Experiences and Outcomes of Government-funded Energy Efficiency Interventions for Low-cost Housing in South Africa:

Case Study of Gauteng and Western Cape Provinces

by

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A research report submitted to the School of Architecture and Planning, University of the Witwatersrand,
in partial fulfilment of the requirements for the degree of

Master of Architecture
(Sustainable, Energy Efficient Cities)

17 November 2021

DECLARATION

I, Phumzile Maseko Seipobi, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in fulfilment of the requirements for the degree of Master of Architecture (SEEC) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Signed at ……………………….**Midrand**………………………………………………

On the …………**17th**………………..day of …**November**……………… **2021**…..

ABSTRACT

SANS 10400-XA is the 2011 amendments to the National Building Regulations aimed at enforcing energy efficiency for new buildings in South Africa. Using a case study approach, this study appraised the outcomes and effectiveness of the implementation of the regulations in low-cost housing in the country since 2014. Primary and secondary data collection methods were used with reference to local and international case studies. By appraising the German and Dutch energy efficiency policies, the study identified how implementation of well-developed policies contributes to their respective effectiveness and impact. This was then applied in guiding the study of South Africa's scenario based on the two case studies of Clayville (in Gauteng Province) and Joe Slovo Park (in Western Cape Province).

In order to understand the effectiveness of the regulations in South Africa, primary data were gathered from the two housing-developments case studies as well as from the respective provincial departments as the policy implementing agents. Analyses of primary data show significant compliance with the regulations thus indicating that the energy efficiency regulations in low-income housing were adequately planned for and implemented in both projects. Primary data, in the form of interviews, from low-income housing occupants indicates mixed outcomes and also highlights critical issues for improvement.

In terms of key findings, the study concludes that the positive outcomes of the energy efficiency regulations in low-income housing contribute towards basic household energy needs. However, one key finding is the existence of a performance gap in relation to the expected outcomes of the regulations. This gap is identified as poor installations of geysers and poor geyser effectiveness in winter. The study has thus identified areas for additional interventions. The study further recommends the specification of high-pressure solar geyser systems for the Western Cape to ensure reliability in access to hot water. Finally, the study also recommends more stringent oversight during construction to minimize the performance gap of installed interventions such as ceiling insulation and solar geysers.

Key words: energy efficiency policies and regulations, low-cost housing, policy effectiveness and impacts

DEDICATION

I dedicate this report to my family, especially my two beautiful daughters, Neo and Naume. I am eternally grateful to my late parents who were exceptional role models and believed in continuing education.

ACKNOWLEDGEMENTS

I thank the School of Architecture and Planning at Wits for this master’s programme that enables us to participate in the shaping of a sustainable future. Special gratitude goes to my supervisor, Prof Daniel Irurah, who has patiently guided me through this journey.

My gratitude also goes to the officials of the Western Cape and Gauteng Departments of Human Settlements who took time to participate in the study and introduced me to the project sites where I was able to carry out most of my fieldwork for primary data collection.

To all the respondents in the two case sites, I thank you for inviting me into your homes and giving me your time.

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LIST OF ABBREVIATIONS & ACRONYMS

CO_2	Carbon dioxide
BMWi	Federal Ministry for Economic Affairs and Energy (Germany)
DENA	German Energy Agency
DEFF	Department of Environment, Forestry and Fisheries
DME	Department of Minerals and Energy
DoE	Department of Energy
DoH	Department of Housing
DTI	Department of Trade and Industry
EE	Energy Efficiency
EEG	Renewable Energy Source Act (Germany)
EU	European Union
FLISP	Finance Linked Individual Subsidy Programme
GBCSA	Green Building Council of South Africa
GIZ	Deutsche gesellschaft Für Internationale
HDA	Housing Development Agency
IDP	Integrated Development Plan
IEA	International Energy Agency
IPPs	Independent Power Producers
KfW	Kreditantstalt Für Wirderaufbau
NAPE	National Action Plan on Energy Efficiency (Germany)
NDHS	National Department of Human Settlements (formerly Department of Housing)
NEEA	National Energy Efficiency Agency
RE	Renewable Energy
SABS	South African Bureau of Standards
SACN	South African Cities Network
SALGA	South African Local Government Association
SANS	South African National Standards
StatsSA	Statistics South Africa
SWH	Solar Water Heating

CHAPTER 1. INTRODUCTION

1.1 Background and Context

There is increasing global awareness that cities are complex and dynamic ecosystems which is primarily contributing to the global pursuit of sustainability. These complex and dynamic ecosystems are largely made of infrastructure and buildings. To contribute to global sustainability in buildings, the built environment has developed green building standards to promote life-cycle thinking in the design of products, materials and building systems (Boyle et al., 2010). In response to the pursuit of sustainable development through sustainable cities, planners, engineers and architects are adopting low impact infrastructure designs towards the mitigation of related negative environmental impacts. South Africa is pursuing various sustainability measures with renewable energy being one of these measures. Community awareness on the urgent need for a greener environment and overall sustainability is regularly reinforced throughout South Africa. As a result households are beginning to understand that renewable energy assists with cost-savings in homes while also contributing to sustainable development globally. Communities are also starting to understand the principle that they pay for what they use and therefore can pay less if they consume less or if there is efficient use of what is available. In South Africa, policy is also shifting towards ensuring the implementation of sustainable, energy efficient designs in developments which yield short and long-term benefits to the end-users as well as mitigate eco-footprint impacts such as climate change caused by greenhouse gas emissions from fossil fuels.

South Africa's efforts to adopt and promote renewable energy are thus underpinned and informed by ongoing concerns about social, economic and environmental sustainability. In particular, greenhouse gas emissions within cities are significantly high due to the country's high reliance on energy from fossil fuels such as coal-powered electricity generation. This places South Africa amongst the world's highest carbon dioxide emitters and is globally ranked twelfth in terms of top emitters per capita (Surridge-Talbot, 2015). It is therefore imperative for South Africa to reduce its overall carbon footprint through improved mix in energy sources especially through promoting renewable energy and improving energy efficiencies across its various sectors. The development of new buildings offers a good starting point for the responsive measures, such that upon occupation and operation, they can be less reliant on fossil-fuel based energy sources.

Cao et al., (2016) pointed out that in the EU and USA over 40% of overall energy use can be attributed to building energy use. Governments and other sector stakeholders should therefore use available tools to mitigate this high-energy consumption and the resulting impact on the environment. The study further argues that significant energy savings can be achieved through appropriate design, construction and operation and that a combination of energy-saving measures must be considered at design stage (ibid. 46). As a follow up on these concerns, this study reviews the South African policy now under implementation with the aim of reducing the consumption of energy from fossil fuels, especially through promoting the use of effective design and integration of renewable energy in new housing developments for low-income households.

In addition, since 2007, South Africa's shortfall in power supply capacity has presented an opportunity for government to reflect on past policies and consider opportunities towards demand-side interventions especially regarding energy efficiency and renewable energy. South Africans have also come to realise how our lives are heavily dependent on the availability and affordability of electricity. Phrases such as 'energy crisis' and 'the need to conserve energy' have now become common in everyday language across all socio-economic groups. The debate around electricity and energy in general has reached a peak and ordinary citizens continue to face critical questions over how the crisis could be effectively addressed. The government has mainly responded through enforcing various policies, regulations and programmes around energy efficiency and the use of renewable energy in buildings. For example, the recent Department of Energy (DOE) licencing of Independent Power Producers (IPP), the solar rebate programme, the Department of Trade and Industry (DTI) regulations on energy-use in buildings (through the 2011 amendment to the National Building Regulations) are a few examples of the key initiatives that have been implemented towards reducing reliance on non-sustainable energy sources.

Within the context of government-subsidised low-cost housing, this study constitutes an evaluation of the outcomes and effectiveness of the amended National Building Regulations aimed at promoting energy efficiency in new buildings (commonly known as SANS 10400-XA (refer to appendix A for SANS 10400-XA elements)). The regulations were promulgated in 2011 in line with government policies on energy regulation to reduce reliance of buildings on non-sustainable energy sources and to pursue the diversification of the country's energy mix with regard to primary energy sources.

The study applies relevant data in responding to the research question with a focus on the experiences and outcomes in the context of two case study housing projects built from 2014. The projects are Clayville Extension 45 in Gauteng Province and Joe Slovo Park Phase 3 in Cape Town, Western Cape Province (see Figures 3.1 and 3.2 for the site locations). The study assesses the effectiveness of the energy policy and related regulations within the low-cost government subsidised housing sub-sector which involves massive roll-out projects throughout the country. So far, a number of such housing projects have been implemented within the guidelines emanating from the SANS 10400-XA regulations. From a policy evaluation perspective, such projects can therefore offer insights towards the ongoing refinement of the implementation processes in pursuit of better outcomes. They have therefore laid a foundation for others to follow on a larger scale.

For low-income households, cost-savings realised through energy efficiency and the use of renewable energy can go a long way towards other basic day-to-day needs. Given that such energy efficiency interventions in low-income housing are fully subsidised by government, it is also important to assess whether this additional investment into energy efficiency is effective in yielding the intended benefits both for beneficiary households and for reduction in CO_2 emissions in the country.

The National Department of Human Settlements (NDHS) is responsible for the delivery of subsidised housing for identified beneficiaries who are defined to be South African citizens earning less than R3 500 per month. After the promulgation of the building regulations in 2011, in 2013, the NDHS drastically increased the housing subsidy quantum per beneficiary in order to comply with the regulations. NDHS also amended its architectural norms and standards accordingly in order to integrate the energy efficiency standards (NDHS, 2013). With reference to the housing subsidy increase, the Minister of Human Settlements, in her 2015 budget vote speech, stated that the subsidy quantum stood at R160 573 per house in 2014 as compared to R77 868 in 2009 (Minister Lindiwe Sisulu, Minister of Human Settlement Budget Speech, 2015). This translated to around 48% increase as compared to past annual increases of around 14% which were mainly linked to building material cost escalations. The NDHS then made it compulsory that all subsidised houses built from 1 April 2014 should comply with the energy efficiency regulations.

1.2 Problem Statement

SANS 10400-XA is an amendment of the National Building Regulations which regulates the use of energy in buildings through efficient design and the use of renewable energy. It was promulgated in 2011 and was integrated into the norms and standards of government subsidised low-cost housing by the NDHS in 2014. In order for the regulations to be adhered to, additional capital outlay was required and this had a direct impact on low-income housing subsidies, such that the NDHS drastically increased the housing subsidy to cater for the requirements of adhering to SANS 10400-XA.

Prevailing studies on energy efficiency in low-income housing mainly focus on energy poverty and the responsive mitigation strategies. The effectiveness of the SANS 10400-XA regulation in subsidised low-cost housing has, however, not been systematically studied. Given that a growing number of responsive projects and houses have now been completed and occupied for more than five years, this study serves as one of the initial studies for the required evaluation. It can therefore be understood as a study within the field of policy evaluation.

1.2.1 Rationale for the Study

The research problem is important because if low-income households are not benefitting from energy efficiency measures implemented, it would be critical to establish the reasons for this. Implications could be that:

- Implementing agents of government's energy efficiency policy are not effective in policy implementation
- Government is funding energy efficiency that does not yield the intended results, and hence households do not benefit from expected thermal comfort and energy cost savings
- Households continue to rely on non-sustainable energy sources for daily household needs like cooking, heating bath water and space heating

Arising from the concerns above, it was therefore important to investigate if government funds geared towards energy efficiency are spent as expected and if the intended energy efficiency measures are effective to the end-users (the beneficiaries who are low-income households).

In 2014/15 the NDHS annual budget allocation from National Treasury rose by R2.2 billion to R30.5 billion. This jump was partly to cater for the national revised architectural norms and standards introduced by the department for the provision of energy efficiency interventions for new homes (Department of Human Settlements, 2014). The Department's allocation over the last two years has been as follows: R32.3 billion in 2018/19 and R33.8 billion in 2019/20 (National Treasury, 2018; NDHS, 2019). With this increasing budget allocation for the construction of low-income houses, it is important to evaluate if this investment by government is achieving the intended results of improving the quality of life of the poor, especially since the subsidy amount to construct each house has been increased specifically to provide for energy efficiency.

Jongelin et al. (2012) supports the importance of such a study by highlighting that after energy efficiency measures have been implemented "monitoring is necessary during the whole life span of the intervention to assure a proper introduction, installation and use of the intervention" (ibid., p.3). The study further argues that with solar geysers, for instance, it is important to monitor the use in order to evaluate the initial capital cost with the benefits of long-term energy savings.

1.2.2 Research Question

Arising from the stated motivation / rationale and problem statement, the study was guided by the following research question:

What is the effectiveness of SANS 10400-XA on low-income houses built and occupied since 2014 towards addressing basic household energy needs?

Resolution to this question was addressed through answering the following sub-questions:

- What are the key insights on household energy efficiency policies and implementation outcomes in developed countries and locally?

- What are the levels of compliance (in the implementation) with the regulations by the two provincial departments responsible for the case study projects?

- Are households benefitting from energy efficiency as regulated in SANS 10400-XA for basic energy needs?

1.2.3 Working Hypothesis

Guided by the increased subsidy in line with the amended NDHS Construction Norms and Standards since 2014, the study anticipated to find proper use of funding directed towards energy efficiency interventions and acceptable levels of beneficiary satisfaction as well as tangible contributions towards CO_2 emissions reductions for South Africa.

Responsive policy and regulations coupled with additional/dedicated funding for EE and RE in subsiding housing delivery enables the outcomes of improved thermal comfort and affordable hot water while ensuring mitigation of energy demand from the grid as well as related GHG-emissions.

1.3 Conceptual Approach

The study adopted a qualitative research method because it pursues responses to a given research problem from the perspective experiences of the subjects involved. It is in this respect that the study explores the experiences and outcomes of SANS 10400-XA, energy efficiency regulations, in low-cost housing in Gauteng and the Western Cape.

A case study approach was adopted as it is most suitable towards addressing the questions of "how" and "why" of issues within complex and dynamic contexts. This approach relied on primary data from interviews and observations as well as secondary data from literature as the key methodological approaches for the study. The two case sites and international cases of policy outcomes are the key contexts explored to ascertain the effectiveness of the regulations in the implementation in the context of low-income housing.

With reference to external practice and in relation to the first sub-question, the study takes a brief look at Germany whose energy efficiency policy is "comparatively seen as a leader in thermal efficiency policy with stringent mandatory standards for insulation, windows and boilers" (Galvin, 2014, p.38). In its assessment of the International Energy Agency (IEA) members' energy efficiency policies, the IEA describes the German policy instrument as particularly innovative (IEA, 2009). The study also appraises literature on the outcomes of Dutch energy efficiency building regulations, as well as other studies, which mainly explore the energy performance gap in their regulations, especially in buildings. The Netherlands Energy Efficiency (EE) policy implementation is reviewed because of its strong commitment to reducing greenhouse gas emissions and its planned rapid transition to a carbon-neutral economy and energy security. Its emissions reduction targets are in five sectors which are comparable to those of South Africa; electricity, industry, the built environment, mobility, and agriculture. Similar to South Africa, the Dutch government has instituted subsidies to support the various energy efficiency drives.

It is through such policies that a developing country like South Africa could benchmark itself in the pursuit of effective energy efficiency measures.

To assist in responding to the second sub-question the study explores how compliance to the regulations was pursued under the two provincial human settlements departments that implemented the projects. The second sub-question explores the various steps taken to ensure compliance. Technical skills as well as an understanding of the regulations and communication among critical stakeholders were key criteria towards ensuring compliance.

To respond to the third sub-question, the study gathered interview responses from beneficiaries on how the effectiveness of the policy is towards improving access to energy for their households. It is important to appraise policy (and especially these regulations) in order to track and monitor progress made towards achieving the overall energy policy objectives of energy efficiency and renewable energy measures.

The overall findings show that both provincial departments have been effective in implementing and are therefore compliant with the regulations for hot water supply from solar energy and improved thermal comfort through insulation and similar energy efficient design. The study further shows that the best rewards of these interventions of energy efficiency are reaped in the summer months which make up to around eight months of the year in South Africa. The study however also finds that communities and beneficiary households are experiencing performance gaps mainly due to poor specifications and installation of related products.

1.4 The Significance of the Study

This research adds value to discussions on energy efficiency in low-cost housing and the effectiveness of the government’s policy and intervention in energy efficiency and sustainable development of human settlements in general. The study thus facilitates an understanding of the end-user experiences as well as their appreciation of energy efficiency and what this means for their day-to-day quality of life. It is equally valuable for decision-makers towards adaptation of future interventions on energy efficiency in low-cost housing both at policy-making as well as implementation stages. Given that the study primarily draws from implementer-experiences, it can therefore serve a feedback role for the Department of Human Settlements in particular, but also for most other stakeholders responsible for translating SANS 10400-XA into low-income housing developments.

1.5 Delimitations of Scope of the Study

The focus of the study is on two low-cost housing projects (Clayville Extension 45 in Gauteng and Joe Slovo Park Phase 3 in Cape Town) which serve as the case study sites with the understanding that SANS 10400-XA has now become part of the architectural norms and standards of the NDHS since 2014. Gauteng and the Western Cape Provinces were purposely selected as implementing agents because they receive the enhanced subsidies and it is important to assess how they interpret the norms through the implementation of their housing projects under the new subsidy regime (especially in planning and product choice as there is a growing variety of energy efficiency products in the market).

Only two climatic zones (as per SANS 10400-XA) are addressed – zone 1 (Gauteng) and zone 4 (Western Cape). The other four climatic zones are likely to show different results. Residential sector development entails a diverse range of housing products which must all comply with the SANS 10400-XA regulations. The study however only prioritised the government subsidised low-cost residential sub-sector under the NDHS. Energy for cooking is also not addressed in SANS 10400-XA and is therefore not included in this study.

The study assessed a purposely selected sample of houses built from 2014 because from 1 April 2014 the NDHS made the SANS 10400-XA specifications compulsory (NDHS, 2013). The sample is not necessarily representative of the emerging practice and outcomes of implementing SANS 10400-XA in the sub-sector.

1.6 Definition of Terms

This section provides an overview of key terms, definitions and phrases used (some interchangeably) in this study:

Beneficiaries / households – Beneficiaries are low-income families that have benefited from the government housing subsidy scheme. They are classified as South Africans with a monthly income of less than R3 500. In this study they are also assumed to be the occupants of the houses in the case study sites.

Climatic zone – An area with a specific climate that is derived from average temperature and average rainfall. SANS 10400-XA characterises South Africa into 6 climatic zones with Cape Town (zone 4) characterised by temperate coastal climatic conditions and Clayville (zone 1) with cold interior climatic conditions. These climatic zones serve as the basis for responsive energy efficiency measures required to contribute to thermal comfort in a house.

Energy efficiency – Energy efficiency in buildings relates to reduced energy consumption for basic household needs which in turn leads to less reliance on coal generated electricity. In this report energy efficiency specifically relates to the measures implemented in low-income houses to ensure less reliance on electricity for domestic water heating and indoor space heating.

Energy poverty – "Energy poverty is the inability of households to afford adequate energy services in the home, which can have several impacts on health and well-being" (Nierop, 2014, page 1). It therefore entails the lack of or inadequate access to modern energy services by low-income households for their basic daily energy needs. In a household, modern energy services refer to electricity for power, energy for hot water supply as well as for space heating especially during the winter season.

FLISP – Finance Linked Individual Subsidy Program (FLISP) is a subsidised housing program targeting people that earn between R3 501 and R15 000 per month. The programme was developed to enable affordable home ownership for low-income earners. Individuals in this income band generally struggle to qualify for housing finance as banks regard them as high-risk borrowers. The government therefore provides part of the financing required to purchase a home.

Low-cost housing – A simple house structure designed and constructed in a cost-effective manner. In the context of this study low-cost houses are fully subsidised by the government of South Africa to ensure access to permanent shelter for poor households.

Low-income housing – This is used interchangeably with low-cost housing above. However, the two differentiating words, income versus cost make reference to different parameters, low-cost makes reference to the cost of delivery especially in relation to the subsidy amounts, while low-income references the target beneficiaries. As a result, outside the subsidised housing model, the two terms cannot be expected to coincide.

Megaproject – A Department of Human Settlement's housing development project of no less than 10 000 housing units of various design typologies targeting different income groups. A megaproject is also a mixed land-use development which includes socio-economic amenities and employment opportunities in close proximity to the houses.

Norms and standards – Architectural design and specification guidelines set by the Department of Human Settlements with which all subsidized house designs and construction must comply.

Passive design – A house or building design that relies on natural energy sources like the sun and shading for heating and cooling in order to reduce dependence on additional energy input for heating or cooling a building.

Retrofit – To modernise existing buildings, to bring them up to current standards especially with respect to energy efficiency.

RDP walk-up unit – A fully subsidised housing unit built in a multi-storey block. Each block has a maximum of 4 storeys and hence no lift is required. These units have to be built with the norms and standards of the Department of Human Settlements.

Social housing unit – A government-funded rental housing unit for households earning between R1 501 and R15 000 per month.

1.7 Structure of the Thesis

The study comprises of six chapters followed by a list of references and appendices. The first three chapters explain the context and scope of the study and the subsequent chapter's present data capture and analyses in relation to the sub questions.

Chapter 1 presents the introduction, contextual background and the statement of the research problem (research question and sub-questions). The chapter then presents the rationale and significance of the study, followed by a section on the definition of key terms of the study.

Chapter 2 presents a review of relevant literature on key themes of the study. These include studies on the outcomes of household energy efficiency policies in Germany and the Netherlands. The review also covers literature on the outcomes of energy efficiency policy implementation from case studies in South Africa

Chapter 3 presents the research approach and method of the study. It motivates for the research approach employed, the data collection tools and analyses method towards the derivation of findings. The chapter concludes with an overview on ethical considerations of the study.

Chapters 4 and 5 present detailed analyses of primary and secondary data to respond to the research question and sub-questions. The two chapters explore the key themes of the study and analyse the implementation of the energy efficiency (EE) building regulations and households' experiences and outcomes. After a brief introduction of the two case sites (in Chapter 3), Chapter 4 goes on to present and analyse data collected in Clayville, Gauteng and Joe Slovo Park, Cape Town in an effort to respond to the sub-question of implementation compliance to the regulations. Chapter 5 presents data that responds to the third sub-question on households' experiences, in both case sites, especially in relation to addressing basic household energy needs through EE measures stipulated in the regulations.

Chapter 6 consolidates all the sub-findings from chapters 4 and 5 into the key findings in relation to the research question in order to draw overall conclusions and recommendations of the study. The conclusions present a measure of the progress made in EE policy implementation and a measure of households' experiences with energy efficiency for basic energy needs.

The study also presents a reference list as well as appendices on data gathered during the research as well as the ethics clearance certificate for the study.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

This chapter appraises a prioritised sample of studies within the field of policy evaluation in energy efficiency policies and related implementation. The first section appraises literature / studies on residential-sector energy efficiency policy in Germany, especially in terms of implementation, levels of compliance with the policy and the experiences of beneficiary homeowners. The section then analyses the energy performance gap as discussed in several studies on the evaluation of the Dutch energy building regulations. It appraises literature from several studies which argue on the existence of an energy performance gap in policies, regulations as well as in experiences of households with the implemented EE measures. It further discusses ways to mitigate this in order to improve policies for better energy efficiency outcomes. The review thus assisted this study in identifying the critical variables and parameters adopted for the study.

The second section looks into South Africa's energy policies with specific reference to low-cost housing. The review looks briefly into the 1998 White Paper on Energy Policy and the Energy Act of 2008 especially with regard to their implementation and outcomes which led to the 2011 SANS 10400-XA as amendment to the National Buildings Regulations that promotes energy efficiency in new buildings. Lastly the section reviews studies on past energy efficiency implementation in low-cost housing projects to understand the outcomes of such projects in order to serve as a guide in the execution of this study.

2.2 The German National Action Plan on Energy Efficiency

The study prioritised the appraisal of the energy efficiency policy of Germany as it is commonly argued in literature to be exemplary in Europe and the world. Galvin (2014) and the International Energy Agency (IEA, 2009) argue that the Germany EE policy is a front-runner in the industry and in Europe. Galvin (2014) noted that Germany is "comparatively seen as a leader in thermal efficiency policy with stringent mandatory standards for insulation, windows and boilers" (Galvin, 2014, page 38). In its assessment of energy efficiency policies of its members, the International Energy Agency (IEA) describe the German policy instruments as particularly innovative (IEA, 2009). Similarly, SANS 10400-XA has strong elements that aim to achieve thermal efficiency and this ties in well with the priorities tackled by the German policy. The BMWi reports that almost 40% of total electrical energy in Germany is consumed in buildings, with heating accounting for the largest portion (BMWi, 2014). The BMWi therefore regards the building sector as a key role player in climate change mitigation and this can be achieved through delivering significant reduction of greenhouse gas emissions and reducing energy consumption from conventional energy sources that are not sustainable (ibid.). The country's energy efficiency policy is therefore not only about securing the supply of energy but also ensuring the efficient use of energy particularly in the residential building sub-sector which is regarded as one of the critical sub-sectors in the mitigation of climate change.

The current energy efficiency policy under implementation in Germany (the National Action Plan on Energy Efficiency - NAPE), is designed to deliver a considerable 20% of energy savings from the residential building sub-sector by 2020, and 50% by 2050 (BMWi, 2014). This target is from the baseline year of 2008 and is derived from a comparison of scenarios of energy-saving measures between 2008 and 2020 from initial estimates by a German Working Group on Energy Balances (ibid. page 10)

It is worth noting that the programme was commissioned under the EU Energy Efficiency Directive and released in December 2014. Drawing from the energy efficiency mandate from the EU, the policy was then promulgated by the German Federal Government in 2014 to set out the energy efficiency strategy for the 18th legislative term (BMWi, 2014).

Residential buildings contribute 26% to Germany's overall energy use and 11% to CO_2 emissions (Baginiski and Weber, 2017). Furthermore, "around 83% of consumed energy in households is used for space and water heating" (ibid. p2). It is therefore important that policy makers in residential energy efficiency consider households as critical stakeholders and investors. Sheng et al. (2018) say that the German residential energy policy follows a hybrid policy model in terms of combining top-down and bottom-up policy designs with more demand side management and high level of public participation. Thus, residential energy policy in Germany is not only initiated at high level, but instead it includes contributions from local communities.

To ensure that residential buildings are energy efficient, the Federal Government adopted technical efficiency measures targeted towards the refurbishment of existing residential buildings and towards the construction of new buildings to reduce energy consumption and

CO_2 emissions (BMWi, 2014). The technical energy efficiency measures promoted under the policy include the following:

- “Retrofit measures of increased insulation of walls, floors and roofs
- Replacement of small windows with big windows to attract passive day lighting
- Usage of energy efficient electrical appliances in homes” (BMWi, 2014, p. 10)

These technical measures require major changes (insulation) to the building envelope (ibid.). Exterior walls, roofs, floors and windows must be made 30% energy efficient, and the envelope must have insulation levels improved by at least 15% (ibid.). Space heating and hot water, ventilation and cooling systems must be upgraded towards higher energy efficiency and integration of renewable energy technologies (ibid.). If the regulation is adequately applied by homeowners through refurbishing buildings with the required building envelope, it was anticipated that Germany would likely accomplish its climate-mitigation targets of 2020 and 2025.

In addition to Germany’s Energy Conservation Act, the country had also earlier adopted the Heating Cost Act of 2009 which regulates the cost of space and water heating in rented properties (ibid.). Literature shows that rentals make up to 60% of German household’s tenure thus making this Act significant (Schröder et al, 2011). The regulation of the cost of space and water heating forces tenants to use energy sparingly which in turn creates bigger incentives for them to save energy. If the landlord adopts these energy efficiency measures, the savings are passed on to the tenant (ibid.).

One sub-sector of rental housing is social housing which is mainly occupied by low-income households. Zheng et al. (2018) analysed the behaviour of social housing occupants in relation to energy consumption. The study found that more energy goes into space heating and preparing hot water (ibid). These two energy uses are also targeted by SANS 10400-XA in order to reduce electricity consumption and improve thermal comfort in buildings.

Findings by Zheng et al. (2018) indicate that social housing occupants do not necessarily employ measures to save on energy. They found this to be mainly because “part of energy cost for space heating and domestic hot water in German social housing is provided by the local government” (ibid, p. 262). As a result, even though the energy welfare program provides access to energy and enables low-income households to fulfil their heating needs, they do not become mindful of the energy cost implications. This defeats the aspiration to reduce consumption as stated in the policy. It can therefore be argued that the German Energy Agency (DENA) still has more work to do on educating citizens about the importance of reducing energy consumption. Similarly, in the two study case sites for this study, the finding is that energy is not systematically saved mainly due to ill-functioning solar geysers and improperly fitted ceiling insulation which force the occupants to consume additional electricity for space and water heating.

Another study on residential energy consumption was conducted by Schitz and Madlener (2019) to understand what drives energy consumption and expenditure among diverse groups of society. The findings are consistent with those of Zheng et al. (2018) presented above that space and water heating prove to be the main energy consumers in the residential sector in Germany. More than 82% of energy expenditure of private households is spent on space heating and hot water preparation (ibid.). Similarly, Gealis et al. (2019) investigated the impact of German energy policy on household energy use and found that the residential demand for space heating constitutes 68%, and 14% for water heating. Schitz and Madlener (2019) agree with this finding and they articulated that space and water heating are drivers of residential energy consumption and they outweigh other domestic energy usage such as lighting and cooking (ibid).

The second vehicle for energy efficiency implementation in Germany is through financial support from the state-owned development bank, Kreditanstalt für Wiederaufbau (KfW). The bank was established by the government at the end of the Second World War to finance the refurbishing of the housing stock (Power and Zalauf, 2011). After the war, the bank became responsible for lending funds for the construction of German infrastructure and buildings through repayable loans on more favourable terms compared to prevailing market rates (ibid.). The mandate of the bank has however evolved over time such that since 1996, the bank has been commissioned by the German government to lead programmes for improving the energy efficiency of buildings (Broc et al., 2015). Over the years, KfW programmes such as the National Climate Protection Programme of 2000 and the Climate Protection Plan 2050 (launched in 2016) have become central elements of the German Government´s climate strategy (Hennes, 2018). For this reason, KfW offers long term low-interest loans and grants (to homeowners, landlords and housing companies) tailored for energy efficiency investment in their properties (ibid.).

In assessing the KfW energy efficiency implementation route, Hennes (2018) and Galvin (2014) noted that the energy efficiency lending criteria of KfW has shortcomings. This is mainly because “the KfW’s concessional lending is not direct, but rather based on the on-lending principle” (Hennes, 2018, p. 8). This means that commercial and public banks facilitate KfW funds to the final customers. Upon application, the on-lending banks asses the credit worthiness of the customer and the viability of the investment (ibid). The two studies provide the understanding that KfW loans are subject to credit checks. As a consequence, potential homeowners with weak credit background may not qualify for these energy efficiency refurbishment loans. Galvin (2014) argued that the loan payback period of 20 years also makes the homeowners reluctant to participate in the scheme due to the long time it will take to receive a return on the investment.

This study notes that in South Africa, energy efficiency implementation in low-income housing is fully funded (subsidised) by the government. For all other owners or developers building new houses, energy efficiency compliance must be catered for within the overall construction cost. There are currently no regulations compelling the implementation of energy efficiency measures in existing houses although there have been some government interventions in existing low-income housing through retrofitting solar geysers. The uptake of the implementation of energy efficiency and the use of renewable energy sources has been voluntary, driven mainly by the increasing cost of electricity and intermittent electricity cuts.

The following section analyses the experiences and reactions of German homeowners with regard to energy efficiency measures designed and implemented by the Federal government.

2.3 Experiences with NAPE and Energy Efficiency in Germany

In line with the EU energy efficiency goals, Germany has an ambitious goal to reduce the energy demand from residential buildings by 20% by 2020. Literature shows that given the current rate of retrofitting, it is unlikely to come close to the 20% reduction goal (Gealis et al., 2019). This is partly due to relatively low uptake of thermal retrofitting by homeowners: “Only 0.8 % of houses in Germany are thermally retrofitted each year” (Galvin, 2014, p. 348). Schlomann et al. (2016) highlighted that in 2014 only 230 000 houses had been refurbished for energy efficiencies (thermal insulation, window replacement and boiler renewals) under the KfW scheme and this is miniscule in line with the 2050 (let alone the 20% by 2020) targets (ibid.). It can therefore be argued that because of the low rate of renovations, at around 0.8% per year, the energy efficiency policy has not been implemented as planned. This further means that the reduction in greenhouse gas emissions and reduction of reliance on fossil fuels for energy by households will continue. Furthermore, it is likely that the current less efficient building stock will constitute a greater share of residential buildings by 2050 (Baginiski and Weber, 2017). Because the progress is slow, it has been concluded that "the current forecast suggest that Germany will miss its interim GHG emissions target of 20% reduction by 2020" (Gealis et al, 2019).

Galvin (2014) concluded that homeowners are reluctant to comply with the policy through renovation or refurbishment of their properties with an efficient envelope design (big windows, insulated walls, floors and roof) as required by the policy. This is supported by Baumhof et al. (2019, page 2) who argue that "despite several governmental actions such as setting legal requirements, grants and low interest loans the refurbishment rate in Germany has currently not yet reached the politically focused target value of 2% per annum." Both these studies point to low implementation of the energy efficiency principles in NAPE. As stated in the previous section, around 60% of tenure is through rentals and around 40% of German homes are owner occupied (Schröder et al. 2011). Under the energy saving programme, homeowners are expected to invest in the required installations. The renting population will therefore not invest in properties they do not own and the owners also cannot fund retrofits through rental income alone (Schröder et al. 2011). This leads to the low rate of implementation of the energy efficiency policy. In contrast to this, in the South African situation, the SANS 10400-XA regulation is targeted at new buildings and it is the responsibility of the property developer (private owner or government) to implement the regulations. The end-user, be it a tenant or a low-income homeowner are not directly burdened with these costs but are expected to reap the rewards of thermal comfort, energy efficiency and the reliance on renewable energy sources.

In order to gain deeper insight as to why homeowners are reluctant to invest in the required interventions, Galvin (2014) highlighted that the policy only takes into account the thermal improvement cost and not the full cost of a refurbishment. For instance, if a homeowner is to insulate external walls, the cost of scaffolding, render and paint would not normally be included as part of the insulation cost (ibid. page341). Applied behavioural research on energy efficiency identifies cost as a critical barrier to investment in energy efficiency (Wilson and Chryssochoids, 2015). Capital costs therefore play a role in the low uptake of energy efficiency in German homes. This then constitutes a blow to the policy and the government's climate change mitigation goals/targets because the technical and financial considerations of energy efficiency refurbishments tend to discourage homeowners.

Another barrier to thermal retrofits is related to the shape and structure of the buildings. Galvin (2014) found that some buildings do not have the physical form that easily takes 16 cm insulation as stated in the policy. For example, if the eaves are too narrow to provide cover for the 16 cm thick insulation of external walls, the eaves have to be widened (ibid.). This can result in roof extension work or a new roof having to be added (ibid.). Homeowners often cannot afford such additional retrofits.

Baumhof et al. (2019) aimed at understanding why the refurbishment rate is far below the politically focused target of 2% per annum. Their study emphasises that Germany might be fined billions of Euros by the EU if the residential energy consumption reduction target of 20% is not accomplished by 2020. Baumhof et al. (2019) compares two groups of homeowners: those who had stated their intentions to conduct specific energy efficiency retrofits in the next few years ('future refurbishers') and a second group consisting of 'non refurbishers'. Both these groups understood the need for energy efficiency retrofit measures but have not taken any action to retrofit their properties (ibid.).

The group of 'future refurbishers' were deemed to be at a decision-making phase, and they understand the advantages of retrofits like reduced electricity bills and indoor comfort which are what mainly encourage them towards energy efficiency (ibid.). Even though this group is optimistic about energy efficiency, the findings of the survey indicate that they are also aware of the financial cost associated with retrofits (ibid.). As a result, this group can change their minds even though they hold positive attitudes toward the outcomes of energy efficiency retrofits.

Baginiski and Weber (2017) investigated the decision-making process when conducting energy efficiency refurbishments. The study found that policy makers interpret EE refurbishments as a rational choice made by a homeowner and that their role in energy efficiency is to make such investments. Contrary to this expectation, the findings indicated that homeowners consider energy efficiency refurbishment measures as mere refurbishments rather than an investment (ibid). The study further reported that homeowners are more likely to consider spending money on new driveway, furniture or new bathrooms, which are mainly cosmetic renovations and have nothing to do with energy efficiency. Many homeowners do not perceive energy efficiency alterations as necessary or as beneficial when compared to cosmetic upgrades. Baginiski and Weber (2017) thus argue that "policy makers have generally neglected behaviour determinants of homeowners' decision making" (ibid. 7). They conclude that in order to design more effective policies that promote widespread EE refurbishment uptake, it is fundamental to bear in mind the under-researched decision-making process of homeowners (ibid). Residential energy efficiency policy that considers homeowners as investors, is not sufficient if it does not also consider the behavioural aspect of the consumer (homeowner) as a decision maker. It can therefore be concluded that engagements with the consumers and consumer’s decision-making process on EE retrofits constitutes a pillar that has to be explored when updating the policy.

The studies appraised above outline homeowners’ reactions and attitudes towards energy efficiency policy implementation in Germany. Several factors emerge as obstacles to investment in energy efficient technologies. While it cannot be denied that German’s policy and regulations for energy efficiency are good and technically innovative; they lack the envisaged uptake. Compliance thereto is currently low due to various reasons as discussed above, with affordability as the most critical one. However, despite this overall low uptake, Scholmann, et al. (2018) argue that the residential sector has carried Germany in its overall energy efficiency compliance. They state that “almost 50% of the total energy savings gained in Germany in the period 2000-2016 are attributed to the residential sector. All this indicates the positive impact of the strong policy measures targeting buildings and heating” (Scholmann et al., 2018, page 86). This is shown from empirical evidence from an energy efficiency index analysis undertaken in their study which shows that the residential sector has achieved the greatest progress towards energy efficiency targets when compared to other sectors like transport and industry.

The literature reviewed above offers a reflection on the experience of the German government in implementing EE policies and regulations in the residential sector. Even though Germany is hailed as a leader in the formulation and implementation of energy efficiency in Europe, literature appraised shows a slow uptake of energy efficiency in the residential sector thus putting Germany at risk of not meeting its climate-mitigation targets of 2020 and 2025.

2.4 Overview of the Dutch Energy Regulations and the Energy Performance Gap

In the last two decades the EU implemented directives to monitor and report on the energy performance of buildings. The main ones are the Energy Performance of Buildings Directive (EPDB) and the Energy Efficiency Directive (EED). These frameworks require EU member states to strengthen and develop energy performance regulations for both new buildings and existing stock. Within these directives many EU-member countries have introduced various energy-saving requirements in their building codes and the Netherlands has adopted these frameworks.

In the Netherlands energy performance requirements for new buildings have been in place since 1995. They are updated on a regular basis while also moving towards the EPDB and EED's targets of an almost carbon-neutral building stock by 2050 and 'nearly zero-energy buildings' (NZEB) target by 2020. Visscher et al. (2016) found that the Netherlands building regulations have put greater focus on the design stage and that "the qualities (orientation, design, specification, built quality, maintenance etc.) of a building can only partially influence energy use. Another significant influence is determined by the behaviour of the occupant" (Visscher et al., 2016, page 553). Several studies concur that the design and building materials used give better indoor temperatures for thermal comfort but Visscher et al. (2016) argue that all other forms of energy consumption in residential buildings such as appliances, washing machines, televisions, refrigerators, stoves are not controlled by building regulations and thus present a gap in the regulations. The study identifies this as an energy performance gap and further notes that the energy demand for appliances can be significant.

A counter argument can be made that in South Africa, for instance, the regulations cover the high energy consuming elements for the highest impact. These are water heating and space heating which are identified in numerous studies as the largest energy consumers. The Netherlands is however pursuing the EPDB and EED frameworks target of 'nearly zero-energy building' (NZEB) target by 2020 and thus Visscher et al.'s, (2016) policy review is in an effort to establish how the NZEB target can be achieved while bearing in mind all aspects of energy consumption.

Visscher et al. (2016) further argue that after a new building is occupied, there is currently limited control over the energy use by occupants which further contributes to the performance gap identified in the study. Typically, energy savings calculations and assumptions are commonly modelled for the design and construction stage, with certain building materials as well as on the heating behaviour of house occupants in mind. Such modelling thus falls short of deriving total energy use and therefore does not accurately portray the actual energy usage in the houses once occupied. The resultant energy performance gap challenge is supported by several including authors Dronkelaar and Santamouris, (2018); Dronkelaar et al. (2016); RIBA (2013). According to the Royal Institute of British Architects (RIBA) 2013 plan of work, the performance gap exists across different stages of the building life cycle.

To address the performance gap through regulations, there is a need for the improvement of design stage calculation methodologies to address all aspects of building energy consumption, including regulated and unregulated uses. In many countries, regulatory energy performance at design stage is determined through compliance modelling which entails the implementation of thermal modelling to calculate the energy performance of a building under standardized operating conditions, (Dronkelaar et al. 2016; Conradie, 2018). Jakica (2018) analysed around 200 solar design tools and their numerous software features regarding accuracy in building design simulation methods. The study noted that there is a significant gap between the early design phase and the detailed building performance simulations methods. This demonstrates a great need for improvement in terms of developing simplified models and tools to ensure that better decisions are taken earlier in the design process. The absence of such simplified tools may explain why architects still widely use rules of thumb during the early stages of design, and this often leads to suboptimal solar protection design (Conradie, 2018).

Even though building energy modelling is becoming an integral part of today's design process, such modelling can contribute to the performance gap, especially because monitoring studies have shown that buildings can use as much as twice the amount of their theoretical energy performance (Dronkelaar et al., 2016; Manfren et al., 2013). In order to achieve improved energy efficiency and to narrow the energy performance gap it is important to validate accuracy levels of the modelling software in the market. Many related initiatives have utilized calibration techniques to fine-tune an energy model over extended time period (Dronkelaar et al., 2016 and Santamouris, 2018). Such calibration techniques take into account actual operating performance versus the initial modelled estimates. The calibration techniques thus highlight operational inefficiencies of a building while also pinpointing to the underlying reasons for differences between modelling estimates versus actual use (Dronkelaar and Santamouris, 2018).

Visscher et al. (2016) state that the performance gap is also related to poor built quality where the mechanical services are not commissioned correctly and thus malfunction and that occupants may not understand how to operate the installed systems. They attribute this poor quality to low levels of construction monitoring by building control in the Netherlands and other countries as well. The study concludes by proposing additional solutions towards energy consumption reduction in new buildings to bring the country close to the NZEB target. These include ensuring that energy efficiency products are correctly installed and monitored;

improving the skills base of builders and installers and an effective building control and enforcement process. They further conclude by stating that with the current outcomes, the further tightening of the energy performance regulation will not yield the intended reduction in energy consumption without addressing the performance gap. For the improvement on governance instruments and regulations, accurate insights are required into building modelling for better performance predictions versus the actual energy use, while recognising user- behaviour as a crucial contributor (Visscher et al. 2016).

Performance gap mitigation proposals identified in Dronkelaar et al. (2016) include extended training to reduce thermal loss in new houses. Extreme tightness of adjoining materials is required to limit air infiltration as air tightness has been found to be compromised during construction by for instance discontinuing insulation material or punctured barriers. The study goes on to argue for improvement in the installation of services like water drainage, electrical piping and air ducts which can often leave gaps that result in indoor thermal loss. Other areas suggested for further improvements include the eaves to wall junction of buildings that require proper insulation, and incorrectly placed doors and windows that reduce the actual performance of the thermal envelope (ibid.).

Several elements of the performance gap challenges identified by the studies appraised here have been identified in both case study sites of Clayville and Slovo Park. In Slovo Park poor on-site monitoring has resulted in extremely poor installation of the insulation which has been basically rendered useless in several houses. In Clayville, during an interview with an inspector, she mentioned that when inspecting the insulation in the ceiling they have to use a step ladder and look into the trap door because it had been previously found that the builder had only installed the insulation around the trap door and not throughout the roof. In line with Visscher et al. (2016), this study also noted that occupants might not understand how to operate the installed services. In particular, this study found that house occupants do not understand the concept of solar water heating where the water is heated by the sun (not by electricity) during the day and hence the best time to take a bath is in the evenings as opposed to the mornings as the water would have cooled down by then. Applying these findings towards improved consumer education would thus influence behavioural change and thus lead to improved energy efficiency outcomes.

2.5 South African Energy Policy Review and Analyses

2.5.1 Low Cost Housing in South Africa

The government provides subsidised housing to people earning less than R3 500 per month. This is done through the Housing Subsidy System under the Department of Human Settlements where prospective beneficiaries apply and are approved for a subsidy. The various provincial and municipal human settlements departments are responsible for the planning, construction and allocation of the subsidised houses.

The journey of low-cost housing in post-apartheid South Africa began in 1994 with the signing of the Botshabelo Housing Accord by the then Department of Housing (DoH). This entailed a partnership between the government and private construction companies to build one million houses in five years in order to address a housing backlog then two million houses (DoH, 2003). This undertaking ran parallel to the Integrated National Electrification Programme under the Department of Energy. In 1994, only 36% of rural and urban households had access to electricity (DoE, 2012). The two programmes were aimed at simultaneously creating access to decent housing and modern energy services for the poor. However, Winkler (2006) argued that the one million houses built in that period were a basic shelter with no thermal comfort intervention. The houses were basically four walled shelters with no ceilings, no internal partitions, no wall rendering and no access to electricity. In chasing the target of building one million houses, the DoH focused on quantity and not quality. The formal houses therefore had no energy efficiency measures and they contributed to unsustainable living that relied on the burning of fossil-fuel for cooking and space heating.

It is now accepted that the provision of affordable housing has to be responsive to our escalating global challenges like global warming and the increasing need for transitioning to renewable energy. However, an overwhelming challenge is the shortage of funds to provide housing efficiently to low-income households. The inadequate finance comes from competing government priorities with an ever-shrinking revenue base. The budget set aside for the delivery of subsidised houses had therefore always been prioritized towards the provision of a basic shelter and not the provision of energy efficient housing that allows the poor to enjoy the benefits of passive energy without having to burn fossil-fuel for their everyday needs. Over two decades (1994-2014) the government’s delivery of low-cost houses remained focused on basic shelter with no thermal comfort or energy efficiency interventions (Thomson, 2001).

In addition, most low-income housing beneficiaries are unable to make the initial capital investment required to enhance energy efficiency in their homes. With the amendment to the National Building Regulations in 2011 (thus making energy efficiency compulsory in all new buildings), energy efficiency became compulsory for low-cost housing as well and the National Department of Human Settlements therefore made budgetary adjustments in support of compliance with the amended regulations.

In addition, the uptake of solar water heating in all residential markets in South Africa has been relatively low considering that South Africa has high solar irradiation and when considering that SA has around 24% of the world's best areas for winter sunshine (IEA, 2019). The low uptake of solar energy technologies has been largely due to historically low electricity tariffs and high upfront capital costs of the related technologies (IEA, 2019). This paradigm is however, rapidly changing even in the low-income sector especially due to the perpetually escalating electricity costs and South Africa's ongoing commitment to sustainable development especially through the mitigation of global warming and climate change.

2.5.2 Progression of South Africa's Energy Policy

This section presents brief overview of the South African energy efficiency policy landscape in order to contextualise SANS 10400-XA regulations (Appendix A). The energy sector in South Africa historically focused primarily on the supply side with security of supply as the key concern and not on the issues of energy efficiency or security (demand side), especially for poor households (SALGA, 2015). Research indicates that South Africa is an energy intensive country, and the continued use of coal generated electricity is the cause of the country's high contribution to greenhouse gas emissions (du Plessis, 2015). This is mainly because South Africa generates electricity at extremely low costs largely due to the availability of very cheap low-grade coal coupled with generation stations built well in the past when capital costs were lower.

The South African energy policy has to a large extent been influenced by global energy policies many of which South Africa is a signatory to. These policies are aimed at mitigating climate change through lowering greenhouse gas emissions and through adjusting systems and societies to withstand the impacts of climate change. The Paris Agreement on climate change is one such global policy which was adopted in December 2015 at the United Nations Framework Convention on Climate Change's 21st session of the Conference of the Parties (UNFCCC CoP21). South Africa became a signatory to this agreement in 2016.The Paris Agreement is a comprehensive framework which guides international efforts to reduce greenhouse gas emissions by 2030 and thus minimize challenges posed by climate change. The target is to ensure that rising global temperatures do not exceed 1.5 °C (Ngwenya and Simatele, 2020).

In 2020 South Africa adopted the National Climate Change Adaptation Strategy (NCCAS) as an implementation vehicle of the Paris Agreement. The strategy outlines objectives, interventions and outcomes that give expression to the commitment to the Paris Agreement objectives (DEFF, 2019). Through the NCCAS South Africa has implemented some notable responses to climate change mitigation such as the provision of access to affordable, sustainable energy.

Access to electricity is reasonably high in South Africa primarily because the first White Paper on energy advocated for the supply of and access to electricity as opposed to energy efficiency and demand-side management. As a result the residential sector is responsible for 23% of total electricity consumption (Bohlmann, 2017). By 2016, 86.11% of all households had access to electricity. However, poor households living in government subsidised houses often spend more than 20% of their income on electricity (ibid). This is mainly because households use electricity for basic household needs such as space heating, cooling, cooking, lighting, water heating and powering their appliances (Sustainable Energy Africa, 2016).

The first policy framework on energy was the energy White Paper published in July 1998 by the then Department of Minerals and Energy (DME, 1998). The paper outlined various energy objectives in different sectors which included the residential sector with low-income housing as one of the sub-sectors. With regard to household energy use, the 1998 White Paper stated that poor households rely on less convenient and often unhealthy fuels such as paraffin, wood and biomass and proposed that energy needs must consider cost, access and health (DME, 1998). This can be viewed as an admission of the reliance on non-efficient and 'dirty' sources of energy and the existence of energy poverty particularly amongst impoverished communities. In order to mitigate the crises, the White Paper mandated the government to determine a minimum standard for basic household energy services and to monitor progress over time (ibid.).

Over a decade later the challenge of energy efficiency was taken up through the National Energy Act, No. 34 of 2008, which ushered in the consumption of renewable energy for low - income households in South Africa. The government made some strides in attaining the policy objective of diversification of sources for low-income homes with interventions such as the solar rebate programme under the DoE. This was a retrofit programme aimed at installing solar water heaters in low-income houses across the country with the aim of reducing a household's reliance on electricity (Thobejane et al. 2019).

As part of the Energy Act, the Solar Water Heating Programme (SWH) was implemented in 2012 and saw the installation of solar water heaters in hundreds of thousands of low-income houses in various municipalities like City of Johannesburg, City of Tshwane, Sol Plaatjie and Naledi. It was funded through a budgetary allocation to the Department of Energy from the National Treasury Department. "The Minister of Energy embarked on a Solar Water Heating programme with the target of installing 1 million solar geysers in households and commercial buildings in 2014" (DoE, 2016, page 54). By January 2013, around 315 000 solar water geysers had been installed, mostly to low-income households (ibid, page 54; Thobejane et al. 2019). The SWH programme was a demand-side-management programme aimed at relieving pressure on the national electricity grid Thobejane et al. (2019).For the first time in the implementation of the energy policy, funding was made available to support the plan for low-income households which led to a systematic implementation. The 2008 National Energy Act thus ushered in the use of renewable energy technologies in low-income households in South Africa through facilitating the above-mentioned retrofit programme.

The implementation of a policy requires the government to acquire relevant resources such as finances, skills and institutional capacity. In a review of the implementation of thermal efficiency in government-subsidised housing, Dobson (2015) argues that past energy policy was not implemented primarily because of lack of institutional capacity within DoE as well as a number of other reasons such as the lack of human and budgetary resources (ibid.). As seen in the case of Germany (where the federal government distributes financial resources to KfW to service the financial needs of energy efficiency implementation by homeowners). In the context of energy efficiency for low-income households in South Africa, the government (through the Department of Human Settlements) only began to fund the entire range of energy efficiency measures in 2014 (see Appendix C) while the other housing markets are expected to self-fund for compliance to the respective regulations.

In a further move to regulate the use of energy in buildings, an amendment to the National Building Regulations was published in 2011. This intervention aimed at regulating energy usage in new buildings through improved energy efficiency measures such as insulation and renewable energy technologies such as solar water heating. This was aligned with the global shift towards implementation of technologies to improve energy efficiency in both commercial and residential buildings (Morrissey et al. 2011). Similar regulations for existing buildings, SANS1544, have been under development since 2011 and are primarily targeted at existing stock of commercial and public sector buildings.

The implementation of the concept of energy from a variety of sources (including from renewable sources) was not vigorously implemented until South Africa's electricity supply crisis in 2007/2008 when the electricity net reserve margin dropped to below 5% and precipitated a national energy crisis that saw a wave of scheduled blackouts (Dobson, 2015). Dobson (2015) noted that the National Department of Human Settlements adopted SANS 10400-XA as the guideline for energy efficiency in new low-income residential buildings. The study thus notes "in April 2014 the national Department allowed for the housing subsidy quantum to be increased in order to execute the norms and standards set out by the SANS 10400-XA in government housing programmes" (ibid, page 13). The study goes further to note, "the subsidy increased from ZAR 78 000 to ZAR 110 947 per standard 40m²" (ibid, page 15). Appendix C is the NDHS letter of the revision of its norms and standards and subsidy quantum to include SANS 10400-XA interventions. From April 2018 the subsidy was revised upwards to a value of ZAR 116 867.00 per beneficiary (Department of Human Settlements, 2018).

One of the objectives for the implementation of energy efficiency measures is to improve passive thermal control in buildings thus improving thermal comfort in a home without requiring the direct usage of additional energy input (Conradie, 2018; Harris & Krueger, 2005). A further objective of introducing energy efficiency is to solve health problems caused by poor indoor air quality in homes (Winkler et al., 2002; Rosenberg and Winkler, 2011; IEA, 2019). Poor and unhealthy indoor air quality results from burning combustible fuels indoors (such as paraffin and coal) to cook or warm-up the house especially in winter. TERI (2008) estimated that annually around 2.5 million deaths can be attributed to indoor air pollution-related diseases. Tucker (2017) further noted that the regulation is intended to be a starting point for future enhancements of energy efficiency interventions for new buildings (Tucker, 2017).

Rosenburg and Winkler (2011) assessed the implementation of the South African energy efficiency strategy and found no self-evident translation of policy into implementation. One of their findings is that this failure to achieve specific strategic policy outcomes can be linked to complex interrelationship across a number of role players. The study thus argues for a critical role of supporting legislation. In particular the study found that "the 1998 energy policy failed because no process has been legally set in motion to guide, enforce and monitor the outputs" (Rosenberg and Winkler, 2011, page 6). Even though no yardsticks were set for monitoring progress, the majority of the anticipated outcomes had not been achieved (ibid.). The study thus affirms the ineffectiveness of policy implementation by highlighting that the National Energy Efficiency Agency (NEEA) had to be established in 2006 to support the policy implementation. It however appears that this intervention was not successful as there was a lack of buy-in to support the mandate of NEEA (Dobson, 2015). The agency was therefore "under resourced, and its authority was limited to oversight of the Eskom DSM programme" (ibid. page 7). Evidence further indicates that "in the first four years of its inception, NEEA was unable to obtain the funds for start-up operations' (Rosenberg and Winkler, 2011, page 7), NEEA 2010 (cited in Dobson, 2015).

There is a recent review and planned amendment of the SANS 10400-XA in the pipeline which will show a further progression of South Africa's energy efficiency in buildings and thus improve the outcomes of South Africa's EE goals.

2.6 Outcomes of Pilot Residential Energy Efficiency Retrofit Projects

2.6.1 Cato Manor Retrofit Project

Most of the secondary data on South Africa's government funded energy efficiency installations are biased towards the general benefits of greening and energy efficiency and the experiences of house occupants are rarely studied. The Green Building Council of South Africa (GBCSA) was a leader in the implementation of a greening retrofit project in Cato Manor Township in KwaZulu-Natal Province. The project was executed by Khanyisa Projects and Carbon Programmes in partnership with government departments and international agencies as primary funders. The aim of the project was to "demonstrate the benefits of energy efficient design and interventions in low-income houses, and also to show that people's quality of life can be improved while keeping the country's development on a low carbon path" (GBCSA, 2012, page 3).

Similar to the case studies covered in this study, the Cato Manor community is a low-income community. As illustrated in Figure 2.1 households use electricity as the main source of energy, mainly for lighting and cooking but also in conjunction with other sources such as paraffin, wood and coal (ibid.).

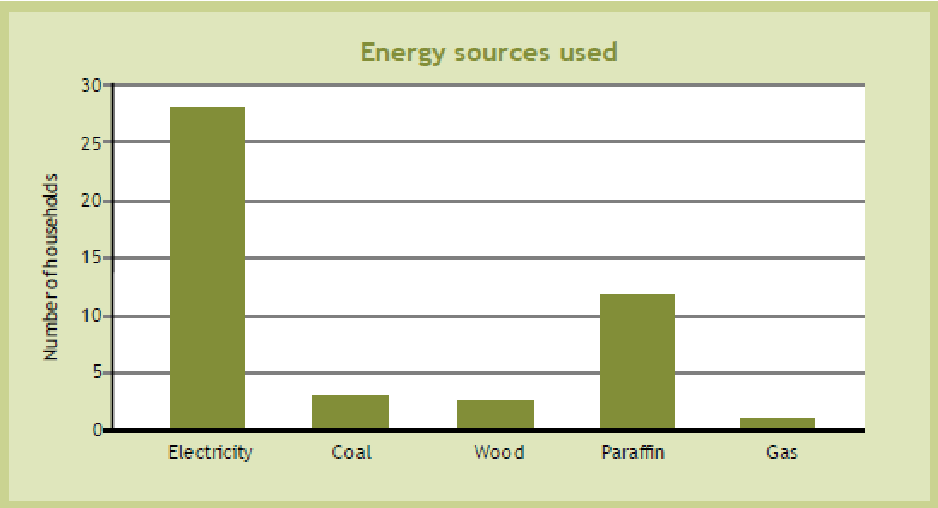

Figure 2.1: Cato Manor Household Energy Sources, Source: GBCSA (2012, 9)

The retrofit project comprised of 30 houses, located in a small section of the larger Cato Manor development which was implemented by the municipality in 2006. Each house received energy efficient retrofits in the form of a 100-litre low pressure SWH, insulated ceilings, efficient lighting and a heat insulation cooking bag called the wonder bag (ibid.). The project was implemented between 2010 and 2011, prior to the promulgation of SANS 10400-XA and the aim was to demonstrate the benefits of greening to low-income communities. The project did not only involve the greening of the houses but also included the provision of rainwater harvesting tanks whereby households were encouraged to harvest rainwater and establish food gardens (ibid.). The project was presented as a climate-change mitigation demonstration project at COP17/2011 which was hosted in Durban (Loggia et al., 2015). After the retrofits, beneficiaries were asked to express their level of satisfaction or dissatisfaction with the installed energy efficiency technologies. The key findings of the post-project qualitative study (Loggia et al. 2015) indicated that:

- There was generally better indoor thermal comfort related to the installation of the extruded polystyrene ceiling.

- The houses presented greater energy efficiency from the solar water heaters, insulated ceilings, CFL lights, and the use of wonder bags for cooking.

- Residents of retrofitted houses were employed in the project for activities such as energy efficiency installations thus creating opportunities for green jobs.

In a similar study on the Cato Manor green street retrofit project conducted by the United Nations Climate Change programme in 2011, beneficiaries reported satisfaction with the overall project and associated technologies. The report indicated that beneficiaries realise significant energy, water and time savings, thus increasing their disposable income and improving their economic status (ibid.). Fresh nutritious vegetables grow on their doorsteps, thus reducing the need for transport to shopping hubs (ibid.). In addition, residents were employed in the project for different roles. Community training workshops were also conducted to educate participating households on the efficient use of resources, the use and maintenance of the new technologies and introduction to climate change (ibid.). Due to additional green economy principles such as rainwater harvesting and food gardens, it can be argued that the Cato Manor project did not only enhance energy efficiency and the lives of the beneficiaries, but it also addressed climate change in terms of mitigation and adaption.

The project also served partly as a quantitative study site where monitoring was done over three months after the installation of all the retrofits to find out the impact of the interventions. Quantitative data were sourced from data loggers that were installed by the municipality's Architectural Department. The data loggers were installed to measure temperature and humidity levels. The key findings of the post project survey were as follows:

- "The SWHs were the most appreciated retrofit product with more than 60% of interviewed beneficiaries pointing to the SWH benefits. "The water from the SWH is primarily used for bathing (97%), washing dishes (90%), cooking (60%) and laundry (30%)" (ibid, page 11)

- Some beneficiaries experienced problems with their SWHs. These were however later fixed and a group of residents were trained for long-term maintenance of the installations.

From quantitative data:

- The ceiling insulation resulted in a drop of indoor summer temperatures by 4-6˚C
- There were electricity cost savings reported by 50% of the households and this was confirmed from meter readings (GBCSA, 2012, pages 3-4)

GBCSA (2012) study shows that, due to energy efficiency measures installed in homes, the quality of life has improved and households are enjoying the benefits of the interventions. This is similar to the outcomes of Clayville and Slovo Park where the quality of life of households has improved from the energy efficiency measures installed. In all three case sites, apart from cost saving, residents also reported that they valued the time saving benefit of having hot water readily available instead of waiting for a kettle to boil. The project was however not without challenges and it is important to review these challenges in order to be aware of them during the undertaking of this study. These included:

- Poor roof quality posed a risk of damage and injury to workers installing SWH
- Roof leaks needed to be repaired before ceilings were installed.

The Cato Manor Project review and other studies referenced above show the positive impact and benefits that energy efficiency interventions have, not only to beneficiaries but also to the environment. These interventions have however been piecemeal and on a pilot-project basis and have been mainly funded by private NGO/aid donor organisations locally and globally. There has not been a full roll-out of such interventions in houses subsequent to the documentation of the successes and impact of these pilot projects. If interventions of this nature were to be implemented on all existing low-cost houses, (estimated at 3.2 million in 2018 by NDHS), together with the intervention brought about by SANS 10400-XA on new buildings, SA would make great strides in reducing energy dependencies on non-renewable sources. This would thus make significant contributions towards South Africa's input into mitigation of global climate change.

2.6.2 Alexandra SWH Project

Another post-installation study on government sponsored energy efficiency was conducted in Tsutsumani (Alexandra Township) and reported in Pooho (2015). The study reported a mixture of benefits and setbacks experienced by households of Tsutsumani from the retrofit installation of 100-litre low pressure SWH systems. Primary data were collected using semi-structured interviews with a purposely selected sample of 20 households. The retrofit project was implemented by the City of Johannesburg and was funded by the then Department of Energy under the Eskom solar rebate programme. The solar rebate programme made the installation of solar geysers affordable with the rebate from Eskom reducing the capital and installation costs by 20-30% (Rankin and van Eldik, 2008).

The Tsutsumani settlement is the outcome of a government funded low-cost housing project built from the early 2000s as part of the government's Alexandra Urban Renewal Project. Beneficiaries in this project were low-income households moved from informal settlements in the nearby Alexandra Township. The study noted that most of the beneficiaries are unemployed and thus depend mainly on government social grants for their livelihood and that most of the households surveyed were headed by females (Pooho, 2015).

The purpose of the SWH retrofit project was to "manage electricity demand through a move to renewable energy for domestic hot water so as to mitigate inadequate capacity and discourage the use of electric geysers" (ibid. page 43). Thobejane et al. (2019) also note that the programme was a positive step towards the use of renewable energy and diversifying the energy mix in the country. It was an introduction of alternative technologies for affordable energy in light of the majority of low-income households not affording electricity. The Tsutsumani project was initiated in 2012 (around the time when the country faced electricity supply shortages with resultant load-shedding) to manage the strain on the electrical grid. Unlike the Cato Manor project, the Tsutsumani project only involved the installation of SWH. Pooho (2015) reported on detailed experiences in three stages of the SWH project: the pre-installation stage (which involves the planning stage), the installation stage and the post-installation stage where households experience the benefits or setbacks of the technology (Pooho, 2015).

The post-installation stage findings closely align with the objectives of this study, especially with regards to analyses of the outcomes of energy efficiency measures in low-cost housing. Pooho (2015) findings in this stage show a combination of benefits and setbacks experienced by households with the SWHs retrofit. The benefits are derived from the effective hot water from the SWH in the summer months and are also related to "utility cost saving particularly in summer months because there is ample hot water heated by the sun" (ibid. page 68). It can therefore be argued that SWH is effective in reducing dependency on the electricity grid.

The project has also proven to be of significant financial benefit to residents as the electricity cost savings provides them with more disposable income for other basic household needs.

An overwhelming finding however was the inefficiency of the SWH in winter. The geysers do not produce enough hot water in winter especially given the size of the households in the homes. Given that hot water is needed the most in winter months especially for bathing, washing dishes and doing laundry, this shortfall renders the system to be highly ineffective. The study also established that households depend on other energy sources like electric kettles and paraffin to heat water in winter. It can thus be concluded that SWH in general and low pressure SWHs in particular are not effective in winter when compared to summer performance (ibid.). Additional experience by beneficiaries was the over boiling and spillage of the SWH in hot summer months (ibid.). This hot water spillage was caused by the geysers overheating and hot water being released through the pressure valve; the water release was excessive and caused damage to interior walls and ceilings and has influenced residents' rejection of the technology (ibid.). Problems of this nature can be attributed to the poor quality of the systems possibly coupled with poor workmanship during installation.

Another post-installation setback reported by Tsutsumani households is that "the capacity of the storage is inadequate for all household members particularly in the morning" (ibid. page 71). The hot water in the tank is not enough for children when they prepare to go to school and adults to go to work. They reported that "the water is enough for just two members of the household to bath; thereafter hot water gets finished in the storage tank" (ibid., page 71). Solar water heaters with electrical back-up are essential for such patterns of consumption.

Lastly, further conditions that exacerbate post-installation problems are "the lack of servicing and maintenance of the technology" (ibid. page 71) by the homeowners. Research indicates that since the solar water heaters were installed, they have not received maintenance and servicing (ibid.). Any system that is not maintained is bound to have technical problems. The setbacks in solar water heating technology as mentioned above suggest that the energy efficiency measures installed by government in these low-income housing has become ineffective in winter months and also due to the lack of maintenance. Thobejane et al. (2019) concluded that there were several failures in the SWH program. They attribute these failures to the lack of training and maintenance of the geysers, poor installation quality, insufficient community awareness and the lack of quality standard specifications for the testing solar geysers before installation, (Thobejane et al. 2019).

The Tsutsumani project provides invaluable lessons on the solar water heating programme implemented by the City of Johannesburg in collaboration with the then Department of Energy. Even though the project was intended to alleviate the strain on the electricity grid when the country was faced with an electricity-supply crisis, Pooho (2015) shows a number of setbacks in the project. It can therefore be argued that in order to achieve a visible impact in getting households off or less reliant on the electricity grid, a combination of measures would be required, as opposed to standalone or piecemeal measures. This provides a highly relevant insight for this study on the outcomes of the suite of energy efficiency measures that come with SANS 10400-XA.

Regarding the studies done so far, the outcomes on implementation of the regulations are yet to be studied. The case studies referenced above relate to implementation of electricity demand management as opposed to an integrated, holistic use of renewable energy with the aim of reducing greenhouse gas emissions and increased reliance on sustainable energy sources. Anecdotal evidence indicates that the provincial governments of the Western Cape (in Joe Slovo Phase 3) and Gauteng (in Clayville Extension 45) have integrated the above-mentioned specifications in low-cost housing built from 2014. For instance, renewal energy interventions such as SWH and thermal efficiency measures (building orientation, proportion of fenestration, roof and ceiling insulation) have now been incorporated into government subsidised houses. Given that post-implementation experiences of beneficiaries have not yet been explored and reported in the literature, the issue was identified as a key research gap for this study. The study therefore prioritised the evaluation of household experiences as a critical component of the outcomes of the regulations.

2.7 Conceptual Framework

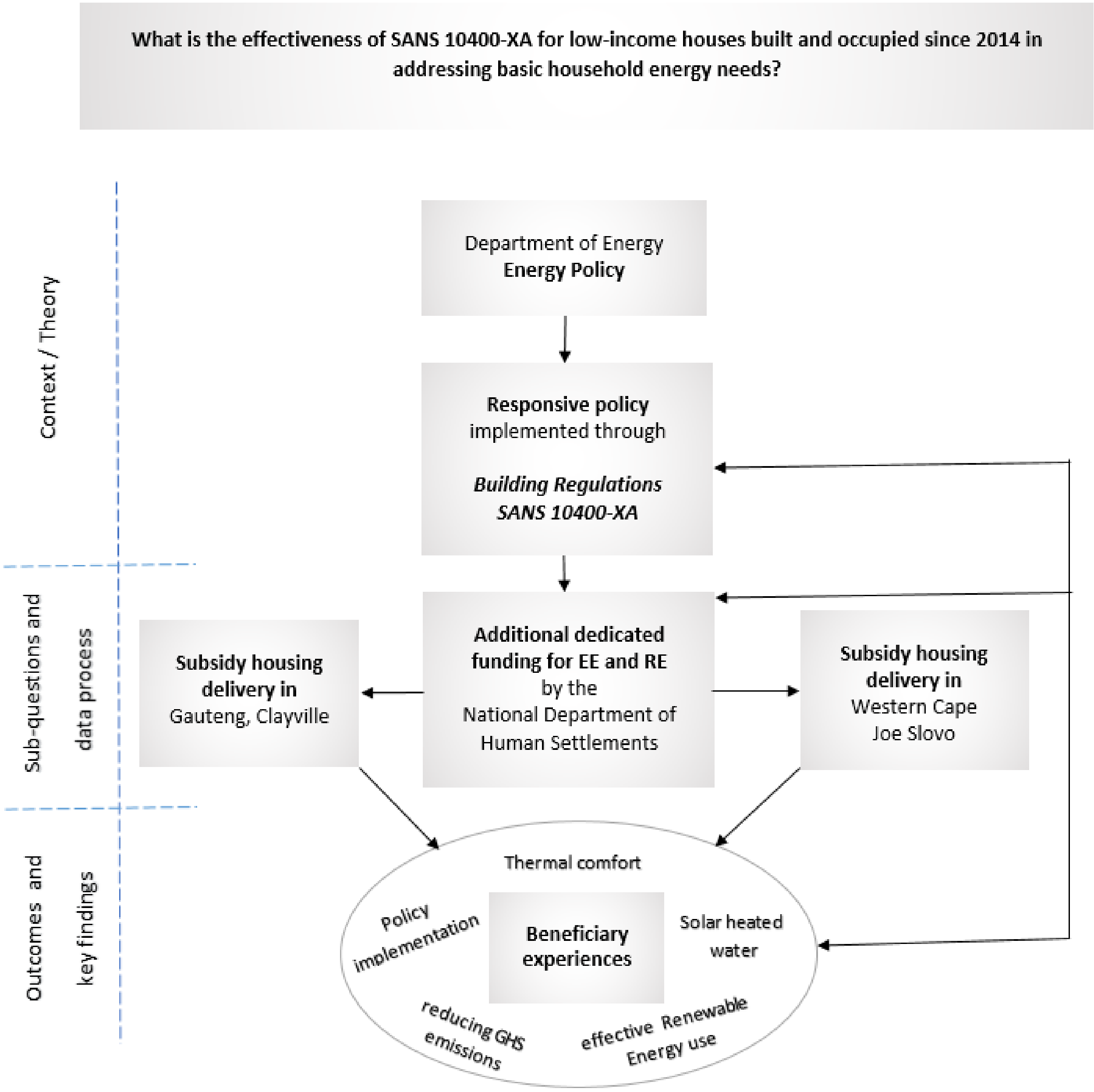

Figure 2.2: Conceptual framework showing key variables

The conceptual framework in Figure 2.2 identifies key components of the study and shows how the related variables interact and influence each other. The first component is the South African EE policy which responded to global EE directives but also laid out the envisaged outcomes of EE initiatives in the country. This component has been implemented through SANS 10400-XA as the building regulations for energy efficiency for new buildings in South Africa. The aim of the regulations, which is the key variable of the study, is to promote thermal comfort and energy efficiency in all new buildings. The envisaged EE would be derived from optimising the use of renewable energy (RE) sources through passive-design interventions for thermal comfort as well as RE technologies for services such as water heating.

The second component is the funding provided by the National Department of Human Settlements to cover the additional costs of EE and RE interventions in low-income housing. Since the houses are targeted for low-income earners, it was necessary for the Department to subsidize the mandated EE and RE interventions. Additional funding is therefore a key variable in the realization of EE in low-income houses. The additional funding for EE is channelled through the overall housing subsidy towards the cost of delivering low-income houses in South Africa.

Based on insights from specific case study project contexts, the conceptual framework thus shows how the key components and their related variables facilitate the translation of policy and regulations to the critical policy outcomes in terms of EE-benefits/experiences for beneficiaries as well as contribution towards reduction in GHG-emissions.

2.8 Conclusion

The main objective of this study is to contribute to the academic literature on the implementation and households' experiences with SANS 10400-XA energy efficiency measures as incorporated in low-cost housing subsidised by the government since 2014. The first sub-question aimed to appraise experiences in household energy efficiency policies and implementation outcomes in developed countries where similar implementation has been systematically undertaken. Despite several challenges as reflected in the outcomes of the German policy, there are successes in the implementation of the EE policy in the residential sector to the extent that this sector has performed better than other sectors in the implementation of energy efficiency policies and the reduction of greenhouse gas emissions.

This outcome is similar to the findings in this study in the South African EE policy implementation outcomes where it has been found that the EE regulations are being implemented in the low-income residential sector. Findings on the outcomes in the Dutch EE regulations review also show similarities with the South African regulations where energy performance gaps have been identified in some of the EE interventions installed in the houses. The similarities occur in the poor installations and lack of training/capacity in the installation of thermal comfort interventions.

As seen in the German studies reviewed, several factors emerge as obstacles to the implementation of the energy efficiency regulations and the resultant impact of reduced reliance on greenhouse gas emissions. As mentioned in Section 2.3, various studies (Achtnicht et al., 2012; Galvin, 2014; Torregrossa, 2015; Baumhof et al., 2019) indicate that the financial cost is a key barrier to energy efficiency renovations. The financial model put in place by the government entails funding from the KfW development bank (with low-interest loans and repayment over up to 20 years). However, homeowners are reluctant to commit to such (long-term) loans hence the 0.8% annual uptake of the retrofits against the envisaged 2% uptake per annum. Zheng et al. (2018) have further shown that electricity for the social housing markets is subsidised by the local government and as a result, it has not yielded reduction in electricity use for daily household needs but has instead contributed to an increase. Based on the overall low implementation of the regulations, Gealis et al. (2019) have forecast that Germany will miss its GHG emissions target of a 20% reduction by 2020 and therefore at risk of incurring EU-penalty set under the EU Energy Efficiency Directive of 2014.

Despite these setbacks in the uptake of energy efficiency, the German residential sector has carried Germany towards its overall targets to reduce electricity consumption and greenhouse gas emissions. Scholmann et al. (2018) have stated that “almost 50% of the total energy savings gained in Germany in the period 2000-2016 are attributed to the residential sector” (Scholmann et al., 2018, p. 86). This is an indication of the positive impact of the strong policy measures targeting energy efficiency in buildings.

As a conclusion to the aforementioned, Scholmann et al. (2018) recommend that Germany resuscitate the funding model by exploring the addition of subsidies to the scheme so that it is not a full loan. This will decrease the loan amount and payback period. In this way the funding model might attract and encourage homeowners to apply for funding and refurbish their homes with the regulated energy efficiency interventions. Furthermore, education campaigns need to be intensified in the social housing sector as the government's investment of subsidising electricity is not yielding the anticipated energy efficiency outcomes.

Visscher et al. (2016) reviewed the Dutch energy efficiency regulations which are modelled in line with the EU energy efficiency frameworks and they find these directives inadequate towards ensuring that actual energy performance is achieved and thus meaningfully contribute towards CO_2 reductions. The study finds that there is a critical gap in the regulations and thus argue that, in order to achieve the set energy savings goals, a radical rethink of regulatory systems and instruments would be necessary. The study further argues that building performance and the behaviour of occupants is not well understood by policy makers, hence the existence of a performance gap and the need for alternative regulations that would have more impact on the intended outcomes (Visscher et al. 2016).

In the context of South Africa, the implementation of energy efficiency was forced onto society after the electricity supply crisis of 2006-2008 when Eskom, the country's major power utility, struggled to supply the required electricity demand which resulted in rolling black outs as a means to stabilise the grid. Large scale energy efficiency implementation in the low-cost housing sector started with the retrofit rollout of SWH by various municipalities around 2012 and from 2014 the National Department of Human Settlements started the implementation of the EE regulations (under SANS 10400-XA) in low-cost housing.

Past projects in energy efficiency in South Africa show that there are valuable lessons to be drawn from such projects even though they have mainly been pilot projects at a very limited scale. In Cato Manor, for instance, the retrofits installed have resulted in energy efficiency and a better quality of life for the house occupants. In Tsutsumani, Alexandra, the intervention was piecemeal because only SWH systems were installed and this improved access to hot water. However, this alone could not significantly improve the quality of life of the house occupants in terms of overall energy needs and related costs. In order to achieve a visible impact on getting households less reliant on the electricity grid, a combination of measures would be required and not standalone or piecemeal measures. It is therefore crucial to study the outcomes of the suite of energy efficiency measures that come with SANS 10400-XA.

Given that a growing number of responsive housing projects have now been completed and occupied for more than five years, this study serves as one of the initial studies to evaluate the implementation of the regulations. The study therefore significantly adds value on the understanding of the effectiveness of energy efficiency in low-cost housing and the effectiveness of related government policy implementation in energy efficiency and sustainable human settlement development as a whole.

CHAPTER 3. RESEARCH METHODOLOGY

This chapter presents the research method used in the collection and analyses of data to respond to the research question. The first section describes the qualitative research design followed by a section on access to and an overview of the communities of Clayville and Joe Slovo. The research tools used to collect data from the research sites and participants are then presented followed by an overview on the key ethical considerations of the study.

3.1 Research Approach

The study adopted a qualitative research approach which seeks to understand given knowledge issues from the perspective of the participants (Hammarberg, 2016). The research design adopted for this study draws from the case study method, which is commonly used to collect in-depth data in a real-life and natural setting where the researcher has minimal opportunity for experimental control over the events underlying the phenomenon to be studied. Qualitative research methods provide a complex textual and visual description of how people experience the phenomenon being researched. Such methods can be further defined as “a form of systematic empirical inquiry into meaning” (Shank, 2002, p. 5). This implies an orderly, well planned process with pre-agreed rules of engagement (especially with interviewees or other participants), as well as knowledge based on direct observations and experiences. The study systematically planned the data collection method and purposely selected participants best suited to respond to the policy subject matter based on their relevant roles in relation to the sub-questions of the study. The data and related analyses formed the process that contributed to insights on the regulations and their implementation as reported in subsequent chapters of the study. In relation to energy efficiency policies and implementation in subsidised housing through SANS 10400-XA, the method was effective in accurately representing the study participants’ views and experiences (Young and Hren, 2017) in relation to energy efficiency policies and implementation in subsidised housing through SANS10400-XA.

3.1.1 Case Studies

Case study methods are considered as one of the key approaches in qualitative research (Flyvbjerg, 2011). In addition, much of what is known today about the empirical world has been studied through case study research (ibid.). In order to understand the experiences and outcomes of government funded energy efficiency measures in low-cost housing, the study collected data on beneficiary households of Clayville and Joe Slovo as sample cases of housing completed since the adoption of SANS 10400-XA in government subsidised housing in South Africa.. In essence, the qualitative case study approach in the communities of Clayville and Joe Slovo enabled the study to use a variety of data sources in order to arrive at a relatively comprehensive picture of the experiences and outcomes of SANS 10400-XA in low-cost housing.

An additional advantage of the qualitative case study research design is that it facilitates for keeping a study focus (Centre for Innovation in Research and Teaching, 2007). For this study, the focus is SANS 10400-XA as an intervention by government to regulate energy-use and also promote energy efficiency in new buildings. In particular, the study focuses on the effectiveness of energy efficiency in low-cost housing in Gauteng and in the Western Cape as specific and interesting cases. The study was guided by the theoretical expectation that as energy efficiency measures such as the regulations detailed in SANS 10400-XA are implemented, the resultant housing would be energy efficient thus improving the quality of life of the occupants socially and financially while also mitigating impacts on the environment through GHG-emissions reduction. The study appraised and evaluated SANS 10400-XA measures by focusing on the four prioritised areas of intervention (orientation, SWH, ceiling and wall insulation). The sections below provide information about the case sites, accessing the communities of both case studies and data collection tools used.

3.2 Data tools and methods of the study

Table 3.1 presents a schedule of data instruments applied in the report. It mainly summarises the data required for each sub-question in the study, the type of data collected and how the data are presented and analysed to arrive at findings with regard to the overall research question.

Table 3.1 Schedule of data required, data presentation and analysis for the study

Overall research question and sub-questions	Data required	Data presentation and analyses
Sub-question 1 What are the key insights on household energy efficiency policies and implementation outcomes in developed countries and locally?	**Secondary data** (locally & internationally) Energy policy frameworks Energy efficiency regulations Data on outcomes of policy implementation evaluation **Sources:** Policy documents, reports, articles	**Chapter 2** Residential energy efficiency policy overview and implementation locally and internationally Implementation processes and outcomes against policy objectives Local case studies on effectiveness of (policy) interventions Quantitative data presented in graphs and charts
Sub-question 2 What are the levels of compliance with the regulations by the two provincial departments responsible for the case study projects?	**Primary data** Interview data on implementation guidelines and processes Observations and notes from case sites **Secondary data** SANS 10400-XA Regulations Department of Human Settlements documentation; subsidy amount/increase; construction norms and standards **Sources:** Literature and primary data	**Chapter 4** Responses from relevant government employees were collected, analysed and presented in this chapter Primary data were analysed to explore the key themes and to analyse the levels of compliance to regulations Secondary data were used in comparison with primary data collected in response to the sub question

		Source: semi-structured interviews and personal observations on case sites, various documentation
Sub-question 3 Are households benefitting from energy efficiency as regulated in SANS 10400-XA for basic energy needs?	**Primary data** Interview data on implementation guidelines and processes Observations and notes from case sites **Secondary data** SANS 10400-XA Regulations Department of Human Settlements documentation; subsidy amount/increase; construction norms and standards **Sources:** primary data and secondary data	**Chapter 5** Responses mainly from residents were collected, analysed and presented in this chapter Primary data were used to explore the outcomes of the regulations on basic household day-to-day energy needs Analysis is mainly with reference to primary data collected and are partly presented in pie charts **Source:** semi-structured interviews and personal interaction on case sites and with participants
Overall Research Question What is the effectiveness of SANS 10400-XA for low-income houses built and occupied since 2014 towards addressing basic household energy needs?	**Chapter 6** The sub-findings on the sub-questions were consolidated towards the resolution of the overall research question. Conclusions and recommendations were then drawn and presented in this chapter.	

3.3 Data Collection

Secondary data sources included academic articles, energy policies, reports and online media articles. Given that the researcher works in the Department of Human Settlements, a significant number of non-confidential secondary data sources were accessed and compiled through work-related activities.

Secondary data were also collected from selected countries with well-developed energy policies and from those leading in the implementation of energy efficiency in buildings (Germany and the Netherlands were purposely selected). Data collection was aimed at obtaining insights into the policy implementation and outcomes thereof for ordinary citizens.

Primary data collection focused on two main issues which are: participants' experiences (beneficiaries) and knowledge on related policies and regulations (government officials). Guided by these issues, interview questions were structured to allow the study to gain a detailed understanding of the outcomes of the energy efficiency regulations as translated through low-cost housing.

Yin (2013) described semi-structured interviews as "an essential source of case study evidence" Yin (2013, p.15). Yin's description was relevant for this study where the primary focus is human experience and human action in homes fitted with energy efficiency measures. However, because interviews are verbal reports, the researcher has been mindful of the fact that other influences like poor memory, personal views instead of actual behavioural trends and inaccurate verbal reports may skew the results. In order to avoid this, the researcher crafted the interview questions as shown in Appendices B and C.

Given that energy and thermal efficiency in low-cost housing is aimed at improving the livelihoods of beneficiary households, the process of interviews aimed for data to appraise whether households do in fact have an improved quality of life through renewable energy for basic household energy needs; if their houses feel warmer in winter; and if they use less money for electricity when an electrical geyser is replaced by a solar geyser. A similar tool was used with government officials to collect data aimed at understanding their experiences of the implementation processes.

Semi-structured interviews were open-ended and allowed the respondents (households and government officials) to develop ideas and speak in detail on the issues and questions raised by the interviewer (Denscombe, 2007). Initially the aim was to interview 20 household participants (ten in each province). In Clayville, out of ten households that were requested to participate in the study, two declined and eight participated. Those who declined to participate said they were not the owners of the homes at the time of data collection – apparently they occupied the houses illegally and were unfriendly to everyone in the community. In Joe Slovo, eleven participants had initially agreed to be interviewed. However, one household participant subsequently declined and the ten selected participants were available to participate.

Household occupant interviews were conducted both in Cape Town and in Johannesburg in the project sites, in or outside the participant's house. Government officials for the Clayville project were interviewed in their offices in Johannesburg and the Cape Town official was interviewed at the project site office. All interviews were conducted between March and May 2019. Some interviews were recorded on a phone and all of them were hand-written and signed by the participants at the end of the interview.

3.3.1 Accessing the Clayville Community and Gauteng Government Officials

To get access to the community of Clayville, the researcher was assisted by the project manager from Gauteng Provincial Department of Human Settlements as he has managed the project from its planning and design stages to full implementation. The project manager and the researcher drove around the settlement, and specifically within the section of community (low-cost houses) where government funded energy efficiency interventions are installed. The project manager introduced the researcher to the first homeowner, but on subsequent visits to the community the researcher went alone to the homes and conducted the interviews.

Relevant stakeholders in the case study of Clayville included government officials from Gauteng Department of Human Settlements and the house occupants (beneficiaries). It was difficult setting appointments with government officials. A few appointments were cancelled due to their work commitments. However, after rebooking, interviews were scheduled to dates convenient to the officials. It is important to mention that not all initial stakeholders ultimately participated. At the proposal stage, the study had intended to also interview suppliers of energy efficiency products (solar geysers and ceiling insulation). As the writer was preparing for the interviews, she realised that their participation would not add significant value to the study as they were not directly involved in post-installation experiences and outcomes. However, in some instances, participants expressed major concerns over poor quality materials and installations which could have been cross-checked with the relevant supplier.

After interviewing government officials, it became clear that the developer and construction entities are responsible for procuring SABS (South African Bureau of Standards) approved materials. This is monitored through construction inspections by inspectors from the department. If there is a problem with the product, the beneficiary has to report this to the main contractor whose responsibility it is to fix the problem (as was the case with a particular beneficiary whose geyser was defective and who called the main contractor to fix it). Table 3.2 presents participants interviewed per category of respondents.

Table 3.2: Clayville interview respondents

Respondent type	**Sampled number**
1. House occupants (Beneficiaries)	10
2. Gauteng Human Settlements officials (Government officials)	4

3.3.2 Accessing Joe Slovo Community and Cape Town Government Officials

For the case study of Joe Slovo in the Western Cape, it was difficult to interview government officials from the Provincial Department of Human Settlements, mainly because possible participants did not initially respond to emails requesting face-to-face interviews. Ultimately, after about three months of persistence the researcher was referred to the Housing Development Agency (HDA) who had been appointed by the Western Cape Provincial Human Settlements Department to manage the project. Thereafter, it was not difficult to secure interviews with officials from HDA as they responded swiftly to email requests. In order to get access to the community and households of Joe Slovo, the project manager from HDA introduced the researcher to the site and to members of the residents' committee who helped in identifying beneficiaries for interviews.

Initially, the researcher and a member of the residents' committee drove around with the intention of familiarising the researcher with the community. Beneficiaries were purposely selected to participate in interviews. For instance, the process included targeting homes that had their doors open during the day. Then the researcher and the member of residents' committee would knock on the doors and request an interview with the respective beneficiary. The purpose of the interview was explained, and most beneficiaries agreed to be interviewed and they signed the consent forms.

Similar to Clayville, semi-structured interviews were conducted with both sets of participants (officials and homeowners). As mentioned in Section 3.2.1, this type of data collection tool allowed the study participants to articulate their experiences regarding energy efficiency technologies installed at their homes. An official from the HDA also explained how they went about planning for the energy efficiency technologies implemented in homes under the project. Whereas the initial intention was to interview four officials, only one official was ultimately interviewed primarily because the data captured through the responses were comprehensive enough. During the initial 'walk about' in the project area, eleven beneficiaries initially agreed to be interviewed, but one of them later declined. She explained that she was uncomfortable to participate in the interview even though it was explained that she could express herself in her home language (isiXhosa).

Table 3.3 presents the categories and numbers of participants interviewed in Joe Slovo.

Table 3.3: Joe Slovo Phase 3 interview respondents

Respondent type	Sampled number
1. House occupants (Beneficiaries)	10
2. Western Cape Housing Development Agency Official (on behalf of Government Officials)	1

3.4 Data Analysis

The primary aim of data analysis is to extract insights that support decision-making to ultimately develop unbiased conclusions. Aim of analysis of the research data was to extract insights from the various primary and secondary data sources in order to find responses to the research question and the sub-question of whether households are benefitting from energy efficiency as regulated in SANS 10400-XA for basic energy needs. As per the hypothesis the study anticipated to find acceptable levels of beneficiary satisfaction through the energy efficiency interventions implemented by both provincial departments.

Content from the various sources was analysed. These sources were the interview question responses from both government officials and beneficiaries, on-site observations and secondary data from reviewed literature. To start the process the researcher ensured completeness of interview data at the end of each interview by making sure that all questions were asked, answered and recorded on the interview sheet. This was done by quickly scanning through the interview sheet to confirm that all responses had been populated making them ready for analysis.

The analysis process started with indexing or grouping where broad similarities were transcribed and grouped together for analysis. For example, responses from the walk-up blocks in Clayville Ext. 45 were grouped together and those from the stand-alone houses were put in a separate group. Sub-groups were also formed for instance, in Joe Slovo Park after most beneficiaries responded that they had to warm their houses in winter, sub-groups were purposely formed in trying to find further patterns on what heating sources were used. It emerged that paraffin and electricity were used as heating sources. In a similar sub-group in Clayville Ext. 45 alternative heating sources ranged from electric, gas to paraffin heaters. Through this process the researcher was able to link patterns that emerged through common responses that started answering the research question.

Data mining was also employed to look for patterns that could lead to predictions of the outcomes. An example of a pattern is the pattern of how frequent similar responses come up to the same interview question. Similar responses were grouped together and on further analysis of the various groups the researcher was able to find hidden patterns in the data that further responded to the research question. For example, a pattern emerged from responses from the walk-up blocks of Clayville Ext. 45, (in response to the question on whether water from the solar geyser was hot), that beneficiaries who live on the fourth floor always had hot water. This was in contrast to beneficiaries on lower floors who had hot water mainly in the afternoons/evenings.

Throughout this process the researcher was aware that there could have been a tendency to select and interpret only the data that proved the hypothesis. To avoid bias the researcher also looked into the detail of data that disproved the hypothesis and avoided drawing any conclusions before the entire data analysis process was finalized. For instance, the north facing orientation of a house allows it to benefit from passive solar heating and hypothetically north facing houses in the projects should benefit from passive solar heat. Primary data from on-site observations and interviews with government officials showed that most households in Joe Slovo do not derive benefit from passive solar and have to warm their houses in winter. These data were further analysed together with secondary data and it was found that the north-orientation had not always been achieved. It had been planned for in the initial stages of the project design however it could not always be achieved due to the densification strategy and the design concept around a communal courtyard that was implemented. From this analysis, for instance, the study concludes that the orientation of the houses was primarily dictated at settlement planning stage. As a result, the north facing orientation was not achieved for all blocks or houses.

Finally, the data analysis process made comparisons between primary and secondary data – comparing the findings from interviews and on-site observations with patterns from reviewed literature.

In Slovo Park, for instance, in response to the question on whether the water from the solar geysers is hot, only 50% of respondents said the water is hot when needed (refer to Table 5.1). On further probing it was established that the 50% with no hot water have dysfunctional geysers. This information was compared with the Dutch studies reviewed, especially Visscher et al., (2016) who write about the energy efficiency performance gap. They argue that the performance gap can be attributed to poor built quality where mechanical products are not commissioned correctly and thus malfunction. In this particular case at Slovo Park the conclusion from analysis and interpretation was that the performance gap phenomena exists in the project and that it is necessary to improve the skills base of builders and product installers in low-cost housing projects while also ensuring improved installation monitoring.

3.5 Ethical Considerations

The study adhered to the research ethics guidance of the University of the Witwatersrand and the School of Architecture and Planning. Research ethics involve the protection of dignity of study participants and the publication of information in the research (Fouka & Mantzorou, 2011). Prior to carrying out interviews, the researcher introduced herself to the informants and explained that she was a student at Wits. Thereafter, she explained the research topic, outlined the duration of time required for the interview and explained that the research was being conducted for academic purposes and therefore no immediate benefits should be expected from the findings. The researcher went through the participation information sheet with the respondents. Once they agreed to do the interview the researcher first took them through the consent form and then started the interview. The research question and objectives of the study were clearly explained to participants. After explaining the purpose of the study, the respondents confirmed that they understood what the study was about and then requested to sign the consent forms. The researcher explained that the signing of the forms did not bind them to stay in the study and that they could pull out from the study at any time. The researcher thus explained that participation was voluntary and there were no rewards such as money, prizes or gifts.

The researcher protected the dignity of the respondents by ensuring that they understood interview questions and no emotional harm was caused. Even though the interview questions were designed in English, it was more comfortable for the researcher to elaborate (where necessary) to participants in their home languages. However, one participant insisted on doing the interview in English. The interviews were therefore conducted in the languages that participants felt comfortable with. For instance, the commonly spoken languages in Clayville are Zulu and Sotho. Participants were free to make a language choice. In Joe Slovo isiXhosa is mainly spoken and the interviews were all conducted in isiXhosa as the researcher is also fluent in isiXhosa. There was therefore no language barrier between the researcher and respondents because the researcher speaks and understands all three languages mentioned above. Furthermore, the interview questions (refer to Appendix B) were simple and straight forward and hence easy to translate. There was no loss of meaning when other languages were spoken due to the simple structure of the questions.

In terms of anonymity and confidentiality, the researcher explained that the names of participants would not appear in the final research report. Interviews were conducted individually in such a way that a participant in one home did not know what participants in other homes had reported to the interviewer. Interview responses were thus kept confidential both in data collection stage as well as in analyses and reporting.

CHAPTER 4. COMPLIANCE IN THE IMPLEMENTATION OF THE REGULATIONS

4.1 Introduction

This chapter begins by presenting preliminary overviews of both case sites from direct general observations during the site visits as well as some statistical information from various secondary sources.

The chapter then presents and analyse data on the planning undertaken to achieve compliance with the regulations and the implementation processes by the two provincial departments in the two study case sites of Clayville Extension 45 and Joe Slovo Park Phase 3. This is done firstly by presenting primary interview data captured from five government employees. The data details the processes adopted by the two departments in the planning and implementation of EE in low-income houses. Secondary and primary data are thereafter analysed in comparison to the local and international case study from literature as presented in Chapter 2. This is done in order to assess the levels of compliance and also to assess similarities and areas of possible improvement in the planning and implementation by the provincial departments.

4.2 Preliminary Overview of Clayville Extension 45, Gauteng Province

Clayville Extension 45 is located in the Ekurhuleni Metropolitan Municipality (Ekurhuleni) in Gauteng Province. It is part of the Clayville Mega Human Settlements Project which is implemented by the Gauteng Department of Human Settlements. The mega project is made up of Clayville Extension 45, 70 and 71 in the north of Ekurhuleni. It is an integrated, mixed land use development and there are plans to build around 14 000 houses centred on sustainable living. It integrates people from different social and financial backgrounds through housing people from informal settlements in surrounding areas alongside working-class people in a mixed land use project with mixed housing typologies. It is located within one of the fast growing residential and economic nodes of Ekurhuleni.

Figure 4.1 shows the geographical location of the case project site, Clayville Mega Project in Ekurhuleni. It shows its location in the greater Gauteng Province.

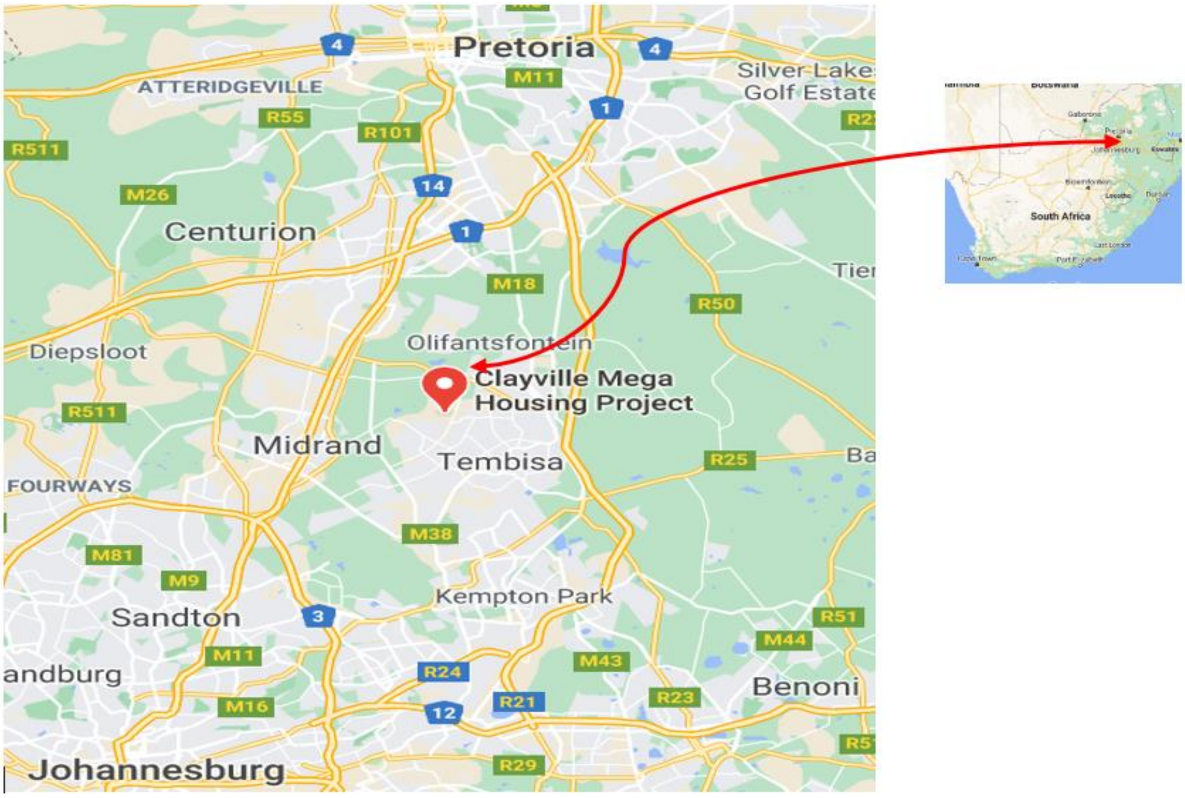

Figure 4.1: Geographic location of Clayville Ext. 45, Gauteng. Adapted from Google maps, (Accessed March 2018)

The economy of the Ekurhuleni Metropolitan area accounts for nearly a quarter of the economy of Gauteng Province. A community survey by Statistics South Africa (StatsSA) (2016) reports that the municipality has a population of 3 379 104 people thus making it the fourth largest municipality by population size in the country after the City of Johannesburg with 4.4 million people, the City of Cape Town with 3.7 million and the City of eThekwini with a population of 3.4 million (StatsSA, 2016). The municipality has the largest number of informal settlements in Gauteng according to its Integrated Development Plan (IDP) (City of Ekurhuleni, 2015). It has a huge housing backlog mainly characterised by residents living in informal settlements with a housing backlog of 144 000 (City of Ekurhuleni, 2015). The high rate of unemployment and the associated informal housing means a high rate of dependence on various levels of government for housing and other basic social services. The planned housing delivery in Clayville megaproject presents an opportunity for government to formally house a large section of the existing informal settlements and also implement the energy policy in this mixed income community, especially for the poor who would under current circumstances struggle to implement energy efficiency measures on their own.

The project is located to the north-west of the municipality in close proximity to the well-established township of Tembisa and Kaalfontein as well as many informal settlements dotted around the area. As the largest township to the north of Ekurhuleni, Tembisa was established in 1957 when black people were relocated from various areas around Johannesburg like Alexandra, Kempton Park and Midrand (Ledwaba, 2014). It has since grown along the many manufacturing plants in the surrounding area such as Modderfontein and Spartan industrial zones which have, over the years, drawn many settlers into the mainly informal settlements around the Ekurhuleni north region. The numerous informal settlements around the township are the main beneficiary feeders for the Clayville megaproject which has already started to assist with alleviating the housing shortage in the region.

In its 2016 survey of municipalities, StatsSA surveyed household energy sources and the data below shows the different energy sources used in Ekurhuleni for basic household needs of water heating and space heating.

Table 4.1: Distribution of households' main energy sources in Ekurhuleni, Source: StatsSA (2016, 51)

District/local municipality	Water Heating				Space Heating			
	Electricity	Other energy source	None	Total	Electricity	Other energy source	None	Total
DC42 : Sedibeng	**302 826**	**25 760**	**1 563**	**330 149**	**279 857**	**33 451**	**17 130**	**330 438**
GT422 : Midvaal	30 128	7 517	401	38 046	26 081	7 091	4 845	38 017
GT 421 : Emfuleni	238 581	13 555	756	252 892	227 411	18 742	6 975	253 128
GT423 : Lesedi	34 117	4 687	406	39 210	26 365	7 619	5 310	39 294
DC48 : West Rand	**270 407**	**55 135**	**4 750**	**330 292**	**238 640**	**52 781**	**38 825**	**330 246**
GT481 : Mogale City	125 810	19 451	1 744	147 005	113 089	18 274	15 661	147 024
GT484 : Merafong City	66 081	11 950	1 712	79 743	54 354	13 282	12 068	79 704
GT485 : Rand West City	78 516	23 734	1 295	103 545	71 196	21 225	11 096	103 517
EKU : Ekurhuleni	**1 090 744**	**194 369**	**12 483**	**1 297 596**	**951 706**	**210 704**	**135 474**	**1 297 884**
JHB : City of Johannesburg	**1 650 579**	**184 190**	**15 598**	**1 850 367**	**1 535 311**	**172 131**	**142 305**	**1 849 747**
TSH : City of Tshwane	**1 012 496**	**109 373**	**12 962**	**1 134 831**	**866 482**	**94 223**	**174 542**	**1 135 247**
Gauteng	**4 327 052**	**568 827**	**47 356**	**4 943 235**	**3 871 995**	**563 290**	**508 277**	**4 943 562**

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The data show that households in Ekurhuleni still rely heavily on electricity for water and space heating and these are the two main types of daily household consumption that SANS 10400-XA attempts to reduce through passive design and renewable energy technologies. Of a total of 1 297 million households surveyed, around 1 million use electricity for water heating and 951 706 households use electricity for space heating. The planned delivery of around 14 138 houses in Clayville that will meet their energy needs from alternative sources should change this because SANS 10400-XA intends to reduce over-dependence on grid-supplied electricity by tapping into renewable energy sources.

The then Ekurhuleni Member of Municipal Council for Human Settlements, Councillor Queen Duba noted that between 2000 and 2012, 94 969 low-cost houses were built in Ekurhuleni (Harrison and Todes, 2013). The low-income houses form part of the data presented above in the StatsSA survey which shows that government has been providing formal houses to poor communities without critical concerns on energy efficiency. Harris and Krueger (2005) argue that the main housing problem in South Africa is not the lack of housing delivery but the shortage of funds to deliver low-cost housing efficiently. This equally applies to Clayville despite delivery having been planned in a manner that promotes integration, sustainability, energy efficiency and the use of energy from renewable energy sources like the sun.

4.2.1 Preliminary Direct Observations - Clayville

Driving towards Clayville Extension 45 from the N1 or from the R21 freeways, one turns into the main road. Along this road to the east is the Winnie Mandela Township which is an extension of Tembisa Township. This visible part of the township is set on a downward slope facing north towards Main Road and in the distance one can see that Winnie Mandela Township is an RDP development. With its north-facing orientation, one cannot ignore the wasted opportunity of a development implemented without solar geysers.

About 2km along Main Road, to the north, is the entrance to Clayville Extension 45 on an unnamed road. As one turn right, the slope starts to ascend up a minor hill and after about 0.5Km one is greeted by the township of Clayville Ext 4 housing which are Finance Linked Individual Subsidy Program (FLISP) houses along tarred roads with paving along the roadside and blocks of multi-storey units in the distance. Driving further one sees a sign directing towards the Curro School, and on the southern boundary of the development is a shopping centre. One can thus observe the manifestation of the concept of mixed land-use and mixed-income housing development.

All Clayville Extension 45 houses built to date are fully or partially government subsidised. In terms of the SANS 10400-XA requirements (refer to appendix A for SANS 10400-XA elements) all houses have solar geysers on the roofs. These include the FLISP houses as well and the RDP walk-up multi-storey blocks.

The houses in the study sample are both stand-alone and multi-storey low-cost houses. The stand layout on some of the stand-alone houses is such that the long sides of the stands are east-west oriented and therefore do not support the north-facing house orientation required for optimised passive solar benefits. Because of the stand orientation, only the living room has a north-facing window and the installation of the solar geysers ended up on the west-facing part of the roof.

The four-storey walk-up units are L- or U-shaped (refer to appendix E-E2 for the Architectural drawings) resulting in most geysers facing north. The windows to the living areas and the main bedrooms are also north-facing. Only the top floors have ceilings with insulation whilst intermediate floors have slabs as ceilings. All the houses sampled (low-cost including the walk-ups) have ceilings with insulation. It must be noted that most of the home occupants were not aware of the in-ceiling insulation and we had to check through the trap door to confirm installation.

Construction in the project started in 2015 and has around 3 058 houses already completed and occupied. The entire Clayville megaproject will deliver 14 138 houses with approximately 5 260 fully subsidised low-cost houses (both stand-alone and multi-storey RDP walk-up units), 5 380 Finance Linked Subsidy Houses (FLISP) and 3 498 social housing units (Department of Human Settlements, 2018).

The development will also include six schools, one of which is currently under construction, a shopping centre, various public open spaces, a multi-purpose centre and various other institutional amenities as summarised in Table 4.2.

Table 4.2: Clayville Ext. 45 Project Profile

Source: Department of Human Settlements (2018, 7)

Locality	Northern Ekurhuleni
Property extent	363 Hectare
Ownership	Ekurhuleni Metropolitan Municipality and Valumax Midrand (Pty) Ltd
Number of development phases	Three
Social Amenities	3 Primary Schools, 3 Secondary Schools, Crèches, a clinic, Community Centre, Business sites, Shopping centre, Parks
Total houses planned	14 138 mixed typology houses
Houses built to date	3 058 (consisting of Walk-ups, BNG stand alone and FLISP houses)
Targeted relocations from	Winnie Mandela informal settlement, Madelakufa 1 & 2 informal settlement and Tembisa backyards

4.3 Preliminary Overview of Slovo Park Phase 3, Cape Town

Slovo Park Phase 3 forms part of the City of Cape Towns' national flagship catalytic project, titled as the N2 Gateway Human Settlements Project. The project was approved as a pilot project of the then new Department of Housing 2004 sustainable development approach titled 'Breaking New Ground: A Comprehensive Plan for the Development of Sustainable Human Settlements'.

Figure 4.2 shows the geographical location of the case project site, Joe Slovo Park Phase 3 in Cape Town. It shows its location in the greater Cape Town Metropolitan Municipality

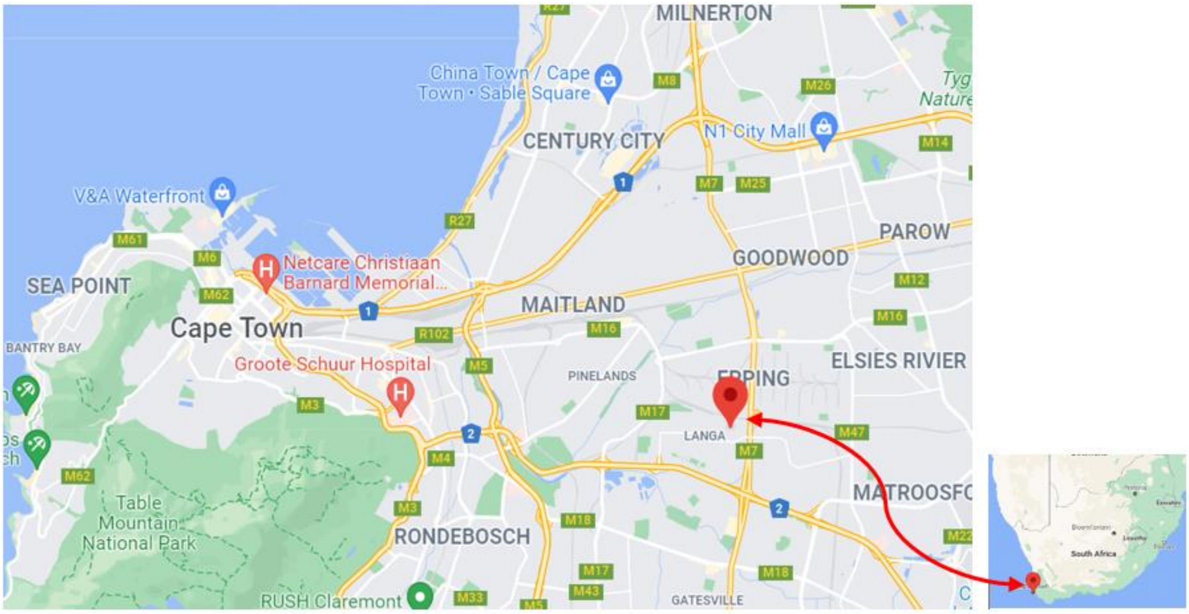

Figure 4.2: Geographic location of Slovo Park Phase 3, Cape Town. Adapted from Google maps, (Accessed March 2018)

Cape Town boasts a population of 4 005 016 people making it South Africa's second largest municipality by population size after the City of Johannesburg with 4 949 374 people (StatsSA, 2016, 7). As in Ekurhuleni, the metropolitan municipality is besieged by rapid immigration and an ever increasing demand for housing.

In its 2016 survey of municipalities, StatsSA surveyed household energy sources and the data below shows the different energy sources used in Cape Town for basic household needs of water heating and space heating.

Table 4.3: Cape Town distribution of households' main energy sources,

Source: StatsSA, (2016, 58)

District/municipality	Cooking			Lighting			Water Heating			Space Heating		
	Electricity	Other energy source	None	Electricity	Other	None	Electricity	Other	None	Electricity	Other	None
CPT: City of Cape Town	**91,5**	**8,3**	**0,2**	**97,6**	**2,3**	**0,2**	**94,8**	**4,2**	**1,0**	**72,8**	**12,3**	**14,9**
DC1: West Coast	88,4	11,3	0,3	94,0	5,9	0,1	91,0	7,7	1,3	73,0	6,4	20,6
WC011: Matsikama	94,1	5,7	0,2	97,0	2,9	0,1	95,6	3,8	0,6	90,5	6,1	3,4
WC012: Cederberg	83,9	15,2	0,9	90,8	8,9	0,3	86,8	11,6	1,4	65,5	3,3	31,2
WC013: Bergrivier	86,9	13,0	0,1	98,2	1,7	0,1	94,4	5,2	0,4	66,1	3,0	30,9
WC014: Saldana Bay	79,2	20,6	0,2	86,2	13,8	0,0	81,9	15,5	2,6	65,3	9,3	25,4
WCO15: Swartland	96,1	3,5	0,4	98,8	1,1	0,1	96,9	2,2	0,9	77,0	6,7	16,3
DC2: Cape Winelands	89,4	10,2	0,4	94,4	5,4	0,3	91,8	6,2	2,0	73,0	11,5	15,5

The data shows that 94.8% of households in Cape Town use electricity for water heating and 72.8% use electricity for space heating. This high reliance on electricity shows poor implementation of the country's energy policy. The findings of this research indicate a continued use of electricity for water heating especially. This is as a result of dysfunctional solar geysers and shows that even though energy efficiency measures have been installed, maintenance and continued functionality of products is paramount. StatsSA (2016) survey also shows that 17.6% of Cape Town's dwellings are informal. This presents an opportunity (together with retrofits) for the review and improved implementation of the energy policy.

Joe Slovo Park is an informal settlement situated in Langa Township along the N2 freeway. It is around ten kilometres east from the city centre. The informal settlement grew within the Langa Township alongside economic opportunities in the area. Langa Township was established in 1923 as a residential area designated for blacks (Sambumbu, 2010). Like all black townships of the time it became one of apartheid era's labour pools where black people who worked in the cities' industries retreated to after work. Typical for all black South African townships, it was characterised by extremely poor social services and social amenities. Over the decades, as Langa became overcrowded, in around 1990, an informal settlement slowly crept up and it was named Joe Slovo (Sustainable Energy Africa, 2014). In 2014 the informal settlement had an estimated population of 7 946 people living in 2 748 shacks (ibid.). Table 4.4 shows Slovo Park project profile.

Table 4.4: Slovo Park Phase 3 Project Profile, Source: Orgill (2014, 26)

Locality	In Langa township along the N2 freeway, Cape Town.
Property extent	8.1 hectares
Land Ownership	City of Cape Town Metropolitan Municipality
Number of development phases	Four (phases 3a, 3b,3c & 3d)
Social Amenities	Schools, clinics, community halls in close proximity in the existing Langa Township
Total houses planned	2886 mixed tenure houses
Houses built to date	Phase 3A = 1 002 Phase 3B = 0 Phase 3C = 452 Phase 3D = 210 (Total = 1 664)
Relocations from	Joe Slovo Informal Settlement and Langa Township backyard dwellers

Construction on the entire N2 Gateway catalytic project started in 2005 with Slovo Park Phase 1. The project, when complete, will yield more than 22 000 houses. A phased approach was necessary as construction was planned where the informal settlement had developed. Sections of the community therefore had to be relocated to temporary accommodation to make way for construction. It was not feasible to relocate the entire informal settlement to start construction. A phased approach also allowed for reflection on the process and realigning plans to suit the needs on the ground (Orgill, 2014). Phase 1 of the project consisted of 705 rental units in line with the integrated development principles of the City. Phase 2 consisted of 567 Finance Linked Individual Subsidy Programme houses and Phase 3, the largest phase of the project to date, has a total of 2 886 government subsidised low-income homes (Western Cape Department of Human Settlements, 2016).

The construction of Slovo Park Phase 3 started in 2011. It is in this phase of the project where energy efficiency was planned and included in the design of the project. This project was marked as an energy efficiency pilot RDP project (refer to Appendix F-F3 for the Architectural drawings).

The design team improved the design concept for Slovo Park Phase 3 in terms of sustainability and efficient use of space which was an innovation departing from the traditional RDP project design of one house per erf. The project thus translated into an infill project within an informal settlement. It is well located in terms of access to well-developed transport routes and close to work opportunities, which motivated for the adoption of the concept of densification in order to accommodate more people on optimally located land. In a research project undertaken for the National Department of Human Settlements, Orgill (2014) stated that "Joe Slovo in this sense applies the sustainable principle of densification of an urban area, rather than increasing the city footprint on the periphery" (ibid, 9). The design concept was developed around densification consisting of 12 to 18-unit duplex, double storey blocks which incorporated pedestrian walkways and public open spaces for communal use. Phase 3 of the project accommodates nearly three times more households per hectare in comparison to a typical stand-alone RDP development (ibid, 9). The advantages of this design principle include the creation of a sense of community and enhanced access to economic opportunities for a larger number of beneficiaries.

4. 4 Preliminary Comparative Analysis

Even though the study method was not designed as a comparative analysis, this approach was applied to understand how the two provinces are complying with SANS 10400-XA as they receive the same subsidy amount per beneficiary for the construction of low-cost houses. The comparative analysis in Chapters 4 and 5 shows similar versus different ways in which the two provinces facilitated the energy and thermal efficiency specifications under SANS 10400-XA in low-cost housing.

As a follow-up to the above findings of the two case studies, comparative analysis was used to understand how the outcomes of SANS 10400-XA have benefited the households of Clayville and Joe Slovo. Drawing from the combination of performance setbacks and benefits mentioned above, the study compares the similarities and differences. King et al. (2013) highlight that comparison is an evaluative tool that allows for an evaluation within a given topic. In the context of this study, comparative analyses is used to evaluate the effectiveness of government-sponsored energy efficiency (SANS 10400-XA) interventions in low-cost-housing in the two case studies. The outcome of comparative analysis can therefore be utilised to guide government officials on future undertakings of energy efficiency projects across South Africa.

4. 5 Planning for EE Compliance and Implementation of the Regulations

Table 4.5 presents a summary of direct responses from four interviewees at the Gauteng Department of Human Settlements and one interviewee at the Western Cape Department in response to the planning undertaken to ensure compliance and implementation of the SANS 10400-XA regulations in Clayville Extension 45 and Joe Slovo Park.

Table 4.5: Presentation of interview data

Interview responses to sub-question 2 - What are the levels of compliance in the implementation of the regulations by the two provincial departments responsible for the case study projects?			
	Interview Question	**Clayville Extension 45, Gauteng**	**Slovo Park Phase 3, Western Cape**
1	What elements of SANS 10400-XA are specified by your Department?	a) A 100-litre high pressure solar geyser b) Orientation c) Ceiling with 135mm insulation d) Internal and external walls are plastered and painted	a) A 100-litre low pressure solar geyser b) Orientation c) Ceiling with insulation d) External walls are plastered and painted
2	If not all elements are specified, please explain why?	Fenestration: the calculations showed that we would need smaller front windows and beneficiaries do not want small windows In-floor insulation: this is expensive for low-cost houses	The subsidy amount doesn't allow for fenestration and in-floor insulation.
3	How do you make sure that all houses comply with	Firstly, we made sure that the Departmental norms and standards include SANS 10400-XA requirements. Then all architects' drawings are checked by the Quality Assurance Unit	All project drawings go through the City Planning Department for building approval. This process

	SANS 10400-XA?	to ensure they comply before they are sent to the municipality for approval.	ensures compliance with SANS 10400-XA.
4	How does your Department ensure that quality products are installed in low-cost houses?	Department inspectors inspect the houses during construction to make sure that norms and standards are adhered to and that SABS approved products are installed.	Department inspectors inspect the houses during construction to make sure that norms and standards are adhered to and that SABS approved products are installed.
5	Are all projects built after 2014 compliant to SANS10400-XA?	Yes	Yes

The responses above show that both implementing agents planned to comply with all elements of the regulations. However, both departments do not comply with the fenestration and in-floor insulation requirement of SANS 10400-XA. This was explained to be due to the cost for the required double glazing and floor insulation. Both departments have controls in place, in-house in Gauteng with their Quality Assurance unit and with the municipal building control units in both Provinces, which ensure that all architectural drawings comply with the regulations.

Figure 4.3 shows two elements of SANS 10400-XA which are solar geyser and plaster to external walls which both contribute to the EE of the units.

Figure 4.3 Slovo Park Phase 3 - SWH installation

4.5.1 Planning through pre-occupation awareness

Stakeholder engagement and communication is a key success factor for community projects. The communication of any community intervention is paramount to its success. This is supported by Jongelin et al. (2012) who argued that monitoring is necessary in the entire life span of an intervention to make sure there is proper introduction, installation and use (Jongelin et al., 2012). Results from the interviews with government officials revealed that community engagement specifically on the energy efficiency measures in their new houses took place starting from pre-occupation.

Beneficiaries who moved into the Clayville Extension 45 houses were relocated from the Madelakufa informal settlement (in close proximity to the project site). At Joe Slovo Phase 3, the project is an in-situ upgrade project where the informal settlement was on the project site and the Department implemented a block-by-block relocation to a relocation site nearby and then after construction, the beneficiaries were moved into the formal houses.

All homeowners interviewed were aware of the concept of solar heating – they understood that the sun heats the geyser which gives them hot water. In both projects before relocation, beneficiary awareness campaigns were held. In Clayville before they were relocated from the nearby Madelakufa informal settlement, they were informed that they would use prepaid electricity in their new houses and that their electrical bill would be less due to the use of a solar geyser. They were not told anything about thermal comfort. In Joe Slovo a consumer education and home maintenance booklet was given to each beneficiary. This booklet is written in English and isiXhosa and explains the various features in the house including the solar geyser and procedures for reporting faults, warranties and that after the warranty period, all maintenance is the responsibility of the beneficiary. In both communities, beneficiaries knew that solar geysers had been installed to help them save on electricity costs. Beneficiaries were also aware that there is insulation above their ceilings which is aimed at keeping their houses warm in winter. In Cape Town some beneficiaries said the insulation also assisted with protecting the ceiling against condensation.

One of Germany’s approaches to the implementation of the energy efficiency policy is information and consultation. According to the Federal government, reliable information and education about energy efficiency enables building owners to inform themselves about how worthwhile investments in energy interventions is and what savings can be realised (BMWi, 2014). Thus, the German Energy Agency (DENA) was established by the government to develop and run awareness campaigns of energy savings at national level. The main activity of DENA is to spread information about energy efficiency and increase public awareness in this regard (Power and Zalauf, 2011). The agency targets different groups such as community members, schools, local authorities and industry through various media and tools (ibid. 35). In addition, education on energy efficiency is an important tool to inspire behaviour change in relation to energy use and consumption. Based on the prioritisation of energy efficiency as the cornerstone of climate change mitigation in Germany, residents are also educated on climate change. Other countries keen on mitigating climate change through energy efficiency can adopt this strategy and educate citizens about the importance of efficient use of energy as a means of mitigation of climate change.

4.6 Outcomes of EE Planning – Analysis of Data Presented

In the process of addressing the second sub-question in terms of levels of planning and compliance in the implementation of the energy efficiency regulations in low-cost houses, a total of five government employees were interviewed, four from Gauteng and one from the Western Cape. The aim of the interviews was to ascertain how compliance to the regulations is planned for by the respective provincial departments responsible for each of the case sites. In general, planning is required to identify the desired goals and the procedures to be carried out to attain these goals. Planning is important as it reduces risks and increases the likelihood of attaining goals. As the custodian of the housing subsidies and with the subsidy increase catering for energy efficiency in low-income houses, it was necessary to find out how the respective Departments planned for the implementation of the energy efficiency measures required under the regulations.

The first interview question therefore focused on how planning for compliance was undertaken. Both the Gauteng and the Western Cape Departments of Human Settlements have planned for energy efficiency implementation in the low-cost houses that have been built since 2014. They have done this by including elements of SANS 10400-XA in the low-cost housing construction norms and standards (Appendix C). In Gauteng, once the architectural drawings have been completed, they are checked by the Departments' Quality Assurance Unit to ensure they comply before they are sent to the municipality for approval. In the Western Cape, the respondent noted that all project drawings also go through the City's Planning Department for building approval. Both processes ensure compliance with SANS 10400-XA. This closely aligns with one of the recommendations of the Cato Manor project report that the Department should include energy efficiency interventions into the Housing Code to ensure that low-cost houses benefit from energy efficiency (GBCSA, 2012).

Despite the fact that both provinces have made considerations for all five SANS 10400-XA elements, some required elements have not been specified because of the costs involved and in consideration of other beneficiary needs. The EE elements implemented are reflected in the respective house construction norms and standards as follows:

4.6.1 Solar Geysers

In terms of the provision of hot water for daily household uses, both provincial departments have specified a 100-litre solar water heater as the commonly implemented system. With South Africa's abundant solar radiation, using a device that harnesses the heat of the sun for water heating can save on electricity consumption and is therefore energy efficient. The Sustainability Institute (2015) states that solar water heating can save between 25-40% of the electricity used by a conventional geyser (Sustainability Institute, 2015). The regulations specify that at least 50% of the hot water should be heated by means other than electrical resistance heating. Solar water heaters are widely used to satisfy this requirement and they have a positive impact on energy efficiency. Passive systems take advantage of hot water's tendency to rise above cold water, allowing natural circulation of water without an electric pump. These systems require that the tank be placed above the collector plate, typically on the roof. Active systems use a little more electricity to circulate the water, but also do allow the tank to be concealed under the roof. Both systems can have an electrical element for backup in times when the sun is not strong enough to heat the water to the required water temperature (Sustainability Institute, 2015).

Figure 4.4 displays three water-heating technologies and their respective annual energy consumption.

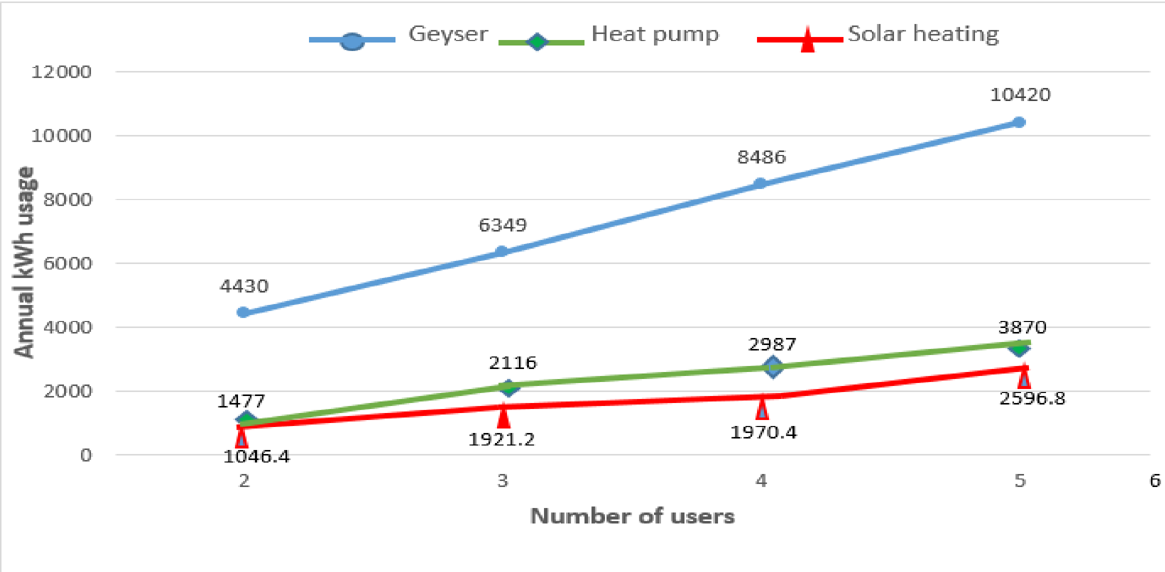

Figure 4.4: A comparison of annual kWh usage between electric geyser, solar heating and heat pump. Source.powersaving.co.za (2016)

Figure 4.4 shows that with five users, a conventional electric geyser uses around 10 420kWh of energy per year. With the same number of users, a heat pump uses 3 870 kWh and a solar water heater uses 2 597 kWh of energy per year. The graph confirms the remarkable energy saving of a solar geyser over a conventional electric geyser.

In the Gauteng case site, high pressure solar geyser is specified whilst in the Western Cape case site a low-pressure solar geyser is specified. It must be noted that both (the low and high pressure) solar geyser systems are fit-for purpose and are also approved by the South African Bureau of Standards (which was reported to have been verified by officials during inspections). There is however a difference between the two systems such that a high-pressure solar geyser has more advantages than a low pressure one. In a high-pressure solar geyser, since the water pressure is high it provides for a controllable flow of water when a tap is opened. It also has an electrical backup switch to heat the water using electrical energy on days when there is not enough solar energy to adequately heat the water. Furthermore, the tank does not have to be located directly next to the collector panels and can therefore be concealed in the roof space for both cosmetic and accessibility reasons. One key disadvantage of the high-pressure solar heating system is that the upfront cost is higher than a low pressure system.

On the other hand, a low pressure system is gravity-fed, meaning that the hot water from the roof mounted tubes runs down into the house via gravity and comes out at a low pressure in the house which is often not satisfactory for the end-users. It consists of a vacuum glass tube collector and an insulated storage tank. The evacuated glass tubes are filled with water and exposed to sun which in turn heats the water in the glass tubes (Orgill, 2014). This process is known as thermosiphon and is based on natural convection. The advantages of this system is that it is simple and there are no moving parts, it is cheaper than a high pressure system and is a very effective way of providing hot water for household needs. The main disadvantage is low water pressure in the house. Another disadvantage is that the entire system has to be shut down for maintenance, for example when one tube breaks and needs to be repaired, especially given that the tubes break easily.

In literature reviewed on the German EE implementation both Power and Zalauf (2011) and Schröder et al. (2011) referred to the Heating Cost Act of 2009 which regulates the cost of space and water heating in rented properties. The Act compels tenants to pay a higher tariff for space and water heating based on consumption which is monitored through the use of smart meters. The authors agreed that this higher proportion on heating forces tenants to use energy sparingly and it forces the landlords to adopt energy efficiency measures. This differs from the South African situation where the regulations aim to ensure savings from the initial occupation of new houses through the planning and implementation of EE measures before occupation. Equally, unlike in the German case, South Africa does not as yet have similar regulations for existing housing stock built before 2011.

4.6.2 Orientation

On the orientation of the houses, the findings from interviews with government officials are that in the design and planning stages of the projects, both Departments included north-facing orientation as a key design specification to support energy efficiency. This, however, was not always achieved for every house. In Joe Slovo, the key design agenda was centred on densification and the creation of communal central courtyards. The design approach was a break away from the traditional RDP housing delivery of a single dwelling per erf to a densified block design which optimises space and creates communities with shared open spaces interlinked by pedestrian walkways (Orgill, 2014). The design resulted in 144 units per hectare with blocks designed into clusters of 12-18 units with individual units having a footprint of 22 square metres with the communal courtyard shared by each household (ibid.

30). Even though every effort was made for maximum passive solar benefits, the design around a courtyard meant that not all houses are north facing and hence some of them do not benefit from optimised passive solar heating.

In Clayville most of the houses are north facing. In the instances of multi-storey blocks, the block design (in some cases) is L-shaped and thus not all units can face north. This orientation is consistent with the SANS 10400-XA regulations as well as Conradie (2018) analysis and recommendation on multi storey buildings that such building orientations are significantly better for solar potential and the benefit of natural daylight.

Figure 4.5 shows the Clayville Ext. 45 site showing both stand-alone and walk-up units. It further shows the orientation of the units.

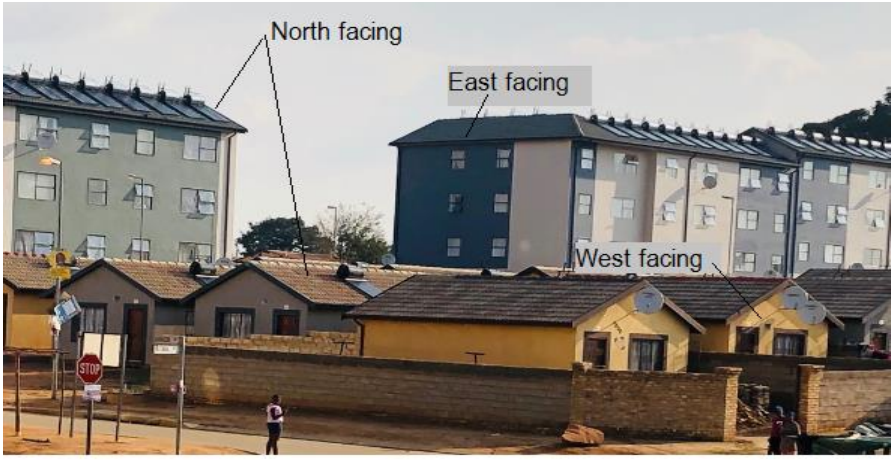

Figure 4.5: Example of main façade of houses in Clayville Ext. 45

4.6.3 Ceiling Insulation

Ceiling insulation is part of the standard requirements by SANS 10400-XA and is included in the architectural specifications of both provincial departments. SANS 10400-XA guides that different climate zones in the country should have different R-value requirements and thus require different thicknesses of insulation in the ceiling. The Western Cape covers three climate zones and Joe Slovo is located within the temperate coastal climate zone. The Department has therefore specified the required ceiling insulation, and this was installed in Joe Slovo Park Phase 3. Gauteng lies within two climate zones; the temperate interior and cold interior zones. For the southern parts of the province (cold interior zone), the requirement is a 135mm thick insulation and the northern parts, which are slightly warmer, require a 120mm thick insulation. The GDHS has specified the 135mm thick insulation (see Appendix

C) for all its projects. Response from the department officials indicates that a 135mm thick insulation has been specified in the Department's architectural specifications for constancies throughout the province's subsidised housing projects.

Part of thermal comfort performance comes from ceiling insulation. Responses to questions on thermal comfort shows that all houses in both projects have ceilings with insulation. Prior to 2011, formal houses in South Africa did not install in-ceiling insulation. For this intervention to be installed in low-cost housing therefore constitutes a great achievement, even though thermal comfort performance is not fully realised as a large percentage of households still require space heating as discussed in Chapter 5.

4.6.4 Wall Insulation

The Joe Slovo project has external plaster as wall insulation and no internal plaster (refer to Figure 4.6 below). In the interview, the department official responded that this was due to cost implications of internal plaster. The decision not to include some of SANS 10400-XA elements was mainly due to cost implications. Even though the subsidy amount was increased to cater for energy efficiency, not all elements could be covered in the increase and location can have a significant effect on the resultant building costs. However, Clayville Extension 45 in Gauteng has both external and internal plaster and paint. The respondents confirmed that this was included in the specifications in order to comply with the wall insulation requirements of SANS 10400-XA. The (wall and ceiling) insulation requirement is similar to the German technical energy efficient measures promoted under the NAPE policy which calls for retrofit measures of increased insulation for walls, floors and roofs (BMWi, 2014, page 10).

Figure 4.6 shows internal walls in the Joe Slovo Project. The internal walls are not plastered showing non- compliance to the SANS 10400-XA regulations.

Figure 4.6: Un-plastered internal walls in Joe Slovo houses

The finding on the exclusion of internal plaster as a measure to conserve energy in the house because of cost is similar to the German situation where Galvin (2014) and Wilson and Chryssochoids (2015) stated that due to various constraints such as cost, not all retrofit interventions can be installed. Galvin, (2014) noted that the German policy only takes into account the thermal improvement cost and not the full cost of a refurbishment for existing buildings. For instance, if a homeowner is to insulate walls, the additional cost of scaffolding, rendering and paint needed to be included as part of the insulation cost thus leads to a low uptake. Similarly, Joe Slovo's construction cost would be increased by including internal plaster. Further to that, the houses have double volume internal walls that would require scaffolding for the application of internal plaster which would increase costs further.

4.6.5 Fenestration and In-Floor Insulation

The last two elements that promote energy efficiency in buildings as specified under SANS 10400-XA are fenestration and in-floor insulation. Responses indicate that these are not specified under both departments. Under SANS 10400-XA the fenestration is only applicable to buildings that do comply with the requirements of orientation and shading. One GDHS respondent however reported that after computing the fenestration R-value calculations, in order to comply, they would have to reduce the window size in the living room and bedrooms and he said from past engagements with communities, beneficiaries do not want smaller windows. There was then a trade-off between the specification and what beneficiaries prefer.

With regard to the in-floor insulation requirement, all respondents said this is not applicable in the GDHS and WC norms and standards because of the significantly higher cost required from the house subsidy amount. Dobson (2015) argued that the implementation of energy efficiency interventions in low-income housing would require creative thinking around how to integrate interventions within the available budgets. The study further mentions that South Africa's public sector financial management legislation has been seen to stifle innovation on the implementation of new technologies to address climate change challenges.

In Germany, the Federal government adopted various instruments for setting standards in energy efficiency investment by energy users. The Energy Conservation Act of 2009 is one such instrument and it requires major changes (insulation) to the building envelope. Exterior walls, roof, floors and windows must be made 30% more efficient, and the envelope must be 15% better insulated (BMWi, 2014, p. 10). Similar to the case of non-compliance at Clayville and Joe Slovo Park, the German EE regulations are not always adhered to. Homeowners do not refurbish their properties within the required timelines, and as a result, Galvin (2014) noted that Germany is unlikely to come close to its 20% energy consumption reduction goal by 2020. This is partly due to the relatively low uptake of thermal retrofitting by homeowners. "Only 0.8 % of houses in Germany are thermally retrofitted each year" as opposed to the envisaged rate of 2% per annum (ibid. 348).

4.6.6 Monitoring for Compliance

The last stage of ensuring that the desired outcome is realised would be through monitoring and evaluation. Visscher et al. (2016) state that the lack of such evaluation significantly contributes to the performance gap. They argue that if there is no monitoring during construction (EE) products can be installed incorrectly thus resulting in poor/inadequate performance and thus contributing to the performance gap. Their study attributes this poor quality to low levels of construction monitoring by building control in the Netherlands. They conclude their study by reinforcing the need for ensuring that energy efficiency products are correctly installed and also monitored both during the installation process and once the building goes into operation.

In terms of monitoring the installation of EE products, both provincial departments deploy building inspectors to ensure that SABS approved (EE) products are installed in the low-cost houses. This process can be compared to the Cato Manor case study where the monitoring of the effectiveness of the EE solutions was carried out three months after installation. The GBCSA (2012) reports that monitoring was carried out through a quantitative approach aimed at establishing the impact of the interventions (GBCSA, 2012). The report further highlights that data loggers were installed to measure temperature and humidity and results showed that "the ceiling insulation resulted in a drop of indoor summer temperatures by 4-6˚C" and "there were electricity cost savings reported by 50% on households which was confirmed from meter readings".(GBCSA, 2012, pages 3-4).

In ascertaining the levels of compliance to the NAPE policy in Germany, Galvin (2014) noted that homeowners are reluctant to comply with the policy. This is supported by Neuhoff et al. (2011) who argue that under the implementation principles, the rate of retrofits is 0.8% per year for residential buildings, against the government's target for thermal retrofits of 2% per annum (Neuhoff et al., 2011). Both studies thus concur on the low compliance in the implementation of the energy efficiency interventions under NAPE. The main factor leading to this non-compliance is the associated retrofit costs which must be borne by the homeowners themselves. An area of commonality with the South African case studies would be the response by the German government in subsidizing poorer households in social housing for full compliance (Zheng et al., 2018).

4.7 Conclusion

In responding to the second sub-question, the findings from the primary and secondary data presented and analysed show extensive planning and compliance with SANS 10400-XA by both provincial departments in the two case studies. The data and analyses indicate that the requirements of SANS 10400-XA are understood and upheld by officials in both provincial departments, even though not all five elements of energy efficiency are specified, which thus makes both departments partly compliant to the regulations. The reasons for the exclusion of the two interventions are understood in the context of a limited housing subsidy. Dobson (2015) argued that the implementation of a policy requires the government to acquire resources such as finances, skill and capacity. In this instance the available finances could not cover all regulated EE elements. This study has however shown that for both the Gauteng and Western Cape departments, capacity has been created/used to ensure the implementation of the regulations. This capacity has not only ensured that the housing specifications (for this and for all low-income housing projects built after 2014) include energy efficiency, but further inspection capacity has been created to monitor compliance during construction. This is a positive outcome which thus contrasts with the Dutch experience where several studies recommend increased construction monitoring.

The government's move to implement the policy through building regulations and municipal codes is an effective way to ensure compliance to the energy policy as all architectural drawings of all new formal buildings must go through the municipal approval process. Literature reviewed showed that in order to implement the 2009 Heating Cost Act in Germany, the government has also taken its implementation down to municipal level where space heating costs were increased thus forcing landlords to implement energy efficiency interventions to cut down on heating costs in their buildings (Schröder et al. 2011).

Planning for energy efficiency by the provincial departments can therefore be viewed to be similar to the German NAPE energy efficiency planning. Like SANS 10400-XA, the NAPE was designed to ensure the efficient use of energy in the German residential building sub-sector among other sectors. The two implementation plans have similarities and differences. NAPE focuses mainly on retrofits to achieve energy efficiency rather than on new buildings. According to Schröder et al. (2011), the construction of new residential buildings in Germany has declined by almost 40% since 2003 (Schröder et al. 2011). The focus on existing buildings therefore makes sense. Schröder et al. (2011) further explain that after the Second World War there was a housing construction boom which has now resulted in a huge 'old' residential stock which consumes energy inefficiently. In order to achieve the objectives of the policy, this housing stock has been targeted under NAPE. In South Africa, the SANS 10400-XA regulations target new buildings as the country is experiencing a high rate of new building construction.

Another difference between the two implementation plans is that the implementation of retrofits in Germany is voluntary and this has led to low compliance. However, the government is also implementing the Heating Costs Act to force homeowners to implement energy efficiency measures. Through this Act, space and water heating costs have been increased thus forcing landlords to implement energy efficiency measures in their properties (ibid. 31). The increased space heating costs have forced tenants to use energy sparingly which results in financial incentives for them. In order to pass savings down to tenants the Act requires landlords to implement the energy efficiency plan.

From the analyses of primary and secondary data presented in this chapter, it is clear there is compliance with all but two elements of SANS 10400-XA. With this finding it is then crucial to assess if housing beneficiaries are benefitting from the implementation of the regulations. The relevant findings would thus contribute towards answering the overall research question of this study.

CHAPTER 5. HOUSEHOLD EXPERIENCES

5.1 Introduction

This chapter presents and analyses data gathered to address the third sub-question on whether households are benefitting from energy efficiency as regulated and as implemented by the provincial departments. Primary data are presented and analysed in relation to household experiences with water heating from solar energy and thermal comfort measures such as, house orientation and insulation. The chapter is structured into three main sections. The initial section presents house occupants' direct responses to interview questions related to how they are benefitting from the interventions. The next two sections present beneficiary experiences on solar geysers and thermal efficiency interventions respectively.

As discussed in Chapter 3, one of the key primary data instruments used was semi-structured interviews guided by questions aimed at assessing household experiences and behaviour in relation to energy efficiency measures installed in the case study houses. The questions to beneficiaries were aimed at assessing the functionality and effectiveness of the solar geyser and thermal comfort arising from energy efficiency measures implemented. The results show varying levels of effectiveness of the EE measures.

5.2 Experiences with Solar Energy

The study initially collected data on the number of occupants per household. This was to assist with analysis on the efficiency of the 100-litre volume of the solar geysers installed in both projects. Mainly because the volume of hot water available (when needed) in any household is directly related to the size of the household and this contributes to the overall experience of efficiency for basic household needs. Ten households were interviewed in each project.

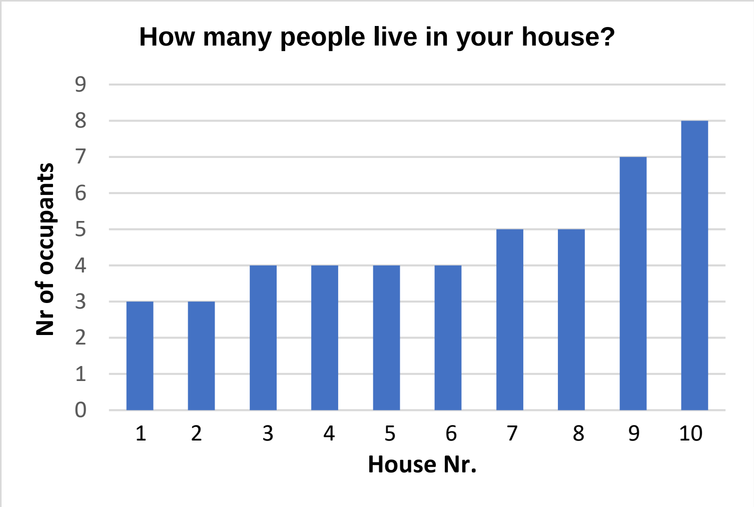

Figure 5.1: Number of house occupants - Slovo Park

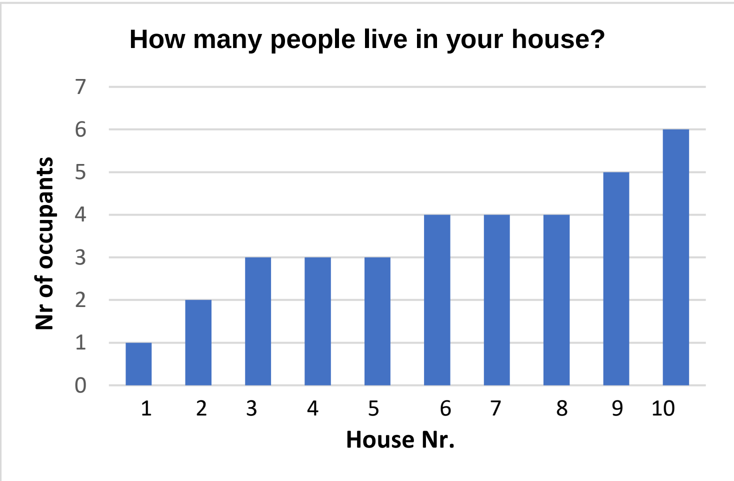

Figure 5.2: Number of house occupants - Clayville

Figures 5.1 and 5.2 above show the number of house occupants in each of the case study sites. Slovo Park has an average of 4.9 persons per household while Clayville has 3.5 persons per household. It is important to look at the household size in relation to the 100-litre solar geyser installed in both projects in order to get insights into the effectiveness of the geyser to the entire household. The next section, section 5.3.1, presents an analysis of the data presented in these two figures.

The following is a summary of direct responses from house beneficiaries on questions related to how they are benefitting from the regulations. Ten households were interviewed in each project.

Table 5.1: Summary of interview data on solar energy

Interview responses to sub-question 3 – Are households benefitting from energy efficiency (solar geysers) as regulated for basic household needs?

	Interview Question	**Clayville Extension 45, Gauteng**			**Joe Slovo Park Phase 3, Western Cape**	
1	Is the water from your solar geyser hot when you need it?	Yes	No	Sometimes	Yes	No
		6	2	2	5	5
2	Is there enough hot water for the whole family?	Yes	No	Sometimes	Yes	No
		5	4	1	5	5
3	In winter or on cloudy days when you don't have enough hot water what do you do?	Switch geyser to electric switch		Use the warm geyser water	Use a kettle to heat water	Use the warm geyser water
		7		3	7	3
4	Do you find the water hotter in the mornings or evenings?	Mornings		Evenings	Evenings	Never hot
		1		9	5	5

5.3 Outcomes from Solar Geysers – Analysis of Data Presented

5.3.1 Solar Geysers

In Clayville, in response to whether the water from the solar geysers is hot when needed, 6 of respondents said the water was hot when needed, 2 said it is hot only sometimes and a further 2 said it is not hot when needed (refer to Table 5.1). There may be various reasons for the 4 that are not benefitting. One of these may be because of the time of the day they are using the water (bathing), because 1 of respondents surveyed said they find the geyser water hot in the mornings and 9 said the water is hot in the evenings. The spread of these results may also be directly linked to the size of the households versus the size of the geyser tank which carries 100 litres of water. Figures 5.1 and 5.2 above show the sizes of households in both study sites ranging from three to eight in Joe Slovo and one to six in Clayville. Despite the above, a key factor to a successful community programme is community awareness and participation. There is a need for a more pro-active approach for creating awareness on how SWH should be used and the benefits thereof (Thobejane et al., 2019). Similarly the SACN (2017) argues that there is a general lack of awareness of the benefits of alternative energy and consumer education is therefore necessary. The SACN (2017) report goes on to say that consumers are not aware of the full life-cycle savings that can be derived from energy efficiency.

In Slovo Park, in response to the question on whether the water from the solar geysers is hot when needed, 5 of respondents said the water is hot when needed and the other 5 said it is not (refer to Table 5.1). On further analysis of the data, it was additionally established that the 50% with no hot water have dysfunctional geysers. It then emerged that the purposefully selected beneficiaries were from blocks completed and allocated in 2012, 2013, 2014 and 2017. Some beneficiaries mentioned that the problems started in 2013 when Cape Town started facing water shortages and as a way to control water usage the Municipality cut the water pressure in the area at certain times of the day. The Project Manager confirmed that they are aware of the geyser problems but they were never fixed. He reported that when the water pressure is cut and the geyser water is used up, the evacuated tubes on the roof lie empty for most of the day and when the water pressure normalizes, cold water rushes into the hot tubes causing them to burst upon contact with the cold water. As mentioned earlier, a disadvantage of the low-pressure solar system is the vulnerability of the tubes which affects the entire solar system. Rosenberg and Winkler (2011) found that the South African energy policy failed partly because no process had been put in place to monitor the outputs. This finding of dysfunctional solar geysers amplifies Rosenberg and Winkler (2011) because if there was monitoring of the products versus the intended outcomes, it would have been clear that the Joe Slovo solar geysers have long been dysfunctional and they could have been fixed for continued reliance on renewable energy. Jongelin et al. (2012, 3) also noted that after energy efficiency measures have been installed "monitoring is necessary during the whole life span of the intervention to assure a proper introduction, installation and use of the intervention". Their study further noted that with solar geysers, for instance, it is important to monitor the use to evaluate the initial capital cost versus the benefits of long-term energy savings (ibid. 3). If this was done at Joe Slovo measures to remedy the situation could have been put in place in the interest of reducing household reliance on electrical energy.

From the literature reviewed in Chapter 2, Pooho (2015) noted a similar outcome and also reported negative experiences with the low-pressure solar geysers in the Tsutsumani project in Gauteng. The aim of both projects was to introduce sustainable energy to reduce the strain on electricity resources as well as cut electricity costs for low-income communities. However, in Tsutsumani, beneficiaries experience dysfunctional geysers that leak when the water overheats and is discharged through the overflow valve causing damage to ceilings and interior walls (Pooho, 2015). In Slovo Park, geyser problems are reported to be due to water pressure changes by the municipality as a way of regulating the use of (scarce) water in the city. One can relate this to the Dutch studies reviewed earlier, and especially Visscher et al., (2016) where the performance gap challenge is addressed. A similar finding is evident here with regards to the dysfunctional solar geysers which remain unmaintained over several years. They argue that the performance gap can be attributed to poor built quality where mechanical products are not commissioned correctly and thus malfunction. They further attribute poor functional quality to the low levels of construction monitoring by building control authorities in the Netherlands.

Participants' responses further indicate impaired performance of solar geysers in the winter months. This finding is common in both Clayville and Joe Slovo where 7 of respondents do not get hot water from the solar geysers in winter. In Clayville 7 of the respondents noted that they switch the geyser to the electric backup while others (3) use the luke-warm geyser water anyway. Joe Slovo residents also use both the lukewarm geyser water for their daily household needs, while 7 use an electric kettle to heat their water. This finding is consistent with Orgill (2014, 18) finding that "SWH are very beneficial in summer, but are not as beneficial in winter when they only provide lukewarm water" (p. 18) as well as Pooho (2015) finding of "dysfunctional solar water heating in winter months and rainy days" (Pooho, 2015, 79). Thobejane et al. (2019) found that most households continue to rely on electricity for water heating towards basic household needs despite having a solar geyser. Several technical problems were identified which led to the failure of the geysers. Because of poor quality installations, several solar geysers were found to be either dysfunctional or leaking just months after installation, (Wang et al., 2015 as cited in Thobejane et al., 2019). In South Africa, training on quality installation and maintenance of SWH is practically non-existent, (Thobejane et al. 2019). Similar to the Dutch studies reviewed, Visscher et al. (2016) proposed solutions to energy consumption reduction in new buildings by highlighting on improving the skills base of builders and installers and effective building control and enforcement process. Mitigating proposals on the performance gap as put forward by Dronkelaar et al. (2016) also include extended training in installations to reduce thermal loss in new houses.

There is consistent and growing understanding that solar geysers are not as effective in winter months. Fortunately, South Africa has only three to four cold months in a year. Winter is therefore the shorter period in a twelve-month cycle, when the solar geyser is not fully effective. SANS 10400-XA regulations specify a minimum of 50% of the annual average water heating requirement must come from an alternative source which is covered in the longer SA hot months. The finding therefore is that, whereas there is general compliance to SANS 10400-XA, the benefits significantly decrease during the winter months.

Various studies have shown that more than 40% of the electricity bill of an average household is contributed by water heating through a conventional electrical geyser (Cao et al., 2016; Thobejane et al. 2019). The Sustainability Institute also reports that "nearly 60% of the world's electricity is consumed by residential and commercial buildings, and the building sector is the single largest contributor to greenhouse gas emissions" (Sustainability Institute, 2015, 2). The specification of a solar geyser in compliance with SANS 10400-XA by the two departments therefore relieves households in Clayville Extension 45 and Slovo Park Phase 3 from high electricity costs thus giving them more disposable income for other household needs. The study findings on benefits from solar geysers further corroborated Orgill (2014) which covered the Joe Slovo Phase 3 project with a focus on energy savings resulting from solar geysers. The study measured energy usage patterns of four households and the results showed energy savings of 8-100kWh per month (Orgill, 2014, 18). These savings were found to be directly related to hot water usage from a solar geyser compared to an electric geyser. Pooho (2015) found that beneficiaries realised financial savings in Tsutsumani from the use of solar energy. The study found “sufficient hot water and a reduction in electricity costs (from between R400 and R500 to between R100 and R150) per month” (ibid. 80). Even though this study did not collect data on cost savings all houses in the study sites are on pre-paid electricity billing system which would complicate the monitoring of the actual cost savings.

On beneficiary experiences with energy efficiency as regulated in SANS 10400-XA for basic energy needs, the study therefore concludes that most beneficiaries are benefitting from the SANS 10400-XA specification of alternative water heating. This conclusion is consistent with findings from similar studies reviewed in this study. Another outcome of the study on beneficiary experiences is the existence of a performance gap where another section of the respondent beneficiaries do not benefit from solar water heating due to ill fitted products which end up becoming dysfunctional. In terms of product specification, the geysers used in Gauteng had an advantage over the ones specified in the Western Cape. This is mainly because the water circulates at high pressure and does not rely on gravity flow as in the low-pressure system. Secondly, the high-pressure systems come with an electrical back-up option (which is not specified by the Department) but has the extra advantage of continuous hot water supply even during cloudy days and in winter months.

5.4 Outcomes from Thermal Efficiency Measures – Analyses of Data Presented

Table 5.2: Summary of interview data on thermal comfort

<table>
<tr><td colspan="9">Interview responses to sub-question 3 – Are households benefitting from energy efficiency (thermal comfort) as regulated for basic household comfort?</td></tr>
<tr><td></td><td>Interview Question</td><td colspan="4">Clayville Extension 45, Gauteng</td><td colspan="3">Joe Slovo Park Phase 3, Western Cape</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Do you have a ceiling with insulation?</td><td colspan="2">Yes</td><td colspan="2">No</td><td colspan="3" rowspan="2">Yes</td></tr>
<tr><td colspan="2">8</td><td colspan="2">2</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Do you have to warm your house in winter?</td><td colspan="2">Yes</td><td colspan="2">No</td><td>Yes</td><td>No</td><td>Sometimes</td></tr>
<tr><td colspan="2">4</td><td colspan="2">6</td><td>7</td><td>1</td><td>2</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">What do you use to warm the house in winter?</td><td>Nothing</td><td>Electric heater</td><td>Gas heater</td><td>Paraffin heater</td><td>Paraffin heater</td><td>Electric heater</td><td>Both</td></tr>
<tr><td>6</td><td>2</td><td>1</td><td>1</td><td>5</td><td>4</td><td>1</td></tr>
</table>

5.4.1 Orientation

The orientation of the building must be in such a way that the rooms that are used the most are north facing. In the case of low-cost houses, this would be the living room and one bedroom. Further to this, SANS 10400-XA states that the building must be compact in plan (Sustainability Institute, 2015). The orientation of the house allows it to benefit from passive solar heating. This refers to the use of the sun's energy to heat and cool rooms in a building. With passive solar, the building or the building materials use their inherent properties to regulate the temperature towards thermal comfort in relationship to solar energy and natural airflow.

The study finds that beneficiaries did not understand this concept. The study further established that that the orientation of the houses was primarily dictated by the orientation of the stand. As a result, the north facing orientation was not achieved for all houses and blocks. In effect, for houses to benefit from passive (north-facing) solar, the process must start with town planners who must ensure that stands are primarily north-oriented. This then enables architects to orientate the houses accordingly on the erven.

5.4.2 Ceiling Insulation

Part of thermal comfort comes from ceiling insulation. The houses in both projects have ceilings with insulation. However, one official respondent in Gauteng mentioned that during inspections, it is important to climb up and look into the ceiling as she once experienced a contractor that placed the insulation only at the trap door to fool inspectors. It is therefore important that thorough inspections are done to ensure proper installation of EE products (Visscher et al. 2016; Dronkelaar, 2016). In Clayville, all walk-up blocks in the project are north-facing with the exception of the L-shaped blocks where the shorter foot print is west facing. The point can therefore be made that these north facing houses can benefit significantly from passive solar in addition to ceiling insulation for thermal comfort. In terms of whether beneficiaries have to warm their houses in winter, 4 responded “yes” they have to warm their houses and 6 responded that they do not have to warm the house (refer to Table 5.2).

The houses in Clayville are a mix of stand-alone houses and walk-up blocks. Of the total of 10 interviewed beneficiaries, five live in stand-alone houses and five live in the blocks. Of those living in the blocks, three live on the top floors and two live on the in-between floors. 4of these beneficiaries reported that they have to warm their houses in winter. Ceilings and insulation are only included in the top floors of the multi-storey block. Not all interviewed beneficiaries live on the top floor and this could be a reason why such a high percentage still have to warm their houses in winter.

It can therefore be argued that ceiling insulation is effective in warming the house in winter in Clayville. This finding is consistent with the expected outcomes of SANS 10400-XA on thermal comfort. The finding is also consistent with the finding on thermal comfort outcome from ceiling and insulation in the Cato Manor project which retrofitted ceilings and beneficiaries appreciated the improved aesthetics and the insulating qualities of the ceiling

(GBSA, 2014). Data loggers were placed in selected houses which monitored indoor temperature and humidity. Data from the loggers revealed lower indoor temperatures in summer. Further to this, a consumer survey was conducted after the completion of the retrofits and beneficiaries reported that the insulation made a difference in cooling the houses in summer months (ibid.13).

Beneficiaries were further asked what space heating sources they use. This was to ascertain if alternative heating sources or the usual electrical heaters were used. One beneficiary said they use an electrical heater, one beneficiary said she uses paraffin to heat her house and cook, another one said she uses a gas heater and another one said they do not use any heating source because electricity is expensive and they are afraid of gas. She went on to say they use blankets to warm themselves and bath with the warm geyser water (refer to Table 5.2). In a study of a low-cost housing community in Mpumalanga, Makapo and Prasad (2005), found that households use a mix of energy sources and they argued that “grid connected households continued to use other fuels like paraffin and wood with electricity for their thermal requirements” (Makapo and Prasad, 2005, page 5). This is constistent with findings of this study where grid connected houses also use alternative sustainable energy for their thermal requirements like solar and gas as well and they only turn to electricity under limited conditions.

In Joe Slovo four beneficiaries reported that insulation is not placed throughout the ceiling but intermittently. This they say became evident when they experienced condensation and the ceiling areas with the insulation did not get damp. If a product is not installed correctly, it will not be effective. Such poor installation results in an energy performance gap contrary to the expected energy saving performance of the ceiling insulation. In their review of experiences with the Dutch energy efficiency regulations, Dronkelaar et al. (2016) reported similar findings of poor installations and thus poor performance of EE products. Their study proposes extreme tightness of adjoining materials to limit air infiltration as air tightness was found to be compromised during construction through, for instance, discontinuing insulation material or punctured barriers (ibid.). They concluded by recommending extended training in installation to reduce thermal loss in new houses.

With regard to the condensation, the Project Manager explained that prior to SANS 10400-XA coming into effect, the house specifications in Joe Slovo included airbricks. Airbricks are bricks with holes used to improve air circulation and avoid condensation in a room by allowing in air from outside. However, airbricks are no longer specified with the implementation of SANS 10400-XA and beneficiaries reported that they experience condensation. Condensation is common in the coastal regions and should have been taken into consideration in conjunction with SANS 10400-XA requirements in the specifications. This finding of poor design (the neglect of airbricks) confirms Moodley and Tramotin (2015) conclusion in their review of South Africa's higher education curriculum on energy efficiency in buildings where they argued that the current curriculum does not equip built environment practitioners to adequately plan for efficient buildings. They stated that in order for South Africa to move toward a more sustainable future, proper education and training of professionals in sustainable and energy efficient design is required (ibid.).

On the interview question as to whether beneficiaries have to warm their houses in winter, 7 responded that they did while 2 responded that they warm their houses only sometimes and 1 said they do not have to warm the house. As in Clayville, the finding points to a mix of space heating energy sources where 5of respondents use paraffin and 4use electric heaters while one beneficiary reported that their household use both paraffin and electricity. The requirement to warm the house with EE measures installed is a set back to the intended outcomes of EE especially when the heating source used is electricity. There is a high percentage of beneficiaries who use paraffin for space-heating and this is concerning as Winkler et al. (2002) argued that one of the objectives of introducing energy efficiency to households is to solve health problems caused by poor indoor air quality in homes. The fumes resulting from the burning of paraffin have negative health impacts especially when combined with poor indoor air quality due to poor air circulation (ibid.). Good air circulation is necessary when heating with paraffin or burning coal indoors and several interviewees complained of condensation in winter which could be viewed as a sign of poor air circulation in the houses since the removal of airbricks.

It can therefore be concluded that thermal comfort as intended by SANS 10400-XA is not fully experienced in Joe Slovo Park and only partially experienced in Clayville (as 4non-benefitting respondents is relatively high). Furthermore, a large percentage (60%) of beneficiaries in both case sites combined still rely on electrical heaters and another 6rely on paraffin for space heating. The intended outcomes of SANS 10400-XA on the use of alternative and sustainable energy sources is therefore not being realised. Orgill (2014) argued that the high density design of Joe Slovo houses should contribute to improved thermal efficiency through the following design attributes: "a block design with shared walls minimises the exposure of middle units to direct outside temperatures with only two exterior walls; the double storey design has a concrete slab separating the two floors creating an additional thermal insulation to the ground floor rooms and lastly the insulated ceilings which reduce the flow of cold or heat from the roof into the house" (Orgill, 2014, page 45). Since the sampled houses are duplex units with no middle floor, the effectiveness of this design approach could not be specifically assessed in this study.

5.5 Conclusion

Data gathered and presented in response to the third sub-question of the study aimed to ascertain whether households are benefitting from energy efficiency as regulated in SANS 10400-XA. The data have shown that beneficiaries are benefitting from these measures to varying degree of satisfaction.

This chapter concludes that most beneficiaries are benefitting from the SANS 10400-XA specification of alternative water heating. Benefits from solar geysers are best derived in the summer months as the geysers provide beneficiary households with adequate hot water for basic household needs. The solar geysers are however not as effective in winter months thus leading to many beneficiaries turning to alternatives such as electric kettles to boil water for bathing or laundry. However SANS 10400-XA specifies that at least 50% of daily household hot water needs must come from an alternative source; of the 20 selected beneficiaries, 11 responded that they have hot water from their geysers when they need it, while two responded that they only have it sometimes and seven of them said they do not have it at all.

In relation to product specification, the findings in this chapter show that the geysers in Gauteng have two major advantages over the one specified in the Western Cape: firstly, they circulate the water at a high pressure, and they do not rely on gravity as a low pressure system does. This high pressure provides for a pressurised flow of water into the house whereas a gravity fed flow is often slow. Secondly, the geyser comes with an electrical back-up unit (which is not specified by the Department but this study has shown it is beneficial in the absence of adequate geyser hot water heated by the sun) but has the extra advantage of continuous hot water supply even during cloudy days and in winter months provided the household can afford the additional cost of electricity consumption.

The finding on thermal comfort from orientation and ceiling insulation was that these are not efficient. In particular, 4- of respondent beneficiaries in Clayville and 7 in Joe Slovo responded that they still have to warm their houses in winter. North-facing orientation for most of the houses had not been planned for and it was not always achieved. In Joe Slovo, due to the densification strategy and the design around a communal courtyard, not all blocks can be north facing. In Clayville, the site layout plan does not allow all houses to be north facing. For example, the L-shaped block design of the walk-up section forces some units to face either east or west.

It can therefore be concluded that thermal comfort as intended by SANS 10400-XA is not yet optimised in Joe Slovo Park and only partially optimised in Clayville (as 4 non-benefitting is relatively high). Furthermore, a large percentage of beneficiaries in both case studies combined still rely on electric heaters and paraffin for space heating. The intended outcomes of SANS 10400-XA on the use of alternative and sustainable energy sources is therefore not fully or consistently realised.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1 Introduction and Overview

The aim of the study was to assess the outcomes and effectiveness of the energy policy and related amended National Building Regulations in relation to government subsidised low-cost housing. The study focused on two case studies of housing developments built from 2014 within the low-cost government subsidised housing sub-sector. The regulations were promulgated in 2011 in line with government policies on energy regulations aimed at reducing the country’s heavy reliance on coal for its power generation.

The study therefore developed three sub-questions in order to derive sub-findings that would assist in responding to the overall research question on the effectiveness of SANS 10400-XA for low-income houses built and occupied since 2014 towards addressing basic household energy needs. In response to the study the first sub-question explored international and local case studies on EE implementation and their respective outcomes. In response to the second sub-question the study analysed implementation compliance by the two provincial departments implementing the case study developments. In response to the third sub-question, the study explored households' experiences, in both case study sites, in relation to meeting basic household energy needs through the EE and RE measures implemented. Insights from secondary data reviewed and primary data collected on each of the sub-questions informs the overall conclusions and recommendations of the study as consolidated in this chapter.

6.2 Conclusions on EE and RE Implementation Compliance

Secondary data in response to the second sub-question provided a good guide on South Africa's energy policy and the related progression. The data highlighted that the policy has evolved over the last two decades. However, policy implementation has been slow and mainly on a piecemeal pilot scale through a few low-cost housing projects. In 2011 the National Building Regulations were amended to make the implementation of EE compulsory in all new buildings and subsequently in 2014, these regulations were included in the construction norms and standards of the National Department of Human Settlements. This then prioritized and extended EE and RE to all low-cost housing developments in South Africa.

The sub-finding on implementation through planning for EE compliance in relation to beneficiary awareness and education are that both provincial departments undertake beneficiary education sessions and when beneficiaries move into their new houses they are aware of the energy efficiency features of the houses. In particular, Joe Slovo residents receive a consumer education and home maintenance booklet that explains a lot about their new house. One of the key conclusions from this sub-finding is that ongoing consumer education is required to strengthen beneficiaries' knowledge and understanding of the energy efficiency products installed and how to optimize their use and maintenance.

The sub-finding on the levels of compliance with the SANS 10400-XA regulations in low-cost housing is that both the Gauteng and the Western Cape Departments of Human Settlements have planned for energy efficiency implementation in the low-cost houses since 2014. They have done this by including elements of SANS 10400-XA in their low-cost respective construction norms and standards. This closely aligns with one of the recommendations of the Cato Manor project report that the Department should include energy efficiency interventions into the Housing Code to ensure that low-cost houses benefit from energy efficiency (GBCSA, 2012). However, despite the fact that both provinces have made considerations for all five SANS 10400-XA interventions two of them (under floor insulation and fenestration) have not been specified under the norms and standards because of their costs. The study therefore concludes that cost continues to be a critical barrier to the full implementation of SANS 10400-XA specifications in low-cost housing.

6.3 Conclusion on effectiveness of Solar Geysers for RE interventions

In terms of the provision of hot water for daily household uses, both provincial departments have specified a 100-litre solar water geyser. Clayville houses have a high-pressure solar geyser while Joe Slovo houses have a low pressure system. Even though both systems are SABS approved, findings show that the high-pressure geyser functions better than the low pressure geyser. The water flows at a high pressure and the specific product installed in the Clayville development has an electrical backup (which is not mandatory). This allows beneficiaries to switch to electrical heating on cloudy days and at times when the sun does not heat the water enough. 70% of Clayville beneficiaries switch to the electrical backup providing them with hot water for their daily household needs.

On solar geysers the study concludes that they are effective for daily hot water needs of beneficiary households. A majority of beneficiaries (60% in Clayville and 50% in Slovo Park) benefit from hot water from the geysers. It is further concluded that the high-pressure solar geyser offers better access to hot water to the beneficiaries for basic daily household needs. In some of the houses surveyed (in both projects) the study found a performance gap in hot water supply due to dysfunctional geysers mainly due to poor product installations, poor post occupation maintenance and the lack of understanding of the best functioning period of the solar geyser in relation to the time of the day. The study therefore concludes that further beneficiary education is required on post occupation procedures in order to get the solar geysers functioning for the optimisation of energy efficiency and improved quality of life through behaviour change. In the Dutch EE implementation, several studies, see for example, (Dronkelaar et al. 2016 and Visscher et al. 2016) presented ways of tightening the energy performance gap and concluded that it is important to ensure that energy efficiency products are correctly installed and monitored (Visscher et. al. 2016). The findings of this study concur and this leads to the conclusion that it is necessary to improve the skills base of builders and product installers in low-cost housing projects while also ensuring improved installation monitoring.

6.4 Conclusion on effectiveness of Thermal Comfort Interventions

With regards to the orientation of the houses in the case study developments the findings from interview responses from government employees is that in the design and planning stages of the projects both Departments included north-facing orientation as a key design specification to support energy efficiency. This, however, was not always achieved for every house. The study concludes that the orientation of the houses was primarily dictated by the orientation of the stand as determined at settlement planning stage. As a result, the north facing orientation was not achieved for all blocks or houses.

Given that part of thermal comfort performance comes from ceiling insulation, the study found it difficult to establish whether ceiling insulation was installed without physical inspection which required the use of a step ladder. Ceiling insulation is however specified under the norms and standards of both departments. Despite the specification, 7 out of 10 beneficiaries in Joe Slovo Park still have to warm their houses in winter. The conclusion is therefore that thermal comfort is not experienced in winter. In Clayville 4 of the surveyed beneficiaries have to warm their houses. The study further found that there is continued use of mixed energy sources for space heating comprising of electric heaters, gas heaters and paraffin. The use of paraffin is particularly high with 5 of Slovo Park and 1 of Clayville respondents responding that they use it. In a study of a low-cost housing community in Mpumalanga, Makapo and Prasad (2005), found that households use a mix of energy sources and they argued that "grid connected households continued to use other fuels like paraffin and wood with electricity for their thermal requirements" (Makapo and Prasad, 2005, 5). This is consistent with findings of this study where grid connected houses also continue to use alternative unsustainable energy sources for their thermal requirements.

6.5 Limitations of the study

The findings of the study allow us to understand the effectiveness of the SANS 10400-XA energy efficiency interventions for low-cost housing. However, there were limitations encountered. The findings on the effectiveness of ceiling insulation are limited to the top floors only as in both case sites the house built are multi-storey. The units on the ground and in-between floors do not have ceilings and insulation. This impacted the research as it is not possible to generalise the findings to all selected housing units in the case study. In order to assess the effectiveness of thermal comfort from ceiling insulation future research would have to purposefully select only houses with ceiling insulation.

Another limitation was the lack of previous research studies on the topic. Literature reviewed assisted in identifying the scope of works that have been studied in this research area. These data were built upon as the foundation for the research. However, there is limited prior research on the effectiveness of the suite of EE interventions as regulated in SANS 10-400XA for low-cost housing. Most past research has been to show the benefits and effectiveness of various individual EE interventions and mainly on small scale pilot-project basis. There is no previous research on the full implementation of SANS 10-400XA in low-cost housing.

6.6 Recommendations

Within the context of government-subsidised low-cost housing, this study constituted an evaluation of the outcomes and effectiveness of the amended National Building Regulations aimed at promoting energy efficiency in new buildings (commonly known as SANS 10400-XA). This research adds value to discussions on energy efficiency in low-cost housing and the effectiveness of the government's policy and interventions in energy efficiency and development of sustainable human settlements in general. The study thus facilitates an understanding of the end-user experiences as well as their appreciation of energy efficiency interventions and what this means for their day-to-day quality of life. The study is equally valuable for decision-makers towards adaptation of future interventions on energy efficiency in low-cost housing both at policy-making level as well as implementation. Given that the study primarily draws from implementer-experiences, it can therefore serve as crucial feedback for the Department of Human Settlements in particular, but also for most other stakeholders responsible for translating SANS 10400-XA into low-income housing developments.

From a policy evaluation perspective, this report offers insights towards the ongoing refinement of the implementation processes in pursuit of better outcomes. SANS 10400-XA specifies measures required for energy efficiency in new buildings. With these measures implemented it is assumed that the resultant houses will be energy efficient. However, the study findings show that even with the SANS 10400-XA measures implemented there are performance gaps across the various interventions. One such element may be modelling assumptions at regulations planning stages as mentioned by Jakica (2018) and Conradie

(2018). Jakica (2018) noted that there is a significant gap between the early design phase and the detailed building performance simulations methods. The study therefore recommends further studies to review the solar energy performance modelling for better accuracy in building design simulations for greater benefits from solar energy.

This research has shown the successes of the implementation of the SANS 10400-XA regulations and an extension of the implementation of the regulations will benefit the country even further. Municipalities should explore the various available funding streams for the implementation of the regulations (EE in buildings) and thus the implementation of South Africa's commitments to reduce emissions. In line with the Paris Agreement, South Africa has established various climate finance streams for climate adaptation and mitigation projects.

In 2010 the UNFCC set up the Green Climate Fund (GCF) that funds developing countries to reduce their greenhouse gas emissions. Climate adaptation and mitigation projects that have been funded include projects from all levels of governments (Ngwenya and Simatele, 2020). The GCF has partnered with the Development Bank of South Africa's (DBSA) Climate Finance Facility, and they have raised funding of over USD5 billion for adaptation and mitigation projects across the country (ibid. page 2). In 2014 the Cities of Joburg and Cape Town municipalities benefitted under this programme.

It is recommended that municipalities explore and take advantage of this funding initiative for EE and the implementation of projects that support SANS 10400-XA.

In their review of South Africa's higher education curriculum in relation to energy efficiency in buildings Moodley and Tramotin (2015) argued that "the lack of capacity of the construction sector to implement sustainable practices has been identified as a major barrier to sustainable construction in developing countries." They state that in order for South Africa to move toward to a more sustainable future, proper education and training of professionals in sustainable and energy efficient design is required (ibid.). This suggests that capacity should be built at various levels and it is therefore recommended that the Department of Higher Education together with research institutions identify and improve the education and training of built environment professionals to improve on hurdles such as modelling of building performance simulation methods.

Given that such energy efficiency interventions in low-income housing are fully subsidised by government, it was important to further assess whether this additional investment into energy efficiency is effective in yielding the intended national-level benefits, especially given that the study findings point to several benefits for the beneficiaries. It is however recommended that the national department of human settlements considers high pressure solar geysers with electrical back up as part of its standard architectural specifications for low-cost housing due to the crucial benefits over low pressure solar geysers. It is further recommended that north facing orientation of houses for better passive solar benefits is enforced at settlement planning stages of all projects.

Lastly, in terms of consumer awareness and education it is recommended that ongoing communication and awareness on energy efficiency products and their maintenance is strengthened. Lastly improved construction installation training and monitoring is recommended to avoid the persistence of the performance gaps and thus ensure that EE products are correctly installed in order to serve their intended purposes.

For future research on the topic it is recommended that the sample of houses is carefully selected to include only houses with ceiling insulation to get a better understanding of the effectiveness of this intervention in relation to thermal comfort.

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SOURCES OF APPENDICIES FIGURES

Appendix A: Map on SANS 10400-XA climatic zones. South African Bureau of Standards (2014).

Appendix E: Clayville extension 45 Architectural drawings. Gary White and Associates Architecture, Urban Design, Project Management (2016). Pretoria.

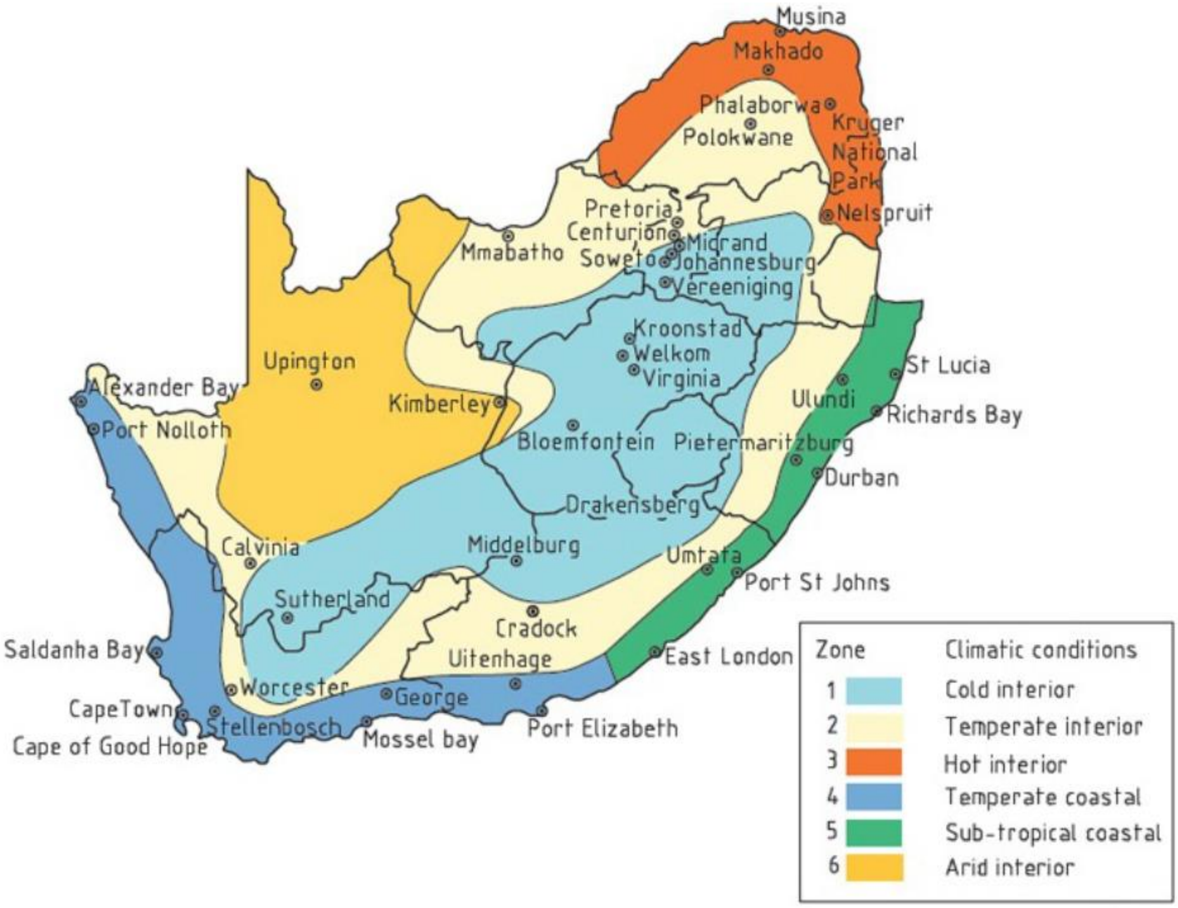
Appendix F: Orgill, A. (2014). National climate change response dialogue. The case of Joe Slovo, N2 gateway project on low income housing. National Department of Human Settlements.

Appendix F1-F3: Joe Slovo Phase 3 Layout plan. JSAssociates Architects & Urban Designs (2010). Cape Town.

APPENDICES

APPENDIX A – MAP ON SANS 10400-XA CLIMATIC ZONES

Source: SABS (2014)



SANS 10400XA has 6 elements that every new building must comply with but focuses on two major streams; hot water supply and energy efficient design. SANS 10400-XA has divided the country into climatic zones with each zone having its specific requirements in terms of the *R*-value. The *R*-value is the thermal resistance of a building component and it is measured in square metre K/W.

Clayville extension 45 is in climate zone 1 and Joe Slovo Park phase 3 is in zone 4. Below is a summary of requirements for each of the 2 zones in the case study.

SANS 10400-XA Element	Zone 1: Clayville ext. 45 requirements	Zone 4: Joe Slovo Park phase 3 requirements
1. Water heating - "*At least 50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating including but not limited to solar heating, heat pumps...*"	*At least 50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance*	*At least 50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance*
2. Orientation – *"Rooms lived in the most should be North facing in order for the rooms to benefit from passive solar"*	North facing between 345°and 15°	North facing between 345°and 15°
3. Roof & Ceiling – Must achieve the minimum total R-value specified	Clay tiles roof min. *R*-value = 3.7 m^2kW	Clay tiled roof min. *R*-value = 2.7 m^2kW
	Ceiling insulation min. *R*-value = 3.3 m^2k/W	Ceiling insulation min. *R*-value = 3.3 m^2k/W
4. Walls – "*Masonry walls (Brick/Concrete) must achieve a minimum R-value of 0.35 Single brick/block with a minimum thickness of 140 mm plastered internally and externally.*"	Masonry walls minimum *R*-value of 0.35 m^2kW. Walls constructed of double skin masonry (220 – 230mm) must have plaster applied to the inside	Masonry walls must achieve a minimum *R*-value of 0.35 m^2kW. Single brick/block with a minimum thickness of 140 mm plastered internally and externally

APPENDIX B - INTERVIEW QUESTIONS

Semi- structured interview questions

<u>Questions to Government officials</u>

1. Do you know why the government decided to provide energy efficient houses?

2. In relation to SANS 10400-XA, what energy efficiency measures are specified by your department in its norms and standards?

a)	Solar water heating	Yes / No
b)	Orientation – North facing main rooms	Yes / No
c)	Ceiling	Yes / No
d)	Glazing (double or single performance)	Yes / No
e)	Floors – under floor insulation	Yes / No

3. If all are not specified, please explain why?

4. Since the 2014 gazetting of SANS 10400-XA - are all government-subsidised low-cost housing projects built thereafter compliant to energy efficiency?

   If not please explain why?

5. How do you make sure that all houses comply with the SANS 10400-XA regulation?

6. There are many materials manufacturers and suppliers, many of which may or may not have quality products. How does your department ensure that good quality products are installed in low cost houses?

7. Do you receive any complaints from homeowners on defective EE products installed in their houses?

   If yes, how do you make sure the complaints are resolved?

8. From your experience would you like to make any suggestions towards a policy review or amendment to energy efficiency in low cost housing?

<u>Questions to house occupant</u>

Pre-house occupation stage

1. How long have you lived in this house?

2. Were there community meetings here where you were informed about the project?

3. Were you informed that you will be receiving an energy efficient house / a house that would help you spend less on electricity?

4. Do you know what things / products have been installed in your house that will help you use less electricity?

<u>Questions related to Hot Water (solar geyser)</u>

1. Is the water from the solar geyser hot when you need it?

2. How many people live in your house?

3. Is there enough hot water for your whole family?

4. For what purposes do you use water from the solar geyser?

5. When do you / does your family bath – In the mornings or evenings?

6. Do you find the water hotter in the mornings or in the evenings?

7. In winter or on cloudy days do you have enough hot water?

8. Has your solar geyser ever given you problems?
   If so what are the most common/frequent problems?

9. Did you tell the contractor about the problem and did they fix it?

10. What else can you tell me about your experiences with the solar geyser?

Questions related to Thermal Comfort (warmth / coolness of rooms)

1. Do you have a ceiling installed?

2. In winter does your house feel warm?

3. Do you have to warm your house at any time or season?

4. What do you use to warm the house and / or bathing water?

5. Do the windows of your house face the direction you would like them to?

6. What else can you tell me about your experiences with the warmth / coolness of rooms of your house?

7. Do you receive a municipal electricity bill?

8. In comparison with neighbours with old houses (houses without energy efficiency) is your electricity bill less than theirs?

human settlements
Department:
Human Settlements
REPUBLIC OF SOUTH AFRICA

Private Bag X644 Pretoria 0001 RSA Tel (012) 421 1311 Fax (012) 341 8512
Private Bag X9057 Cape Town 8000 RSA Tel (021) 466 7600 Fax (021) 465 3610
http://www.housing.gov.za Fraud Line: 0800 701 701 Toll Free Line: 0800 1 46873 (0800 1 HOUSE)

Mr.T Mguli
Head of the Department
Department of Human Settlements
Private Bag X9083
CAPE TOWN
8000

Dear colleague

ENHANCEMENTS TO THE NATIONAL NORMS AND STANDARDS FOR THE CONSTRUCTION OF STAND ALONE RESIDENTIAL DWELLINGS AND ENGINEERING SERVICES AND ADJUSTMENT OF THE HOUSING SUBSIDY QUANTUM

The Minister of Human Settlements, after consultation with the nine Members of the Executive Councils responsible for Human Settlements/Housing of the nine Provincial Governments and SALGA, approved the enhancement of the National Norms and Standards for the Construction of Stand Alone Residential Dwellings and Engineering Services (Norms and Standards). These enhancements to the Norms and Standards will take effect on 1 April 2014.

The enhanced Norms and Standards in respect of the dwellings are based on the requirements of the 2011 revised National Building Regulations; South African National Standard (SANS) 10400 XA- Energy Usage in Buildings.

In addition to the enhancements to the Norms and Standards, The Minister also approved two new house typologies. A special dwelling comprising 45 square metre of gross floor area designed to cater for the needs of disabled persons who are wheelchair dependant has been approved This new dwelling provides adequate internal space for wheelchair movement. In line with the agreement reached with the Department of Military Veterans, a special dwelling comprising 50 square metre of gross floor area with higher level of finishing has been approved for delivery to approved military veterans subsidy beneficiaries. This approval is subject to the condition that the difference in the cost of the revised new subsidy financed house, available to households earning R0 to R3 500 per month and the cost of the enhanced house for military veterans, is financed by the Department of Military Veterans.

To ensure that the new enhanced Norms and Standards are achieved, the Minister also approved the adjustment of the Housing Subsidy quantum with effect from 1 April 2014. The new subsidy quantum is based on current market prices and includes escalation cost. The details of the revised Norms and Standards are as follows:

The minimum standard 40 square metre subsidy house

The Norms and Standards for the minimum size 40 square metre house, to be delivered to qualifying beneficiaries earning R0 to R3 500 per month, have been adjusted by the addition of the following measures to improve the thermal performance of the dwellings:

- The installation of a ceiling with the prescribed air gap for the entire dwelling;
- The installation of above-ceiling insulation comprising a 130mm mineral fibreglass blanket for the entire house;
- Plastering of all internal walls;
- Rendering on external walls;
- Smaller size windows; and
- Special low E clear and E opaque safety glass for all window types as prescribed;

In addition to the above enhancements, approval was also granted for the revision of the current Pre-paid Ready Board electrical installation. These improvements entail a standard basic electrical installation comprising a pre-paid meter with a distribution board and lights and plugs to all living areas of the house.

The total cost of the new dwelling amounts to R110 947,00. The detailed cost breakdown for the 40 square metre house is attached as **Annexure A**.

Certain other minor adjustments to the general specification of the dwelling were also effected and these are contained in the detailed Bill and Elementary Bill of Quantities for the dwelling, which will be forwarded to your office in electronic format via e-mail facility.

Internal municipal engineering services

In regard to internal municipal services, approval was granted that Provincial Human Settlement/Housing Departments and Municipalities may decide to install either A Grade or B Grade levels of services as required by the development context of each project area. Typically A Grade level of services will be required in new Greenfield developments where the Integrated Residential Development Programme is applied to finance the development of holistic, all inclusive and integrated township, providing access to the variety of housing, business and institutional land uses. B Grade level of services will on the other hand be feasible in Informal Settlement upgrading areas, infill schemes in areas where such services are the norm etc.

It should be noted that in all cases, except in projects where the Rural Housing Subsidy Programme: Informal Land Rights are applied, the minimum level of services as prescribed in Volume 2: Technical and General Guidelines of the National Housing Code, 2009, must be adhered to.

It is furthermore acknowledged that the cost of municipal infrastructure is by and large determined by the nature of the township design and layout. The street front length of the stands is a determining factor in this regard and this must be taken into account when townships are designed. It is therefore not feasible to prescribe a predetermined maximum amount to be used for infrastructure provision. Approval was thus granted that provinces and municipalities should design new townships on the principle to achieve the most economic outcome possible and that the final cost of the infrastructure will be determined on a per project basis at the discretion of the Members of the Executive Councils of the nine Provincial Governments based on the prescribed procurement process outcomes.

To facilitate planning and budgeting processes, the Department has determined the current cost of delivering a serviced stand at A and B Grade levels. These amounts will be adjusted annually in terms of the current approved application of the Bureau of Economic Research- Building Cost Index (BER-BCI) of the University of Stellenbosch. The approved guideline amounts are as follows:

The cost of A Grade engineering services:

Indirect cost	R 6 556
Direct cost	R37 070
Total	**R43 626**

The cost of B Grade engineering services

Indirect cost	R 6 556
Direct cost	R27 845
Total	**R34 401**

The detail composition of the direct and indirect cost is illustrated in **Annexure B and C**

The special dwelling for disabled persons dependent on wheelchairs use

The cost of the dwelling designed for disabled persons dependent on wheelchair use amounts to R164 136. The detailed cost breakdown of this dwelling is illustrated in **Annexure D.** The Elementary Bill of Quantities for the relevant dwelling will be forwarded electronically.

It is important to note that the new house designed for disabled persons, who are dependent on wheelchair use, replaces the current provisions of the Variation Manual for the Adjustment of the Housing Subsidy Scheme Quantum to Cater for Extraordinary Precautionary Measures. All the additions to the house for a disabled person dependent on wheelchair use, as prescribed in the Variation Manual, have been catered for in the new house design, the specification and the cost of R164 136,00. No variations will, with effect from 1 April 2014, be available for disabled persons dependent of wheelchair use.

The house designed for provision to approved Military Veterans

The cost of the dwelling designed for provision to approved military veterans subsidy beneficiaries, which dwelling also comply with the revised National Building regulations SANS 10400 XA, amounts to R188 884,00. The detailed cost breakdown is illustrated in **Annexure E.** The Bill of Quantities for the relevant dwelling will be forwarded via e-mail facility.

The house for military veteran beneficiaries must comprise the following:

- The size of the house must be at least fifty (50) square metre of gross floor area;
- Interior walls must be plastered and painted;
- Two bedrooms;
- A combined kitchen/living area and a kitchen basin;
- Floor tiles throughout the house;
- Fitted kitchen cupboards, stove, solar water heating device, with hot and cold water taps;
- Basic electricity installation/comprising at least one light in each room, two lights in the combined kitchen/living area and an electrical plug in each of the bedrooms and two plugs in the combined kitchen/living area;
- Single carport with paving; and
- Fencing around the stand perimeter.

The following National Housing Programmes are affected by the revised National Norms and Standards that will take effect on 1 April 2014:

The Individual Housing Subsidy Programme

The Individual Housing Subsidy Quantum increases to:

• House cost:	R110 947
• Services cost:	R 43 626
• Raw land cost	R 6 000
• **Total subsidy**	**R160 573**

Consolidation subsidy Programme

The Consolidation Subsidy quantum will amounts to R110 947.

The Institutional Housing Subsidy Programme

The subsidy quantum in respect of the Institutional Housing Subsidy Programme amounts to R110 947. The requirement that the approved housing institution must make a financial contribution towards the total cost of the units, is sustained. The minimum contributions will thus be equal to the cost of the raw land and/or the municipal engineering services cost.

The Integrated Residential Development Programme and the People's Housing Process Programme

The subsidy quantum in respect of these programmes amounts to:

- The house cost: R110 947
- The municipal engineering services cost will be equal to the actual services installation cost of the relevant approved service levels. The guideline amounts are:
    - A Grade engineering service level R43 626
    - B Grade engineering service level R34 401;
- Raw land cost will be equal to the actual land acquisition cost.

It is once again confirmed that provinces and municipalities must ensure that housing subsidy beneficiaries are informed of the value of the subsidy products transferred in their ownership. The relevant Deeds of Grant of the properties must contain the detail composition of the product cost to ensure that beneficiaries are fully aware of the value of their assets.

In regard to the following National housing Programmes, it is confirmed that the annual BER-BCI based grant quantum adjustment is currently being considered and that a further communication may be expected in this regard:

- The Emergency Housing Assistance Programme;
- The Blocked Project Programme;
- The Social and Economic Amenities Programme;
- The Upgrading of Informal Settlements Programme

In conclusion, it is acknowledged that the approval of the new Norms and Standards for the dwellings to be financed from the National Housing Programmes was delayed and that dwellings delivered under the Programme since 10 November 2011 may not have complied with the provisions of the revised National Building Regulations. The Department is in the process of engagements with the Department of Trade and Energy on the matter and you will be advised of the outcome of the deliberations. In addition, Human Settlements MINMEC requested the Department to engage with the Department of Energy on the possibility of a financial contribution by that Department towards achieving the approved full electrification of the subsidy financed houses. You may expect a further communication as soon as the matter has been resolved.

The Department is in the process to revise Section 2.1.7 of Volume 2: Technical and General Guidelines: The National Norms and Standards for Standalone residential Dwellings Financed Through the National Housing Programmes of the National Housing Code, 2009. The revised document will be provided to you in due course.

The enhancements to the Variation Manual as supported by the Task Team: Development of National Housing Programmes will now be feed into the MINMEC decision-making process. As soon as approval of the revised Manual is obtain the revised document will be disseminated to all provinces and municipalities.

DIRECTOR-GENERAL
Date: 19/12/2013

APPENDIX D – GDHS CONSTRUCTION NORMS AND STANDARDS

GAUTENG PROVINCE
HUMAN SETTLEMENTS
REPUBLIC OF SOUTH AFRICA

GAUTENG DEPARTMENT OF HUMANSETTLEMENTS
STANDARD SPECIFICATIONS FOR LOW COST HOUSING 2014/2015 FY

Please note these specifications may change subject to revision of the subsidy budget

GENERAL:

All of the following should be included in the Notes/ Specs on all drawings title blocks

- ✓ All building materials to be SABS approved (stamped where applicable)
- ✓ All workmanship to be carried out in accordance with National Building Regulations and Building Standards Act (Act 103 of 1977, as amended)and the NHBRC Home Building Manual
- ✓ In case of uncertainty National Building Regulations and the NHBRC Home Building Manual should take precedence
- ✓ All raft foundation inspection requests to be accompanied by the Engineer's certificate.
- ✓ Wall plate inspection to be done on un-plastered walls

DESIGN SPECIFICATIONS

1. **Area of unit:** 40 square meters
2. **Bathroom:** The bathroom is to contain a wash hand basin [whb] and water closet [wc] and a bath [b].(Refer to Gauteng Department of Housing (GDoH) approved drawings GDoH/A1/05 & GDoH/A2/05)
3. **Bedrooms:** The unit is to consist of two bedrooms.
4. **Privacy:** The unit designs shall allow for privacy of the occupants in terms of i) all rooms to have lockable doors, 3 lever lock set for exterior doors & 2 lever lock set for interior doors.

5. **Lounge / open plan Kitchen:** This to be allowed for as open plan type design. The kitchen space shall allow for a sink/tap unit securely mounted to the wall with hot and cold-water supply.
6. **Access/Entrances:** The unit to have two (2) external doors
7. **Orientation of building:** Building should be orientated in accordance with SANS 204 & 10400XA

CONSTRUCTION SPECIFICATIONS:

FOUNDATIONS

1. Foundation shall be as per the Engineer's design and specifications (a note to this effect to be on drawings).
2. Foundations shall be inspected and certified by a registered Engineer.
3. **On the foundation drawings it must be clearly stated which soil class the design is for (the geotechnical report used to design the foundation is required)**
4. Trenches must be dug out so that the foundation rests on hard ground, with the trench width and depth conforming to the Engineers drawings.

STORMWATER MANAGEMENT

1. 900mmX75mm 15 MPA Concrete apron to be provided on eaves side of house sloping away from the foundation. Concrete aprons to have 10mm thick expansion joints at 3m intervals all as per Engineers detail and specification.

WALLS

1. External walls to be single leaf 140mm thick cement Maxi bricks (290x140x90) or similar approved (min 7mpa) on 375micron DPC.
2. Provide 2,8mm brick force every 4th course, as well as every course above windows and doors or as specified by the Engineer
3. Brick-force to be tied securely between internal and external walls
4. Internal walls to be 140mm maxi brick on flat (or 290X90X90mm high special brick) and duly bonded (built into) to external walls every 4th course, with DPC and brick force as above
5. The maxi brick to be built into the 140mm door frames and into the clisco window frames
6. Horizontal DPC to be laid with mortar above and below the membrane, which extends over the full width of the wall including plaster thickness
7. Cement mortar mix for walls to be of 1:5 proportion by volume **2 bags cement (1wheelbarrow): 5 builders wheelbarrows sand**

8. Building sand to comply with SABS 1090 and be well graded from 5mm downwards. Sand should be evenly graded and should not contain an excess of dust or other fine material.
9. Provide a 150mm wide plaster band around the door and window openings. Paint colour to differ from the rest of the external walls paint colour.
10. Openings for waste pipes in walls to be neatly core drilled and not knocked open.

DOORS AND WINDOW FRAMES

1. Clisco type steel window frames (1.3mm) or similar approved.
2. For window sizes and quantities refer to GDoH approved drawings GDoH/A1/05 & GDoH/A2/05 as revised.
3. External doors: Hardwood 2 or 4 panel Meranti or Saligna door on Clisco frame.
4. Window frames other than Clisco to comply with SABS 727.
5. ND4 type window frame to living room, ND2 to bedrooms, NC1 type to kitchen and NE1 to bathroom.

PLUMBING
(All plumbing installation by a registered Plumber)

1. Provide a 1700X700mm standard Perspex built in bath with 2 tap holes, securely built-into brick up stand support, silicone sealed all round against the walls, with cleaning eye with access, with SABS hot and cold water pillar taps or a mixer tap (no plastic taps allowed). Bath to have a 30X52mm wastepipe, P- trap, an overflow drain outlet and a 400mmx400mm openable service hatch.
2. Provide a ceramic wash hand basin in bathroom min 350mm DIA with 2 tap holes and hot and cold SABS pillar taps or a mixer tap. Silicone sealed at wall and securely fixed to wall
3. Cistern to be made of porcelain 11 litres water capacity, complete with ball and beta valve, flushing mechanism and flush pipe.
4. Water closet pan to be of glazed fire-clay or glazed porcelain, fixed to floor with 1:3 cement mortar mixes. Seat to be heavy duty plastic type with flap and hinges of similar quality properly fixed to the pan.
5. Provide 1 stainless steel sink with 2 tap holes and hot and cold SABS pillar taps or a mixer tap (no plastic taps allowed) to Kitchen area. Sink to be at least 900mm long and securely fixed to wall with 2 brackets & silicon sealed against walls.
6. Class B Galvanized pipes as per SABS 62 and 509 to be used on in feed pipe (external). Internally SABS plastic “Polycop” class 16 or similar approved.

GEYSER INSTALLATION

(All plumbing installation by a registered Plumber)

1. Geyser to comply with SANS 0254 and SANS 10400XA.
2. Water tank capacity 100 liter high pressure geysers to be installed as per manufacturer's specification.
3. Provide hot water supply from tank to 3 points (bath, WHB and kitchen sink)
4. Roof support to be in place for Geyser as per Structural Engineers drawing. Installation to be signed off by Engineer/Manufacturer.

DRAINAGE

1. Provide one (1) 110mm concrete gully with grid and trap. Provide a 12mm hose bib tap above gulley.
2. All water supply piping to run inside house, only 1 inlet to be visible on exterior of house no longer/higher than 300mm above T.O slab.
3. Provide a 50mm diameter vent pipe to the drainage system.
4. Provide rodding eye at head of drain and within 1,5m of connection point, and an inspection eye at each junction.
5. Provide marked covers at ground level for Rodding eyes.
6. Drainpipes to be at least 1m away from the walls/foundations
7. Drainpipe invert level to be min. 450mm at head of drain

FINISHES

1. **Floors** to be power-floated or a have **a smooth** steel-trowelled finish.
2. All steel window **frames**, including concealed areas of these, to be painted with 1 coat of universal undercoat (oil based) and 2 final coats of enamel paint in addition to factory painted red-oxide.
3. External doors to be treated with mixture of linseed oil and turpentine and to be finished with I (one) coat polyurethane varnish.
4. Timber trusses – all exposed parts to be treated (painted) with wood creosote.
5. All External walls to be plastered and painted with an undercoat & 2 final coats SABS approved PVA paint with 2 different paint colours as per elevations.
6. Internal walls to be finished with cement slurry. Internal walls to be painted with one undercoat & 2 final coats SABS approved PVA paint.
7. 150mm plaster band around all window and doors. Paint colour to contrast that of the walls

ROOF (OPTION A)

1. Concrete **roof tiles** or similar approved with SABS (SANS 1783-20) underlay on 38X50mm SA pine battens @ 320mm C/C on 152X38mm SA pine grade 6 prefabricated timber (or similar approved) trusses @ 20 degrees @ max 760mm centres on 114X38mm timber wall plates fixed with approved 40mm serrated galvanised clout nails
2. Tapered ridge tiles to have 1:3 cement mortar mix at overlaps and to be laid in full (cutting not allowed)
3. Trusses to be tied down with 2 strands of 4mm galvanized roof wire anchors built-in 6 courses deep into walls tied over a nail in purlin
4. Matching tapered verge tiles or barge boards to the gable ends and fascia boards to the eaves end of roof and nailed with 40mm serrated galvanized clout nails
5. Storm clips on the bottom 2 rows on both eaves

ROOF (OPTION B) Rational roof designed by a competent Engineer

1. SABS approved 0.8mm “Full Hard” (cromadeck) through coloured IBR roof sheeting of steel grade ISQ230 or similar, colour to be baked into the metal sheet and not painted.
2. 150X50X20mm min cold formed lipped channel beams. Min 4 beams per roof. 35x32x2.5mm wall plate
3. Roof slope to be 20 degrees.
4. Roof sheets must be laid with one corrugation side lap and shall be fixed through the crests of alternate flutes to purlins using 65 mm top speed or tex screws into steel purlins and 90 mm Tex or Top Speed screws into timber rafters, all fasteners to have 26 mm dia bonded washers.
5. Beams to be tied down with 2 strands of 4mm galvanized roof wire anchors built-in 6 courses deep into walls tied over a nail in purlin
6. 4mm galvanized roof wire anchors built-in 6 courses deep into walls, tied over nail over timber purlins and spaced at 1m intervals along a length of wall plate purlin
7. Roof to be fixed with approved galvanized roof nails or hook bolts with water-proofed cups/washers. Provide for 3 hook bolts/nails per purlin per roof sheet (1 at each side lap and one in the middle of the roof sheet).
8. Barge boards to the gable ends and fascia boards to the eaves end of roof and fixed with 40mm serrated galvanized clout nails.
9. Storm clips on the bottom 2 rows on both eaves
10. Provide Engineers Certificate of Compliance after roof installation.

<u>CEILING</u>

1. Ceiling as per SANS 10400XA
2. A minimum of 2,5m ceiling height

3. 6.4mm Gypsum board ceiling with 135mm insulation to be fitted on 38X38mm, SA pine brandering at 450mm C/C, painted white, with 75mm standard cornice painted white fitted with Rhino bed. And 600X600mm standard trap door painted white.

ELECTRICAL

(All electrical installation by a registered Electrician/ Wireman)

1. One (1) electrical plug per room (excluding bathroom) (Double 15AMP power point @300mmAFFL)
2. and one (1) light switch per room (1-way switch @1500mmAFFL), one light above each exterior door. Ceiling mounted low voltage Compact Fluorescent Light (CFL) fittings to all rooms.
3. I stove isolator
4. A ready Distribution board
5. SABS and Municipality approved pre-paid electrical meter
6. Conduiting to all areas surface mounted.
7. Provide Electrical Certificate of Compliance after installation.

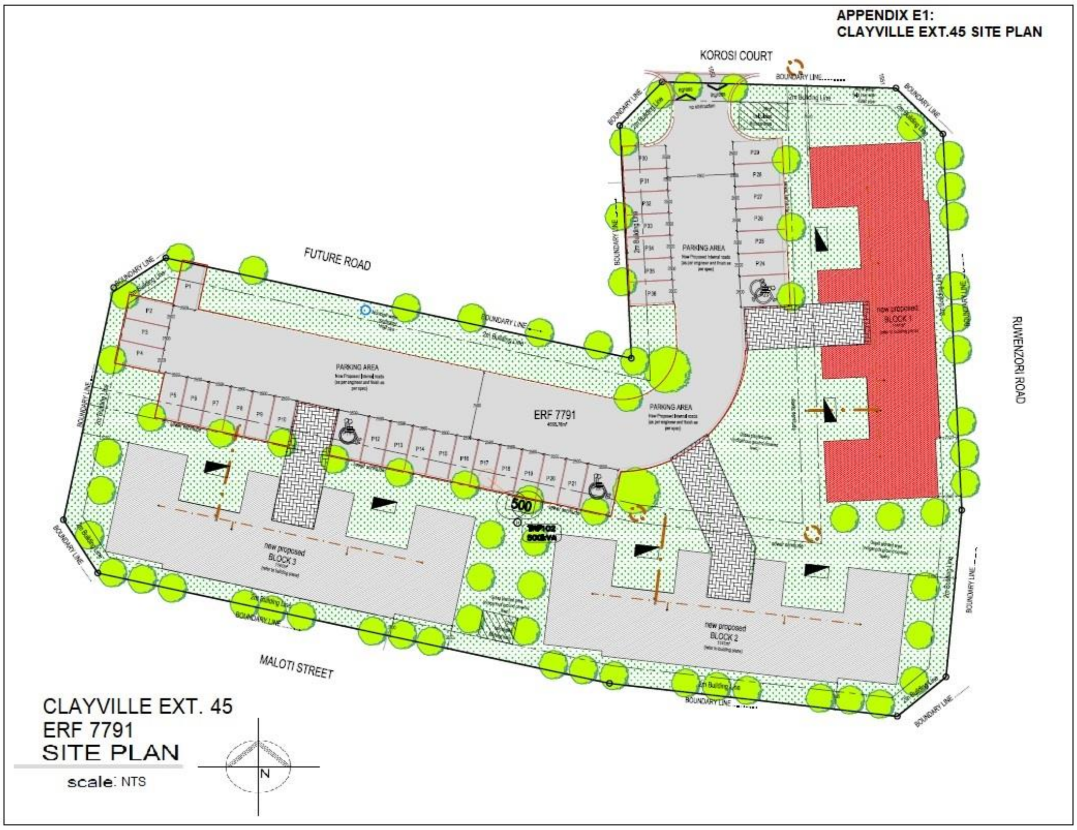
GLAZING

1. Glass area of less than 0,75m2 to be 3mm thick.
2. All glass more than 0,75m2 to be 4mm thick.
3. Glass to bathroom to be 4mm obscured glass.
4. All putty to be treated with a hardener and finished off with universal undercoat and 2 coats enamel-based gloss paint to final colour and finish.
5. Glass to comply with SABS 0137

END

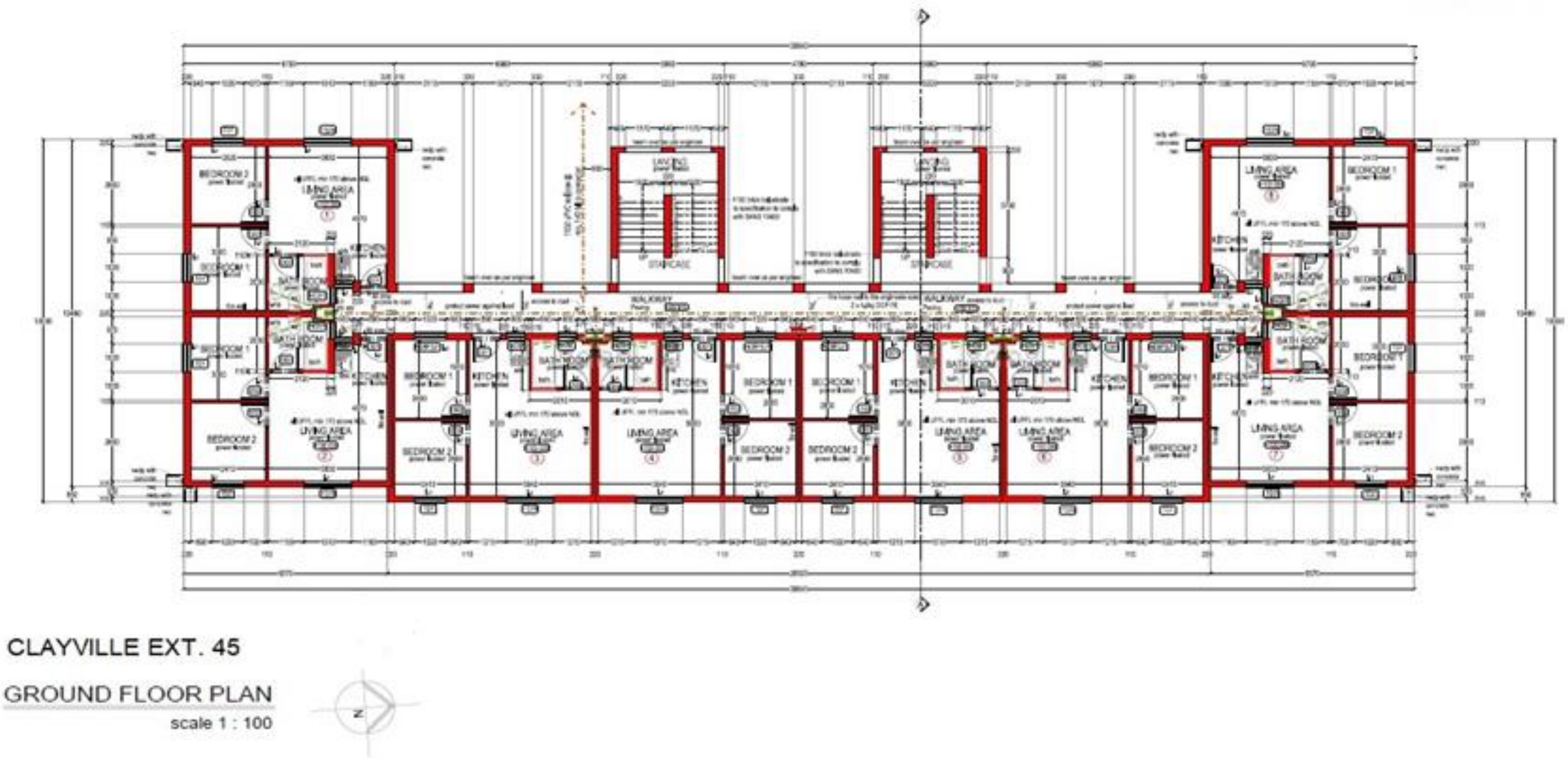
APPENDIX E – CLAYVILLE EXT. 45 ARCHITECTURAL DRAWINGS

SITE PLAN



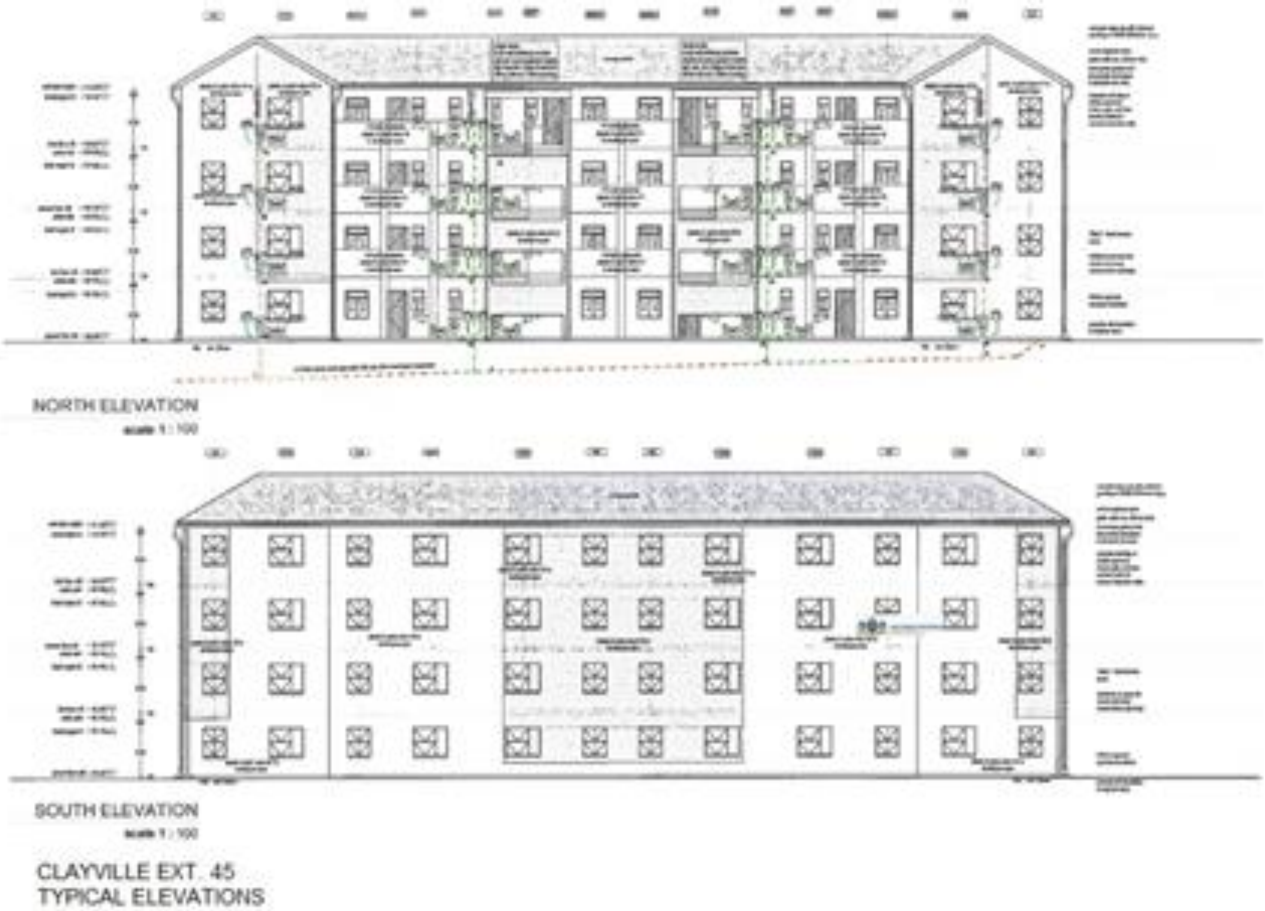
APPENDIX E1 – CLAYVILLE EXT. 45 ARCHITECTURAL DRAWINGS

TYPICAL FLOOR PLAN



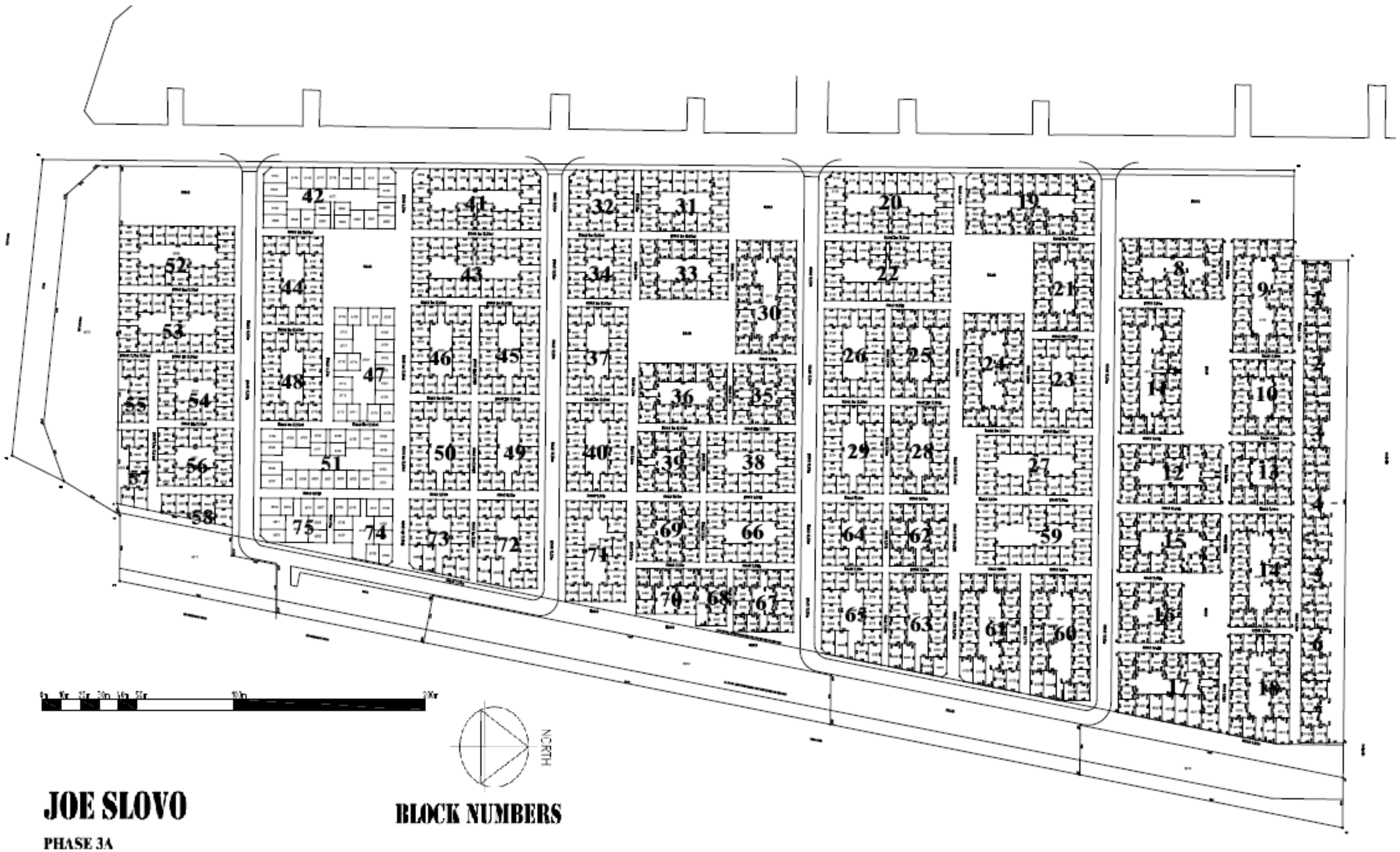
APPENDIX E2 – CLAYVILLE EXT. 45 ARCHITECTURAL DRAWINGS

TYPICAL ELEVATIONS

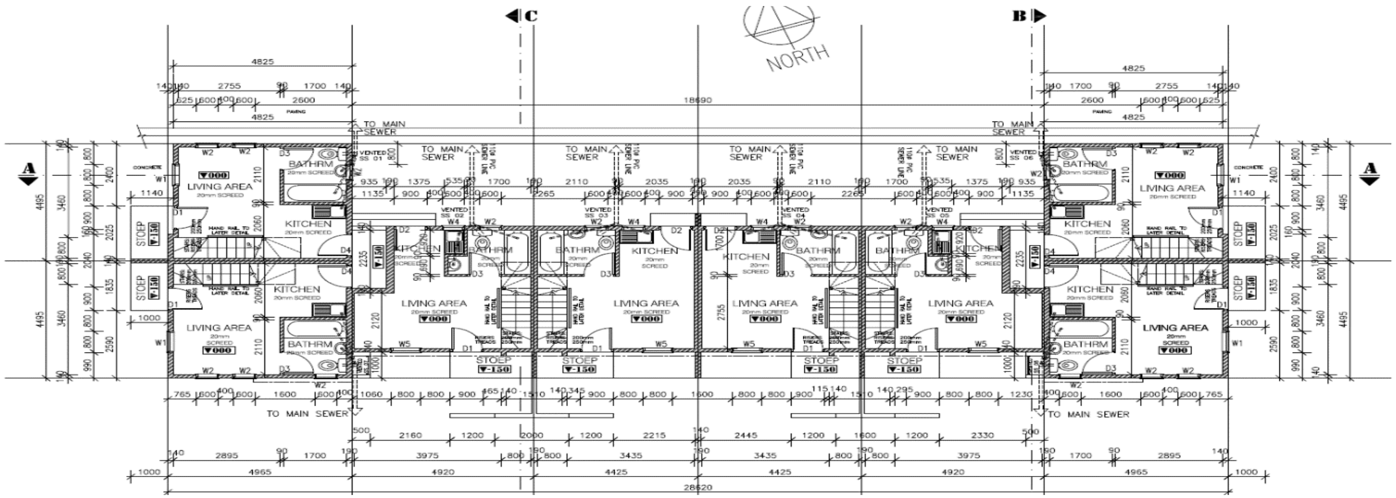


APPENDIX F – JOE SLOVO PHASE 3 EE INTERVENTIONS SKETCH SECTION

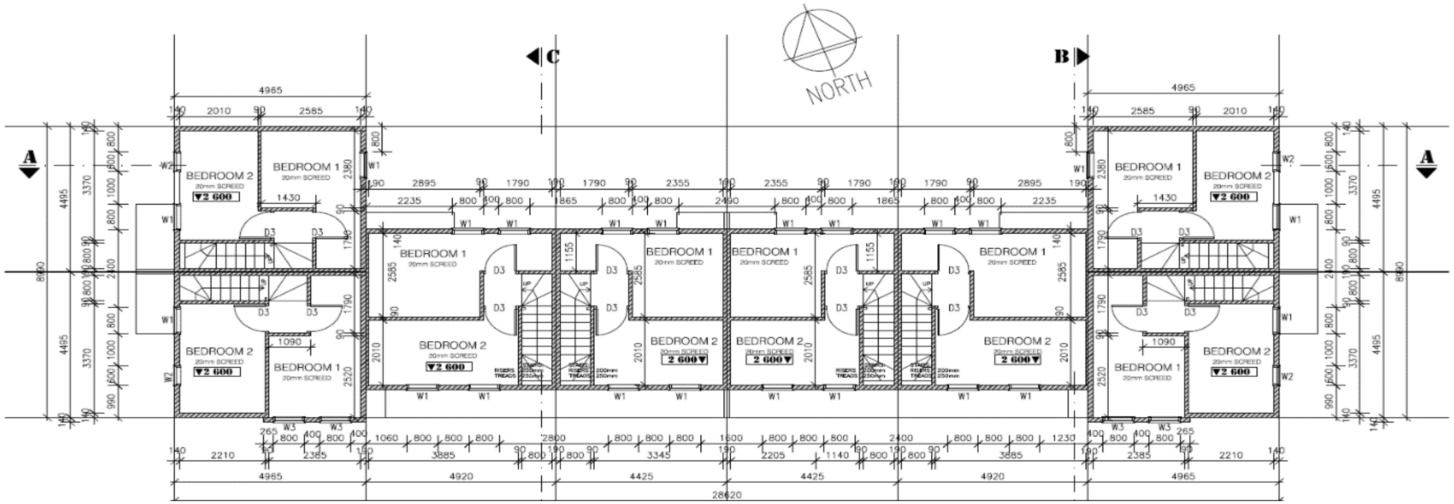
APPENDIX F1 – JOE SLOVO PHASE 3 LAYOUT PLAN



APPENDIX F2 – JOE SLOVO TYPICAL FLOOR PLANS

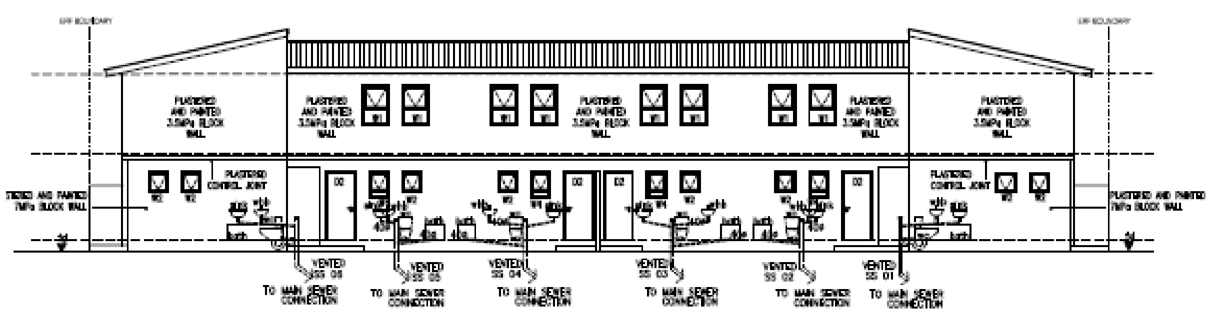


TYPICAL GROUND FLOOR PLAN

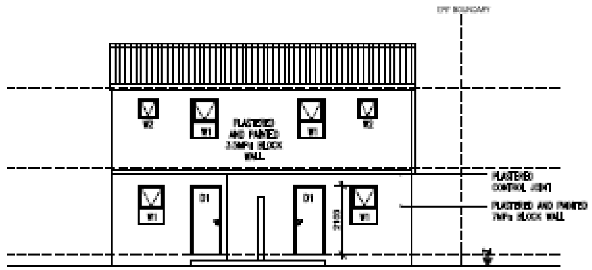


TYPICAL FIRST FLOOR PLAN

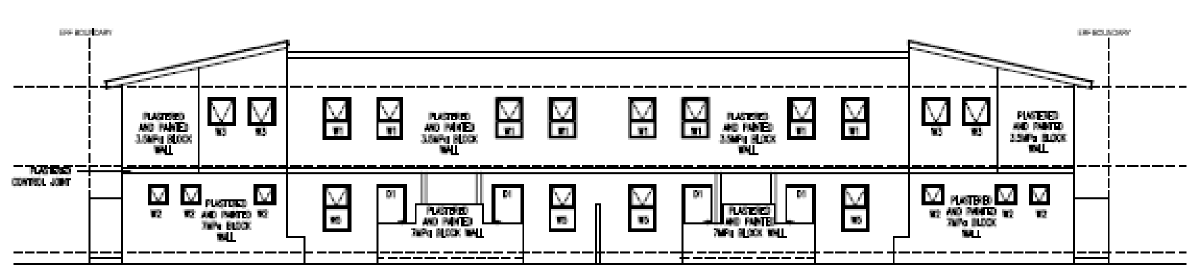
APPENDIX F3 – JOE SLOVO TYPICAL ELEVATIONS



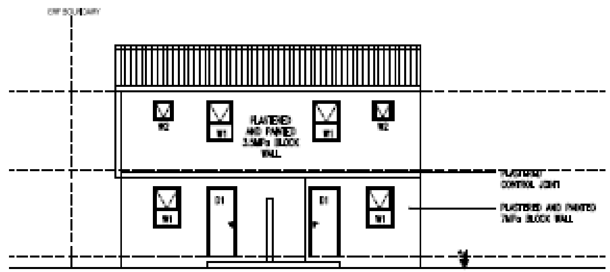
NORTH ELEVATION
SCALE 1:100



WEST ELEVATION
SCALE 1:100



SOUTH ELEVATION
SCALE 1:100



EAST ELEVATION
SCALE 1:100

APPENDIX G – ETHICS CLEARANCE CERTIFICATE FOR THE STUDY

SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESERCH ETHICS COMMITTEE

SCHOOL OF ARCHITECTURE PLANNING

CERTIFICATE OF RETROSPECTIVE ACKNOWLEDGEMENT
PROTOCOL NUMBER: SOAP034/04/2018

PROJECT TITLE:	Appraising the experiences and outcomes of government-funded energy efficiency in low-cost housing in Gauteng and the Western Cape
INVESTIGATOR/S:	Phumzile Maseko (Student no#809336)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	Master of Architecture Sustainable Energy and Efficient Cities (MSEEC)
DATE CONSIDERED:	10 June 2019
EXPIRY DATE:	10 June 2020
DECISION OF THE COMMITTEE:	Retrospective Acknowledgement

CHAIRPERSON BCBoshoff
(Dr Brian Boshoff)

DATE: 11/6/19

cc: Supervisor/s: Daniel Irurah

DECLARATION OF INVESTIGATORS

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date** 14/06/19

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