heating interventions whilst still maintaining adequate thermal comfort levels. The thermal comfort level adopted for this study was 21 degrees Celsius (°C) for indoor buildings. In order to determine the required heating energy demand for the winter period accurately, a predictive tool was developed. The predictive tool was based on a 40 square metre house with one occupant.

The predictive tool, which determines the level of heating energy required during the winter periods, is affected by various elements. These elements were measured and determined by weather software and household surveys, and include:

- Outdoor climate;
- Building envelope (the outside walls, foundation and roof of a building, which forms part of the outside structure);
- Indoor heat gains and losses; and
- Air changes.

Furthermore, the predictive tool was used to create a model for the baseline houses. This model determined the heating requirements to achieve 21°C during the heating periods. The baseline house included the following features:

- Random orientation;
- No ceilings;
- No plaster;
- Standard floor slab;
- Built with standard building materials with no thermal interventions, and
- Normalised monitored behaviour (*i.e.*, occupancy, internal heat gains, and air changes were averaged).

By using the same virtual house in the baseline case, certain interventions were added and simulated with random orientations to generate the new heating requirements. The difference between these gives the energy savings due to the thermal interventions needed to achieve thermal comfort. The thermal interventions and simulated energy savings are shown in Table 13 below:

Table 13: Thermal intervention energy saving results

| Intervention | Energy saving per annum |
|---|---|
| Installation of a ceiling and a thermal floor (ThermocousTex ceiling, INNOFILLA vermiculite floor) | 164.4 kWh |
| Design orientating: North facing | 26.1 kWh |

Source: (Stewart & Gest, 2011)

Translating the energy savings of the thermal interventions into carbon savings enables us to create a parallel and thus a comparison with the efficient lighting and SWH interventions. Table 15 below summarises the calculations related to the thermal interventions:

Table 14: $CO_2$ emissions calculations related to thermal interventions

| |
|---|
| **$CO_2$ calculations: Ceiling and floor installation**<br>$f(x) = \text{energy saving } x \ (emission\ coefficient)$<br>$f(x) = 164.4\ kWh\ x\ \left(0.89 \frac{kg\ CO2}{kWh}\right)$<br>$f(x) = \ 146.32.\text{kg C02 emissions per annum per house}$ |
| **$CO_2$ calculations: Design orientation**<br>$f(x) = \text{energy saving } x \ (emission\ coefficient)$<br>$f(x) = 26.1\ \ kWh\ x\ \left(0.89 \frac{kg\ CO2}{kWh}\right)$<br>$f(x) = \ 23.23 \text{ kg C02 emissions per annum per house}$ |

Source: (Stewart & Gest, 2011)

The thermal interventions presented in Table 13 indicate only a minor carbon saving compared to the interventions discussed previously, i.e. the installation of efficient lighting and SWHs. The thermal efficiency intervention thus has a smaller energy saving potential compared to other interventions; however, it does also contribute to the increased thermal comfort levels of the inhabitants, improve their living standards, and provide a technological and social advantage to communities.

## 6.6. The combined climate change mitigating potential of subsidised housing

The following section estimates the combined climate change mitigation potential and energy use reductions that might be achieved in future subsidised housing projects, if various interventions were to be implemented. Table 15 below summarises the annual climate change mitigation potential of various energy efficiency interventions per household:

Table 15: Summary of climate change mitigation potential of different energy efficiency interventions

| **Energy efficiency intervention** | **kg $CO_2$ emissions saving per household per annum** |
|---|---|
| Efficient lighting | 226 kg C02 |
| SWH | 643 kg C02 |
| Space heating | 170 kg C02 |
| Total | 1,039 kg C02 |

Source: Compiled by researcher

This suggests that a total annual saving of 1,039 kg $CO_2$ emissions can be achieved per household, if certain fairly straightforward energy services interventions were implemented in the area of subsidised housing in South Africa. The total saving of 1,039 kg $CO_2$ emissions is considered to be inline, as a study conducted by EXXARO Coal Mining in Limpopo Province on building low-energy housing resulted in an annual saving of 1.524 kg $CO_2$ emissions per unit. Furthermore it is estimated that the total annual $CO_2$ emissions from subsidised housing equal about 3,264 kg $CO_2$ emissions per annum per unit. The savings calculated in this study thus present a 30% saving of the supposed total $CO_2$ emissions of a standard subsidised housing unit (Sanedi, 2014).

As discussed in Section 2.4 of this study, it is projected that about 2.8 million subsidised housing units will have to be built in the near future in order to ensure that all the country's citizens are properly housed. By using the annual $CO_2$ emissions saving per household and the current demand for subsidised housing, the total extent to which subsidised housing can contribute to climate change mitigation can be estimated. The following formula expresses the potential annual $CO_2$ emissions saving, if the current demand for subsidised housing were to be completed:

$$Annual\ potential\ \ C02\ saving = \frac{2\ 800\ 000\ x\ 1039\ kgC02}{1\ 000\ 000\ 000}$$

$$Annual\ potential\ C02\ saving = 2.91\ \ MtC02$$

South Africa's current annual $CO_2$ emissions are about 460 Mt $CO_2$. The residential sector accounts for about 20% for South Africa's total emissions, amounting to 92 Mt $CO_2$. Taking into account the 2.91 Mt $CO_2$ calculated potential $CO_2$ savings for the subsidised housing sector, this sector alone presents a 3% saving of the total residential sector emissions and an overall saving of 0.06% against South Africa's total $CO_2$ emissions for all sectors (DEA, 2013).

## 6.7. Summary

The chapter focused primarily on the different interventions available in the subsidised housing sector to mitigate climate change. Also, two different projects were described, which displayed the actual energy savings for each energy intervention. The actual energy savings from the projects were used to forecast the total impact of each intervention.

Based on the current demand for subsidised housing units and the $CO_2$ emissions saving that are projected to result from the various energy services interventions, the total extent to which subsidised housing can contribute to climate change mitigation was calculated. The results above indicate that if the current demand for subsidised housing units were to be completed with the suggested energy interventions, the total annual $CO_2$ savings can be 2.91 $MtC0_2$ emissions. This translates to 3% of the total current $CO_2$ emissions from the residential sector and 0.06% of South Africa's total $CO_2$ emissions.

# 7. Conclusion and Recommendations

## 7.1. Introduction

This chapter will review and summarise the dissertation research, identify the main methods used and discuss their implications in the study. After all aspects of the study have been concluded, a final recommendations section will present further research options related to the topic of this study.

The data obtained for this study are primary derived from a desktop research, with semi-structured information seeking interviews being used to fill the gaps identified. Throughout the study, both international and local literature was considered, although the main focus of the legislative and policy related literature was on the South African context. In the next section, the problem statement will be reiterated, and the findings presented.

## 7.2. Problem statement and drawing together the chapters

This study set out to explore to what extent subsidised housing can contribute to climate change mitigation in South Africa. The study has also sought to provide the nexus between climate change and buildings. To fully understand this nexus, it is important to understand each underlying topic, for example, how does climate change relate to energy and how does energy relate to buildings.

Climate change as a global problem is primarily affected and accelerated by the production and use of energy. As such, energy can be seen as the main contributor to climate change. In a local context, the biggest contributor to climate change is the burning of fossil fuel to generate electricity. Furthermore, a high demand for electricity exists in the building sector;

without electricity, this sector will not be able to operate. The main reasons why buildings are high consumers of energy is highlighted by Hui (2013:1):

- Energy used to construct buildings;
- Embedded energy; and
- Energy for operational activities.

However, the building sector presents many opportunities to reduce energy demand and, as a result, reduce $CO_2$ emissions, which then again mitigates climate change. The theoretical cases for reducing energy in buildings need to be revisited in order to understand the current trends on how buildings can be made more sustainable. The three main classifications of sustainable buildings are (Attia & De Herde, 2010; Marszal *et al.*, 2011):

- Zero Energy Building;
- Zero Impact Building; and
- Passive Building.

This study focused primarily on the subsidised housing sector, which exists because of the state's obligation to provide adequate shelter and/or housing to those who are not in a financially viable position to do so for them selves. Many South Africans still live in poverty and without adequate housing, and therefore a current estimated demand of 2.8 million housing exist in South Africa. The subsidised housing sector presents a considerable potential to mitigate climate change: if sustainably planned and designed, the building of subsidised housing units to satisfy the demand for subsidised housing can offset a significant amount of $CO_2$ emissions.

## 7.3. Summary of results

In South Africa, the subsidised housing environment has sufficient programmes and legislative support to succeed in building 2.8 million housing units. As a result of newly introduced energy standards, the construction of buildings utilising green and sustainable principles are available for implementation, although such principles are not yet fully functional and not yet in widespread use.

After reviewing existing subsidised housing projects, which have incorporated sustainable green building principles, the most effective energy efficient initiatives and interventions were identified. Ranging from the least to the most energy efficient, the initiatives and interventions are:

- Space heating;
- Energy efficient lighting; and
- SWHs.

The presented energy saving interventions identified above resulted in an estimated 1,039 $kgCO_2$ saving per housing unit. Taking into account current demand for subsidised housing units in South Africa, the total estimated mitigation potential could be as much as 2.91 $MtCO_2$ per annum. This total $CO_2$ emissions saving is equal to 3% of the total annual $CO_2$ emissions from the residential sector and 0.06% of South Africa's total annual $CO_2$ emissions.

From the results above, it is clear that the housing sector can substantially contribute to climate change mitigation to achieve South Africa's future energy reduction targets of 34% by 2020 and 42% by 2025 (UNFCCC, 2014b).

## 7.4. Further research recommendations

This study focused only on subsidised housing, which is a small sector of the overall building environment. Further related research could investigate the following:

v) To what extent can the overall building environment contribute to climate change mitigation, if the four main energy interventions used in this study were to be implemented extensively?

vi) What are the social co-benefits that can result from implementing energy efficient interventions?

vii) What is the most important design principle for reducing energy demand in buildings?

viii) How do embodied energy savings compare to operational energy savings?

ix) To what extend does the $CO_2$ emissions saving fluctuate from practical feasibilities when energy services interventions are introduced? and

x) What financial benefits could be reached per household when energy services interventions are introduced?

# 8. References

Attia, S. & De Herde, A. 2010. Towards a Definition of Zero Impact Buildings. *Sustainainable Buildings. Bâtiment international journal du Conseil international du bâtiment. 2010.* 1(1):105–112.

BREEAM. 2014. *About BREEAM.* Available at: http://www.breeam.org/about.jsp?id=66. Accessed on 23 January 2014.

CBE. 2008. *Getting to Zero.* Berkeley, University of California.The Lawrence Berkeley National Laboratory. Center for the Built Environment. University of California. Berkeley California.

CECODHAS Housing Europe. 2014. *Energy refurbishment for sustainable Social, Public and Cooperative Housing: insights on the current market & trends towards 2020.* European Union's Seventh Framework Programme for research, technological development. Brussels.

Cheung, C., Fuller, R., & Luther, M. 2005. Energy efficient envelope design for high-rise apartments. *Energy Buildings.* 37(1):37–48.

DHS. 2013. Stats for the delivery of serviced sites and housing: Available at: http://www.dhs.gov.za/uploads/Delivery_Statistics_HSDG_only_per_province_2009_10_to_2012.pdf. Accessed on 20 November 2013.

CIDB. 2014. *Mandate for the Construction Industry Development Board.* Available at: http://www.cidb.org.za/about/mandate/default.aspx. Accessed on 23 January 2014.

CIDB Board Notice 66 of 2011, 2011. *Best Practice Green Building Certification*. Government gazette. Vol:550. 1 April. General notice no. 34158. Pretoria: Government Printers.

Cook, M.F., Bradshaw, W., Connelly, E.F., & Baumann, L. 2005. *The costs & benefits of affordable housing*. New Ecology and The Green CDC Initiative. Cambridge.

Crawford, R.H. & Stephan, A. 2013. The Significance of Embodied Energy in Certified Passive Houses. *World Academy of Science, Engineering and Technology*. 7:475–481.

Department of Trade and Industry (DTI), 2011. *Introduction of amendments to the national building regulations to introduce requirements for energy usage in buildings*. SABS: South AFrica.

Department of Environmental Affairs (DEA), 2013. GHG Inventory for South Africa 2000 - 2010. South Africa

Deparment of Planning Monitoring and Evaluation, 2014. Twenty year review of South Africa: Background paper for Sustainable Human Settlements. South Africa.

DCLG. 2007. *Building a Greener Future: Policy statement*. Department for Communities and Local Government. London

Desmedt, J. & Bael, J. Van. 2010. *Efficiency investigation and energy saving of vertical ground source heat pump*. Flemish Institute for Technological Research. Mol, Belgium

EBPD. 2010. The Directive 2010/31/EU of the European Parliament: The energy performance of buildings. *Official Journal of the European Union.* 53:13–35.

Emmerich, S.J., Dols, W.S., & Axley, J.W. 2001. *Natural Ventilation Review and Plan for Design and Analysis Tools.* The National Institute of Standards and Technology of the America. Colorado.

European Environment Agency. 2008. *Energy and environment report.* European Union: Luxembourg.

European Environment Agency. 2012. *Towards efficient use of water resources in Europe.* no 1/2012 ed. European Union: Luxembourg.

Frenkel, A., & Ashkenazi, M. (2008). Measuring urban sprawl: how can we deal with it?. *Environment and planning b planning and design, 35*(1), 56.

Füssel, H. M. 2007. Adaptation planning for climate change: concepts, assessment approaches, and key lessons. *Sustainability Science. 2*(2), 265-275.

GBCSA. 2012. *Improving lives by greening low-cost housing: Case study report of the Cato Manor Green Street*. The Green Building Council of South Africa. Pretoria.

GBCSA. 2014. About the GBCSA. Available at: http://www.gbcsa.org.za/about/what-is-green-building/. Accessed on: 23 January 2014.

Ghent, P., & Keller, C. 1999. *A comprehensive review of market research on solar water heaters.* National Renewable Energy Laboratory.

Harris, H. 2013. *Handbook for the application of the amendments to the national building regulations for energy usage*. Trade Max Publications. Cape Town.

Housing Development Agency (HAD), 2012. South Africa: Informal settlements status. A research series published by the Housing Development Agency. South Africa.

Hernandez, P., & Kenny, P. 2010. From net energy to zero energy buildings: Defining life cycle zero energy buildings (LC-ZEB). *Energy and Buildings*, *42*(6), 815-821.

Herold, M., & Menz, G. 2001. Landscape metric signatures (LMS) to improve urban land-use information derived from remotely sensed data. In *A decade of trans-European remote sensing cooperation: Proceedings of the 20th EARSeL Symposium, Dresden, Germany, 14–16 June 2000*: 251-56. Lisse, The Netherlands: AA Balkema Publishers.

Hui, S. C. 2013. *Assessing carbon footprints of zero carbon buildings*. In Sustainable Building Hong Kong Regional Conference. The Construction Industry Council & Hong Kong Green Building Council.

IEA. 2013. *Modernising Building Energy Codes to Secure our Global Energy Future*. United Nations Development Programme. New York.

IPCC. 2000. *Special Report on Emissions Scenarios*. Working Group III of the IPCC. Cambridge University Press: Cambridge.

IPCC. 2007. Climate Change 2007: Mitigation. *Contribution of Working Group III to the Fourth Assessment Report of the IPCC*. Cambridge University Press: Cambridge, United Kingdom and New York.

IPCC. 2007a. *Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Solomon.

IPPCC. 2007b. *Climate Change 2007: Synthesis Report.* Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. Geneva, Switzerland.

Iqbal, M.T. 2004. A feasibility study of a zero energy home in Newfoundland. *Renewable Energy.* 29(2):277–289.

Jo, J. H., Golden, J. S., & Shin, S. W. 2009. Incorporating built environment factors into climate change mitigation strategies for Seoul, South Korea: A sustainable urban systems framework. *Habitat International, 33*(3), 267-275.

Jongeling, R., W. Klunne, S. Maathuis, Y. Suurenbroek (2002). Low cost energy efficient housing by South African housing associations. Sustainable Building 2002, Oslo.

Hammond, G. P., & Jones, C. I. 2008. Embodied energy and carbon in construction materials. *Proceedings of the Institution of Civil Engineers-Energy, 161*(2), 87-98.

Kelly, N. J., Cockroft, J., & Ghauri, S. 2010. Performance analysis of air source heat pumps using detailed simulations and comparison to field trial data. In *e-Sim2010, International Building Performance Simulation Association Conference.*

Kurnitski, J., Allard, F., Braham, D., Goeders, G., Heiselberg, P., Jagemar, L., & Virta, M. 2011. How to define nearly net zero energy buildings nZEB. *REHVA Journal, 48*(3), 6-12.

Laustsen, J. 2008. Energy efficiency requirements in building codes, energy efficiency policies for new buildings. *International Energy Agency*, 477-488.
Letete, T., Guma, M., & Marquard, A. 2009. *Information on climate change in South Africa: greenhouse gas emissions and mitigation options*. Energy Research Centre, University of Cape Town. Cape Town.

Levine, M., Ürge-Vorsatz, D., Blok, L., Geng, L., Harvey, D., Lang, S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., Rilling, J., & Yoshino, H. 2007. *Residential and commercial buildings*. Cambridge University Press: United Kingdom and New York, NY, USA.

Lodge, T. 2003. *Politics in South Africa: From Mandela to Mbeki*. David Phillips Publishers. Cape Town.

Mahmudul, M., Mahmudul, K., Azharul, B., & Richard, J. 2012. I*nvestigation of cooling energy performance of commercial building in sub-tropical climate through the application of green roof and living wall*. In: Healthy Buildings 2012, 10th International Conference, Official Conference of the International Society of Indoor Air Quality and Climate. Brisbane.

Marszal, A. J., Heiselberg, P., Bourrelle, J. S., Musall, E., Voss, K., Sartori, I., & Napolitano, A. 2011. Zero Energy Building–A review of definitions and calculation methodologies. *Energy and Buildings*, *43*(4), 971-979.

Mertz, G. a., Raffio, G.S., & Kissock, K. 2007. *Cost Optimization of Net-Zero Energy House*. In: Department of Mechanical and Aerospace Engineering, University of Dayton, Ohio, U. (Ed.), ASME 2007 Energy Sustainability Conference. Asme: Dayton, pp. 477–487.

Monash University. 2014. *Indoor thermal comfort*. Available at: http://www.monash.edu.au/ohs/topics/info-sheets/thermal-comfort.html. Accessed on: 28 August 2014.

NAHB. 2006. *The potential impact of zero energy homes*. National Renewable Energy Laboratory. Marlboro.

Nengomasha, C. (2011). *Social Housing Sidelined: An Assessment of the Institutional Framework for Social Housing in EThekwini Municipality*. Doctoral dissertation, University of KwaZulu-Natal, Durban.

Noguchi, M., Athienitis, A., Ayoub, J., & Berneche, B. 2008. *Net Zero Energy Homes of the Future : A Case Study of the EcoTerra House in Canada*. In: Renewable Energy Congress of Scotland. Glasgow.

NRC. 2010. *Advancing the Science of Climate Change*. The national academies press. Washington, D.C.

Passive House Institute. 2014. Ge*neral quality requirements for Passive Houses/EnerPHit-buildings*. Available at: http://www.passiv.de. Accessed on: 25 June 2014.

Pless, S. & Torcellini, P. 2009. Getting to Net Zero. *Journal of American Society of Heating and Air-Conditioning Engineers: September*, Vol. 51(9).

Radikeledi, L.C. 2007. *An analysis of the low-cost housing policy in South Africa*. Department of economics and econometrics at the University of Johannesburg. Johannesburg.

Republic of South Africa. 1994. White Paper on Housing: a new housing policy and strategy for South Africa. Government Gazette No. 354(16178), Notice No. 1376. Government Printer. Pretoria.

Republic of South Africa. 1996. Constitution of the Republic of South Africa. Government Gazette No. 17678, Notice No. 2083. Government Printer. Pretoria.

Republic of South Africa. 1997a. Housing Act 107 of 1997. Government Gazette No. 390(18521), Notice No. 1661. Government Printer. Pretoria.

Republic of South Africa. 1997b. Urban Development Framework of 1997. Department of Human Settlements: South Africa.

Republic of South Africa. 1998. Prevention of illegal eviction from and unlawful occupation of land act 19 OF 1998. South Africa. *Gazette No. 18964, Notice No. 789*. Government Printer. Pretoria.

Republic of South Africa. 1999. Rental Housing Act 50 of 1999. Gazette No. 20726, Notice No. 1506. Government Printer. Pretoria.

Republic of South Africa. 2000. National Housing Code of 2000. Department of Human Settlements: South Africa.

Republic of South Africa. 2004. Comprehensive Plan for the Development of Sustainable Human Settlements. Department of Human Settlements: South Africa.

Republic of South Africa. 2005. Energy Efficiency Strategy of the Republic of South Africa. Gazette No. 32342, Notice No. 908. Department of Minerals and Energy. Government Printer. Pretoria.

Republic of South Africa. 2006. Community Residential Unit Programme of 2006. Department of Human Settlements: South Africa.

Republic of South Africa. 2008. Housing Development Agency Act 23 of 2008. Gazette No. 31472, Notice No. 1072. Government Printer. Pretoria.

Republic of South Africa. 2009. The National Housing Code. South Africa Department of Human Settlements: Pretoria.
Republic of South Africa. 2010. Individual Subsidy Programme of 2010, National Housing Code. Department of Human Settlements: South Africa.

Republic of South Africa. 2010. Programme to Provide Social and Economic Facilities, National Housing Code. Department of Human Settlements: South Africa.

Republic of South Africa. 2010. Integrated Residential Development Programme of 2010. Department of Human Settlements: South Africa.

Rovers, R. 2009. *Material-neutral building: Closed Cycle Accounting for building construction*. In Proceedings of Smart and Sustainable Built Environments conference, Delft, The Netherlands (pp. 15-19).

SANEDI, 2014. The Status of ENERGY EFFICIENCY in the HOUSING SECTOR – mapping energy efficiency in South Africa. South Africa.

Sanner, B. 2003. *Current status of ground source heat pumps in Europe*. In Futurestock 2003 Conference, Warsaw, Poland.

SERI. 2011. *A Resource Guide to Housing in South Africa* 1994 2010. Available at: http://www.seri-sa.org/images/stories/SERI_Housing_Resource_Guide_Feb11.pdf. Accessed on: 10 April 2014.

Sharma, S.K. 2013. Zero Energy Building Envelope Components: A Review. *International Journal of Engineering Research and Application*. 3(2):662–675.

Shelton, N. 2012. *The Good Life Crisis.* Createspace Independent Publishing Platform. Canada.

STATSSA. 2007. Statistical release Community Survey. Pretoria.

STATSSA. 2011. General Household Survey. Pretoria.

STATSSA. 2012. Statistical release: Census 2011. Pretoria.

Stewart, A. & Gest, A. 2011. *First Rand Bank Cosmo City Pilot Project.* Pretoria, South Africa.

Torcellini, P. A., & Crawley, D. B. 2006. Understanding zero-energy buildings. *Journal of American Society of Heating and Air-Conditioning Engineers:* September, *48*(9), 62-69.

Torcellini, P., Pless, S., Deru, M., & Crawley, D. 2006. *Zero energy buildings: a critical look at the definition.* National Renewable Energy Laboratory and Department of Energy, USA.

Buildings, U. S., & Construction Initiative. 2009. *Common Carbon Metric for Measuring Energy Use & Reporting Greenhouse Gas Emissions from Building Operations.* United Nations Environment Programme. Paris, France.

United Nations Environment Programme Sustainable Buildings Climate Initiative. 2009. Buildings and Climate Change: Summary for Decision Makers. *UNEP SBCI.* Paris, France.

United Nations Environment Programme Sustainable Buildings Climate Initiative. 2009. Greenhouse Gas Emission Baselines and Reduction Potentials from Buildings in South Africa. *UNEP SBCI.* Paris, France.

UNFCCC. 2010. Monitoring Report for the UNFCCC CDM for the Kuyasa project. Avaialble at: https://cdm.unfccc.int. Accessed on 01 September 2014.
UNFCCC. 2014a. Essential Background. Available at: http://unfccc.int/essential_background/convention/items/6036.php. Accessed on: 03 January 2014

UNFCCC. 2014b. Appendix II - Nationally appropriate mitigation actions of developing country Parties. Available at: http://unfccc.int/meetings/cop_15/copenhagen_accord/items/5265.php. Accessed on: 03 January 2014.

United Nations Habitat. 2015. Green Building Interventions For Social Housing. United Nations Human Settlements Programme. Nairobi, Kenya .

United Nations. 2007. Ban Ki-moon calls on new generation to take better care of Planet Earth than his own. Available at: http://www.un.org/apps/news/story.asp?NewsID=21720&Cr=global&Cr1=warming#.U3X4P15EnBc. Accessed on: 03 January 2014.

USA Department of Energy. 2011. Guide to Geothermal Heat Pumps. Available at:
http://energy.gov/sites/prod/files/guide_to_geothermal_heat_pumps.pdf. Accessed on 03 June 2014.

Valentine, G. 1997. Tell me about...: using interviews as a research methodology. *Methods in human geography, 2,* 27-54.

Winkler, H. 2005. Climate change and developing countries. *South African Journal of Science.* 101(July/August):355–364.

Zuo, J., Read, B., Pullen, S., & Shi, Q. 2012. Achieving carbon neutrality in commercial building developments–Perceptions of the construction industry. *Habitat International*, *36*(2), 278-286.

# 9. Appendix 1: Questionnaire for Interviews

Researcher: PJ Krog

Institute: University of Cape Town, Energy Research Centre

Topic: To what extend can subsidised housing contribute to climate change mitigation.

Considerations:

All information will be considered confidential.

Approval by interviewee to use name as a reference: yes/no

The statements in the interview are considered the personal views of the interviewee and is not the view of his/her organisation: yes/no

Interviewee details:

Title:

Name and Surname:

Occupation:

Institution/company:

Role:

Email:

Tel:

Interview Questions:

xi) What is your role in your current industry? (are you involved in the design/procurement/construction aspects?)

xii) What is your understanding of climate change/GHG emissions/Energy and buildings?

xiii) Do you think social housing can play a role in reducing GHG in emissions South Africa?

xiv) Do you see other benefits beyond reduction of emissions (e.g. cost saving/internal air quality)?

xv) What is your definition of a green building?

xvi) What do you consider as the important elements of a building life cycle with regard to green building?

xvii) How do green building elements change specifically for low cost housing (e.g. mixed fuel use, end use?)

xviii) Are you aware of dedicated standards/processes/regulations focusing on low carbon low cost housing?

xix) Do you think adequate standards/regulations of green building is part of the social housing life cycle process i.e. from design to demolition?

xx) Can green building standards/regulations be implemented in the social housing life cycle process? If so how & at what point?

xxi) What is the current procurement process related to social housing? (who is involved? Are the future tenants involved?)

xxii) What is the target or balance of social housing units to be built in South Africa and will it be satisfactory for the current needs in SA?

xxiii) Is the current target of social housing units sufficient for South Africa?

xxiv) Do you have any suggestion of other people/organisations to talk to?

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