Overcoming energy constraints on future development in Stellenbosch through energy efficiency: Retrofitting of solar water heaters and gas stoves in middle and high income households in the residential sector

by

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DECLARATION

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ABSTRACT

South Africa faces an energy crisis which presents itself in two forms; electricity generation dominated by coal fired power stations and current electricity supply capacity being unable to meet growth in demand. South Africa urgently requires new generation capacity: however, power stations take time to plan, construct and commission, meaning that South Africa has to consider other options to meet electricity demand. This necessitates quick and innovative ways of meeting future demand.

Energy efficiency has been identified as "a low hanging fruit" on the energy tree to address supply constraints and reduce energy related greenhouse gas emissions. There are various energy efficiency programmes aimed at raising awareness of measures that households can take to reduce energy consumption. Some of South Africa's key objectives of energy efficiency in the residential sector are to mitigate the effect of peak demand on power capacity and to introduce state of the art technologies. In terms of these technologies, there is an overlap between energy efficiency and renewable energy.

The widespread installation of renewable energy technologies such as SWHs has the potential to delay the need to construct new power stations. SWHs are a viable renewable energy option for South Africa. It is a mature and proven technology with the potential to address South Africa's electricity capacity problems. Not only does a SWH provide financial savings to the customer in the long run but it offers the additional benefit of a reduction in greenhouse gas emissions to society. Although awareness of the benefits of solar water heaters is increasing, SWH uptake remains low. However the uptake is increasing due to; a SWH rebate offered through Eskom, electricity price increases which are forcing consumers to seek alternatives and a national building code requiring energy efficient water heating in new buildings which is expected to come into effect in 2012.

Liquid Petroleum Gas is a low carbon emitting source of fuel for cooking. In South Africa, middle–high income households rely on the electric stove for cooking. Cooking contributes to electricity peak demand. Reducing electricity demand by replacing the electric stove would help in reducing electricity peak demand from the grid. LPG use has been increasing due to the following reasons; electricity supply shortages, shifting government policy on LPG and increasing electricity tariffs forcing lifestyle changes.

This case study sought to investigate the opportunities, as well as the barriers for a Stellenbosch municipality - initiated energy efficiency programme. In terms of energy supply and demand management, the municipality has identified energy efficiency and the introduction of renewable energy sources as options for achieving sustainability. One of the barriers facing energy efficient technologies is up-front costs in the case of SWHs and the cost of appropriate equipment such as gas stoves in the case LPG. The study sought to investigate financial mechanisms that the municipality could use to overcome these barriers and promote the use of SWH and gas stove in the residential sector. Data was collected through a combination of a mini Delphi – expert opinion technique, questionnaires, secondary data analysis, telephone and personal interviews with solar water heater industry stakeholders, LPG industry stakeholders and municipal officials.

The conclusion drawn from this research is that Stellenbosch Municipality can initiate its own energy efficiency programme instead of waiting for national government. Although the municipality can initiate an energy efficiency programme, it needs to find another institution to fund the programme. Funding mechanisms however do overcome the barrier of high up -front costs and high gas equipment costs making energy efficient technologies affordable.

OPSOMMING

Suid-Afrika staan voor ŉ energiekrisis wat op twee maniere gestalte kry: elektrisiteitsopwekking wat oorheers word deur steenkoolkragstasies en huidige elektrisiteitsvoorsieningsvermoë wat nie in die groeiende aanvraag kan voorsien nie. Suid-Afrika benodig dringend nuwe kragontwikkelingsvermoë. Dit neem egter tyd om kragstasies te beplan, op te rig en in diens te stel, wat beteken dat Suid-Afrika ander opsies moet oorweeg om in elektrisiteitsaanvraag te voorsien. Dit noodsaak vinnige en innoverende maniere om in toekomstige aanvraag te voorsien.

Energierendement is as "ŉ laaghangende vrug" op die energieboom geïdentifiseer ten einde beperkings in kragvoorsiening die hoof te bied en kweekhuisgasuitlatings wat met energie verband hou te verminder. Daar is verskeie energiebesparingsprogramme wat ten doel het om die bewustheid te versterk van maatreëls wat huishoudings kan volg om energieverbruik te verminder. Van Suid-Afrika se vernaamste doelstellings ten opsigte van energierendement in die residensiële sektor is om die uitwerking van spitsaanvraag op kragvermoë te verlig en om die jongste tegnologie in te voer. Ingevolge hierdie tegnologieë is daar ŉ oorvleueling tussen energierendement en hernubare energie.

Die algemene installering van hernubare energietegnologieë, soos sonkragwaterverwarming (SWV), het die potensiaal om die noodsaaklikheid van die oprigting van nuwe kragstasies uit te stel. SWV is ŉ lewensvatbare nuwe energieopsie vir Suid-Afrika. Dit is ŉ ontwikkelde en bewese tegnologie met die potensiaal om Suid-Afrika se probleme ten opsigte van elektrisiteitsvermoë die hoof te bied. SWV sorg nie slegs vir die kliënt vir finansiële besparing op die lang duur nie, maar dit bied ook vir die samelewing die bykomende voordeel van ŉ afname in kweekhuisgasuitlatings. Alhoewel die bewustheid van die voordele van sonkragwaterverwarming toeneem, bly die gebruik van SWV laag. Die gebruik is egter besig om toe te neem vanweë ŉ SWV-korting wat deur Eskom aangebied word, elektrisiteitsprysverhogings wat verbruikers dwing om alternatiewe te soek, en ŉ nasionale

boureglement wat energiedoeltreffende waterverwarming in nuwe geboue vereis en wat na verwagting in 2012 in werking sal tree.

Vloeibare petroleumgas is ŉ brandstofbron wat vir kook gebruik word en wat ŉ lae koolstofvrystelling het. In Suid-Afrika gebruik huishoudings met ŉ middelhoë inkomste die elektriese stoof om te kook. Kook dra by tot elektrisiteitspitsaanvraag. Die vermindering in elektrisiteitsaanvraag deur die vervanging van die elektriese stoof kan help om die elektrisiteitspitsaanvraag op die netwerk te verlaag. Die gebruik van VPG het toegeneem weens die volgende redes: elektrisiteitsvoorsieningstekorte, veranderende regeringsbeleid ten opsigte van VPG en die verhoging in elektrisiteitstariewe wat veranderinge in lewenstyl afdwing.

Hierdie gevallestudie het gepoog om die geleenthede, sowel as die hindernisse vir ŉ energierendementprogram wat deur Stellenbosch Munisipaliteit geïnisieer is, te ondersoek. Ten opsigte van energievoorsiening en -aanvraagbestuur het die munisipaliteit energierendement geïdentifiseer en die ingebruikneming van hernubare-energiebronne as opsies om volhoubaarheid te bereik. Een van die hindernisse waarvoor energierenderende tegnologieë te staan kom, is voorkostes in die geval van SWV en die koste van toepaslike toerusting soos gasstowe in die geval VPG. Die studie het ondersoek ingestel na die finansiële meganismes wat die munisipaliteit sou kon gebruik om hierdie hindernisse te bowe te kom en die gebruik van SWV en gasstowe in die residensiële sektor te bevorder. Data is ingevorder deur middel van ŉ kombinasie van ŉ mini-Delphi – kennermeningtegniek, vraelyste, sekondêre data-ontleding, telefoon- en persoonlike onderhoude met belanghebbendes in die sonkragwaterverwarmingsbedryf, belanghebbendes in die VPG-bedryf en munisipale amptenare.

Die gevolgtrekking wat uit hierdie navorsing gemaak word, is dat Stellenbosch Munisipaliteit sy eie energierendementprogram kan inisieer in plaas daarvan om vir nasionale regering te wag. Alhoewel die munisipaliteit ŉ energierendementprogram kan inisieer, moet dit ŉ ander instelling kry om die program te befonds. Befondsingsmeganismes oorkom egter die struikelblok van hoë voorkostes en hoë kostes van gastoerusting wat energierenderende tegnologieë bekostigbaar maak.

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List of Abbreviations

CCSE	-	California Center for Sustainable Energy
CEF	-	Central Energy Fund
CFCs	-	Chlorofluorocarbons
CFL	-	Compact Fluorescent light bulb
CHP	-	Combined Heat and Power
CO_2	-	Carbon Dioxide
CSI	-	California Solar Initiative
DME	-	Department of Minerals and Energy
DoE	-	Department of Energy (formerly DME)
DSM	-	Demand Side Management
EIA	-	U.S. Energy Information Administration
ETA	_	ETA Energy
ESTIF	-	European Solar Thermal Industry Federation
FEW	-	Freiburger Energie- und Wasserversorgungs-AG
GDP	-	Gross Domestic Product
GHG	-	Greenhouse gas
GW_{th}	-	Giga Watt Thermal
ICLEI	-	International Council for Environmental Initiative - Local Government for Sustainability
IDM	-	Integrated Demand Management
IDP	-	Integrated Development Plan
IEA	-	International Energy Agency
IPCC	-	Intergovernmental Panel on Climate Change
KVA	-	Kilo Volt Ampere
kWh	-	Kilo Watt hour
LPG	-	Liquefied Petroleum Gas
LPGSASA	-	Liquefied Petroleum Gas Safety Association of Southern Africa
MVA	-	Mega Volt Ampere
MW	-	Mega Watt
MW_{th}	-	Mega Watt Thermal
NMBMM	-	Nelson Mandela Bay Metropolitan Municipality
NPV	-	Net Present Value
OECD	-	Organization for Economic Co-operation and Development
RECs	-	Renewable Energy Certificates
SDA	-	Secondary Data Analysis
SALGA	-	South African Local Government Association
SANS	-	South African National Standards
SEA	-	Sustainable Energy Africa
SESSA	-	Sustainable Energy Society of South Africa
SPV	-	Special Purpose Vehicle
SWH	-	Solar Water Heater
SWHs	-	Solar Water Heaters
SWHPP	-	California Solar Water Heating Pilot Program
UN	-	United Nations

UNDP	-	United Nations Development Programme
WCED	-	World Commission on Environment and Development
WEC	-	World Energy Council
WLPGA	-	World Liquid Petroleum Gas Association
WWF	-	World Wide Fund for Nature

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Chapter 1:

Setting the context

1.1 Introduction

Energy is a crucial factor in production and it has played an important role in global economic and human development. Energy usage is a direct outcome of the relationship between energy, population and gross domestic product (GDP) (Jaccard, 2005). Energy demand has been steadily growing in response to industrialisation, urbanisation and population growth (World Commission on Environment and Development), 1987; United Nations Development Program), 2004). Urbanisation is accelerating. According to existing projections point out that by 2030, 60% of the world population is expected to live in urban areas (Girardet, 2007: 111). Rapid urbanisation is set to take place in the developing countries especially in Asia Pacific and Africa. Cities consume a greater share of global energy. By 2008, cities and towns used more than two thirds of the world's energy and accounted for more than 70% of global carbon dioxide (CO_2) emissions (International Energy Agency, 2008:180).

Energy needed for services such as cooking, lighting, heating and power for transportation and for industrial applications is currently obtained from fossil fuels; oil, gas, coal, and peat. Fossil fuels emit greenhouse gases (GHG) when they are combusted and converted into useful energy, the most common gases being CO_2, methane and nitrous oxide. These gases are linked to the "greenhouse effect" that causes global warming/climate change (UNDP, 2004). Most of the global increase in carbon dioxide emissions is due to the combustion of fossil fuels for use in urban areas (UNDP, 2004). There is growing concern about the long–term sustainability of the energy intensive lifestyle that the industrialised world has developed.

A city's design and the built environment have significant implication for energy consumptions and greenhouse gas emissions (Bulkeley and Betsil, 2003; Girardet, 2007). This means that cities and towns must begin to play a major role in addressing long-term environmental problems such as global climate change and dependence on fossil fuels by switching to sustainable energy sources. Future development requires energy. Considering that fossil fuels are finite and are not environmentally friendly, it seems that future development will have to depend on alternative sources of energy. In the long-term, renewable energy sources need to replace fossil fuels in meeting our energy needs. However, since renewable energy technologies have high capital costs (Bulkeley and Betsil, 2003: Droege, 2006), it will take a long time to bring this about. In the short-term, strategies to improve energy efficiency stand out as the least expensive and quickest way to curb demand and emission growth (Bulkeley and Betsil, 2003: Droege, 2006; Sebitosi, 2008).

Globally, the application of energy efficiency has the potential to reduce energy demand from the current 435 000 PJ (petajoules) per year to 422 000 PJ per year by 2050 (Greenpeace International and European Renewable Energy Council, 2007:8). Energy efficiency can take place at different stages of the energy conversion chain from production to end–use. According to Lovins (2005) energy end–use efficiency offers the greatest potential benefit.

1.2 Background and justification

Stellenbosch is a developing town and is expected to double in size in the next 20years according to the Stellenbosch Human Settlement Strategy (Sustainability Institute, 2008). A major constraint is that there is limited additional electricity supply, at least for the next 20 years until when Eskom’s new capacity is expected to come on line. This means that Stellenbosch has to expand by decoupling demand rates for energy from the rate of increase in the supply of grid-electricity. To achieve this Stellenbosch has to increase the use of energy efficiency and renewable energy strategies in general, and increase the use of gas stoves and solar water heaters in particular.

In addition, the internal electricity infrastructure is divided into two parts. The first part is managed by Stellenbosch Municipality and the second part by Eskom, South Africa’s electricity utility. Eskom supplies electricity to the municipality which distributes to its users in the municipal area. The Stellenbosch Municipality capacity is based on substations that supply particular areas however; supply from the power utility has been capped. For development planners this means that further developments in these areas will not be possible due to constraints posed by the utility's limited capacity. This will be discussed in detail in section 1.5 on the national energy situation.

In the middle-to-high income houses an electric geyser consumes about 40% to 50% of household electricity consumption (Dinchev, 2004; Eskom, 2008; Department of Minerals and Energy (DME), 2005). In the Western Cape total monthly electricity consumption per middle-to-high income household is about 774kWh (Winkler, *et al*, 2005:9). Of this amount 380.8 kWh per month is used for water heating and 148.2kWh is used for cooking (Winkler *et al* 2005:9). Cooking and water heating a middle–to-high income household consumes a total of 529 kWh monthly. There were 20 000 households in Stellenbosch in 2008 and of these about 17 000 can be classified as middle-to-high income (Carolissen, 2009). This means that geysers and stoves in middle-to-high income households consume a total of about 8.9 million kWh per month. If this could be saved additional power would become available for new developments and electricity could be supplied to about 25 000 housing units assuming consumption per unit of 350kWh per month.

It is apparent that a key to solving Stellenbosch's energy constraints will be to discourage and reduce the use of electricity by middle-to-high income households by phasing out the use of electric geysers and stoves. The simplest way to do this would be to introduce a by-law that makes it mandatory to install solar water heating (SWH) and gas stoves in new developments. There could be incentives for installing a SWH and penalties for installing an electric geyser. However, this ignores the existing households that use electric geysers and stoves. Another solution is required to address this problem.

This research is based on the assumption that in the near future as part of an energy efficiency and renewable energy strategy, it will be mandatory for everyone to install a SWH and gas stove: no one will be allowed to use electric geysers and stoves. The question therefore is: what interventions and strategies can persuade or compel current users of electric geysers and stoves to switch to SWH and gas stoves?

1.3 Objectives of the study

This study aims to investigate potential municipal financial incentives that could be introduced to promote the uptake of SWHs and gas stoves. The study has the following objectives:

i. to investigate the opportunities and barriers to the implementation of an energy efficiency programme by the Stellenbosch municipality;
ii. to show the potential and savings with respect to grid electricity that would result from the use of SWHs and gas stoves by middle-to-high income households;
iii. to highlight the environmental benefits that will flow from achieving sustainable development.

1.4 Significance of the study

The importance of the study is that it will inform policy makers about the possible options to overcome energy constraints in Stellenbosch. The town of Stellenbosch is likely to double in size but there is limited electricity supply for future developments. In addition other municipalities will be able to draw lessons from this case study.

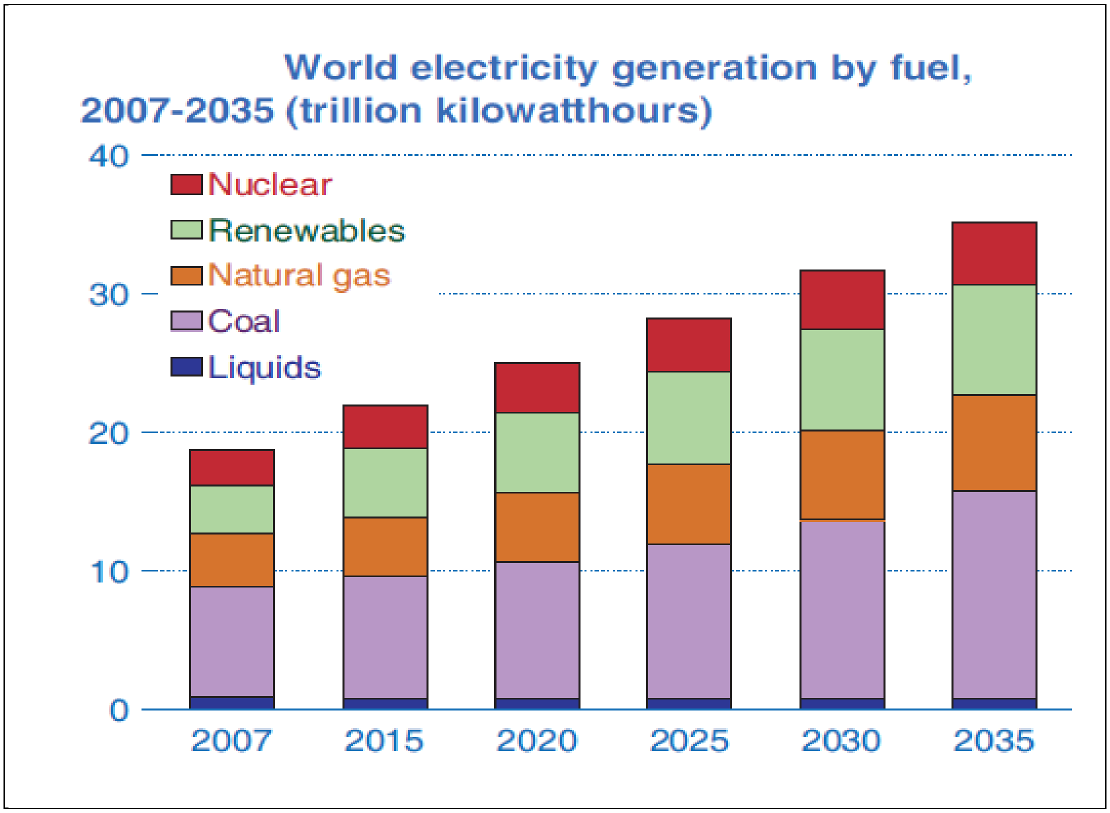
1.5 Setting the context

This chapter discusses the global and national energy outlook. It begins by giving an overview of electricity generation by looking at fuel and electricity consumption trends. The national context provides the basis for this research. Terms will then be defined and an overview of the following chapters will be provided.

1.5.1 Global energy situation

Fossil fuels dominate global electricity generation. Coal plays the most important role followed by hydropower and a tiny percentage of energy is generated from other renewable sources. Coal contributed about 42% of the world's electricity supply in 2007 and its share is projected to remain unchanged through to 2035 (EIA, 2010:12). Figure 1.1 shows world electricity generation by fuel for the period 2007 - 2035.

Figure 1.1: World electricity generation by fuel

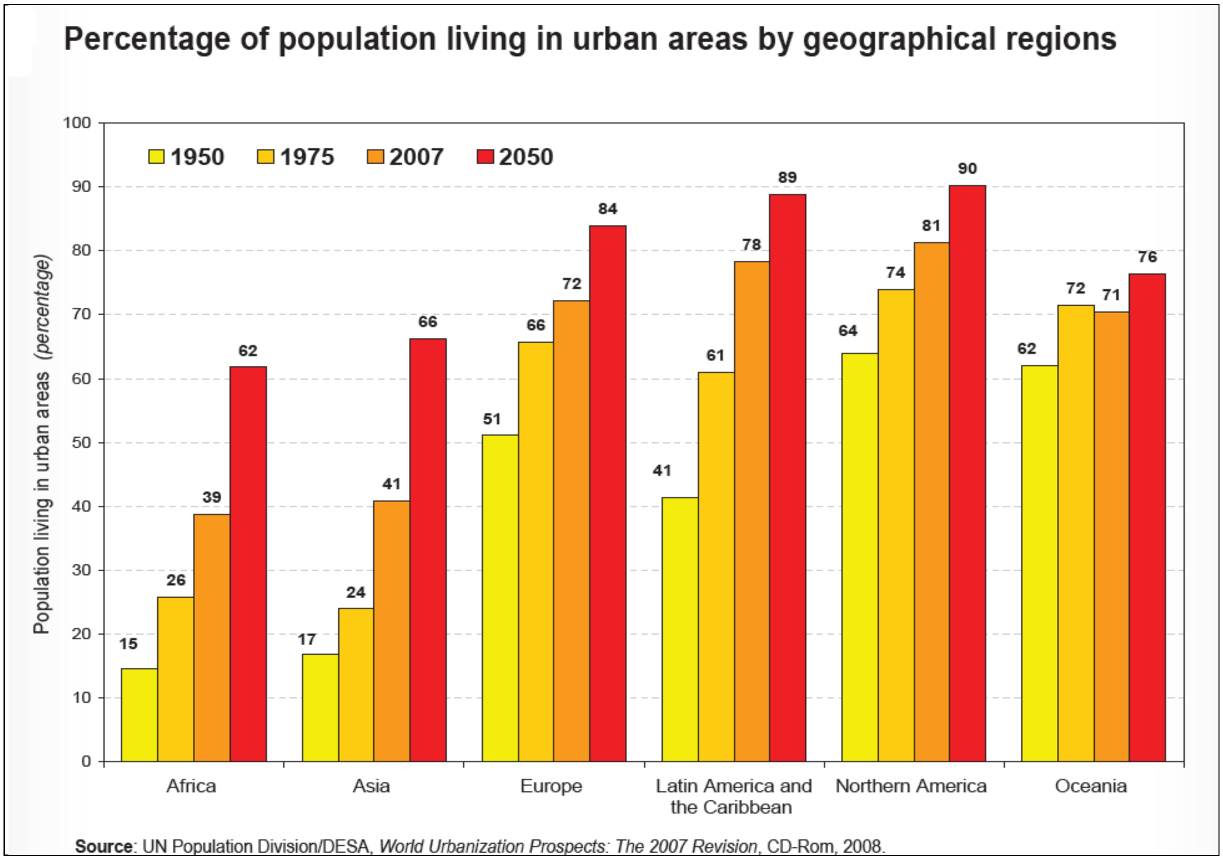


Source: EIA, 2010:12

Figure1.1 shows that fossil fuels are likely to dominate electricity generation through to 2035. Renewable energy use in electricity generation on the other hand will be increase steadily. Although coal is going to be in use for the foreseeable future there has been a shift towards the use of clean coal technologies that focus on reducing carbon emissions from coal. This is, however difficult to police, since some countries are not obliged to reduce carbon emissions. Global energy consumption continues to increase. Developing and newly industrialised countries are largely responsible for this growth in demand. This is because some countries, such as China and India have entered the energy-intensive stage of development. The main drivers of growth in energy demand are urbanisation, population growth, and economic growth. The United Nations predicts that the global population will increase to 9.8 billion by 2050.

The majority of this population will live in urban areas. Figure 1.2 shows the percentage of regional urbanisation trends.

Figure 1.2: Percentage of population living in urban areas by geographical regions



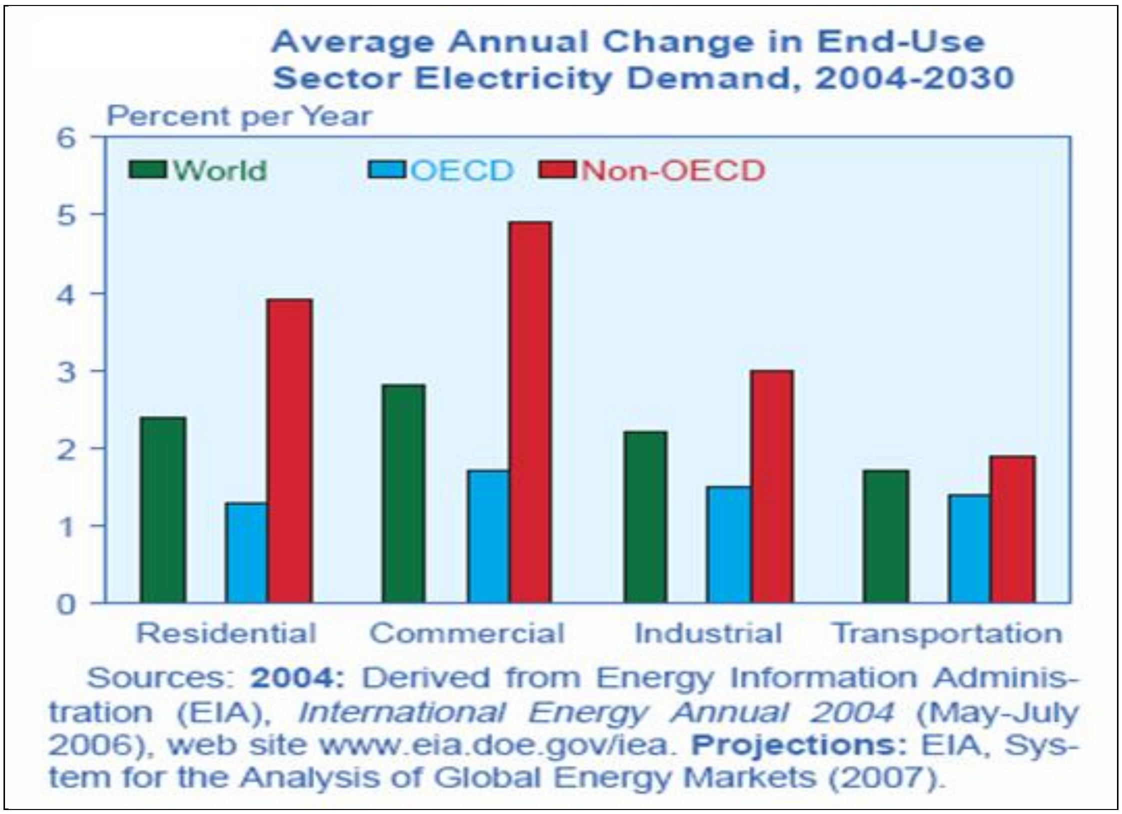
Source: UN Population Division, 2008

Figure 1.2 shows that by 2050 the majority of the world's population will reside in urban areas. The greatest growth in urban population is expected to occur in Asia and Africa.

Predictions by the UN indicate that about 79.6% of South Africa's population will be living in urban areas by 2050 (UN Population Division, 2008). This means that there will be a greater demand for energy services in the urban areas. Local authorities in urban areas need to plan for this growth. This presents an opportunity for urban local authorities to consider sustainable development in their territories and shift to the use of sustainable energy sources.

Economic development of countries leads to an increase in the demand for energy. Trends in end-use energy demand in the residential and commercial and industrial areas and transportation influence the economic development process. In the early stages of economic growth the share of total energy use in industry is high. The process of industrialisation is characterized by huge increases in energy consumption. In the later stages of development the proportion of energy used by transport, residential and commercial sectors increase. As incomes increase the demand for consumer services also increases, which leads to increases in energy consumption (Medlock III and Soligo 2001; Jaccard, 2005). Different countries are at different stages of development, and this means that end-use energy demand also varies according to these stages. Countries in the earlier stages of economic development experience a high demand in industrial sector, while in developed countries demand is high in the residential and commercial sectors. Figure 1.3 shows average annual changes in sector end – use electricity demand for the period 2004 – 2030(EIA, 2007: 62).

Figure 1.3: Average annual change in end-use sector electricity demand 2004 - 2030



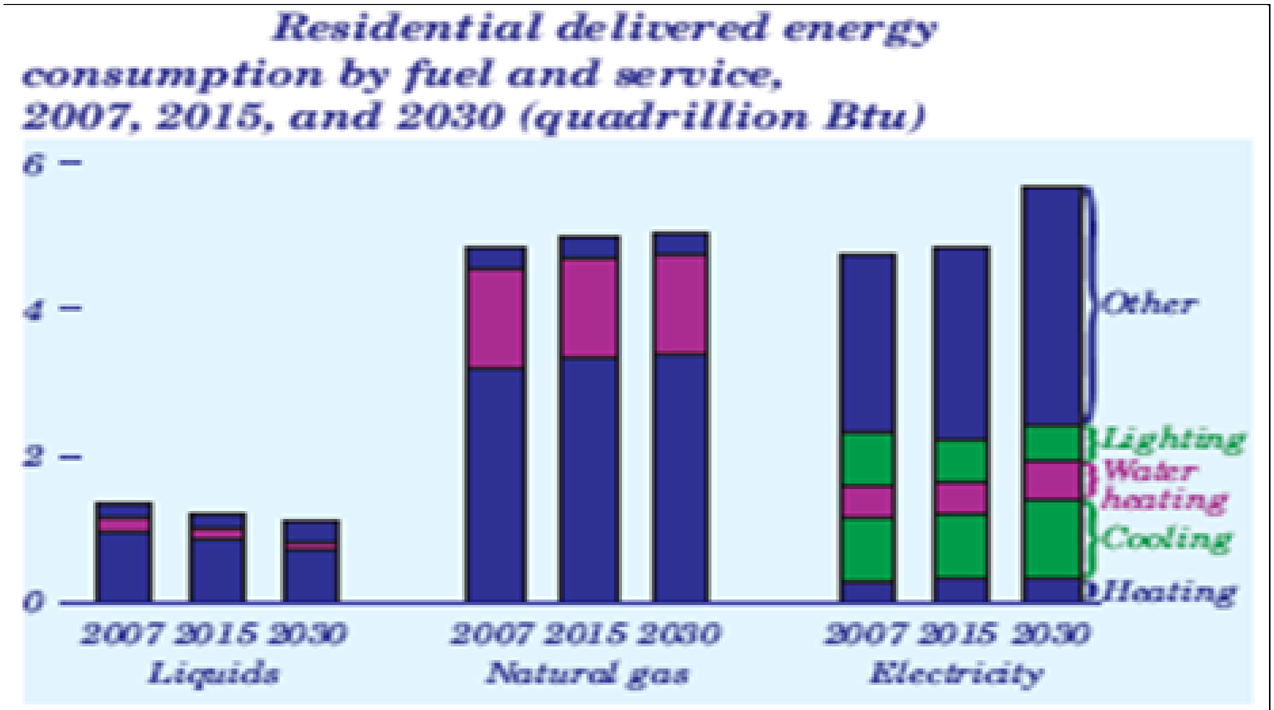
Source: EIA, 2007: 62

Figure 1.3 shows that growth in electricity demand is expected to occur in non – OECD countries. This means that non–OECD countries need to take an alternative development path that is not energy intensive.

In terms of consumption, residential electricity consumption has increased by about 23% over the last decade (EIA, 2009: 63). Residential electricity consumption is expected to continue growing due to the projected 24% increase in the number of households which will lead to an increase in the demand for electrical appliance (EIA, 2009).

Figure 1.4 shows residential delivered energy consumption by fuel and service for the period 2007 to 2030.

Figure 1.4: Residential delivered energy consumption by fuel and service



Source: EIA, 2009; 63

Figure 1.4 shows that consumption in lighting and heating is expected to decrease.

Residential electricity consumption is predicted to increase in the following end-uses water heating, cooling and electricity for other appliances. This presents an opportunity for end-use energy efficiency and the use of renewable energy for these end-use services.

1.5.2 **The national energy situation**

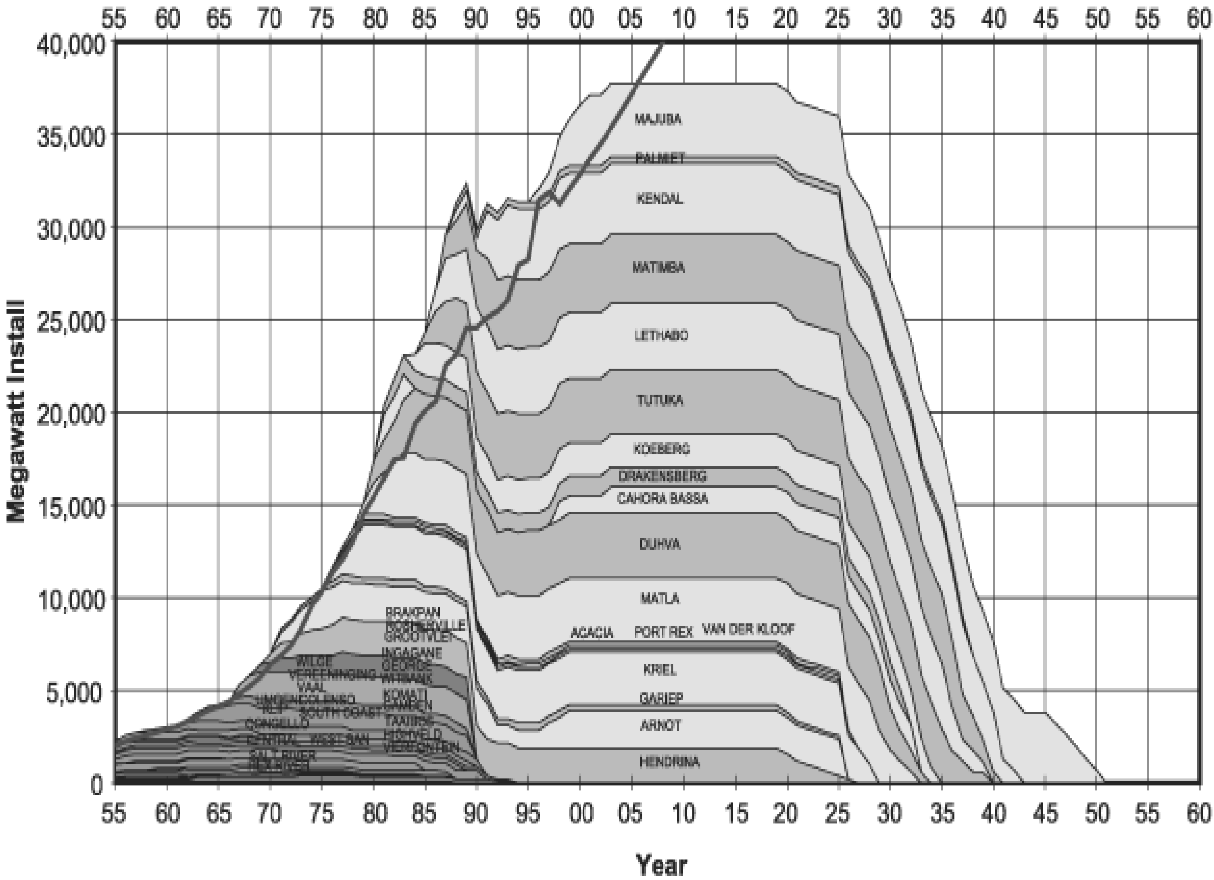
In South Africa, energy especially electricity, plays a major role in economic development by powering productive activities and also providing the basic energy services needed to sustain human life. Historically, electricity supply in South Africa was driven by the needs of the mining industry. As the manufacturing industry grew, so did the country's energy needs. 1994 marked the beginning of a new era and the focus of shifted from energy supply to demand. The major concern of the new government was to address the inequalities of the apartheid era. In addition to addressing these inequalities by increasing access to energy, South Africa also faced the problem of urbanisation.

In 1998, the White Paper on Energy Policy was drafted. Its main objectives were to increase access to affordable energy services, improve energy governance, stimulate economic growth, manage energy–related environmental impacts and ensure security of supply through diversification. The major strategy for extending access to more people has been reliance on electrification. There has been a marked growth in access to electricity in the residential sector (Winkler, 2009).

Eskom, the power utility, produces about 96% of South Africa's electricity (Ward, 2002:19). Electricity generation is dominated by coal-fired power stations. This is a result of coal's availability and low cost. South Africa has the sixth largest coal reserves in the world after China, the United States, India, Russia and Australia (Winkler, 2009). This reliance on coal makes South Africa the "15th largest emitter of GHG in the world…." (Eggertson 2002:42). South African coal power stations have high levels of particulate and CO_2 emissions.

Other contributors to electricity generation include nuclear power stations, pumped hydro-storage and hydropower, and gas, wind and solar energy. Current generation capacity is about 40 000MW but there have been shortages since 2007 with demand exceeding supply. Figure 1.5 below shows Eskom's generation capacity, projected demand and life span of the power stations.

Figure 1.5: Eskom generation, projected demand and power stations life span



Source: RSA, DME, 2003

Figure 1.5 shows that demand (bold line) will exceed supply by 2008 and that most of the power stations need to be replaced between 2025 and 2050. This means that South Africa urgently requires new generation capacity. Eskom's plans to increase capacity include measures to meet short to medium term increases in demand by returning mothballed power stations to service, constructing new nuclear and coal-powered stations for base load generation as well as increasing pumped storage and building gas turbines to meet peak demand. The table below shows some of Eskom's projects for capacity expansion.

Table 1.1: Eskom capacity expansion projects

Project	Fuel	Capacity	Expected date of commissioning
Medupi Power Station	Coal	4 764 MW	2015
Grootvlei Power Station	Coal (Return to service)	1 200MW	2010
Bravo Power Station	Coal	803MW	2015
Kusile Power Station	Coal	4 800MW	2017
Komati Power Station	Coal	1 000MW	2012
Ingula	Hydro Pumped Storage	1352MW	2014
Arnot	Coal (Upgrade)	2 400MW	2010
IPP	Open Gas Cycle	1000MW	2010
Sere	Wind	100MW	Planning stage
-	Concentrating solar Power	100MW	Planning stage

Source: Adapted from Eskom, 2011

In addition, there are plans to increase the contribution of nuclear power from 6% to about 15% of total energy generation in the next 30 years (Republic of South Africa, 2008: 410). Nuclear power is linked to radioactive waste and its disposal requires great care. There is also the threat of nuclear proliferation. There is ongoing debate about the use of nuclear power but this is beyond the scope of this thesis.

It takes time to plan, construct and commission a power plant. This means that Eskom's new capacity will come online between 2010 and 2017. In the current plans to increase capacity, coal and nuclear appear to be the preferred options for base load electricity supply, and gas and pumped storage for peak load electricity supply. This is a worrying situation because coal is carbon intensive and is associated with carbon emissions. Limitations in capacity are a constraint on future development in South Africa.

Future development requires energy to operate. South Africa needs to find quick and innovative ways of meeting this demand. The alternatives to coal in South Africa are the increased use of renewable energy sources (World Wide Fund for Nature, 2009). The government is aware of

South Africa's vulnerability to climate change, and of the urgent need to increase capacity, and it is aware of the benefits of renewable energy.

1.6 Clarification of terms

1.6.1 Energy

"Energy" is an abstract concept; energy cannot be seen, touched, or smelled but we can sense the effects of energy. The most commonly used definition of energy is "the ability to do work or make things happen" (Solway, 2008; Cheshire 2006; Swanepoel, 2007). Energy is contained in matter and does not exist in a vacuum. Energy occurs in various forms such as sound energy, potential energy, kinetic energy, nuclear energy, renewable energy and electrical energy.

Energy is governed by the law of conversion of energy which states;

E*nergy cannot be created or destroyed but can be transformed from one form into another*.

This ability to transform means that energy can flow between systems. Energy is a measurable quantity of light, work or heat. It is measured in barrels of oil, tons of oil equivalent, calories, British Thermal Units etc. In this thesis "energy" refers to power measurable in Watts. Power is defined as the rate of performing work or energy transfer (Cheshire, 2006).

Power	=	Work X Time
	=	Joule/Second (J/s or Ws)

Energy is also measured in kWh. This measure is associated with energy savings, and with the cost of energy etc. It should be noted that this measure (kWh) is normally associated with electrical energy.

1.6.2 Ecological Design

Ecological design is defined as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes" (Van der Ryn and Cowan, 2007:33). Integration in this case refers to both adaptation and working with natural processes. It provides a way of redesigning our buildings, cities, landscapes, manufacturing, waste disposal and systems of food, energy and water (Van der Ryn and Cowan, 2007). Eco – design is an approach that questions conventional design and it is based on the following ideas;

- the need to minimize resource use through restorative material cycles, and
- the need to minimize generation of wastes and consider the ecosystem's ability to absorb wastes,
- where feasible, the need to use renewable sources of energy (Birkeland, 2002, Van der Ryn and Cowan, 2007).

Eco–design takes a life cycle view to ensure that "products are low–impact, low–cost and multi–functional on as many levels as possible" (Birkeland, 2002: 28). Eco–design is not only about reforming existing design but about establishing a new approach to design that brings ecological and economic needs together (Madge, 1997: 49).

1.6.3 Eco-retrofitting

Eco–retrofitting means "modifying buildings or urban areas to create positive social and environmental impacts both on–site and off–site" (Birkeland 2009: 1). The definition introduces the idea that the modification of buildings can occur at micro and macro levels. Retrofitting can refer to a comprehensive home retrofit or to an upgrading of some types of equipment, such as electrical stoves, air conditioners and electric geysers (Knight, *et al.* 2006). Comprehensive home retrofitting has a greater potential for peak demand and

long-term energy savings. There is a need to differentiate between retrofitting, refurbishment and renovation. Refurbishment and renovations refer to adaptations that involve the building envelope such as roof, wall and floor insulation, etc. Renovation is associated with passive solar concepts such as the use of glazed balconies and solar walls (Dalenbäck, 1996:40). The common factor in ecological design is that the main purpose of retrofitting, refurbishment and renovation is mainly to reduce energy consumption in a building thereby reducing CO_2 emissions. Retrofitting can be carried out in conjunction with both refurbishment and renovation. In this thesis retrofitting refers to "efficiency retrofitting" (Birkeland, 2008) that is to the replacement of household appliances/equipment, particularly an electric stove with an LPG gas stove and an electric geyser with a solar water heater.

1.6.4 Climate change

Climate change refers to an increase in global surface temperature caused by an increase in concentrations of atmospheric greenhouse gases (Bulkeley and Betsill 2003; Girardet 2007). It is a result of two major factors, the combustion of fossil fuels and the reduction of the biosphere's capacity to deal with the release of greenhouse gases, such as methane, nitrous oxide, CFCs and CO_2.

1.6.5 Renewable Energy

Renewable energy generally refers to energy sources that are continuously replenished by the natural world. These are primary sources of fuel that are regarded as inexhaustible and do not disturb the natural balance of the earth. They are inexhaustible because they emanate from the electromagnetic radiation created from the sun through fusion (Swanepoel, 2007: 79; Winkler, 2009). This process is expected to continue over a long period of time. The range of possible renewable energy sources is almost endless. The United Nations World Energy Assessment overview of 2004 classifies renewable energy sources into two groups:

(i) traditional renewable for example large hydropower and traditional use of biomass; and

(ii) new renewable energy sources that include modern biomass, bio-fuels, geothermal energy, small-scale hydropower projects, low temperature solar heat installations, wind electricity, solar photovoltaic and solar thermal electricity and marine energy (UN,2004).

What is regarded as renewable energy sources differs from region to region and country to country. For instance the Energy Information Portal of the United States Department of Energy notes that there are seven sources. These include biomass, hydropower, hydrogen, ocean, geothermal, solar and wind energy. In South Africa renewable energy sources include solar, wind, hydropower, wave energy and bio-energy (RSA, 2003). It seems these differences in definition are based on the resources available in different regions and countries.

It should be noted that some renewable energy technologies are already developed and ready for commercial use. Other potential technologies are, however, still in the development stages for example algae bio-diesel production and solar concentration for electricity generation (Leidl and Lubitz, 2009). This thesis focuses on the use of solar energy, particularly for solar water heating.

1.6.6 Energy efficiency

Energy efficiency, simply defined, refers to the ratio of energy services output to energy input (Lovins, 1992; Schipper and Meyers, 1992; Lovins, 1996; Moeller, 2002,). It means getting more out of every unit of energy you use. As a country replaces its inefficient stock of appliances or as its transport system, industrial equipment and buildings are made more efficient or are retrofitted to reduce energy waste, energy efficiency savings take place (Moeller, 2002). Energy efficiency is sometimes interpreted as doing less or doing without resulting in reduced comfort. However the concept in fact means that you get the same service, but with less expenditure of energy (Lovins, 2004; Jochem, 2007). According to Lovins (2004), energy efficiency efforts focus on extraction, conversion and distribution but they ignore end-use and hedonic efficiency. Energy savings from energy efficiency come in small invisible measures and not lump sums that Lovins calls ‘Negawatts” (Lovins, 2004). Energy end-use efficiency refers to the amount of energy used to provide a service. Energy end-use efficiency therefore means consuming less end-use energy for the same amount of service. This can be achieved through organisational, institutional, structural, technical and behavioral changes (Wuppertal Institute, 2008). The focus of this thesis is on energy end-use efficiency through replacement of electric stoves and geysers with gas stove and solar water heaters respectively. The focus is on these two end-use efficiencies because these appliances are major household electricity consumers. These end uses efficiencies fall within the technical and behavioral changes described in the Wuppertal Institute’s classification.

1.7 Thesis outline

Chapter 1 sets the context for the global and national energy outlook. It also explains how Stellenbosch Municipality can overcome energy constraints on future development through measures to improve energy efficiency. The terms used in the research study are also clarified.

Chapter 2 discusses the research methodology used in this thesis. Chapter 3 reviews the literature which argues that sustainable development, sustainable energy and sustainable urban development are necessary It also argues that retrofitting in residential and commercial buildings is necessary for sustainable development and that local authorities need to be involved in promoting energy-efficient measures using available technologies such as SWH and gas stoves in residential buildings. Chapter 4 presents international and local experiences in promoting SWHs to arrive at best practice and to provide lessons for the Stellenbosch Municipality. It will also discuss the repeatability of these practices by other local authorities. Chapter 5 describes the local Stellenbosch Municipality context. It looks at the socio–economic aspects, at the electricity supply situation and at plans for future development. Chapter 6 presents the research findings and Chapter 7 provides the conclusion and makes recommendations regarding the future options for the Stellenbosch Municipality.

Chapter 2

Research design, methodology and data collection

2.1 Introduction

The aim of Chapter 2 is to outline the research design, research methodology and research processes that inform this thesis. This research is based upon ecological design, which places emphasis on a holistic multi-dimensional view of complex systems. Due to the exploratory nature of the research it is guided by both qualitative and quantitative paradigms.

2.1.1 Research design

Research design refers to "the blueprint of how you intend conducting the research" (Babbie and Mouton, 2008:74). This research is exploratory as it seeks to answer the following questions: What mechanisms can Stellenbosch municipality use to promote the use of SWH and gas stoves amongst middle-to-high income households? What are the opportunities and barriers to Stellenbosch municipality implementing energy efficiency programmes? What electricity savings can be achieved by middle-to-high income households in Stellenbosch? What are the environmental benefits of installing SWHs and gas stoves in middle-to-high income households? The research objective entails researching factors which influence the energy consumption of the mid-to-high income households in Stellenbosch municipality. Babbie and Mouton, in the *Practice of Social Research*, summarize the objectives of exploratory research as being to:

- satisfy the researcher's curiosity and desire for better understanding;
- test the feasibility of undertaking a more extensive study;
- develop methods to be employed in any subsequent study;
- explicate the central concepts and constructs of a study;
- determine priorities for future research; and
- develop new hypotheses about an existing phenomenon' (Babbie and Mouton, 2008:80).

The objectives of this study are to satisfy the researcher's curiosity and desire for better understanding and to test the feasibility of undertaking a more extensive study.

Exploratory studies normally make use of case studies, literature reviews, in-depth interviews and informants to gain insight and understanding. This study utilises case studies, a literature review and interviews. The main weakness of exploratory studies is that they seldom provide satisfactory answers to research questions, although they can give insights into the research methods that could provide answers. However exploratory studies can provide clues to the answers. The research process is governed by two research designs, namely the case study and secondary data analysis.

2.1.2 The case study design

The case study research approach is appropriate "when a 'how' or 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control and the focus is on a contemporary phenomenon within a real-life context" (Yin, 2009: 2). However this is not a limiting factor since the exploratory 'what' question in this thesis is appropriate for the case study research method. Berg (2009) notes that the case study approach focuses on 'holistic description and explanation, and, as a general statement, any phenomenon can be studied by case study methods' (Berg, 2009: 318).

A case study is appropriate when the researcher is interested in understanding a clearly defined entity. Flyvberg (2006: 22)1 argues that "the case study produces the type of context-dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners to virtuoso experts". In this case, knowledge relating to Stellenbosch municipality was generated.

There are four possible case study research designs, namely:

- single case embedded designs;
- single case holistic designs;
- multiple case embedded designs; and
- multiple case holistic designs (Yin, 2009).

Single case embedded designs are a case study containing more than one sub-unit of analysis (Yin, 2009). This type of case study is preferred when examining contemporary events. On the other hand single case holistic designs are a case study with a single unit of analysis. It is used in cases where no logical sub-units can be identified. Multiple case embedded designs include multiple case designs and are used for comparative studies. Multiple case holistic designs involve multiple cases with more than one sub-unit of analysis. The major difference between embedded and holistic designs is that embedded method examines different views of multiple units concerning a particular phenomenon, while the holistic method examines one particular phenomenon (Yin, 2009).

The case study design has been criticised on various grounds (Babbie and Mouton, 2008:280; Mouton, 2001:150; Yin, 2009:114). The most common criticism is that case studies are scientifically useless since general theories cannot be deduced from them. This however ignores the fact that case studies are useful in generating context-based knowledge that allows for particularization (Adams *et al* 2007). Questions have also been raised concerning the lack of rigour and the quality of data gathered in case studies. Another criticism is that case studies are useful during the early exploratory stages of the research, but cannot be used in the advanced stages of a study. Concern is also raised about the close bond between the researcher and the case study, and possible researcher bias.

To enhance the quality of the case study approach, the data gathering should meet three requirements. It should "use multiple sources of evidence, create a case study database and maintain a chain of evidence" (Yin 2009:113). Using multiple sources of data makes triangulation possible and this increases data validity and reliability.

2.1.3 Secondary Data Analysis (SDA) design

SDA is defined as "using existing data (mostly quantitative); SDA aims at reanalysing such data in order to test hypotheses or validate models" (Mouton, 2001: 164). Although this definition seems to limit SDA to quantitative data, this researcher utilised market analysis to understand the South African residential market. Secondary data analysis yielded data regarding residential market characteristics and market segmentation.

The advantages of this research design are that it allows for large body of thorough and extensive data to be analysed and saves resources and time spent on gathering primary data. However, it places limitations on the study since constraints and errors in the original research are carried over (Mouton, 2001: 165).

2.2 Research methodology

The "real life" problem defined in this study is based on the three worlds framework as developed by Mouton (1996) in *Understanding Social Research* (Mouton, 2001:137) and in Babbie and Mouton (2008:1-67). The Three Worlds Framework is an instrument used to distinguish the various levels of scientific enquiry in our everyday life. World 1, the world of everyday life and lay knowledge, is concerned with generating non-scientific knowledge that enables one to deal with everyday tasks or problems; World 2, the world of science and scientific research, is concerned with generating scientific knowledge or "truthful knowledge" through scientific inquiry. World 3, the world of metascience, is concerned with critical reflection and the analysis of scientific knowledge generated in World 2 for the purpose of validating the findings. The research problem identified in this thesis is located in the world of science and scientific research, World 2. It necessitates undertaking scientific research on a real-life problem to so that a solution can be found. Babbie and Mouton(2008:47-68) identify quantitative, qualitative and participatory action methodological paradigms as paradigms associated with World 2 and linked to critical theory, and to phenomenological and positivist meta-theories). The quantitative paradigm uses surveys and statistical analyses and places emphasis on the quantification of constructs. A qualitative paradigm, on the other hand, uses an insider's perspective to study human action for the purpose of describing and understanding, rather than explaining and predicting human behaviour. It therefore uses methods of observation such as unstructured interviewing, participant observation and personal documents. In terms of data analysis the emphasis is on grounded theory and inductive analytical strategies.

Due to the complex nature of the problem being investigated, the researcher adopted both quantitative and qualitative paradigms to approach the problem in a holistic manner and to avoid reducing the context to a single perspective. The qualitative paradigm was more dominant.

2.3 Data collection

There are a variety of data-gathering methods and each method is appropriate to the data source (Mouton, 2001: 104). The researcher used a mixed-data collection approach, utilising a combination of mini-Delphi expert opinion techniques, questionnaires, and telephone and personal interviews. A description of the data collection methods utilised in the research follows.

2.3.1 The Delphi Technique

The Delphi technique is "a flexible research technique well suited when there is incomplete knowledge about the phenomena" (Skulmoski *et al* 2007: 12). The Delphi method is a group technique whose objective is to obtain a consensus of opinion from a group of experts by way of a series of questionnaires with controlled opinion feedback (Landeta, 2006: 468). It has evolved over time and its latest versions have done away with the requirement for consensus.
It has recently been defined as "a social research technique whose aim is to obtain a reliable group opinion using a group of experts. It is a method of structuring communication between a group of people who can provide valuable contributions in order to resolve a complex problem" (Landeta, 2006: 269). The number of rounds is variable and dependent upon the objective of the research. Skulmoski *et al* (2007:12) argue that "fewer than three rounds may be sufficient to reach consensus, theoretical saturation, or uncover sufficient information".

Due to the relatively new field of research, the researcher opted for the mini-Delphi method, a single round which uses face-to-face meetings to arrive at an expert opinion on the financial mechanisms that a municipality can use to promote solar water heaters. The researcher opted for one round since sufficient information was obtained in the first round.

2.3.3 Interview technique

The interview technique is commonly used by both quantitative and qualitative researchers to collect data, on the assumption that the results are a true reflection of the respondents' views (Fontana and Frey, 2005). The purpose of an interview is for one person to obtain information from another person in a structured conversation based on prearranged questions (Babbie and Mouton, 2001; Neuman, 2003; Fontana and Frey, 2005). Fontana and Frey (2005) note that interviewing is subjective and that the process is politically, contextually and historically bound. Interviews may be conducted with groups or via electronic surveys or by telephone, but the most common form of interviewing is face-to-face interaction (Gillham, 2000; Babbie and Mouton, 2001; Neuman, 2003; Fontana and Frey, 2005). The researcher used face to face interaction for all the interviews that took place in Stellenbosch and Cape Town, and for informal, conversational interviews for mid-to-high income households. Telephone interviews were used for the other participants.

2.3.4 Questionnaires

A questionnaire is a defined as "set of questions on a form which is completed by the respondent in respect to a research project" (Delport, 2002: 172). The questionnaire can be in the form of closed or open questions, or statements to which respondents react (Delport, 2002: 172). Questionnaires can be administered in various forms, namely mailed questionnaires, telephonic questionnaires, personal questionnaires, hand-delivered questionnaires or group-administered questionnaires (Delport, 2002: 172-175). The researcher distributed the questionnaires via electronic mail since this enabled the data to be gathered data more quickly and was convenient for collecting information from widely dispersed respondents. Using this method, the researcher was able to gather data quickly. However, the drawback was that respondents did not answer all the questions, so only partial information was collected. To address this problem, the researcher opted to make use of face-to-face interviews as well.

2.4 The research process

The research process described below shows how the fieldwork was conducted and explains the decisions that influenced the process. The research process was a dynamic process which required the constant interaction between qualitative and qualitative data.

2.4.1 Panel of experts meeting

The literature review showed that there are several financing mechanisms that are used globally to promote the use of solar water heaters. The researcher met with solar water heating experts from the Stellenbosch and Cape Town municipalities in order to brainstorm and identify mechanisms that could be used to promote the use of solar water heaters at a municipal level.

Experts from Stellenbosch and surrounding areas were identified and a list of potential experts was drawn up. The researcher first called to confirm availability, after which invitation letters were distributed via electronic mail (Appendix 1). Ten invitations were sent and seven experts attended the meeting. The panel of experts had to be small enough to ensure that each expert was given an opportunity to express his or her opinion. The meeting took place at the Sustainability Institute on the 5 May 2009 between 2 p.m. and 4 p.m. The researcher gave a ten minute presentation highlighting the problem, the need for energy efficiency and for the introduction of renewable energy. Possible solutions, such as the use of solar water heaters to reduce energy consumption and mechanisms used internationally to promote SWHs, were also outlined.

The presentation posed the question, what strategies can the municipality use to persuade or coerce current users of electric geysers to use SWH (retrofits)? This was followed by a discussion of the possible mechanisms. The researcher recorded the information in a journal and used this to prioritize the mechanisms for further investigation.

2.4.2 Interviews with municipal officials

Respondents were selected from Directorates within the Municipality which were most likely to be involved in energy efficiency and human settlements. The researcher conducted four interviews with municipal officials, three in 2009 and one in 2010. All interviews took place at municipal offices in Stellenbosch. The interviewer used structured questionnaires. The first interview on 7 July 2009was with Yeki Mosomothane, Manager: Stakeholder Relations in the Municipal Manager's office. The aim of this interview was to gain an insight into municipal functions, powers, planning processes and municipality's perspective on sustainable development in relation to energy efficiency and renewable energy. The second interview was with Mr. Calorissen, Deputy Director of Integrated Human Settlements on 18 September 2009. The purpose of this interview was to gain an understanding of the housing situation and of the residential classification and the number of units under each category in Stellenbosch. The other three interviews were with James Hames, Nombulelo Zwane and Floris Koegelenberg, Managers from the Electrical Engineering Directorate. Two interviews took place in 2009 and the third in April 2010. The interviews yielded data about the municipality's current energy situation, the short-term and long-term energy efficiency measures that the municipality is implementing and the municipality's vision with regard to energy efficiency and renewable energy. The researcher took copious notes during the interviews.

2.4.3 Interviews with middle-to-high income households

The literature showed that the middle-to-high income households consumed more electricity in the residential sector than low income households. To the researcher it made sense that energy efficiency measures should target this group. The researcher had interviews with two current SWH users from Stellenbosch which yielded information about their reasons for adopting SWH, and about their views regarding this technology and other energy-efficient technologies being used by the households.

2.4.4 Interview with solar water heater manufacturer

Solar water heaters are either imported or manufactured locally. The researcher visited a local manufacturer, Solardome, and had an interview with the Production Manager in June 2009. The aim of the interview was to gain an insight into local manufacturing development, industry job creation opportunities and the production process. The interview ended with a tour of the manufacturing plant.

2.4.5 Interview with SWH industry respondents

The researcher had an interview with Andrew Janisch, Project Manager at Sustainable Energy Africa on 17 May 2011 in Cape Town. From this interview the researcher gathered information about the way a municipality can promote SWH, about the barriers to municipal financing mechanisms, about the role a municipality could play (instead of funding energy efficiency programmes) and about the way forward for a municipality like Stellenbosch.

The researcher also had an interview with Arno van Wyk and Corrine Geledenhuys of Solarent in Cape Town on 26 May 2011. The purpose of this interview was to find out about the SWH rental mechanism, performance of the programme since its inception, and the role that the municipality could play.

The researcher received email correspondence from Paul Ross of Teljoy, as he was unavailable for a telephone interview. Information obtained from this correspondence related to Teljoy's Green Credit Scheme, the performance of programme since its inception, and the role that the municipality could play.

A telephone interview was conducted with Robert Thompson of SESSA. The interview yielded information about the role the municipality could play in promoting energy efficiency through social marketing, that is, by getting current users of SWH to influence others to adopt energy efficient technologies. It also highlighted the municipality's need to have a champion to drive an energy efficiency programme.
Another telephone interview was conducted with Herman Weber, Technical Director of Kwikot. The information obtained from this interview was on the impact of the reduction of Eskom SWH rebate, and the use of legislation as a way to drive SWH uptake.

2.4.6 Interviews with LPG industry respondents

The researcher had a telephone interview with Kevin Robertson, Communications Manager Liquefied Petroleum Gas Safety Association of Southern Africa on 9 June 2011.

The interview yielded data on changes in LPG government policy and their likely impacts on the industry, on the impact of LPG price regulation and on LPG supply constraints in the event of increased demand.

Other LPG industry respondents who were unavailable for interviewing opted to send email responses.

2.5 Data analysis

To analyse and organise data two general methods, coding and scoring, were used. From the perspective of a qualitative research paradigm, coding of data involves organising the raw data into conceptual categories and creating themes or concepts to assist in the analysis of the data (Neuman, 2003). The process entails two simultaneous activities of "mechanical data reduction and categorization of data into themes" (Neuman, 2003:442). Strauss (1987, in Neuman (2003)) suggested that a three-phased approach be used when coding, namely open coding, axial coding and selective coding.

In the process of open coding, themes are identified in the data and initial codes are assigned and then the data is condensed into categories (Neuman, 2003). The second review of the data (axial coding) then focuses on the actual data where codes are assigned to the themes. Lastly, selective coding entails scanning in the data and previously assigned codes. This enables the researcher to compare and contrast the results across cases (Neuman, 2003). Applying this method to this study, categories in the questionnaires allowed for open coding, and general themes were assigned. A second review of the data (axial coding) was carried out to determine the main themes and this was followed by a more descriptive coding (selective coding) of the data to allow for analysis.

From a quantitative research paradigm the researcher used descriptive statistics to summarize the data being studied. Comparative analysis was used for the financial model, comparing the costs of an electric geyser and stove with the costs of SWH, a gas stove and an electric stove. In addition computer program Excel was used to assist with data analysis.

2.6 Research limitations

This research is contextually bound to South Africa at the macro-level, and at micro-level it is bound to Stellenbosch Municipality. Inferences made in the research findings cannot be transferred and applied to other municipalities and countries; however they can be utilised as empirical insights into a problem for which further investigation is required. They may be useful for the purposes of comparison and contrast.

Insights into the topic were gained through an extensive literature review which was conducted before the data was collected. This had the potential to create researcher bias in the form of preconceived ideas about interviewee responses. To minimize this bias the researcher used non-leading questions to probe respondents' knowledge.

Amongst the respondents identified were major players in the field of energy efficiency such as Eskom, DoE, the National Energy Efficiency Agency and Southern African Association for Energy Efficiency. However the researcher was unable to obtain interviews or personal communication, either telephonically or by email from these organisations despite numerous attempts. The researcher resorted to secondary data in the form of reports, organisation websites and newspaper articles to obtain information. This proved to be sufficient for the purposes of the study.

Not being a municipal employee, the researcher did not have an understanding of the organisational culture and climate of the municipality when interpreting the findings. However the researcher explored these issues as well the decision-making and planning process of the municipality in order not to misrepresent the organisation.

2.7 Chapter summary

This chapter described the research design, methodology and process. The research design is governed by two models which guided this exploratory research, namely case study and secondary data analysis. The national residential market context was informed by SDA design in general and market analysis in particular.

Qualitative and quantitative paradigms informed the single case study design of Stellenbosch. It was necessary to understand the Stellenbosch context and its efforts at implementing energy efficiency and renewable energy technologies. In addition the technological focus on energy efficiency necessitates an understanding of the built environment where retrofitting will occur.

Chapter 3

Literature review

3.1 Introduction

The literature review is carried out within sustainable development discourse. The literature review is presented in two parts. Part 1 is theoretical and argues that sustainable energy is necessary for sustainable living. Sustainable urban development and sustainable human settlements are important for achieving sustainable development. Energy efficiency and renewable energy are an integral part of the path to sustainable development. Local authorities have an important role to play in promoting energy efficiency measures and the use of renewable energy. Mature energy efficiency and renewable energy technologies exist and can be utilised by local authorities to reduce energy demand and mitigate climate change. The second part (Chapter 4) presents international and local case studies of local municipalities that have begun to implement energy efficiency and renewable energy programmes.

3.2 The need for sustainable development

The most commonly used definition of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987:8). This definition brings out three main aims of sustainable development: (i) the improvement of human well-being; (ii) the inter- and intra-generational equitable distribution of resources; and (iii) environmental protection. Sustainable development challenges mainstream development which focuses on improving the quality of life through economic development. Economic development is, however, associated with increases in resource use without regard for environmental limits. Sustainable development acknowledges that resource use needs to be within the limits of regeneration.

There are different approaches to sustainable development. Anthropocentric approaches towards sustainable development advocate for justice and human rights in resource allocation. (Hattingh, 2001:9, 11–12; Gallopin, 2003: 14; Mebratu, 1998:511).

The Human Development paradigm (Wise, 2001:48-49, Ul Haq, 1995, 2001), the Ecological Governance and Sustainable Livelihoods paradigms (Chambers, 1992; Norberg-Hodge, 2000; Sachs, 2002:7, Eco Socialism (Pepper, 1993 in Mebratu, 1998:507–508) and the Ecological Space paradigm (McLaren, 2003; Wackernagel and Rees, 1996) question power relations and how these influence resource distribution between countries. The central point is the need to recognize that all people have a right to the earth's natural resources. This calls for the redistribution of resources with the aim of redressing the current inequalities in resource distribution among nations.

Ecocentric approaches to sustainable development advocate a deep, narrow, strong concept of sustainability that focuses on recognising the intrinsic value of looking after the earth (Hattingh, 2001; Gallopin, 2003; Mebratu, 1998). Deep ecology (Deval, 2001; Naess in Deval, 2001; Macy and Young Brown, 1998), Eco-theology (Macy and Young Brown, 1998; Mebratu, 1998) and Eco-feminism (Mies and Shiva, 1993; Macy and Young Brown, 1998; Mebratu, 1998) call people to ask deeper questions and evaluate their relationship to the power hierarchies in society and with nature.

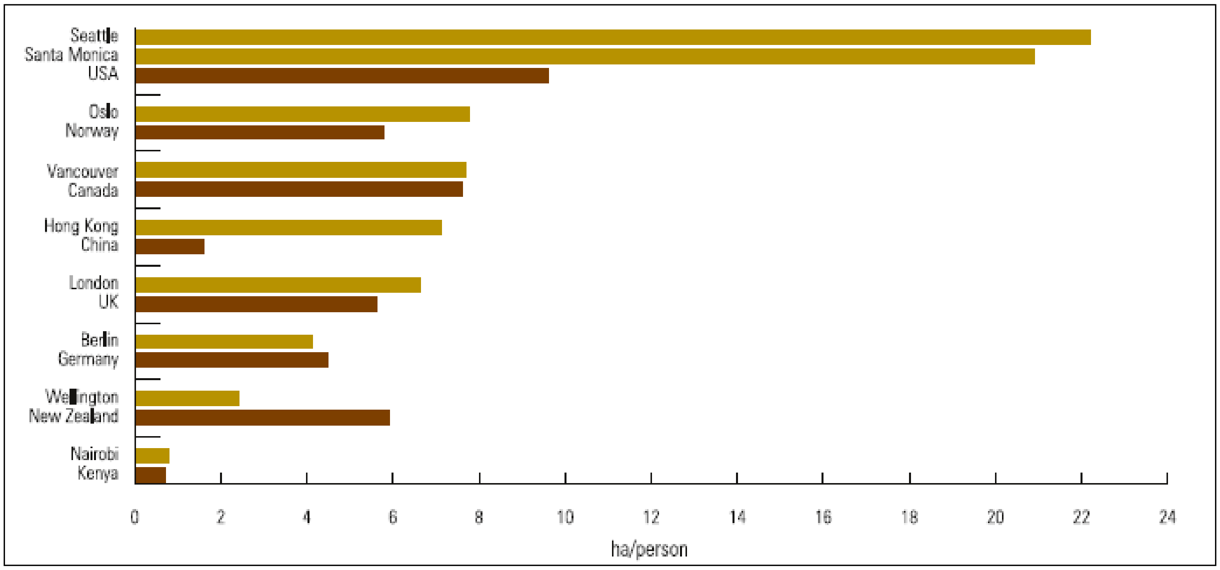
There may be differing opinions about sustainable development but there is a general consensus that there is a need for a transition to a sustainable way of life. This means taking action to reduce the risk of environmental problems affecting the ecosystem that supports human life.

3.3 The need for sustainable cities

Cities are home to an increasing number of people who need services. In order to provide these services, cities need huge amounts of energy. By 2008 cities used more than two-thirds of the world's energy and accounted for more than 70% of global CO_2 emissions (IEA, 2008:180). Urban energy use is expected to be three quarters by 2030 (IEA, 2008:180). In South Africa, the seventeen largest cities use approximately 50% of the country's energy (Sustainable Energy Africa (SEA), 2009: 1). Cities' energy use is expected to grow, driven by urbanisation. Predictions indicate that urbanisation will continue to increase and that globally about 9.8 billion people will be living in urban areas by 2050 (IEA, 2008; UN Habitat, 2008).

The pattern and scale of energy use has important implications for both global greenhouse gas emissions and energy security. Cities rely on fossil fuels to meet their energy requirements. The main urban energy issues include the depletion of fossil fuels, urban greenhouse gas emissions and the form of the built environment, which consumes a lot of energy. This means that cities have huge ecological footprints. Human beings are living beyond the planet's ecological limits. The global economy and population continue to grow, yet the planet is still the same size. The concept of an "ecological footprint" was proposed by William Rees (1992) and it is used to as an instrument to assess the environmental impact of cities and to aid sustainable urban planning. The ecological footprint "measures the land area required per person (or population) … on a continuous basis to provide all the energy/material resources consumed, and to absorb all the waste discharged" (Wackernagel and Rees, 1996:52). Cities usually have higher ecological footprints than those of the country they are located in. However there are some exceptions that have lower ecological footprints than that of their countries (UN Habitat, 2008). Figure 3.1 shows the ecological footprints of selected countries and cities.

Figure 3.1: Ecological footprints of selected countries and cities



Source: UN Habitat, 2008:163

Figure 3.1 shows that Seattle, Santa Monica, Oslo, Vancouver, Hong Kong, London and Nairobi have greater ecological footprints than those of their countries, while Berlin and Wellington have smaller ecological footprints. Cities with very big ecological footprints are wasteful in terms of resource use and emit large quantities of CO_2 without taking ecological limits into account. It is important that cities with large ecological footprints "find ways to reduce their footprint without compromising the quality of life for their citizens" (Global Footprint Network, 2006:10). A city with a small or nimble ecological footprint does not waste resources and limits and reabsorbs its CO_2 emissions (K'Akumu, 2007:224). It is desirable that cities should have small ecological footprints. The footprint needs to be smaller than the available bio–capacity, as this is an indication of "strong sustainability" (Wackernagel *et al*, 2006). Urban planners need to address these energy issues to ensure that they improve the quality of life of urban dwellers.

Local municipalities "as the level of governance closest to the people… play a vital role in educating, mobilising and responding to the public to promote sustainable development" (UN, 1992:233). Local authorities have taken the responsibility of ensuring sustainability and attempting to translate rhetoric into action through Local Agenda 21 (LA21) in ways that seek to mitigate climate change (Beatley, 2000). According to Chapter 28 of LA21 many of the problems and solutions to urban issues have their roots in local activities. This means that local authorities have a major influence over what goes on in their local areas. The adage "think globally, act locally" applies in this case. Cities and towns are at the centre of the development process.

Sustainable urban development is an integral part of the goal of achieving global sustainable development. There are many approaches to achieving sustainable urban development. These include sustainable cities, the eco-city (Roseland, 1997; Register, 2006) green urbanism (Beatley, 2000), new urbanism and positive development (Birkeland, 2008). The differences between these concepts are in their underlying approach to sustainable development: some can be classified as "deep green" ecocentric approaches while others are "light green" anthropocentric approaches (Haughton, 1997).

These approaches reflect different sets of values and judgments about urban and environmental development. At times they advocate for similar policies and measures to limit the impact of human activities on the environment. Their differences stem from the fact that some are more radical than others. It should be noted that there is general agreement that urban development needs to be sustainable. Some cities such as Freiburg and the state of California are already actively involved in reducing energy use and CO_2 emissions (ICLEI, 2009).

Wackernagel *et al.* (2006: 112) aptly conclude that "the global effort for sustainability will be won, or lost in the world's cities, where urban design may influence over 70% of people's Ecological Footprint". Cities can play a major role in reducing the impact of human-related activities on the environment through various strategies to reduce resource consumption, reduce waste (including energy waste), increase energy efficiency and meet energy needs through the use of renewable energy sources.

3.4 The need for a sustainable energy system

In terms of energy, sustainable development by definition includes providing energy to meet the needs of the current generations, while at the same time ensuring that future generations will be able to meet their energy needs. An energy system is defined as the "combined processes of acquiring and using energy in a given society or economy" (Jaccard, 2005:6). This system comprises the sources of primary energy and secondary energy. Energy forms as primary sources are converted into final energy services or energy end-uses such as lighting, cooling and space heating.

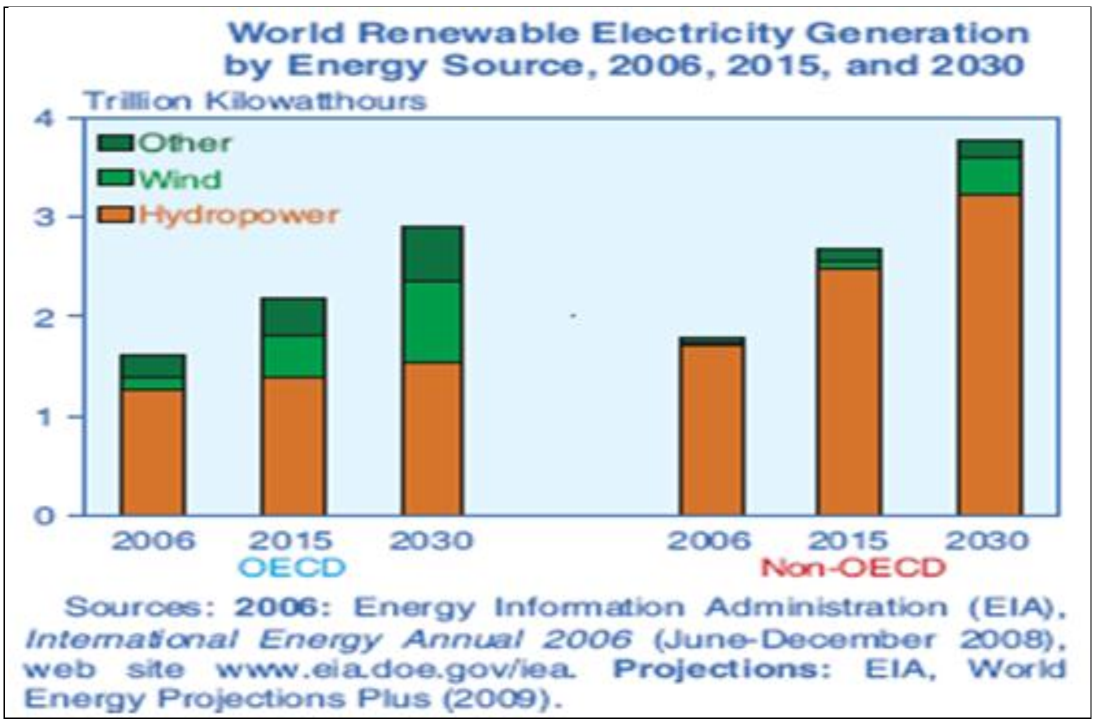
What makes an energy system sustainable? An energy system is sustainable if it has the potential to endure indefinitely and if its extraction, conversion, distribution and consumption of energy is friendly to people and the environment. This means that it must be able to support the ecosystem and human health over a long period of time (Jaccard, 2005). There is growing concern about the sustainability of our current energy system. Fossil fuels play a prominent role and they are an exhaustible energy source; they also emit greenhouse gases when they are combusted and converted into secondary energy, such as electricity. "In 2007, the combustion of fossil fuels released nearly 30 billion tons of CO_2 to the atmosphere, … coal and oil contributing roughly 40% each and natural gas accounting for the rest" (Flavin, 2008:9).

In addition energy security is a matter of concern for countries that depend on others for their energy supplies. For example, oil reserves are concentrated in the Middle East and many countries rely on imports of oil. This means that energy supply depends on the relations between the exporting and importing countries. Energy security is not guaranteed in this case (Jaccard, 2005; Droege, 2006). In Africa there are recurrent energy crises which present themselves in the form of energy rationing. These crises are a result of capacity problems at power utilities (Karekezi, 2002). In addition predications indicate that the supply of fossil fuels will run out soon. Given the expected increases in energy demand, forecasts predict that gas will run out by 2040; coal is expected to run out by 2100, uranium by 2030 and oil by 2050 (Droege, 2006). It seems that we cannot continue to rely on these sources of energy in the long run due both to their negative impact on the environment and because they are likely to run out (they are finite resources). This means that we have to wean ourselves off this dependency on fossil fuels.

What are the alternatives to fossil fuels? Renewable energy sources include biomass, hydropower, solar energy, wind energy and geothermal, wave, tidal and oceanic energies. Their advantages are that they are inexhaustible, they reduce pollution and emissions from fossil fuels, and they are suitable for grid-connected applications, such as space and water heating in urban areas. They increase the flexibility of power systems as demand changes, and they are suitable for small off-grid applications, making them suitable for supplying energy to remote rural areas (UNDP, 2004:48).

Renewable energy sources currently supply a small percentage of global primary energy use, mainly through the use of biomass for cooking and heating. In terms of electricity generation, hydropower supplies a greater percentage, followed by wind energy and other sources. Figure 3.2 shows the dominance of large hydropower electricity generation in 2006 and projections for the years 2015 and 2030 in OECD and non-OECD countries.

Figure 3.2: World renewable electricity generation by source for 2006, 2015 and 2030

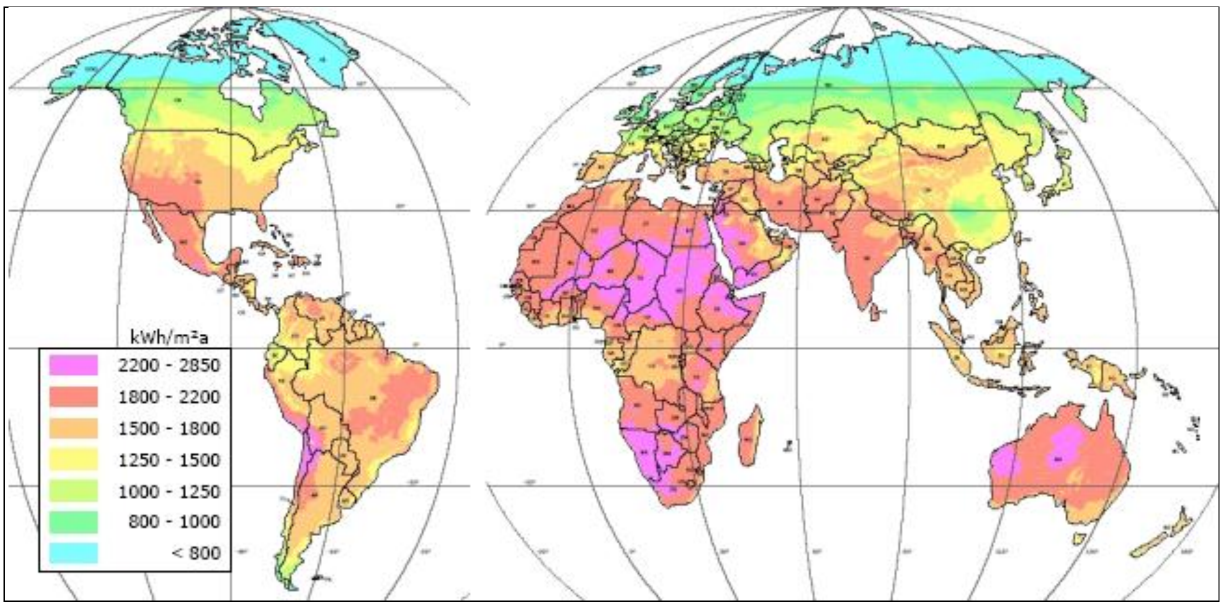


Source: EIA, 2008:

Figure 3.2 shows that hydropower will continue to dominate other renewable energy sources for the foreseeable future.

Solar energy is, however, the most abundant renewable energy resource. The sun emits energy at a rate of 3.8 $x10^{23}$ kW. Of this a small fraction (about $1.8X10^{14}$ kW) is intercepted by the earth and 60% of this (about 1.08 X 10^{14}) reaches the earth's surface. Put differently, solar radiation is more than 7 500 times the world's total yearly primary energy consumption of about 450 EJ (WEC, 2007:381). Figure 3.3 below shows the average annual solar radiation received by the different countries and regions.

Figure 3.3: World average annual solar radiation



Source: Water Rhapsody, 2010

The map shows the differences in the solar resources available for exploitation in the different countries. Solar radiation varies according to the time of day and the season. Solar radiation is highest in the summer time and lowest in winter. Solar energy can be used directly to generate electricity, using photovoltaic panels, solar concentrating technologies and solar thermal collectors for heating purposes. Solar energy is arguably the most abundant resource at the world's disposal. Future energy demand can be met using solar resources. Beatley, (2000:286) argues that "solar energy must become a more central part of the energy mix that cities depend upon". The concept of the "solar city" was developed by Droege in 2002 as part of IEA research in a bid to find ways of encouraging the use of renewable energy. This idea focuses on the local carbon-neutral production of food, energy and materials, on promoting solar energy and the use of other renewable energy sources, and on using waste to generate energy and create a local economy (Droege, 2006). A solar city is one "that aims at reducing the level of greenhouse gas emissions through a holistic strategy for the introduction of renewable energy systems and the rational use of energy to a climate stable and thus sustainable level in the year 2050" (Roaf *et al*, 2005: 357). The concept of becoming a "solar city" has been adopted by cities such as Dundee, Rizhao, Adelaide, Townsville, Alice Springs, Blacktown, Perth, Moreland, Ann Abor, San Diego, Santa Rosa, Nagpur, and Rajkot (Roaf *et al*, 2005; Droege, 2006; ICLEI,2009).

Solar energy has gained ground in the energy mix of cities such as Freiburg, Berlin and Saarbrücken. These cities have begun to refer to themselves as solar cities. Solar technologies can supply the energy requirements for a building's heating, hot water, light, cooling and electricity requirements without incurring the harmful effects of carbon emissions from fossil fuels. Solar technologies are applicable anywhere in the world and can be used for all types of building, both commercial and industrial, for schools, public buildings and hospitals, and for single-family houses and multi-family residences. The benefits of solar energy have been identified as energy security through local production. It is environmentally friendly. Solar energy displaces carbon-emitting energy sources, and it promotes economic growth through job creation and provides savings for the end-users of electricity (IEA, 2009).

In South Africa the policy environment for the adoption of renewable energy has been set. The White Paper on Renewable Energy sets a target of 10 000GW from renewable energy by 2013 (DME, 2003: 25). This is the equivalent of replacing two 660 MW coal-generated power stations (Republic of South Africa, SA Yearbook 2007/8: 417). This target is to be met by both electricity generation and the use of non-electric technologies such as solar water heating and bio fuels.

Table 3.1 shows the theoretical potential for various renewable energy technologies in South Africa. The potential of solar energy is highlighted.

Table 3.1: Theoretical potential of renewable energy technologies in South Africa

Renewable Energy Technology	Potential in GWh/year
Solar PV	**40 000 000**
Solar Thermal electric	**20 000 000**
Hydro	10 000
Wind	5 700
Bagasse	5 000
Wood waste	2 600
Landfill gas	900
Solar water heating	**500**

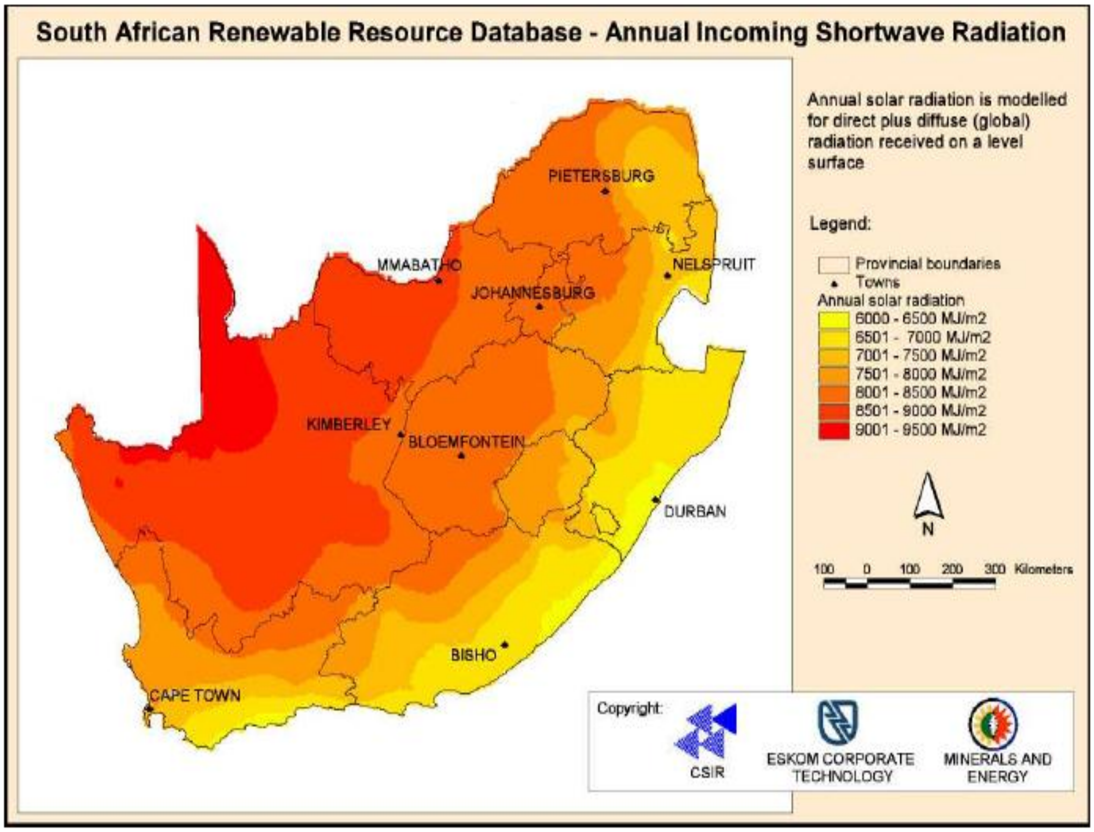
Source: Adapted from Eggertson, 2002

Table 3.1 shows that solar energy has the greatest potential in South Africa, followed by hydro, wind, and bagasse and landfill gas.

It should be noted that renewable energy sources remain under-utilised despite the fact that South Africa is endowed with many of these resources. The main reason for the slow implementation of renewable energy technologies has been the absence of financial incentives (Winkler and Marquard 2007). The National Energy Regulator of South Africa (NERSA) has introduced a feed-in tariff for selected renewable energy technologies. The idea behind the feed-in tariff is to improve the use of renewable energy technologies. Various studies have demonstrated the potential of renewable energy resources in South Africa, especially solar energy.

Figure 3.4 shows the annual solar resources available in South Africa.

Figure 3.4: South African Annual solar resources



Source: DME, 2003 White Paper on Renewable Energy

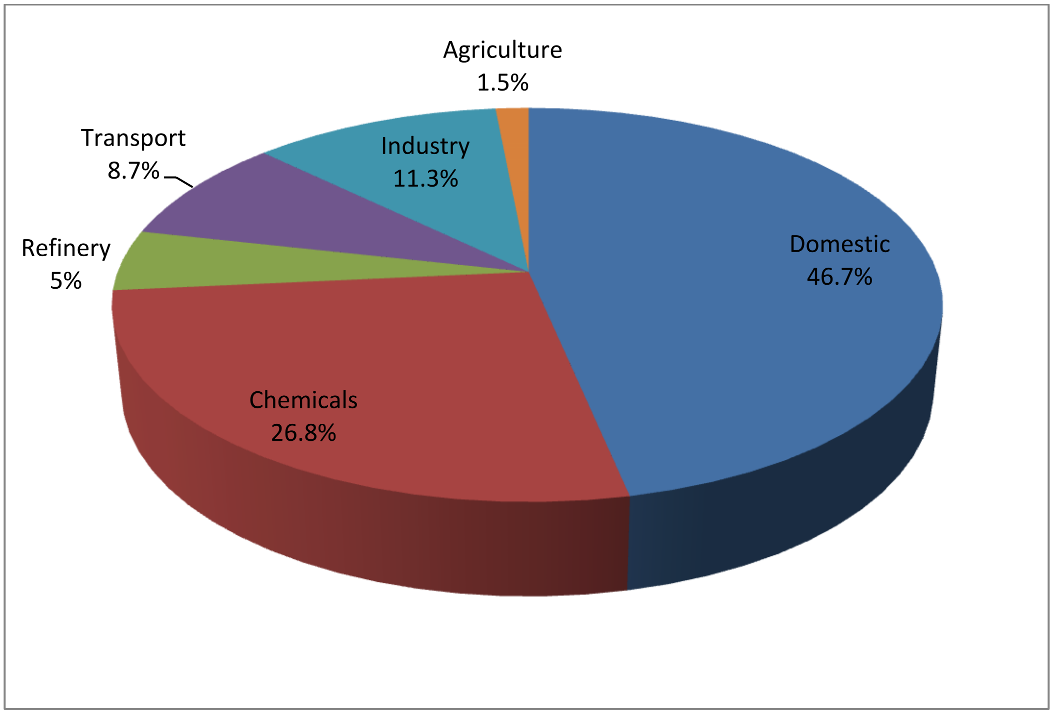
Figure 3.4 shows that South Africa has an excellent solar regime (4.5 to 6 kilowatt-hours per square metre per day throughout the country). This could provide power for energy services such as water heating and space heating (Ward, 2002; Banks and Schäffler 2005). These services are currently provided by electricity or, in the case of houses without electricity, by coal or paraffin in urban areas, or biomass in the rural areas. This means that it should be possible to introduce energy efficiency measures that make use of solar energy in South Africa. The move towards renewable energy needs to be done concurrently with energy efficiency strategies in order to address energy security concerns and reduce carbon emissions. Pringle *et al.* (2007: iii) describe this combination as the "twin pillars of sustainable energy policy". Both strategies need to be developed aggressively in order to reduce and stabilise carbon emissions.

3.5 Liquefied Petroleum Gas (LPG)

LPG was discovered in 1912 by Walter O. Snelling and was known as ‘gasol’. LPG is a generic name for a combination of hydrocarbon gases comprising mainly butane and propane with traces of propylene and butylenes. The mix of butane, propane and other compounds varies according to climatic conditions (Anyon, 2009). LPG can be obtained from various sources but the two most common methods are (i) direct extraction from a mixture of wet gases recovered from gas and oil fields, and (ii) extraction as a by-product of the petroleum refining process. LPG is an odourless gas, and for safety a sulphur-based odourising agent is added to allow for easy detection of leaks.

Although LPG is a fossil fuel it is considered clean because it can be combusted efficiently and it emits few pollutants, once released into the atmosphere, LPG undergoes photochemical degradation (Lloyd and Rukarto, 2001; Antes *et al*, 2007; Schlag and Zuzarte, 2008; Anyon, 2009). Liquified Petroleum Gas is abundantly available in many parts of the world through existing distribution channels, and it can be easily transported and delivered to countries that do not have natural gas and oil fields. LPG is a multi-purpose fuel that can be used where heat, light and power are needed. Gas is used in the domestic, commercial, industrial and transport sectors. In the domestic sector its main application is for cooking and for space and water heating. LPG is a low-carbon fuel and it offers a partial solution to greenhouse gas emission reduction and climate change mitigation (Antes *et al* 2007). LPG production and consumption is growing: in 2008 production grew to about 242 million tonnes (World LP Gas Association, 2009). Figure 3.5 shows global LPG consumption by sector.

Figure 3.5: Global LPG consumption by sector



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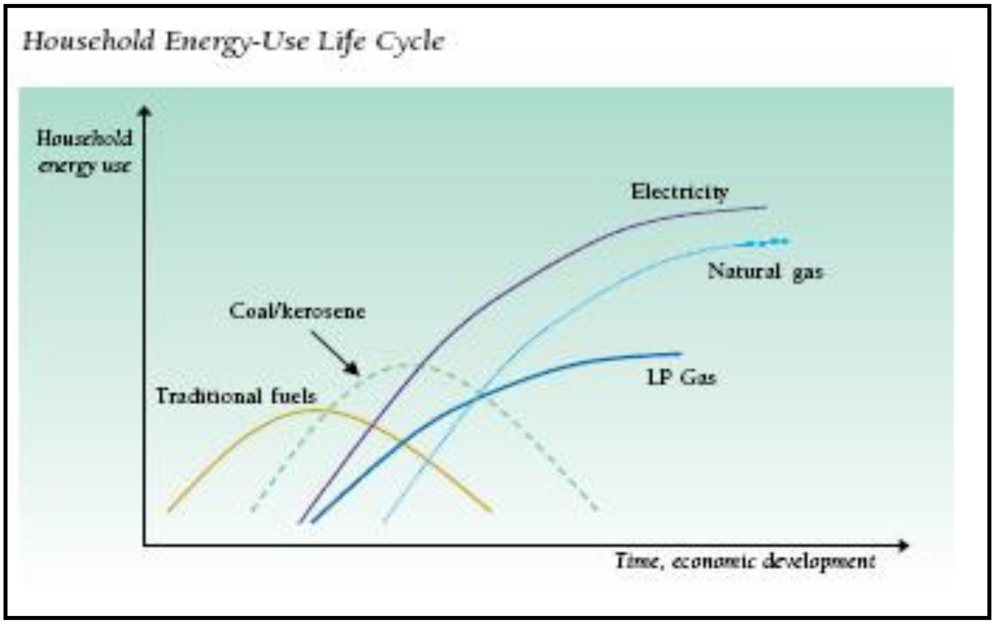
Source: Adapted from WLPGA, 2009

Figure 3.5 shows that the domestic sector consumes the largest share of global LPG resources, followed by the chemical industry, other industries, transport, oil refineries and agriculture.

Historically LPG use began as a replacement for coal and other traditional cooking fuels, due to its high heat content, cleanliness, safety, portability and convenience (Bizzo and de Calan, 2004). LPG continues to be a transition fuel as households move from traditional to modern sources of energy. LPG is replaced by natural gas and electricity as household income increases (World Bank and WLPGA, 2009). Figure 3.6 shows the household energy-use life cycle.

Figure 3.6: Household energy use life cycle



Source: World Bank and World LP Gas Association, 2009

Figure 3.6 shows the transition to modern fuel from traditional fuels which are replaced by coal and kerosene, then LPG, and then natural gas and electricity. It should be noted that electricity and natural gas replace LPG mainly in urban areas where the electricity and natural gas grids are readily available. In areas that are far from the electricity grids, traditional fuels, coal, kerosene and LPG remain the most commonly used fuels.

Concerns about climate change and greenhouse gas emissions have led to efforts to find sustainable energy solutions by investigating low-carbon energy resources that can replace high-carbon resources. The LPG greenhouse gas emissions profile shows that LPG is one of the lowest carbon-emitting sources of fuel for cooking: it "emits 60% fewer GHG than electric coil cooking tops, 50% fewer emissions than some biomass stoves, and 19% fewer GHG than kerosene stoves" (Antes *et al*, 2007:6). LPG also offers low carbon emissions for residential space and water heating, and for distributed power generation.

Efforts to promote LPG globally focus on improving access to modern energy for rural and peri-urban communities. For instance the United Nations Development Programme (UNDP) in partnership with the WLPGA has developed the LP Gas Rural Energy Challenge initiative. This initiative was designed to contribute to sustainable energy solutions that can improve people's lives by creating viable LPG markets. The main aim is to address the adverse impacts on health, economic productivity and the environment associated with reliance on biomass fuels in rural and peri-urban areas (UNDP, 2003). South Africa, Honduras, Ghana, Vietnam, China and Morocco were selected for the LPG challenge. LPG use for cooking varies significantly between countries and it is dependent on government policy.

In South Africa LPG is manufactured at local refineries from both crude oil and coal as part of the refining process. In South Africa LPG is considered a leisure fuel for the wealthy who can afford it (Annecke *et al.*, 2008). The main barrier to the adoption of LPG have been identified as end-user perceptions, as LPG is still perceived by many to be dangerous. Other considerations are accessibility and affordability (RSA DEAT, 2005; Robertson, 2010). Efforts to promote LPG use have been focused on shifting LPG from a leisure fuel to a cooking fuel for the masses, especially for low-income households.

Pilot projects were carried out in Soweto and Orange Farm where valuable lessons were learnt, such as how to decrease the cost of supply, how to achieve a fast-fill capacity and how to ensure the equipment was child-safe (RSA DEAT, 2005). The Western Cape experienced a power crisis following a failure at the Koeberg Unit 1 generator on 25 December 2005. This was followed by extensive blackouts in 2006 (Annecke *et al*, 2008: 1). In order to minimize electricity usage, Eskom launched an LPG exchange programme for low-income households. This entailed the exchange of two-plate electric stoves for two-burner LPG stoves. The programme was to be implemented in two phases: Phase 1 of the exchange programme was to swap 100 000 two-plate electric stoves for 100 000 LPG stoves and cylinders, with four coupons per household (the coupons were to be redeemed when the cylinder was refilled for four consecutive months). Phase II was intended to roll out 400 000 LPG cylinders and stoves to low-income households over an extended area (Annecke *et al.*, 2008:2). The programme was terminated after the first phase of implementation.

The programme was officially implemented in Khayelitsha, Gugulethu, and Langa from May to July 2006, and some elements of the programme were extended until December 2006. When the programme was terminated about 90 000 households had received LPG. The programme created a market for LPG where there had been none. On the end-user side it had mixed outcomes: the number of people who thought LPG was user-friendly increased from 53% to 86%. On the other hand, the proportion of people who thought that LPG was expensive and not easily accessible increased from 69% to 74% and 55% to 70% respectively (Annecke *et al*, 2008:51). In terms of minimizing electricity consumption, a minor saving of only 20 MW was achieved (rather than the 40 MW which was targeted). The LPG exchange programme ignored the mid-to-high income households that actually consume more electricity than low-income households. Although there is a perception that in the residential sector, it is the mid-to-high income households that use LPG, it was difficult to obtain data to verify this.

In order to reduce electricity consumption in their areas, local municipalities should consider encouraging mid-to-high income households to shift from electricity to LPG for cooking. The use of LPG for cooking in the residential sector is a way of mitigating climate change and reducing household electricity consumption.

3.6 The need for energy efficiency

Energy efficiency is important for sustainable energy utilisation because of the expected potential energy savings (WEC, 2008; Lovins, 2005, Pringle *et al.*, 2007).

Energy efficiency has been described as “a low hanging fruit on the energy tree” (Anderson 2006) which can help to address environmental impacts, the security of energy supply, investment requirements, competitiveness, the balance of trade and social implications at a low cost (WEC, 2010). Sebitosi argues that it is the “best energy resource” because it reduces the amount of energy drawn from the national grid. In the long run it will postpone the need for new generation capacity (Sebitosi, 2008).

There are several reasons for advocating for energy efficiency but the most common are:

- it saves money by reducing government expenditure;
- it reduce dependence on fossil fuels, oil imports and on nuclear energy. Energy-efficient use reduces consumption and it reduces the speed at which fossil fuels are depleted;
- it mitigates the effects of climate change;
- it will help to shift the world towards sustainability (Anderson, 1993).

There are both short-term and long-term reasons for advocating energy efficiency. The most important reasons are connected to the need for energy security and the protection of the environment. In developed countries the main reason is to reduce greenhouse gas emissions and to meet the Kyoto Protocol targets. In developing countries the concern is more with security of supply, improving access to electricity and reducing government expenditure on oil imports (WEC, 2008). Energy efficiency policies and measures focus on reducing energy intensity and electricity intensity. Improving energy efficiency in electricity use has two main benefits. It will

- "supply more customers using the same electricity production capacity, which is often a constraint in many countries of Africa and Asia; and
- slow down the electricity demand growth, and reduce the investment needed for the expansion of the electricity sector; this is especially important in countries with high growth of the electricity demand such as China and many East Asian countries" (WEC, 2010: 4).

In terms of energy efficiency implementation, some countries have set up a National Energy Efficiency Agency and adopted national energy efficiency programs with quantitative targets.
The aim is to increase energy efficiency, but these programmes are sometimes combined with programmes for greenhouse gas reductions and for the promotion of renewable energy sources. The strategies used include regulations for buildings, labelling and efficiency standards for household electrical appliances, mandatory energy audits, mandatory efficiency standards for new buildings, energy-saving obligations and the inclusion of renewable energy sources. Some scholars, such as Sebotosi (2008), identify a hierarchy of prioritisation for energy efficiency. The first priority are measures focused on changing behaviour to reduce demand. This is followed by the introduction of energy efficient appliances. Power generation measures are implemented next

(this applies especially to distributed renewable energy). Finally measures are introduced for the adoption of low- or no-carbon technologies.

It seems that energy efficiency can be carried out using various strategies. Energy end-use efficiency has been described as the "largest, least expensive, most benign, most quickly deployable, least understood and most neglected way to provide energy services" (Lovins, 2005:1). This means that energy efficiency is cost-effective and environmentally friendly, and has implications for arresting climate change.

Some authors argue that energy efficiency does not lead to energy savings due to the "take back or rebound effect" (Greening *et al*, 2000; Herring, 2006). The "take back effect" refers to a situation where energy savings from energy efficiency improvements are reduced due to higher energy consumption. The "take back effect" can be either a direct rebound or an indirect rebound. Direct rebound is when energy consumption increases due to a reduction in the price, while an indirect rebound effect occurs when the savings to the consumers lead households to purchase more energy-consuming goods. This is a valid concern but it seems to be based on the assumption that monetary savings made from increased energy efficiency will be used for energy consumption. These savings are, however, likely to be spent on other needs and not spent solely on energy needs, as there are competing household needs.
.Energy efficiency is an important tool for saving consumers money and stimulating economic productivity. The major aim should to be to improve the quality of life and to help to fund the transition to a green and sustainable future (Herring, 2006).

3.6.1 Energy efficiency in residential and commercial buildings

Buildings are the main energy users in an urban environment, but their energy consumption can be reduced through energy efficiency, thereby also reducing greenhouse gas emissions (Levine *et al.*, 2007; IEA, 2008; Harvey, 2009). In 1990, the residential, commercial and institutional buildings sector was responsible for roughly one-third of global energy use and associated carbon emissions, both in the Annex I countries and globally (Watson *et al.*, 1996:13). In 2004, when taking into consideration emissions from electricity use, energy-related CO_2 emissions were 8.6Gt a year, representing a quarter of total global emissions (Levine *et al.*, 2007:391).

Strategies to reduce greenhouse gas emissions from buildings fall into three categories: (i) reducing energy consumption and embodied energy in buildings; (ii) shifting to low-carbon fuels by including a higher share of renewable energy; or (iii) controlling non-CO_2 greenhouse gas emissions. Mature technologies for energy efficiency already exist and have been successfully utilised. There is the potential to reduce about 29% of projected baseline emissions by 2020 in the residential and commercial sectors (Levine *et al.*, 2007:389).

Chwieduk (2003) distinguishes between conventional and modern energy efficiency. Traditional energy efficiency produces energy efficient and environmental friendly buildings. Modern energy efficiency, on the other hand, focuses on sustainable buildings. In this case energy consumption and the building's environmental impacts are based on a life cycle analysis. The idea is to consider the three significant "flows" through a building, that is, water, energy and materials (Chwieduk, 2003). Energy use in a building depends on how the different energy-using devices are combined as a system.

The conventional process of designing a building is linear in nature: the architect makes the design and passes it on to the engineers who have the responsibility for making the building habitable through the use of mechanical systems. This process is linear and system components are specified with little or no regard for the need for an efficient system (Harvey, 2009: 140; Lovins, 1994). This means that buildings are designed to reduce construction costs rather than life-cycle costs, such as energy, water and material use. Energy efficiency is left to the user of the building. There is, however, a shift towards reducing the energy intensity (annual energy use per floor area) of new buildings and existing buildings through comprehensive renovations, refurbishments and retrofitting.

In new buildings the focus is on an integrated ecological design process which incorporates building orientation, form and thermal mass, a high-performance building envelope, the utilisation of passive heating, cooling, ventilation and daylight, the use of energy-efficient appliances and the proper commissioning of the building. The main elements in this process are load reduction and maximisation of daylight opportunities. In new commercial buildings this leads to energy savings of between 35% and 50%, compared to a standard building (Harvey, 2009:141). New buildings, however, make up only a small percentage of actual buildings. Since buildings have a long lifespan with a low turnover of stock, it is important that they consume energy efficiently throughout their lifespans. If energy use is to be reduced in the building sector then some effort needs to be focused on existing buildings. In many countries most buildings that will be in use between 2030 and 2050 have already been built (Levine, 2007; Harvey, 2009). Technical improvements in energy efficiency which are applicable to existing buildings can be retrofitted, added during minor renovations or added during major renovations (i.e. during deep energy-saving renovations) (Lovins, 2005; Harvey, 2009).

South Africa established an Energy Efficiency Agency in 2006 and has an energy efficiency target. The Energy Efficiency Strategy First Review of 2008 revised the target to a 10% reduction in final demand by 2015 (RSA, 2008a:17). It should be noted that South Africa's approach has been somewhat *ad hoc* with no follow-up legislation for energy efficiency (Sebitosi, 2008). Internationally, the energy efficiency of buildings is regulated by mandatory codes, while some countries use voluntary programs. In South Africa a voluntary rating system was introduced in 2008. Building owners voluntarily submit their building to be rated by accredited Green Star officials (accredited by the Green Building Council of South Africa). Time will tell how the rating system will impact on energy efficiency in the built environment in South Africa, since it is voluntary and depends on the building owners' willingness to be rated. Green rating is applicable to both new builds and existing buildings (Green Building Council of South Africa, 2008). In addition, the South African National Standards 204 of 2008 (SANS 204) also deals with energy efficiency in the built environment (RSA, 2008b). This standard is applicable to new buildings. These two instruments represent an attempt to reduce energy consumption in the built environment in South Africa.

Buildings last a long time and contribute to greenhouse gas emissions, growth in energy demand and material flow (Birkeland, 2008). Because of energy and material flows, waste generation and environmental damage, sustainability cannot be achieved through current practices, or by replacing existing buildings with green buildings,.

Given that new buildings make up a small percentage of the total building stock, new buildings will have little impact on the rate of energy consumption or the greenhouse gases generated by existing buildings (Birkeland, 2009; Verbeeck and Hens, 2005; Roberts, 2008; Harvey, 2009). Sustainability requires retrofitting existing buildings to reduce their energy consumption and their greenhouse gas emissions. Buildings are built on the basis of 'planned obsolescence'; this means that during their life cycle they are refurbished regularly. For instance commercial buildings need to be refurbished after about 15 years (Birkeland,2008:27). This presents an opportunity for 'efficiency retrofitting'.

Energy efficiency measures for retrofitting in residential and commercial buildings fall into two categories: no-cost to low-cost and medium-to-high cost measures that require substantial capital investments. No-cost to low-cost measures include reducing the setting of geyser temperatures, retrofitting CFLs in place of incandescent lights, and replacing inefficient electrical appliances with more energy-efficient appliances. Medium-to-high cost measures can be classified into two groups, the first involving upgrading windows and insulating the roof, the floor and the façade. These measures focus mainly on the building envelope to ensure thermal comfort (Dalenbäck, 1996; Verbeeck and Hens, 2005; Levine *et al*., 2007; Harvey, 2009). The second group involves replacing of large domestic appliances such as air conditioners, electric geysers and stoves. Electric geysers are replaced with solar water heaters and electric stoves with gas stoves. In the case of stoves this also involves switching from electricity to LPG (Winkler, 2009:132).

Table 3.2 shows energy efficient technologies and practices for buildings.

Table 3.2: Energy efficient technologies and practices for buildings

Building Envelope	• Energy efficient windows • Insulation (walls, roof and floor) • Reduced air infiltration
Space conditioning	• Air conditioner efficiency measures (e.g. thermal insulation, improved heat exchangers, advanced refrigerants, more efficient motors) • Centrifugal compressors, efficient fans and pumps and variable air volume systems for large commercial buildings
Appliances	• Advanced compressors, evacuated panel insulation (refrigerators) • High spin speeds in washing machines and dryers
Cooking	• Improved efficiency biomass stoves • Efficient gas stoves (ignition, burners) • Induction stoves
Lighting	• Compact fluorescent lamps • Improved phosphors • Solid state electronic ballast technology • Advanced lighting control systems (including day lightning and occupancy sensors) • Task lighting
Motors	• Variable speed drives • Size optimisation • Improvement of power quality
Other	• Building energy management systems • Passive solar use (building design) • Solar water heaters

Source: UNDP, 2004: 48

Table 3.2 shows technologies and practices applicable to residential and commercial buildings. Technologies and practices that are applicable to residential buildings include energy-efficient windows, insulation, the use of high-speed washing machines and dryers, the use of efficient gas stoves, and the use of CFLs, task lighting, passive solar design and SWHs.

One of the barriers to retrofitting has been identified as the "split incentive" between owner of a building and tenant: the owner is interested in construction costs rather than the running costs of the building since the benefits do not nor accrue to the owner (Dalton *et al*, 2007). Tenants may wish to make improvements but see no way to recover their investment at the end of the lease period. The other barrier is the imperfect information that is available to consumers about retrofitting technologies and their benefits. It should be noted that energy use in a building is dependent on the behaviour and decisions of both the owners and occupants. This means that technological changes alone may not have a major impact on energy savings; they need to be supported by complementary strategies to inform owners and occupants of the need for behavioural change – such as regular performance monitoring of energy-saving technologies. Another barrier is the high upfront costs which are both a financial and psychological barrier for many people (Fuller *et al*, 2009). This barrier can be overcome by introducing financial incentives, such as rebates, grants and tax deductions, that encourage retrofitting. This will improve energy efficiency and encourage the use of renewable energy.

3.6.2 Conducting an Energy Audit

Energy auditing is a concept borrowed from the accounting field. The term "energy audit" was first used in the 1970s and 1980s. The main idea of carrying out an energy audit is to establish where, when and how much energy is being used by businesses, by the transport sector and in homes. An energy audit can be done at city/town level and at a building level (Bennett and Newborough 2001). The purpose of an energy audit at city/town level is to obtain information about the energy consumption of the different sectors to determine which energy efficiency measures might be appropriate.

Before implementing end-use energy efficiency in a building there needs to be an energy audit of a building. An energy audit is carried out to evaluate energy consumption in a building, with the aim of identifying opportunities for saving energy. An energy audit can be a simple walkthrough carried out by anyone, or it can be a highly technical, complicated process that is performed by professionals (City of Cape Town, 2008; SEA, 2007). The principle of any energy audit is to estimate the relative contribution of all significant electrical appliances towards the total energy consumption of a building. An energy audit is carried out in the following four steps:

i. identification of electrical appliances;
ii. determining the power rating of the appliance from the product label or from available power rating averages (in kW)
iii. Estimating the daily, weekly and monthly periods of time during which the appliance will be in use (in hours);
iv. determining the monthly energy usage by multiplying the kW rating in Step (ii) by the duration of usage estimated in step (iii) in order to calculate the energy consumption in kWh

(Energy = Power x Time)

After this basic energy audit has been completed, the focus shifts to an examination of load management matters such as load profiles, peak power and other power factors, hot water systems, etc. The insulation status of the ceiling and piping must be verified, and thermal conductivity calculations of the building materials must be carried out; the passive solar factors and the fuel sources of the electricity must also be taken into consideration.

The main areas where energy savings can be made can be identified by reviewing the relative contribution of the various appliances (those used for lighting, space heating and cooling, cooking and water heating). The energy consumption of the residential sector derives from cooking, water heating, and from lighting and electrical appliances for other uses. It should be noted that there are regional differences when it comes to opportunities for energy saving, especially in the residential sector (IEA, 2008).

In OECD countries space heating is the most significant energy user, followed by domestic appliances, water heating, lighting and cooking (IEA, 2008). This means that energy-saving measures focus primarily on space heating, followed by the other end-uses. In the case of South

Africa, water heating, lighting, cooking and space heating are the major household electricity consumers (Winkler *et al., 2005*).

3.6.3 Cooking

Cooking is an important domestic energy end-use. Stovetop cooking is one of the major energy-consuming activities globally (WLPGA, 2009). In developed countries people have the choice of stovetops using LPG, natural gas and electricity. In developing countries the majority of the people still rely on wood-fuel. Other sources of fuel that are used for cooking include kerosene, biogas and electricity. In South Africa in the mid-to-high income households the appliance mainly used for cooking is an electric stove. Cooking in South Africa contributes significantly to the peak demand for electricity in the residential sector. Reducing electricity demand by replacing electric stoves would help to reduce the peak demand from the electricity grid. An average household in the Western Cape consumes about 148.2 kWh per month for cooking (Winkler *et al*, 2005:9). Replacing an electric stove with an LPG stove would reduce household electricity consumption by about 1778.4 kWh annually. This could translate into a monetary saving of about R 1600.56 per year.

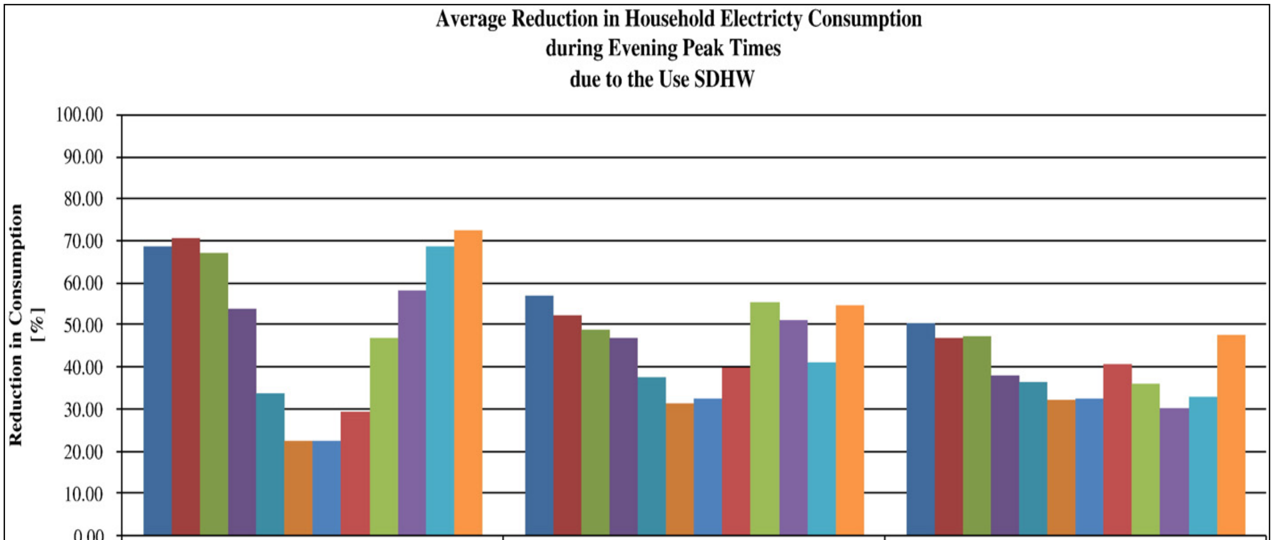
3.6.4 Water heating

Water heating is a major consumer of energy in residential buildings. An electric geyser is usually used for water heating in middle-to-high income households, making up 30–50 % of their total electricity consumption (Ijumba, Sebitosi and Pillay, 2008: 1). Total monthly electricity consumption per middle-to-high income household is about 774 kWh per month (Winkler *et al.*, 2005:9). Of this amount 380.8 kWh per month is used for water heating (Winkler *et al.*, 2005:9). Replacing an electric geyser has the potential to save about 4570kWh annually for an average middle-to-high income household. This could translate into a monetary saving for the household of about R 4113 per year.

Various studies have shown that electricity consumption by electric geysers coincides with Eskom's peak times, so this presents an opportunity for peak demand reduction (Ijumba *et al.*, 2008; Ijumba, 2008; SEA, 2009). Peak demand refers to "the largest average amount of power required by a utility's customers within a specific time frame, normally averaged over an hour" (Ijumba, 2008: 2). This indicates the amount of electricity the utility should produce within a short timeframe to meet its customers' maximum demand. Electricity demand fluctuates daily and also seasonally. Eskom experiences daily peaks in the morning from 06h00 to 09h00 and in the evening between 18h00 and 21h00. It also experiences a winter seasonal peak due to increased heating loads and longer burning hours for lights (Ijumba, 2008).

The problems associated with peak demand on Eskom's power system have been identified as decreased system reliability, increased line losses resulting from the transmission of power over long distances, and outages caused by demand exceeding capacity and/ or transmission constraints (Ijumba, 2008). In South Africa residential electricity consumption accounts for about 37% of peak demand, of which 40% is attributed to water heating (Ijumba, 2008: 2). In a recent study Ijumba *et al*. (2008) show that a solar water heater can reduce household electricity consumption and can reduce the demand on the electricity grid during the evening peak period. It should be noted that the reduction varies according to location in South Africa and also according to time of the year. Figure 3.7 below shows the average reduction in household electricity consumption during the evening peak times when a solar water heater is used.

Figure 3.7: Average reduction in household electricity consumption during evening peak times when a SWH is used



	CAPE TOWN	JOHANNESBURG	DURBAN
Jan	68.74	56.77	50.35
Feb	70.39	52.11	47.04
Mar	67.15	48.80	47.07
Apr	53.68	47.00	38.12
May	33.72	37.43	36.32
Jun	22.25	31.34	31.94
Jul	22.59	32.33	32.56
Aug	29.42	39.95	40.82
Sep	46.93	55.25	36.17
Oct	58.24	51.08	30.19
Nov	68.77	40.85	32.71
Dec	72.55	54.43	47.54

Source: Ijumba *et al.* 2008:89

Figure 3.7 shows that during the evening peak, the reductions in household electricity consumption due to solar water heater usage are greatest in summer and lowest in winter. The study also concluded that large–scale implementation of solar water heating will reduce loading and losses on the power systems' transmission lines, especially during peak periods. For instance, the reduction in losses would only amount to about 180MW, which is the capacity of one Open Cycle Gas Turbine (OCGT) (Ijumba *et al*. 2008: 94). This means that solar water heating can be used to reduce peak electricity demand from the grid.

3.7 Energy efficient technologies

3.7.1 Gas stove

A gas stove is a cooker which uses a flammable gas such as propane, natural gas, butane and LPG as a source of fuel. It is one of the appliances that can be used for end-use energy efficiency in the residential sector.

3.7.2 Solar water heater

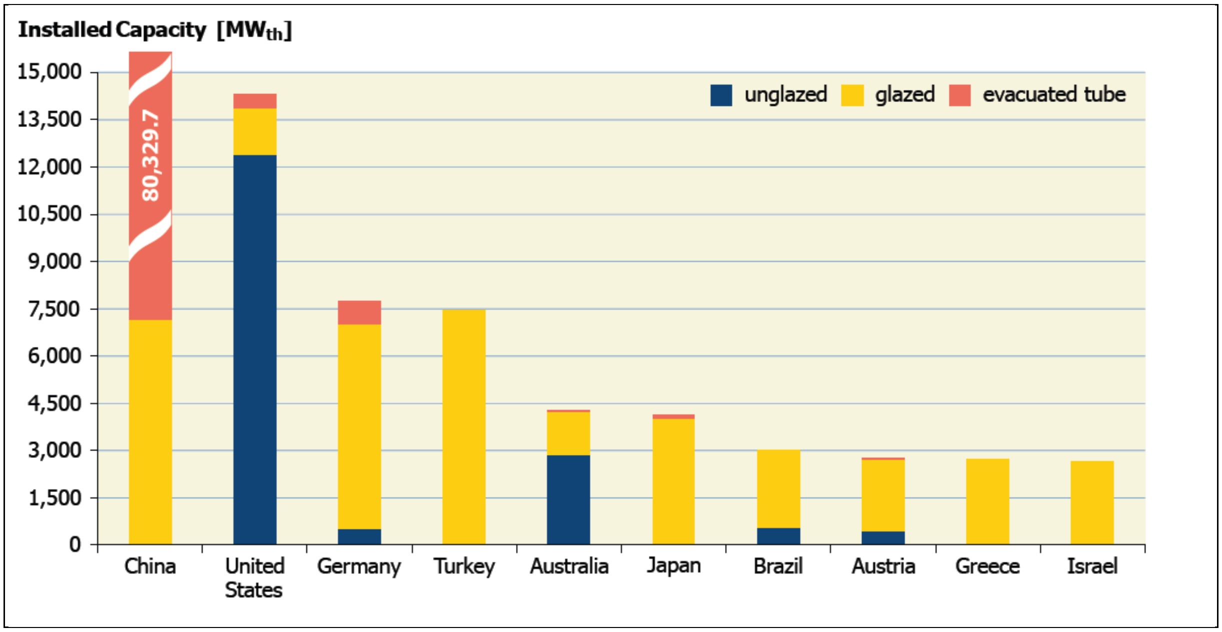
A solar water heater heats water using energy from the sun. It works on two principles: namely, black objects absorb heat, and hot water rises because of the density differences between cold and hot water. A solar water heater consists of three main components: the collector, the storage tank and energy transfer fluid. The storage tank stores water; the water is then heated by a heat transfer fluid in the collector and it flows around a jacket which surrounds the tank, thereby heating the water. There are various kinds of solar water heaters, namely, passive, active, direct and indirect systems. A passive SWH uses the thermo-siphon effect for circulating water between the collector and storage tank. An active SWH uses a pump for water circulation. A direct SWH directly heats water which then circulates between collector and tank. This system is suitable for areas that are lime and frost free. An indirect SWH heats water via a heat transfer liquid which is heated in the collector and flows around the jacket surrounding the tank. An indirect system is suited to all conditions. Two types of collectors are common in South Africa: flat plate and evacuated tubes. A flat-plate collector comprises a closed glass tube inside which is a metal absorber sheet with a heat pipe in the middle with the heat transfer fluid. Evacuated tubes on the other hand consist of rows of parallel glass tubes comprising two tubes fused together. The inner tube is coated with a selective absorber coating. Heat is collected inside the glass tubes and transported to a heat transfer fluid by a heat pipe. Evacuated tubes perform well in overcast and low temperature conditions.

Solar water heaters function as high water pressure or low water pressure systems. Low water pressure systems are gravity fed. This means that the higher the solar water heater the stronger the pressure of water at the water point. Low pressure systems are mainly targeted at low-income households. High pressure systems are more expensive since they use high quality materials that are strong enough to withstand the pressures created by the system. High pressure systems are targeted at mid-to-high income households.

Solar water heaters can be installed in different ways. They can either be close-coupled or split-coupled systems. The close-coupled system is the most commonly used system. It consists of a roof-mounted solar collector that is combined with a storage tank mounted horizontally and is placed above the collector (SEA, 2009; Leidl and Lubitz, 2009). Split-coupled systems are systems that have the storage tank located elsewhere, usually within the roof. The tank is installed above the collector in a passive system that uses a thermo-siphon to circulate water. In cases where the tank cannot be placed above the collector, a pump (active system) needs to be installed to circulate water. Split-coupled systems work well in cases where the consumers are concerned with aesthetics.

Solar water heating is the most developed of solar technologies (WEC, 2007). Solar water heating is a mature technology that has reached commercial status in countries such as China and Greece. Solar water heating is used for various purposes including domestic, commercial and pool water heating. Internationally as well as in South Africa solar water heating is a mature technology that has been identified as being “one of the simplest and least expensive ways to harness renewable energy and can be comparatively cost-effective for reducing greenhouse gas (GHG) emissions” (Milton and Kaufman 2005:2; RSA DME, 2003; 2008). The uptake of solar water heaters varies between countries and regions. These differences are attributed to policy differences rather than to variations in solar resources. There are also differences according to the technology used. Worldwide 29.1GW_{th} or 41.5 million square meters of SWH had been installed by 2008 (IEA - SHC, 2010:15).The top ten countries in terms of installed capacity are China, USA, Germany, Turkey, Australia, Japan, Brazil, Austria, Greece and Israel.

Figure 3.8: Installed SWH capacity for top ten countries by collector type



Source: IEA - SHC, 2010: 10

Figure 3.8 shows that China is the leader in installed capacity and relies more on evacuated tube collectors. The USA comes second and uses mostly unglazed collectors. Australia also uses mainly unglazed collectors, while the rest of the top ten rely mainly on glazed collectors.

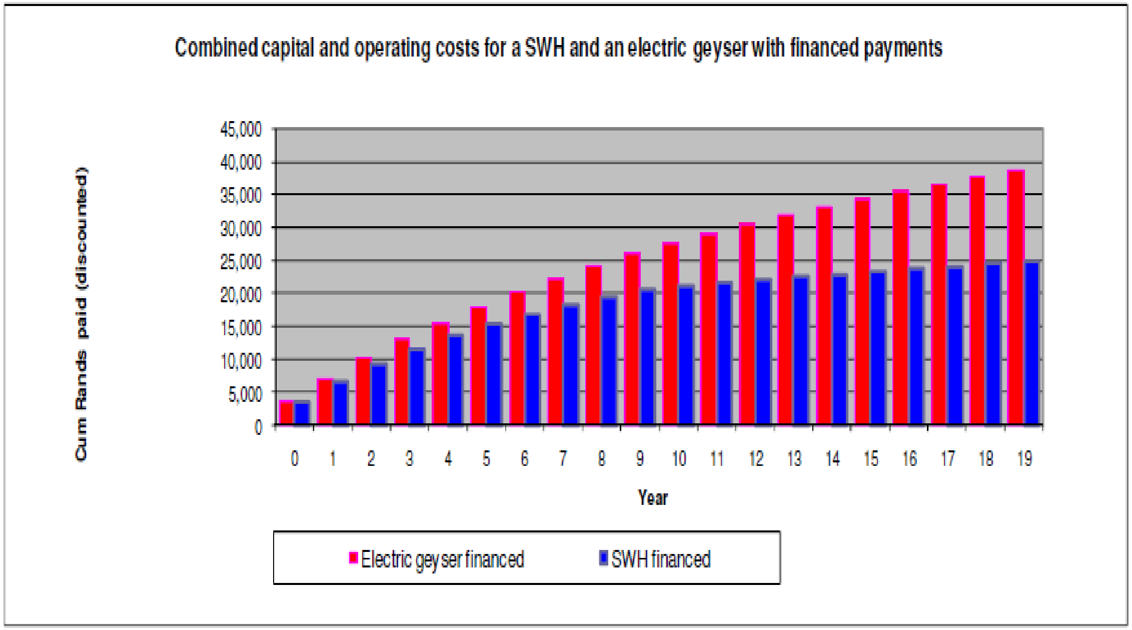
In Europe solar water heater uptake is increasing. The reasons for this have been identified as: (i) the realization that gas, oil and electricity are becoming expensive and fossil fuels are running out; (ii) building codes which require renewable energy use; and (iii) the cost-effectiveness of solar water heaters (ESTIF, 2009). SWH uptake in developing countries is limited even though they have very good solar radiation when compared to developed countries (Hack, 2006; Jones, 2006; Banks and Schaffler, 2005). Some of the barriers to SWH uptake in developing countries are financial. These include the high capital cost coupled with lack of financial incentives, the low cost of electricity, inadequate legislation to promote technology deployment and a lack of awareness (Dinchev, 2004; Hack, 2006; Jones, 2006; ESTIF, 2009).

In South Africa, solar water heaters have been identified as one the “low hanging fruits” for early implementation (Holm, 2005). The potential of solar water heaters is huge. About 100 000 new houses constructed every year with an estimated 2 to 3 million installed electric geysers (Holm, 2005:41). About 30 000 houses undergo renovation and about 400 000 electric geysers are replaced annually (Gcabashe, 2009:9).

This means there is an opportunity to replace electric geysers with solar water heaters. Solar water heating has the potential to save the country about 2000 MW of capacity, which is equivalent to one coal-powered plant (Ward, 2002:25). SWH use in South Africa is, however, low. Efforts to transform and open up the solar water heater market began with the CEF 500 pilot program launched in 1999: the aim was to roll out 500 solar water heaters in mid-to-high income households in KwaZulu Natal, the Western Cape and Gauteng provinces. The objectives of the program were to improve SWH quality, SWH accessibility and affordability and to reduce $C0_2$ emissions. Eskom initiated the National SWH Demand Side Management program in 2007. The target was to install about 1 million SWHs by 2014. By the end of 2010 about 30 974 SWHs had been installed nation-wide (RSA DoE, 2010).

In order to increase the uptake of SWHs, cities need to include SWHs as part of their service provision: SWH could be installed as city infrastructure and the building owner would pay a monthly rate for the service (SEA, 2009). The advantage of this system is that the city can diversify its traditional income stream of electricity sales by including hot water provision (SEA, 2009). The idea is that the city would own, maintain and replace SWHs and the customers would pay for the service through their monthly rates bills. Local governments in South Africa are beginning to include SWH in their energy strategies (SEA, 2009: South African Cities Network, 2011). Provincial and local governments have developed SWH programs. These include the Western Cape Provincial Government that has installed 1000 SWHs in rural homes in a pilot program. The City of Cape Town has a programme for the large-scale installation of SWHs in low-income households. The programme includes the installation of ceilings and CFLs in Kuyasa, which is also South Africa's first CDM project. Nelson Mandela Bay Municipality has a Go Green policy which includes a programme to retrofit 100 000 SWHs by 2012. This programme will be discussed in detail in Chapter 5. Studies carried out by the Cape Town City Council and Sustainable Energy Africa show that through innovative financing SWHs are becoming more affordable.

Figure 3.9: Comparison of financed electricity geyser and financed SWH



Source: SEA, 2009:4

Figure 3.9 shows that a SWH is a better investment than an electric geyser (EWH). When comparing the capital and operating costs for a SWH and an electric geyser over a twenty-year period, a SWH shows greater savings and is financially beneficial from the first year.

The barriers to SWH installation in South Africa have been identified as follows:

- the low cost of electricity has led to a massive rollout of electric water heaters at both commercial and domestic levels;
- SWHs have higher initial costs when compared to electric water heaters;
- consumers are generally not aware of the environmental impacts of EWHs and the potential of SWH to reduce the energy bill for households; and
- there is a inadequate legislation to facilitate the deployment of the technology (Dintchev, 2004).

In order for the uptake of SWHs to improve it is necessary to overcome these barriers.

It should be noted that the adoption of energy efficient technologies such as SWH and gas stoves depends on the existing technology and its efficiency, and on the behaviour of users and their willingness to change. Existing technology may be in a "locked-in" state and consumers may not be willing to shift to new technologies (Kritzinger, 2011b).

3.7.3 Heat pumps

A heat pump is a device that moves heat from one source to another. It uses mechanical work to transfer heat from a low temperature source to a high temperature sink (Eskom, 2011). There are two types of heat pumps: split systems where the tank is separated from the pump, and integrated systems where the whole system is one unit. A heat pump is an efficient and cost effective way of heating water, saving 67% energy when compared to a conventional water heater (Eskom. 2011). Eskom offers a heat pump rebate under the Eskom IDM programme. The rebate is in two categories, depending on the size of the pump. Table 3.3 below shows heat pump rebate.

Table 3.3: Heat pump rebate

Heat pump tank size	Rebate offered
100 – 300 litres	R 3 668
301 – 500 litres	R 4 320

Source: Eskom, 2011

The rebate will remain unchanged until end of 2013 (Eskom, 2011). The rebates constitutes between 27% and 30% of total heat pump cost depending on system size. It should be noted that the rebate only applies in retrofitting cases where the consumer is replacing an existing working electric geyser and that the target market is middle-to-high income households, the hospitality industry, corporate organisations and municipalities. Eskom expects the programme to save about 54 MW of electricity and expects that 65 000 systems will be installed by 2013 (Eskom, 2011).

3.8 Behaviour change

Energy efficiency necessitates behaviour change in order for a household to move to energy efficient technologies. Various techniques are used to encourage people to shift from electric geysers to solar water heaters. These include information techniques such as awareness campaigns to persuade people to act, positive motivational techniques such as financial incentives and coercive measures such as regulation that forces people to act under duress (De Young, 1993). Energy efficiency decisions are based on trade-offs between immediate costs and future decreases in energy expenses resulting from increased efficiency. The greater the anticipated energy price, the more attractive are energy efficient solutions. Consumers base their decisions on the payback period rather than on life cycle costs. A short payback period means that this option is attractive (World Energy Council, 2008; Reddy, 1991). Financial incentives are targeted towards "first-cost sensitive" (Reddy, 1991: 5) consumers. Financial incentives are offered to address the barrier of the high upfront cost of solar water heaters. The question is, what sort of incentives or mechanisms can be used to promote solar water heaters at the household level?

3.9 Incentives/Mechanisms for promoting the use of domestic solar water heaters

Mechanisms for promoting solar water heaters can be classified into two categories, financial incentives and regulatory mechanisms/police law (Hack, 2006). Financial support is usually received by the beneficiary through the application of grants or subsidies, rebates, low interest rates or soft loans, tax deductions, fees for service mechanisms such as the sale of energy leasing/renting or contracting systems, and tradable certificate schemes such as renewable energy certificates (RECs), or green and white certificates.

Although fees for service incentives are classified under financial incentives, no direct financial support is offered to the beneficiary. Financial incentives are an effective way to stimulate growth in the solar water heater market (European Solar Thermal Industry Federation, 2007) and overcome the barrier of high upfront costs. It should be noted, however, that they do not work well if they are not supported by flanking measures to overcome other barriers, such as a lack of awareness. Financial incentives can be offered at local, regional and national levels of government.

3.9.1 Direct grant/subsidy

A direct subsidy is the most commonly used incentive. Payment to the beneficiary is made per installed collector area in square meters, or is based on the performance of the system. There are basically two procedures used for payment of the grant. The first is that the purchaser of a solar water heater makes an application for the grant using the receipts for purchase and installation as proof of purchase and installation. Payment is the made in cash or by transfer to the applicant's account. The second method is that the buyer pays a lower price for purchase and installation to the system installer. The installer then makes the application to the responsible institution and the institution makes payment to the installer.

Countries that use the direct subsidy system include Germany, Austria, Netherlands, Australia and Sweden. The subsidy related to collector area has increased the uptake of solar water heaters in Germany and Austria. Germany had an installed capacity of $1.5GW_{th}$ (2.1 million m^2 collector area) in 2008 and Austria had a capacity of $243MW_{th}$ (350 000 m^2) in 2008 (ESTIF, 2009:3). The Netherlands and Sweden utilise the performance-based subsidy but these have been associated with less efficient solar water heaters.

3.9.2 Tax credits/deductions

In this system, part or all of the solar water heater investment is deducted from income tax. The customer pays for the solar water heater and only claims repayment via income tax returns. France and Greece have used this incentive with success. Greece has since abandoned it since their market was mature and viable (Roulleau and Lloyd, 2008). Tax deductions translate to a benefit after one or two years when the income is declared and the tax returned. This is a disadvantage of the system as people expect an immediate benefit. This incentive may also be problematic since it does not overcome the barrier of high initial costs as the customer pays the upfront costs, and is only reimbursed at a later stage.

3.9.3 Rebate

Investments in solar water heaters can be supported by a point-of-sale rebate. In this case a customer fills out an application form and countersigns the details of the installation that would have been recorded by an installer. Once the installer is satisfied that the criteria have been met, the installer allows a point-of-sale discount. The form is then returned to the responsible authority. The State Government of Victoria used this type of incentive in cases where the replacement of conventional water heaters with solar water heaters would contribute to the reduction of greenhouse gas emissions (Guthrie, *et al.*, 2005:3; Roulleau and Lloyd, 2008). During the first four years (2000-2004) a total of 9507 systems attracted the rebate (Guthrie *et al.*, 2005:3). South Africa also uses the rebate system at national level. Since its inception in 2008, 30 974 systems had been installed by December 2010 (RSA DoE, 2010). The subsidy was doubled in January 2010 and now ranges from R2100 to R12 500 per SWH unit installed (Eskom, 2010).The turnaround time between installation and payment is between six and eight weeks.

3.9.4 Low interest/soft loans

Promotion is also provided by means of credits with low-interest loans, normally at below market level. Low-interest loans are usually offered by public promotion banks, but in some cases it is the producers of solar water heaters that offer them. Low interest loans are used successfully in India. Soft loans can also be used to complement to other measures, as is the case in Germany. The public bank KfW offers soft loans for the overall energy performance improvement of existing buildings, and this includes solar water heaters.

3.9.5 Leasing and contracting

Leasing and contracting have the potential to increase the uptake of SWHs. Under this method the power supplier or producer leases the SWH for a leasing contract period over which payment of a leasing rate is paid. The lessee has an option to purchase the SWH at the end of the lease, after which ownership transfers to the lessee. This method overcomes the barrier of huge upfront cost since payment is made in instalments. Scholars such as Hack (2006) argue that SWH investments are too low to warrant the use of this mechanism at household level. It seems that this might be true in cases where the costs of SWH are beginning to come down, but not in cases where SWH is still a niche market and the costs remain high. Ontario Ministry of Environment and Energy conducted a study in 1991 which showed that leasing programmes offered the potential to increase the uptake of energy efficient appliances and renewable energy technologies in the residential sector (Ontario Ministry of Environment and Energy, 1991).

3.9.6 Sale of energy

The sale of energy system requires no capital investment by the beneficiary. An energy service provider owns, installs and services the solar water heater. The energy service provider then sells the energy generated by the solar water heater to the beneficiary (Guiney, 2006). Another way of administering the sale of energy is for a third party to own the solar water heater while the energy service provider or utility manages the administration. This mechanism depends on the performance of the solar water heater: if the SWH performs well then more energy will be sold (and vice versa)

3.9.7 Tradable certificates system

In this system, those purchasing a solar water heater obtain certificates representing the energy saved through the system. The certificates can then be sold on a certificates market driven by the requirement that certain stakeholders (such as energy suppliers) cover a share of their energy trading with certificates (ESTIF, 2007, Roulleau and Lloyd, 2008). It should be noted that in countries where this system is used it was not developed specifically for the promotion of solar water heating but for renewable energy in general, and particularly for electricity generation systems. Tradable certificates are used in Australia and Italy.

The system in use in Australia requires the issuing of the green or renewable energy certificates (RECs). This is part of the national policy to promote the uptake of renewable energy. It has been operating since 2000. In 2001, 22.8% of valid RECs were for solar water heaters; this figure increased to 52.3% in 2002. The percentage has been decreasing since 2002; the decreases in 2004 and 2005 were due to a reduction in REC price (Roulleau and Lloyd, 2008:1847). The prices of RECs do not depend on solar water heaters only but also on other renewable energy technologies, and on such variables as the oil price, electricity tariffs and carbon market negotiations. This means that these variables can affect the uptake of solar water heaters. Italy utilises white certificates and the scheme's main aim is to develop energy efficiency measures. In both the Australian and Italian cases the quantity of certificates given for solar water heaters installation is predetermined and based on known system parameters.

3.9.8 Regulations/ police law

Regulations are a system of law or ordinances that make it mandatory to install solar water heaters (Hack, 2006; Roulleau and Lloyd, 2008; Menanteau, 2007). Israel became the first country to introduce mandatory regulation. The policy has been successful and about 90% of Israeli households have installed solar water heaters (Roulleau and Lloyd, 2008). Spain became the second country to initiate a regulatory policy. The city of Barcelona passed the first ordinance, the Barcelona "solar thermal ordinance" which came into effect in August 2000. The ordinance affected new buildings and the retrofitting of existing buildings undergoing major renovations. The Barcelona model has been successful: 40% of all new buildings have solar water heaters installed (Hack, 2006:35). This has led other municipalities to follow suit and 75 of the 8108 Spanish municipalities have implemented similar solar thermal ordinances, particularly along the Mediterranean coast (Roulleau and Lloyd, 2008). In 2006, a new building code (Technical Building code) was enacted at national level that specifies minimum solar hot water and solar photovoltaic requirements in new buildings and those undergoing renovation. Solar hot water must meet between 30% and 70% of energy requirements for hot water, depending on the climatic region, the back-up fuel and the energy consumption level (Martinot, 2006:7; Jones, 2006:8). Spain has the second highest installed capacity in Europe after Germany. In 2008 it had 300MW_{th} (434 000m^2) (ESTIF, 2009). In China the city of Rhizhao has made it mandatory to install solar water heaters on all buildings in the 1990s. As a result 99% of households in the central district have installed solar water heaters (World Watch, 2007).

In South Africa, the city of Cape Town has drafted a by-law proposing to make it mandatory for all new buildings to install solar water heaters. The city aims to have 10% of households install solar water heaters by 2010 (Ward, 2009).

The success of a financial incentive is determined by a number of factors.

(i) the first is the duration and stability of the incentive: the incentive needs to be available for a reasonable term and for a number of years and the funding needs to be stable. Short-term incentives lead to a "stop and go" effect which impacts negatively on market development. This effect could encourage the emergence of "gold diggers" whose aim is to make a quick buck (ESTIF, 2006). This would damage the reputation of the industry.

(ii) the amount of the incentive needs to be high enough to stimulate interest and result in an increase in new investments.

(iii) the quality of the solar water heaters needs to be controlled through minimum equipment requirements so as to ensure system performance.

(iv) the application process needs to be simple and easy. If the application process is cumbersome, early adopters may spread the word to others and this could affect the rate of uptake.

(v) customer education and awareness are important. Financial incentives need to be supported by campaigns to educate the public about solar water heaters and the availability of incentives.

(vi) monitoring and evaluation are necessary for continuous evaluation and this needs to be done in conjunction with market experts.

(vii) lastly, financial incentives need to have other complementary incentives.

3.10 Chapter summary

Sustainable development is a worldwide challenge because economic development and its associated growth trends perpetuate anthropogenic resource use that has negative consequences for the environment. The shift towards sustainable development is necessary to ensure equitable resource distribution and environmental protection. Energy is an important resource and its usehas implications for future sustainable development. The current energy system is based on fossil fuels that are associated with GHG emissions that lead to climate change. A transition to sustainable energy systems based on renewable energy sources and increased energy efficiency is necessary for sustainable development.

Sustainable urban growth is an integral part of the goal of achieving worldwide sustainable development. Urban growth presents new challenges as far as resource use is concerned. Urban areas consume a lot of energy and are responsible for a considerable proportion of GHG emissions. Cities and towns can influence how resources such as energy are generated and used in their localities by implementing various strategies to reduce energy consumption, increase energy efficiency and meet their energy needs through renewable energy systems.

Sustainable energy can be implemented via the twin solutions of energy efficiency and increased use of renewable energy sources. Energy efficiency is considered the "low hanging fruit" because it is "the best energy resource", is commercially viable, and allows for financial savings resulting from decreased energy consumption. In addition organisations and households can implement it at anytime. The literature on the subject highlighted the importance of end-use energy efficiency, based on the idea of compounding efficiency losses during energy conversions. The limitations of energy efficiency measures as well as their unintended consequences were also noted. These reservations do not warrant the argument that energy efficiency is irrelevant, but suggest that it cannot be the only solution for a sustainable energy future.

Technologies that are available to implement end-use energy efficiency and the introduction of renewable energy were identified. A range of possible options for retrofitting residential and commercial buildings were discussed to indicate how end-use energy efficiency can facilitate sustainable energy use. These included energy-efficient options for water heating systems and cooking end-uses, and these options are directly relevant to this thesis.

The literature revealed that energy efficiency necessitates behaviour changes if people are to shift from the use of current equipment to more energy efficient appliances. Various techniques may be used to encourage the shift to energy efficient equipment (such as a SWH). These included awareness campaigns to persuade people to act, positive motivational techniques such as financial incentives, as well as coercive measure (such as regulations) that force people to act under duress.

In conclusion, the literature review presented an argument which explains why sustainable energy and sustainable urban development are necessary, and it describes the technologies that enable the use of sustainable energy. In addition it provides examples of mechanisms that are used internationally to encourage households to adopt SWHs. These three golden threads are woven together, and lead to the question: What financial mechanisms can be used by the Stellenbosch municipality to promote the uptake of SWHs and LPG stoves in middle-to-high income households?

Chapter 4

International and local case studies of cities promoting SWH.

4.1 Introduction

Globally local authorities have begun to introduce measures that seek to reduce greenhouse gas emissions and their ecological footprints. Strategies that are being used include energy efficiency and renewable energy technologies. International organisations such as C40 Cities – Climate Change Leadership, The International Council for Environmental Initiative (ICLEI) – as well as Local Government for Sustainability and local organisations such as SEA support local governments in their efforts to implement sustainable development locally. These organisations offer consultation, technical assistance, project coordination and assistance with training and capacity building to local authorities to develop strategies to reduce climate change through a variety of energy efficiency and sustainable energy initiatives. The underlying principle is that locally designed programmes provide cost-efficient and effective ways to achieve national, local and global sustainability goals.

This chapter looks at the following cases: (i) the California Solar Water Heating Pilot Programme (SWHPP); (ii) the California Solar Initiative – Thermal Programme; (iii) the Freiburg Solar Initiative; and (iv) the Nelson Mandela Bay Municipality solar water heaters programme. These programmes represent efforts by municipalities "to apply old tools such as municipal financing, to the new problem of reducing the amount of carbon in the energy supply" (Fuller *et al.*, 2009:24). Municipal financing mechanisms have the potential to assist in the transition to sustainable energy use, reduce emissions, create jobs and reduce the strain on the electric power system and provide more comfortable buildings (Fuller *et al.*, 2009; SEA, 2009). An assessment of repeatability of the programmes run by other municipalities will also be given. Local authorities that would like to promote energy efficient technologies such as solar water heaters could learn from these experiences.

4.2 California SWHPP

4.2.1 Background

California is the third largest state in the United States – by area, 163 707 square miles.

Figure 4.1: State of California

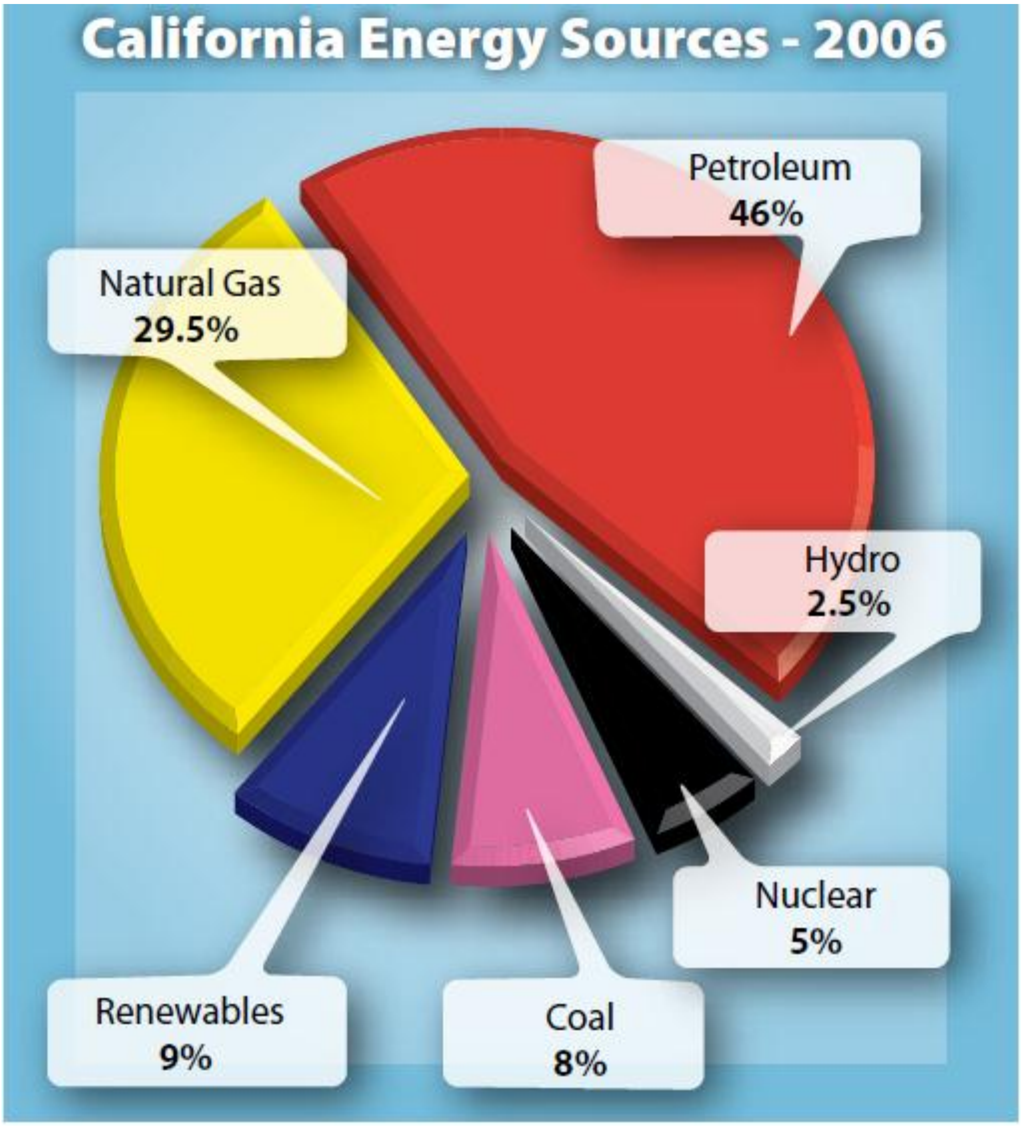
Source: Maps of the World, 2010

It is the most populous state in United States, with a population of about 38 million in 2010 (US Census Bureau, 2010). The population is expected to grow to 44 million by 2020 and 60 million by 2050 (State of California, Department of Finance, 2007).

4.2.2 Energy in California

Fossil fuels dominate the state's energy system.

Figure 4.2: California's energy sources in 2006



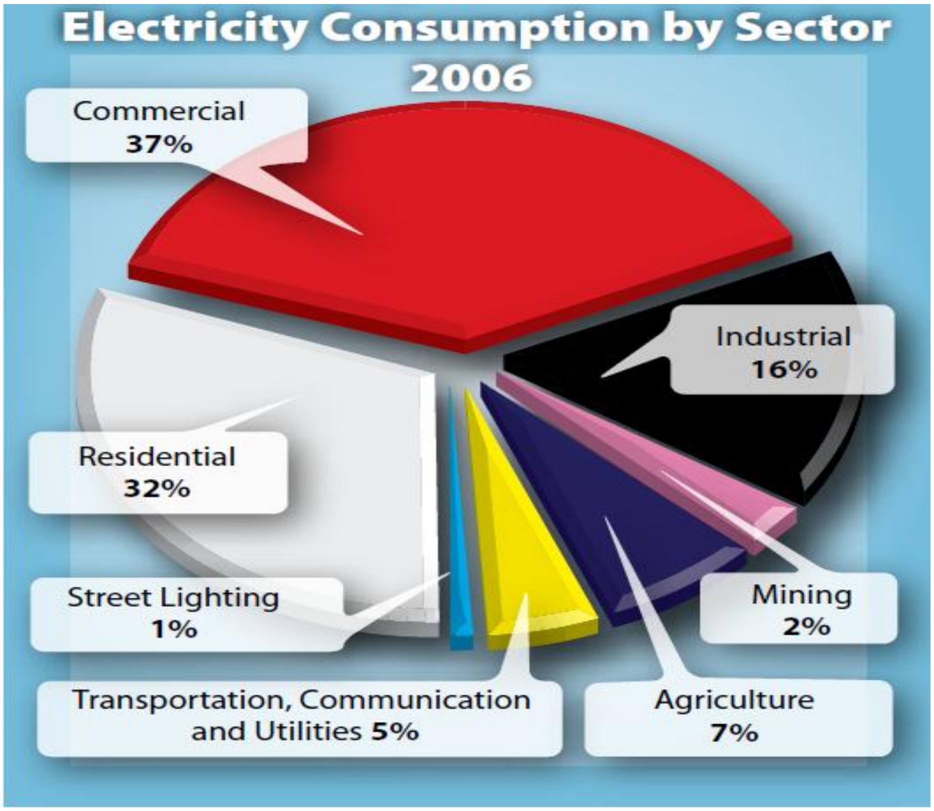
Source: California Energy Commission, 2006.

Figure 4.2 shows that petroleum and natural gas dominated California's energy system in 2006. Natural gas was used for electricity generation or heating water and buildings while petroleum was used for transportation. Despite efforts to diversify energy sources, 80% of the energy consumed in the state still comes from fossil fuels (California Energy Commission, 2007: 22). In terms of energy consumption, about 41% of all energy consumed in California was used for transportation, followed by industrial uses with 22%, commercial uses with 19% and residential uses with 18% (California Energy Commission 2007: 22).

Electricity is mainly generated from natural gas. Electricity in California is supplied by three large investor-owned utilities and over a 100 municipal utilities (Franco and Sanstad, 2008). The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E), the publicly owned Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District (SMUD) supply about 80% of all electricity consumed in the state. The remaining 20% is supplied by three smaller investor-owned utilities (Bear Valley, PacifiCorp, and Sierra-Pacific Power) and by 24 municipal utility districts, three rural cooperatives, about 12 irrigation or water districts, and one state and one federal water agency (electricity is used for pumping water). About 22% of electricity used in the state of California is imported from Canada, Mexico and 11 western states.

The commercial and residential sectors dominate electricity consumption in the state.

Figure 4.3: California's electricity consumption by sector in 2006



Source: California Energy Commission 2006.

Electricity consumption has been growing steadily and it is forecast to continue increasing. Electricity consumption increased from 250 241 GWh in 2001 to 270 927 GWh in 2004. During this period consumption grew by 8%. Consumption is forecast to grow by between 1.2 and 1.5 per cent annually, from 270 927 GWh in 2004 to between 310 716 and 323 372 GWh by the end of the forecast period in 2016 (California Energy Commission, 2005: 47).

The main drivers of growth in electricity consumption in the residential sector have been identified as population growth and personal income. This can be attributed to the vibrant economy. In addition California has a peak demand problem. Electricity demand increases greatly in summer due to air conditioning loads. The problem of meeting peak demand arises from the power plants: the new gas-fired plants are combined-cycle plants that have less capability to ramp up and down to meet peak demand (California Energy Commission, 2005). State-wide, annual peak demand is projected to grow by on average of 850 megawatts per year for the next 10 years, or 1.35 percent annually (California Energy Commission, 2007: 37). In terms of CO2 emissions, electricity accounts for about 28% of state emissions. Energy efficiency has been identified as the state's least expensive strategy and renewable energy is essential to meet the state's climate mitigation goals. As a result of this scenario, policy debates have sought to shift California's energy path towards climate change mitigation and renewable energy use. Leaders such as state Governor Arnold Schwarzenegger have taken a proactive role and decided to prioritise climate change action and promote renewable energy, particularly solar energy (Schreurs, 2008).

4.3 Solar Energy in California

The state of California has abundant solar resources. The state receives an average of more than 5 kWh of solar energy per square metre per day (Del Chiaro and Gibson, 2006:353). California has been actively harnessing solar resources. The history of solar energy in California dates back to the 1800s. In January 2006 the California Solar Initiative (CSI) was approved by the California Public Utilities Commission (CPUC). In August 2006, State Governor, Arnold Schwarzenegger signed into law the Million Solar Roofs Bill, introducing policy to support CSI. The solar initiative is part of the Go Solar California Campaign. The California Solar Initiative is a $2.16 billion incentive programme to promote solar development through 2016 with the aim of installing 1940 megawatts (MW) of new solar generation and assisting in creating a sustainable solar industry (California Public Utilities Commission, 2010: 1). Under the CSI, funding provision was made for about $100.8 million to be used for incentives for solar thermal technologies that would displace electricity usage (California Public Utilities Commission, 2010: 1). The eligibility of SWH technology for incentives from the fund was deferred until after a pilot programme for SWH was conducted in SDG&E territory. The objective of the state-wide incentive is to install about 200 000 SWH systems in homes, government buildings, and businesses by 2017 (Itron, 2009:1). In order to determine whether solar water heating technology is suitable for state-wide incentives, the SWHPP was launched.

4.4 California Solar Water Heating Pilot Programme (SWHPP)

4.4.1 Background

Solar water heater usage is not new in California. The state's attempt to promote solar water heating technology began about a century ago. It attempted to promote solar water heating technology in the 1970s and 1980s following the energy crisis and the environmental awakening. Its first SWH rebate programme was created in 1980 and was known as the Demonstration Solar Financing Programme. The programme was implemented from 1980 to 1983 and it supported the deployment of hundreds of thousands of SWH systems in California (California Public Utilities Commission, 2010).

Although the early programmes were successful, they were abandoned due to the return of fossil fuels and the lack of strict quality controls. There is renewed interest in solar water heating due to the following factors:

- the need to reduce dependence on imported fossil fuels;
- the need to address global warming;
- the need to dampen volatile energy prices; and
- the need to create green jobs.

4.4.2 Solar Water Heating Pilot Programme

The SWHPP was launched in July 2007 for a period of 18 months. It was administered by The California Centre for Sustainable Energy and was implemented in the area supplied by San

Diego Gas and Electric. The SWHPP was launched to test incentives for SWH systems in order to evaluate the following:

- the impact on equipment and installation costs;
- the current SWH market and the impact an incentive would have on market demand; and
- the impact on the cost-effectiveness of SWH (Itron, 2009: 1).

Residential, industrial, commercial, and agricultural customers were eligible for the incentive. The programme catered for both retrofits and new builds. In the residential, commercial and industrial sectors, SWH systems that offset energy use by an existing water heater or boiler could displace any of the following fuels: electricity, propane, natural gas and diesel.

4.4.3 SWHPP Incentive Structure

The programme utilised the prescriptive and area-incentive methods. The prescriptive method applied to small commercial and residential SWH incentives. The area method applied to large commercial SHW systems. The prescriptive method will be discussed in this thesis since it applies to residential customers. The prescriptive method was based on estimated system performance. Calculations were based on the system rating, solar orientation and other inputs. A system should have a minimum system rating of 1200 kWh if the SWH is replacing an electric water heater and 60 therms if replacing a natural gas or propane heater. The rebate was capped at US$ 1500 per system and would be paid within 30 days after final inspection of the system (California Centre for Sustainable Energy (CCSE), 2008).

4.4.4 Marketing and outreach activities

In order to raise awareness about SWH and the incentive programme, CCSE engaged in numerous marketing and outreach activities. The SWHPP was marketed through various media, which included radio, web, print, direct mail, television, events and email blasts ("e-blasts"). For television and radio advertisements the CCSE used the San Miguel Fire Chief as the spokesperson. Other programmes targeted contractors and homeowners. These included training workshops for both installers and homeowners, and partnerships with industry to increase its reach.

4.4.5 Evaluation of Solar Water Heating Pilot Programme

An evaluation of SWHPP was undertaken in January 2009 by an evaluation contractor, Itron Inc., who was hired by CCSE to access SWHPP. The SWHPP Interim Report noted that participation lagged behind expectations. For instance the incentive budget was intended to cater for about 750 participants over 18 months but less than 180 applications had been filed at that time.

Table 4.1 below shows the distribution of applications broken down by incentive type, retrofit or new build and by estimated incentive.

Table 4.1: Number of applications and estimated incentive in SWHPP

Total Applications	Number of Reserved Applications	Reserved Incentive Amount	Number of Paid Applications	Paid Incentive Amount
Retrofit				
--Prescriptive*	44	$56,087.00	100	$124,884.00
--Area†	3	$9,370.00	12	$33,900.00
New Construction				
--Prescriptive*	6	$8,150.00	7	$7,950.00
--Area†	0	$0.00	0	$0.00
Total	**53**	**$73,607.00**	**119**	**$166,734.00**

* The Prescriptive method of calculating incentives is primarily used for residential customers.
† The Area method of calculating incentives is used only for large, innovative systems.

Source: Itron, Inc. SWHPP Interim Report, 2009: 7

The total amount of incentives paid out was US$166 734: $33 900 to 13 commercial customers, based on the area method for calculating incentives. The remaining US$132 834 was paid out to 110 residential customers, based on the prescriptive method for calculating incentives. By May 2009 the programme had received 211 applications amounting to about US$ 291 000 in direct incentives (Itron, 2009: 48). Due to low levels of participation the programme was extended until

December 2009 or until the incentive ran out. The reasons for the lower than expected participation were identified as lack of knowledge of SWH, high upfront capital costs, the lack of a well-developed SWH workforce and permitting costs and requirements. An attempt to address these barriers needs to be incorporated in plans for a state-wide SWH incentive programme.
Interest in residential systems for the SWHPP was relatively constant and the programme witnessed an average of eight applications per month.

Potential growth areas were also identified in the Itron, (2009) SWHPP Interim Report. The report noted that commercial and multi–family residential households had favourable economies of scale and therefore presented significant growth potential. In the commercial sector the potential for SWH market growth was located in the health, restaurant and lodging sectors. Although single-family households are the largest single users of natural gas water heating, the report noted that it had the least favourable economic return.

Areas for potential SWH cost reductions were also identified in the Interim Report. The first category was reduced equipment costs. An example of an opportunity for the reduction of equipment costs could be the introduction of new materials in SWH systems, such as plastic piping in place of copper piping. The second category was reduced labour costs. Reduced labour costs could drive down the total system costs. The introduction of plug and play/cookie cutter SWH systems could also reduce labour costs.

4.4.6 Lessons from SWHPP

The SWHPP generated some useful information about SWH equipment requirements, permitting procedures, installation practices, marketing and outreach. In terms of equipment requirements, SWHPP demonstrated that methods for ensuring adequate freeze protection differed widely in the marketplace: some systems were more prone to water quality issues than others. In addition, in a state-wide programme storage tank requirements might have to be more flexible than the SRCC standards.

The SWHPP experience brought to the fore the problems associated with permitting procedures. SWH building permits have been difficult and at times expensive to obtain, and local permitting offices had different permitting requirements.

When it comes to installation practices, SWHPP showed that there were variations in the insulation quality of SWH systems and in their methods of freeze protection, especially for outdoor-exposed pipes. Furthermore installers could benefit from education regarding the proper installation of components and practices meant to protect against freezing and thermal migration. Another lesson was that there was need for a minimum anti-scald requirement. On the marketing and outreach side, the SWHPP experience proved that increasing public awareness of SWH has an impact on participation in an incentive programme.

4.4.7 CSI – thermal programme

In 2007, Governor Arnold Schwarzenegger signed a Bill (AB 1470) giving authority to CPUC to create an incentive programme to promote the installation of 200 000 SWHs in homes and businesses, displacing natural gas by 2017 (CPUC, 2011: 5) Installing 200 000 SWH would reduce about 100 000 tons of GHG emissions annually.

In January 2010 the CPUC approved an eight-year SWH incentive programme, the California Solar Initiative – Thermal Programme (CSI-Thermal). The main objective of the CSI–Thermal Programme is to install an additional 200 000 solar thermal systems in the state of California by 2018 (CCSE, 2010). SWH systems that would be eligible for incentives under the new programme include SWH systems that displace natural gas and electricity. SWH systems installed on new constructions with electric back up heaters were not eligible for the incentive. The initial rebate for single-family SWH project displacing natural gas was up to about US$1875 while an electricity replacing system would qualify for up to about US$1250 (CPUC, 2009). The actual incentives would be based on system performance as predicted by positioning and the system rating. CSI–Thermal started accepting applications for single-family households on the 1 May 2010. The target date for accepting applications for multi-family and commercial applications was the 1 June 2010.

4.4.8 Progress of the CSI – thermal programme

The programme began to accept applications from single family systems on 1 May 2010 and by July about 26 applications had been received state-wide (Global Solar Thermal Energy Council, 2010). This meant that the programme got off to a slow start. Multi-family and commercial systems applications were accepted from October 2010. The following have been identified as barriers to the programme's success.

- Motivating customer interest was problematic. The majority of households (90%) in California used natural gas for water heating. The problem was the long payback periods for buying a solar water heater, which costs about US$7000.
- The public could not readily access information about the programme. Solar water heating was viewed as similar to photovoltaic systems, which has been subsidised for about three years.
- There was a shortage of skilled solar and plumbing contractors who were experienced in SWH systems. Training focused on how to apply for the subsidy and not how to install a SWH.
- The process of applying for a building permit was challenging. There are about 900 different building departments in California, each with varying requirements, and the permit fees can cost up to US$1000 (Global Solar Thermal Energy Council, 2010).

These barriers have to be overcome if the programme is to succeed. In order to overcome the barrier of insufficient customer interest, there are plans to run a state-wide solar thermal awareness campaign. By June 2011, a communications company had been appointed to spearhead the campaign (CPUC, 2011). To address the shortage of skilled solar contractors, CSI-Thermal programme training workshops was held and by August 2011 there were 334 licensed solar contractors in the state (CPUC, 2011:16).

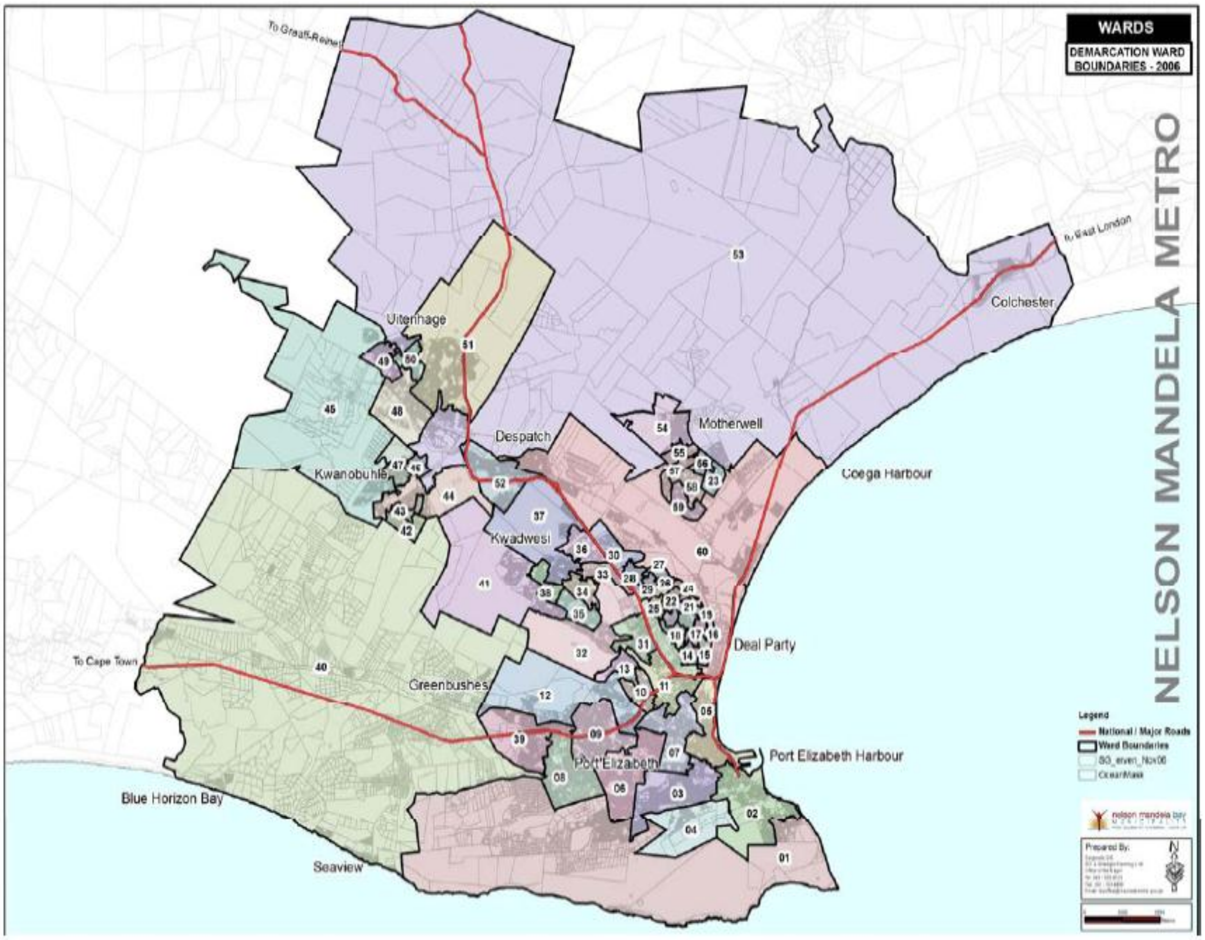
This case demonstrates the importance of leadership. Arnold Schwarzenegger's leadership role has made the State of California a proactive state in relation to climate change and renewable energy.

4.5 Nelson Mandela Bay Metropolitan Municipality (NMBMM) solar water heaters Programme

4.5.1 Background

NMBMM is located in the Eastern Cape province on the shores of Algoa Bay, and comprises the towns of Uitenhage and Despatch, the city of Port Elizabeth, and the surrounding rural area. NMBMM is the second largest city in South Africa and the fifth largest by population. It has a population of about 1,1million and it covers an area of 1,950 km² (NMBMM, 2008/2009: 7).

Figure 4.4: MBMM map



Source: NMBMM, 2009/2010

4.5.2 Energy in NMBMM

After closing its Swartkops power plant, NMBMM relies on Eskom for all its electricity demand. In the event of incoming supply failure there are two gas turbines to supply the central business district with electricity. Electricity demand is about 610 MW and it is expected to increase to about 2500 MW within ten years (Armstrong, 2008). NMBMM has taken the initiative to lead in the provision of renewable energy to its residents. The municipality is concerned about climate change and global warming and would like to play a part in assisting to meet the renewable energy target set at national level. The municipality has identified SWH as one of the technologies that can be easily implemented since it is proven both locally and internationally.

4.5.3 Solar Water Heating Project

NMBMM is one of the municipalities pioneering renewable energy projects as part of its Go Green Campaign, which is a response to Eskom's Power Conservation Phase, whose goal is to reduce demand side consumption levels. The Electricity and Energy Directorate initiated two solar water heating projects in NMBMM. These are the Zanemvula Subsidised Housing Solar Water Heater Pilot Project (1200SWH) and the 100 000 Solar Water Heaters Project. The Zanemvula Subsidised Housing Solar Water Heater Pilot Project was initiated in 2008 for RDP houses with the aim of improving the livelihoods of low-income homeowners. In addition it is a demonstration project for future low-income housing projects to offer guidance for national-level rollout. The 100 000 Solar Heaters project, on the other hand, targets existing buildings and is an energy efficiency project with a renewable energy component whose aim is to reduce electricity use in NMBMM. The aim of the project is to provide an affordable option for middle-to-high income groups for the replacement of their electric geysers with SWHs. NMBMM is working with Central Energy Fund (CEF) on this project. Although the project was initiated by NMBMM, CEF is responsible for funding the programme. The expectation is that the project will save about 41 MW of electricity use, which translates to about 5% of the total metro usage (CEF, 2010: 10).

The SWHs are financed via a flexible six-year (72 month) repayment plan through the municipal account. The interest rate is 10% (Kritzinger, 2011a). ETA Energy, a division of CEF, is responsible for marketing the Switch2Solar programme. ETA Energy works in partnership with Eskom-accredited suppliers who provide SABS tested and approved SWH systems. The project began in November 2010 and has since installed 100 SWH systems (Kritzinger, 2011a).
The lesson from this case study is that a municipality can get around legislation such as the Municipal Finance Management Act and initiate a SWH programme locally. In addition, a municipal can initiate local energy efficiency and does not have to wait for the national government to act.

4.6 Freiburg Solar Initiative

4.6.1 Background

The city of Freiburg is located in the state of Baden-Württemberg, Germany. It covers an area of 150 km^2 and by 2008 its population was about 220 000 (Salomon, 2009:2). The map of Germany (below) shows the location of Freiburg.

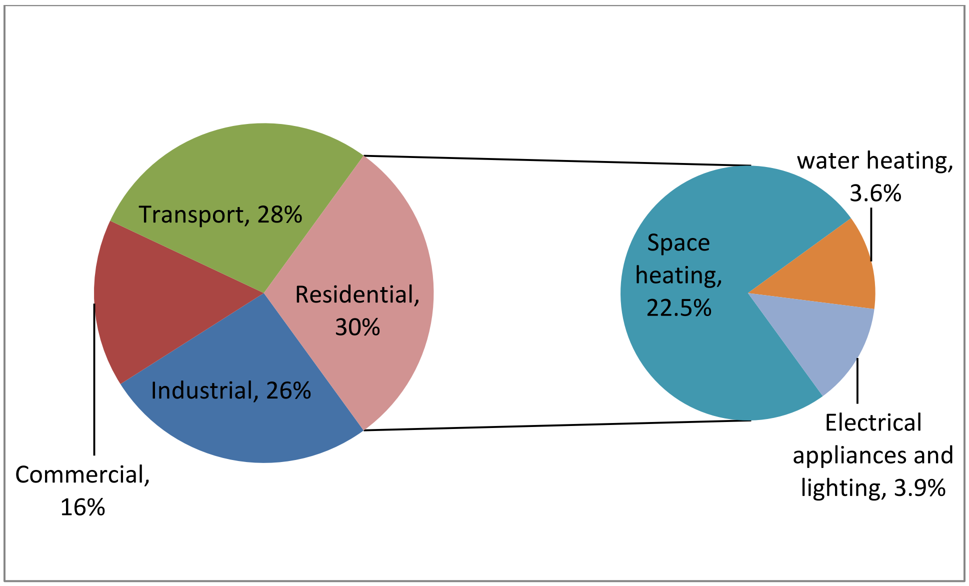
Figure 4.5: Location of Freiburg City

Source: Maps of the World, 2010

4.6.2 Energy in Freiburg

Freiburg utilises a variety of methods to generate local electricity. About 50% of electricity comes from heat-capture facilities and small-scale cogeneration plants; 30% comes from nuclear power and the remaining 20% from wind, hydropower, biomass and solar energy (Bissinger and Bouraee, 2009: 5). Despite efforts to employ a variety of renewable energy sources, solar energy remains the most visible and important renewable resource in Freiburg. The residential sector dominates energy consumption in Germany.

Figure 4.6: Energy consumption by end-use in Germany



Source: Adapted from Beyer, 2009 ICLEI

Figure 4.7 shows that the residential sector consumes 30% of the total energy consumed. Of this 22.5% is used for space heating, 3.6% for water heating and 3.9% for electrical appliances and lighting. Energy efficiency efforts in the residential sector will target space heating since it consumes the bulk of residential energy.

4.7 The **Solar Initiative**

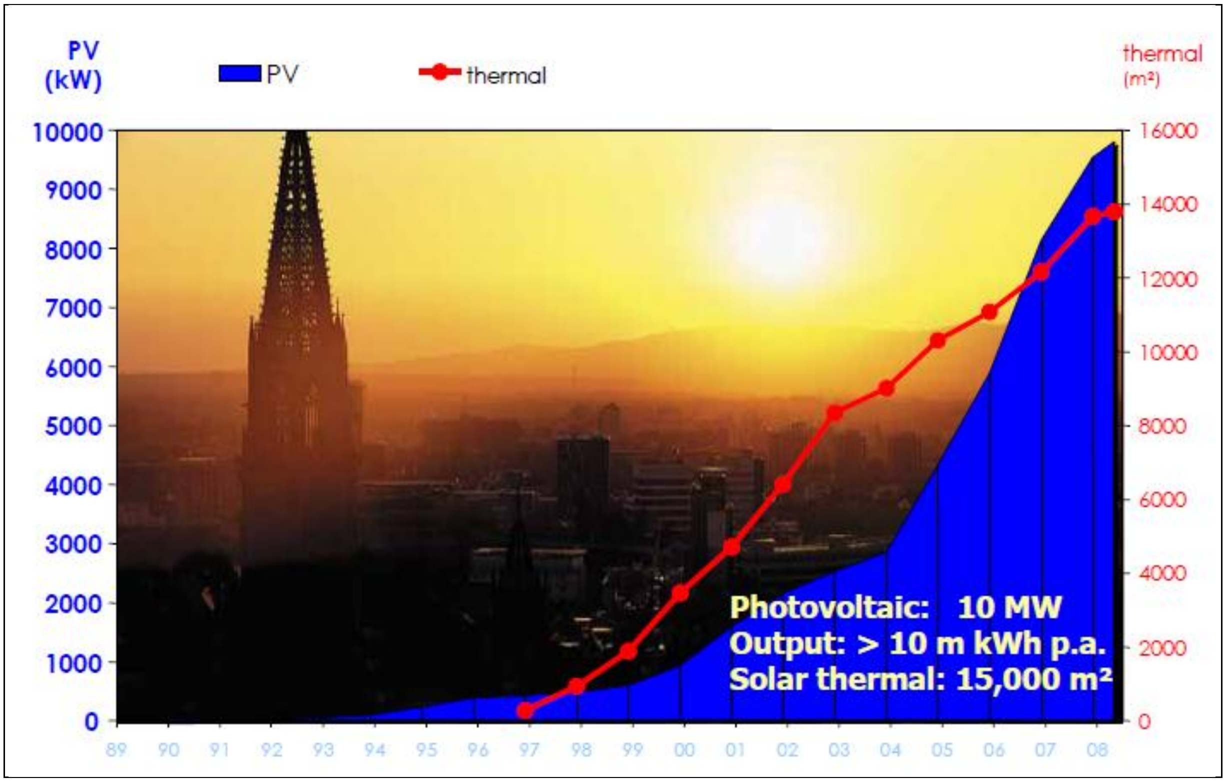
4.7.1 Background

The move towards renewable energy sources in Freiburg began with the opposition to the construction of a nuclear power plant in Wyhl in the 1970s (Energie–Cites, 1999; Hopwood, 2007; City of Freiburg Sustainability Office, 2008; ICLEI, 2009). Plans to construct the nuclear power plant were shelved in 1975 (Hopwood, 2007: 54). The question then became, where would the energy come from? Networks of individuals, environmentalists, student associations and anti-nuclear activists began to mobilise and search for alternatives to nuclear power. This marked the start to Freiburg's search for local renewable energy sources. After the Chernobyl nuclear disaster in 1986, the Freiburg council abandoned nuclear power and adopted an energy policy which encouraged energy conservation and the use of renewable energy resources such as solar and combined heat and power (CHP) to meet energy demand (Thompson, 2007/8; City of Freiburg Sustainability Office, 2008). The city's Sustainability Office notes that "solar energy was to become the new principle source of energy" (City of Freiburg Sustainability Office, 2008:3). The city also established the Environmental Protection office in 1986 (City of Freiburg Sustainability Office, 2008:3). The city adopted its first Climate Protection Action Plan in 1996.

4.7.2 Solar Energy

The city of Freiburg has developed an identity as a "Solar Region" and it markets itself as a "Green City", representing a shift from the solar city to incorporate other issues of sustainability and quality of life (ICLEI, 2009). Freiburg is one of Germany's sunniest areas: it receives about 1117 kWh per square meter of solar radiation per year with about 1800 hours of sunshine annually (City of Freiburg Sustainability Office, 2008: 5; WWF, 2008: 1). The city has encouraged building and housing design that integrates passive solar design and active solar energy such as solar thermal for water heating and photovoltaic cells for electricity generation. The municipality works together with the municipal energy company (FEW) to implement the municipal solar programme. The diagram below, duplicated from City of Freiburg's presentation, shows the solar energy situation in Freiburg by 2008.

Figure 4.7: Installed PV and solar thermal in Freiburg 2008



Source: Salomon, 2009:7

Figure 4.8 shows that solar photovoltaic systems were generating about 10MW electricity, and contributing about 1% of electricity demand (ICLEI, 2009: 3). There were about 14 000m^2 solar thermal units installed in Freiburg in 2008 (Salomon, 2009:7). By August 2010 the municipality was aware of "16,500m^2 of thermal collectors but there might be more which have not received, or applied for, any funding" (Dresel, 2010).

4.8 Energy efficiency retrofitting and insulation

Energy efficiency also forms an important aspect of Freiburg's sustainability strategy. Old buildings form the majority of buildings in Freiburg: about 70% of the city's building stock is old and this presents an opportunity for energy efficient renovation (ICLEI, 2009). New houses constructed on city land are required meet "low energy efficiency design standards set at 40 kWh/m2 p.a., compared to a typical European home of 220 kWh/m2 p.a." (Thompson, 2007/8:

26). Existing building stock on the other hand is covered by a support programme providing for energy efficient retrofitting and insulation.

In Baden-Württemberg state "heating and hot water cause about 30 per cent of CO_2 emissions"; about 90% of this comes from existing buildings (Ministry of Environment and Transport, Baden-Württemberg, 2008). In order to reduce CO_2 in existing residential buildings and mitigate climate change mandatory regulations for reducing energy consumption and introducing renewable energy sources have been passed. The regulation that governs energy efficiency retrofitting and insulation in Freiburg is the Heating Renovation Regulation. It covers optimisation of heating and new heating systems for both space heating and water heating. Optimisation of heat covers the replacement of old heat pumps with energy efficient pumps. New heating systems cover the replacement of electric heaters and electric water heaters. It should be noted that the new heating systems should be renewable, according to the state regulation, the Renewable Heat Law of the Land, Baden-Württemberg, of 2007 (EWärmeg BW). The law requires that 10% of a residential building's heat energy should be met by renewable energy (Ministry of Environment and Transport, Baden-Württemberg, 2008). The choices of renewable energy to meet heating needs include solar thermal water heating, wood or pellets, biogas or bio-oil and heat pumps for space heating. The Solar thermal water heating requirement applies to residential buildings with over $50m^2$ of living space and includes retirement and nursing homes (Ministry of Environment and Transport, Baden-Württemberg, 2008). The solar thermal system size is determined by the size of living area: for each square meter one requires $0.04m^2$ of solar collector.

However if one cannot meet their heating requirements with renewable energy then one has to meet other requirements. These include insulating the roof or façade, sourcing heating energy from a combined heat and power network, or installing photovoltaic cells for electricity generation (Ministry of Environment and Transport, Baden-Württemberg). A residential building can be exempt from the renewable energy requirement for technical reasons, such as shading, structure and undue hardships due to personal circumstances (Ministry of Environment and Transport, Baden-Württemberg, 2008). These energy efficiency measures are supported by local subsidies, federal grants and low-interest loans from kfw-foerderbank through the KFW Building Rehabilitation programme.

This case serves to demonstrate that a crisis time can be an opportunity to seek innovative solutions to problems. For Stellenbosch this means that the municipality can use its supply crisis as an opportunity to seek new sources of energy supply.

4.9 Repeatability of programmes by other local municipalities

It should be noted that the above programmes cannot be simply duplicated by other municipalities, but will have to be adapted to suit local contexts. Pilot programmes are suitable in cases where incentives need to be tested and the market needs to be developed. The pilot programme would serve the purpose of revealing the problems in a programme before its rollout to cover a broader area. If a small town such as Stellenbosch municipality that intends to adopt solar water heating systems, the way to go would be to implement a fully-fledged programme that takes local context and objectives into consideration.

4.10 Lessons drawn from these experiences

Each local authority needs to design its own programme to meet the needs of the local market and the local context. However, for a SWH programme to be successful it should meet the following criteria:

- objectives need to be well defined;
- resources need to be well defined and technology well proven;
- transparency is needed, and financial incentives need to be precise and clear;
- the duration of incentive needs to be long enough to achieve market stability;
- industry support is crucial in terms of standards, supply and manufacturing; and
- simplicity is needed to ensure public participation (Roulleau and Lloyd, 2008).

The California case study demonstrated the importance of leadership at the local or state level. NMBMM showed that local governments can go ahead and initiate renewable energy projects without necessarily waiting on national government, and that it is possible for local governments to get around national legislation and implement renewable energy projects. The case of Freiburg demonstrates that a crisis time can be an opportunity to seek innovative solutions to problems. For Stellenbosch municipality this suggests that before it embarks on a programme it needs to find a leader; it can use its supply crisis as an opportunity to implement energy efficiency and promote the use of renewable energy.

4.11 Chapter Summary

Some local authorities have begun to introduce energy efficiency measures and renewable energy technologies in their areas as a way of reducing GHG emissions and reducing energy consumption. This is based on the view that locally designed programmes provide cost-effective ways to achieve sustainability goals.

If countries are to move towards sustainable energy, cities and towns are important partners in the process. Local authorities are using various municipal financing mechanisms and other sources of funding (such as banks) in a bid to assist in the transition to sustainable energy use. Local authorities' efforts to make the transition to sustainable energy use have begun by promoting "low hanging fruits" such as SWHs. International and local authorities are promoting SWHs, but are taking their local context into account. Because of the state's size and the need to evaluate the current SWH market and the impact that incentives would have on market demand, California began with a pilot programme.

The move towards renewable energy sources in Freiburg began with the opposition to the construction of a nuclear power plant; this initiated Freiburg's search for local renewable energy sources. There are similarities between these case studies: energy security was threatened in some way or the other, and in all cases solar energy was identified as an abundant resource that could be utilised.

The case of California's SWHPP highlighted some of the barriers associated with implementing a SWH programme. Municipalities need to be aware of these barriers to avoid falling into them in their own programmes.

In conclusion local authorities play an important role in assisting a nation to meet the goals of sustainability. Municipalities do not have to wait for national government to take the lead but they can take a leading role in the search for local renewable energy sources and energy efficiency.

4.12 LPG Promotion through a local authority

It would have been ideal include a case study of a local municipality promoting LPG in its area. It seems that there are no local authorities, either locally and internationally, which promoting LPG. The case studies available were at national levels and have been discussed earlier (in 3.5). This means that Stellenbosch municipality will become a pioneer in promoting LPG.

Chapter 5

The Stellenbosch Municipality context

5.1 Introduction

Stellenbosch is a small town that will almost double in size over the next 20 years. However, it faces energy constraints on future developments as a result of a requirement from the national utility, Eskom, that it reduce demand by 10%. For the municipality this means that innovative ways must be found to meet future energy needs. Energy efficiency and the use of renewable energy in the residential sector could assist the municipality to overcome the energy constraints on future development.

5.2 Description of Stellenbosch Municipal Area

The greater Stellenbosch Municipal territory covers an area of about 900 square kilometers. The major urban settlements that make up the area include Stellenbosch town, Franschhoek town, De Novo, Muldersvlei, Klapmuts, Elsenburg and Koelenhof to the north of Stellenbosch town. To the South and west there are Vlottenburg, Lynedoch, Raithby and Jamestown. Johannesdal, Kylemore, Pniel, Lanquedoc and Groot Drakenstein lie in the Dwars valley between Stellenbosch and Franschhoek. Wemmershoek, La Motte and Maasdorp are situated in the Franschhoek valley.

Figure 5.1: Greater Stellenbosch area

Source: Stellenbosch Municipality, 2009.

5.3 Population growth in Stellenbosch

The last census in Stellenbosch was in 2001 and at that time the population was about 117 705.

Table 5.1: Population growth trends for the period 1970 - 2001

Census Data					
Population Group	1970	1980	1991	1996	2001
African	293	6140	14754	17514	24145
Coloured	43170	48180	73096	65967	67528
Asian	65	40	184	299	235
White	19629	23900	34081	28655	25797
Total	63157	78260	122117	112434	117705

Source: Zietsman, 2007:10

The population has almost doubled, according to 2007 data. Projections indicate that the population growth is likely to continue.

Table 5.2: Stellenbosch population projections 2009 - 2015

Projected population totals (2009 - 2015)

	2009				2010				2015			
Population group	Linear	Geometric	Exponential	Average	Linear	Geometric	Exponential	Average	Linear	Geometric	Exponential	Average
African	55797	56983	60439	57740	58996	61626	70619	63747	74991	88720	112121	91944
Coloured	112808	110110	113770	112230	116929	114242	127549	119573	137529	135596	154656	142594
Asian	947	842	922	905	1007	919	1306	1077	1305	1345	1894	1515
White	36866	35835	36622	36441	37687	36518	40328	38178	41790	39875	43523	41729
Total*	206418	203774	211753	**207315**	214618	213304	236419	**222575**	255615	255056	239802	**277782**

*Sum of estimates per population group

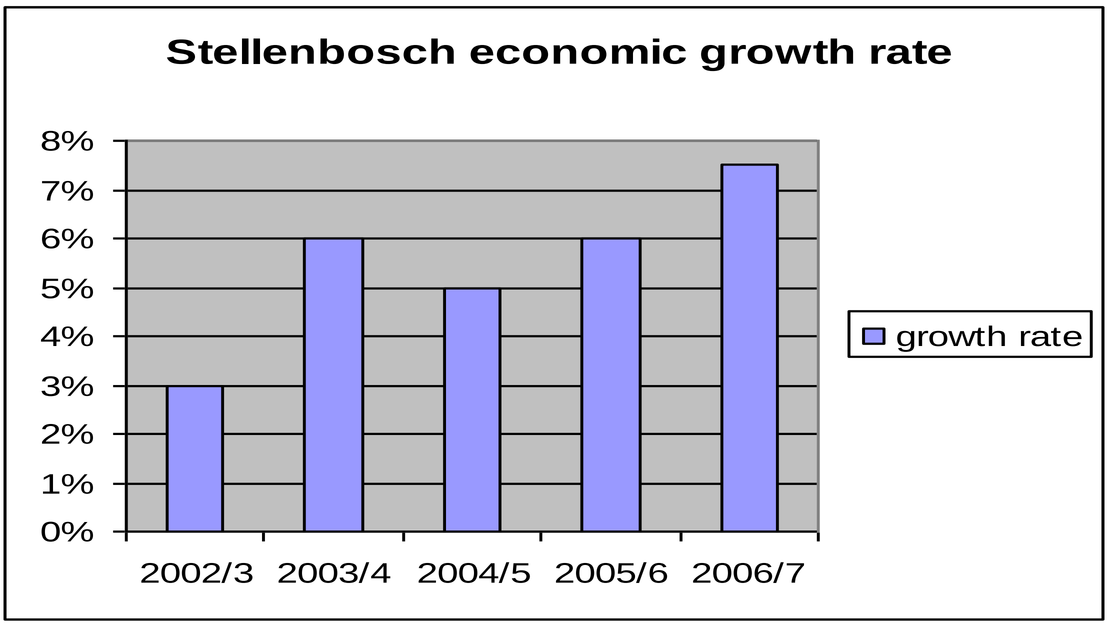
Source: Stellenbosch Municipality, 2009

The growth rate is high. For planners this means that there is need for "targeted intervention to ensure adequate land for residential and other purposes as well as [to ensure] infrastructure and service delivery" (Stellenbosch Municipality, 2009: 17).

5.4 Economic growth

Recent data indicates that Stellenbosch's economic growth has been rising steadily. According to the Cape Winelands District Municipality Annual Report 2007/8, Stellenbosch Municipality has experienced high economic growth since 2002, when compared to other municipalities in the district.

Figure 5.2: Stellenbosch economic growth trends since 2002



Source: Adapted from Cape Winelands District Municipality 2008

If this steady economic growth continues it is likely that people will continue to migrate to the town in search of employment opportunities.

5.5. Infrastructure and service provision

5.5.1 Housing

There were about 20 000 formal houses in Stellenbosch in 2008. About 40% of these can be classified as middle-income houses, 45% as high-income houses and 15% as low-income houses (Stellenbosch Municipality, Department of Housing, 2009). There is a housing shortage in Stellenbosch which presents itself through about 6 210 informal structures, with 9 000 households living as backyard dwellers and with overcrowding in formal housing units (Stellenbosch Municipality, 2009; 47). Table 5.3 below shows the housing requirements in the municipal area.

Table 5.3: Stellenbosch housing requirements

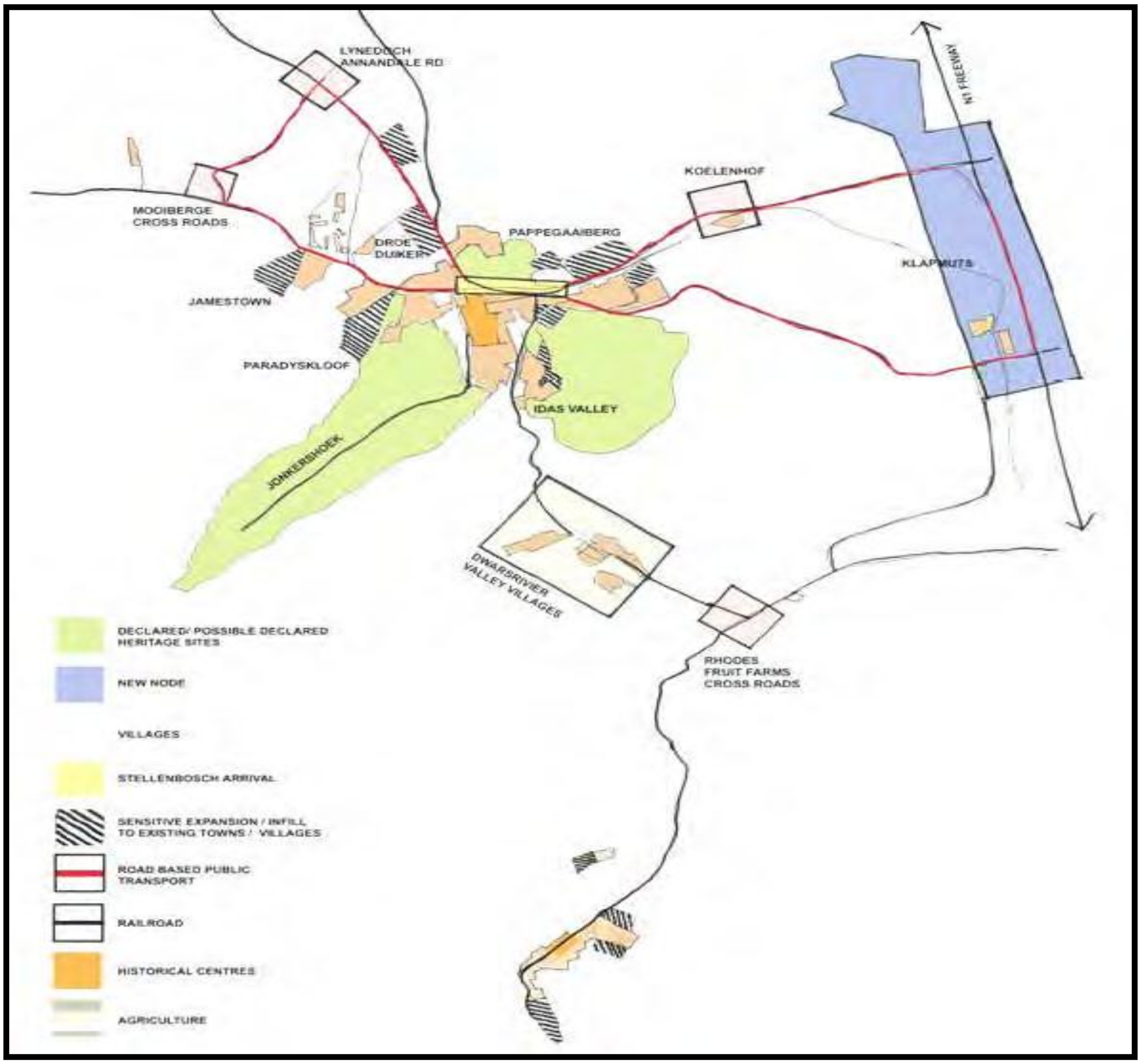
Origin of backlog	Current backlog	Future backlog (20 years)	TOTAL BACKLOG
Informal structures	7 643[1]	7 718[3]	24 361
Overcrowded formal structures	9 000[2]		
Established middle and upper income housing		21 001[4]	21 000
TOTAL HOUSING REQUIREMENT	**16 643**	**28 719**	**45 362**
Annual delivery for current backlog (5 years)	3 329		
Annual delivery for backlog growth (20 years)		1 436	
Total annual delivery (1st five years)	4 765		
Total annual delivery (next 15 years)		1 436	

Source: Sustainability Institute, 2008:7

Table 5.3 shows that there is a current backlog of over 16 000 and that this will increase to more than 28 000 in 20 years. The municipality has a plan, the Stellenbosch 2017 Housing Strategy, to address this backlog. The objective of this strategy is to provide 20 546 new housing units by 2017 (Stellenbosch Municipality, 2008:5), based on the pro-poor approach.

Nineteen development nodes have been identified as the focus of the housing strategy. These nodes are Idas Valley, Cloetesville, Lynedoch, Vlottenburg, Droe Dyke, Inner Stellenbosch town, Kayamandi, Rhodes Fruit Farms Crossroads, La Motte, Franschhoek, Outside Franschhoek, Dwars River Complex, Paradyskloof Mixed Income project, Spier Mixed income project, Koelenhof, Klapmuts, Raithby, Mooiberge Crossroads and Jamestown.

Figure 5.3: Stellenbosch development nodes



Source: Sustainability Institute, 2008:28

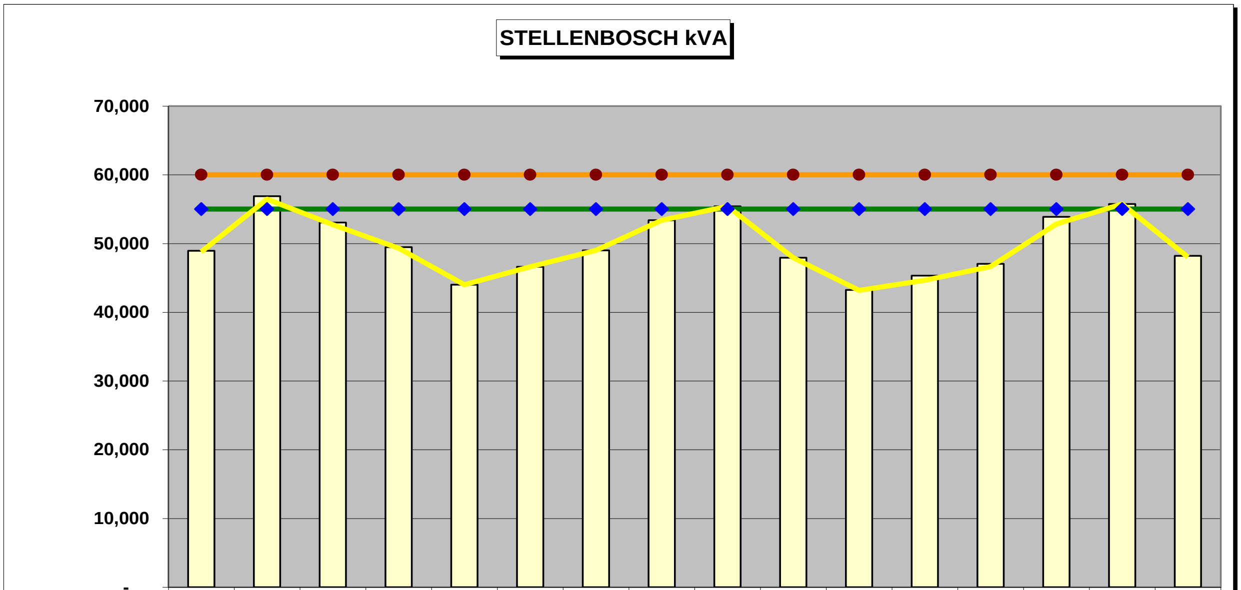
The implementation of the housing strategy depends on the availability of services such as energy, sanitation, water etc.

5.5.2 Electricity distribution

Stellenbosch Municipality's electricity is supplied in bulk by Eskom through two main areas, Stellenbosch and Franschhoek towns. Franschhoek has one 11 kilovolt (kV) intake and Stellenbosch has two 66kV intake meter points (Stellenbosch Municipality, 2006). The municipality is responsible for distribution within its supply area, as approved by the National Electricity Regulator. Stellenbosch Municipality does not supply the whole area. Eskom supplies the rural areas of Jamestown, Raithby, Kylemore and Klapmuts. Drankenstein Municipality supplies Johannesdal, Simondium and Pniel. Electricity is distributed through a network of substations and distribution lines. Franschhoek substation and switching station is well maintained and is in good condition, but the Stellenbosch network is ageing and still uses old equipment (Stellenbosch Municipality, 2006b).

The maximum demand for Stellenbosch Municipality is about 68MW (Stellenbosch Municipality, 2009: 52). Figures 5.4, 5.5 and 5.6 show Stellenbosch's electricity demand for the period January 2008 to April 2009 for the following substations Stellenbosch, Francshhoek and Cloetesville.

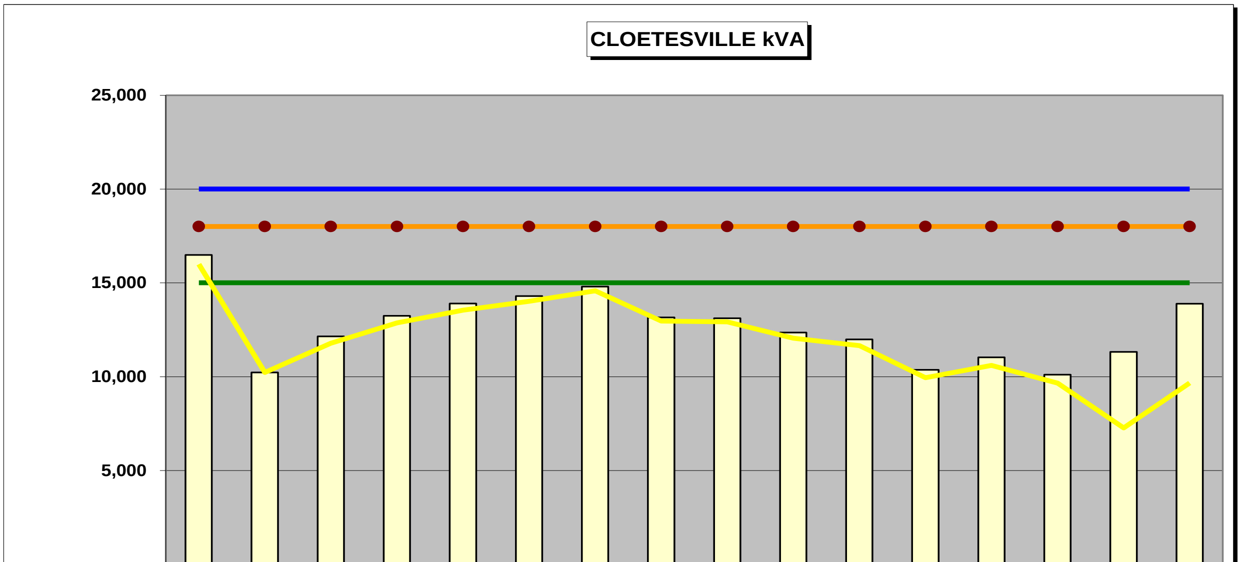
Figure 5.4: Stellenbosch substation electricity demand for Jan 2008 – April 2009



	J'08	F	M	A	M	J	J	A	S	O	N	D	J'09	F	M	A
ACT	48,956	56,892	53,037	49,480	44,012	46,610	49,015	53,382	55,424	47,948	43,257	45,340	47,056	53,892	55,744	48,223
NMD	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Requested	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
Charged	48,778	56,462	52,758	49,318	44,012	46,610	49,015	53,382	55,422	47,948	43,186	44,654	46,654	52,840	55,744	48,020
Suggested	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000

Source: Stellenbosch Municipality, Electrical Engineering Department, 2009

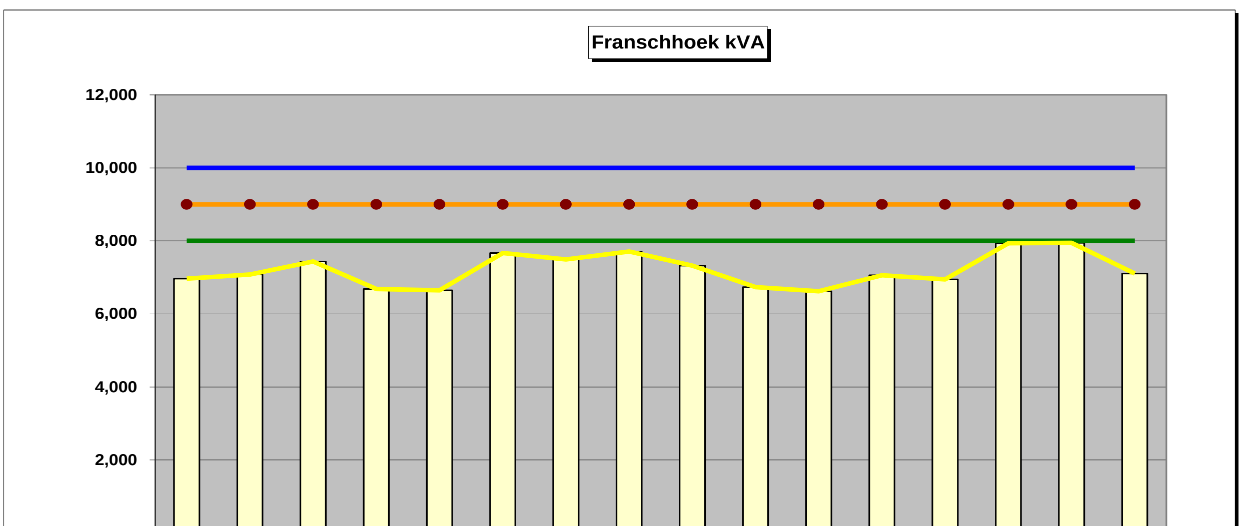
Figure 5.5: Cloesesville substation electricity demand for Jan 2008 – April 2009



	J'08	F	M	A	M	J	J	A	S	O	N	D	J'09	F	M	A
ACT	16,488	10,225	12,142	13,243	13,896	14,292	14,800	13,153	13,109	12,345	11,979	10,358	11,026	10,105	11,318	13,888
NMD	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Requested	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Charged	15,996	10,225	11,784	12,864	13,538	14,018	14,575	12,958	12,921	12,051	11,652	9,942	10,597	9,647	7,270	9,667
Suggested	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000

Source: Stellenbosch Municipality, Electrical Engineering Department, 2009

Figure 5.6: Franschhoek substation electricity demand for Jan 2008 – April 2009



	J'08	F	M	A	M	J	J	A	S	O	N	D	J'09	F	M	A
ACT	6,963	7,080	7,436	6,680	6,644	7,666	7,492	7,707	7,319	6,735	6,620	7,059	6,945	7,933	7,946	7,104
NMD	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Requested	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Charged	6,963	7,080	7,436	6,680	6,644	7,666	7,492	7,707	7,319	6,735	6,620	7,059	6,945	7,933	7,946	7,104
Suggested	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000

Source: Stellenbosch Municipality, Electrical Engineering Department, 2009

Figures 5.4, 5.5 and 5.6 show that the maximum demand for the Stellenbosch substation was 55 000 kVA, Cloetesvile was 15 000 kVA and Franschhoek was 8000 kVA. These figures represent capacity that is reserved by the municipality and that should not be exceeded without Eskom's consent. In terms of actual demand the graphs show that peak electricity demand almost matches maximum supply at the three substations.

In addition, however, Eskom has imposed a 10% constraint on the municipality (Stellenbosch Municipality, 2007/8: 13). In order to meet the 10% constraint and also meet new electricity demand, the municipality should consider implementing and promoting energy efficiency and the use of alternative energy sources (Stellenbosch Municipality, 2007/8, 2008). The expected growth in Stellenbosch necessitates the upgrade of substations and cable supplies. The upgrading of substations requires Eskom's approval. The municipality has sought Eskom's approval to increase supply to Franschhoek and Cloetesville by 1000 kVA in each case (Koegelenberg, 2010). Electricity demand is expected to grow annually by about 4% between 2006 and 2025 (Stellenbosch Municipality, 2006b: 21).

Table 5.4: Expected demand on Cloetesville and Franschooek substations, 2006 and 2025

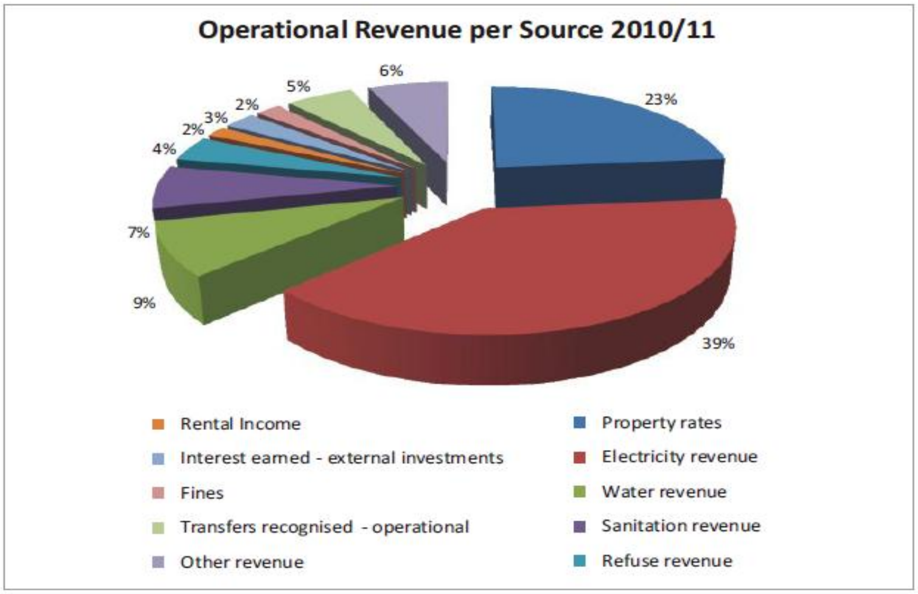
Substation	**Load in 2006**	**Expected Load in 2025**
Cloetesville Substation	8,7MVA	22,3MVA
Franschhoek Substation	6,5MVA	19,2MVA

Source: Adapted from Stellenbosch Municipality, 2006b: 22 – 23

Table 5.4 shows that load on both substations is expected to more than double by 2025. For planners this means that alternative ways must be found to supply electricity to new developments. The residential sector presents an opportunity for both energy efficiency and the introduction of renewable energy through retrofitting electric stoves and geysers with gas stoves and SWHs.

It should be noted that the sale of electricity is a major contributor to municipal revenue. Figure 5.7 shows municipal operational revenue sources for the 2010/2011 period.

Figure 5.7: Stellenbosch municipality operational revenue sources 2010/2011



Source: Stellenbosch Municipality, 2010: 5

Figure 5.7 shows that for the 2010/11 financial year 39% of municipal revenue will come from electricity revenue, and 23% from property rates, with small contributions from water, sanitation, fines, rental, refuse collection, interest on investments , transfers and other revenue. For the municipality this means that mechanisms used to promote SWH and the use of gas stoves need to protect this municipal income stream.

5.6 Water heating and cooking in the residential sector

The residential sector in Stellenbosch consists of both electrified and un-electrified households. Water heating in the electrified household is by electric geysers and in low-income households by electric stoves. Hot water is used for cooking, washing dishes, bathing/showering and for other hygienic purposes.

An average middle-to-high income electrified household in the Western Cape consumes on average 774kWh of electricity; about 380.8kWh is consumed by electric geyser and 148.2 kWh is used by the stove (Winkler *et al*, 2005:9). This means that a middle-to-high income household uses a total of 529 kWh monthly for cooking and water heating. Water heating and cooking coincide with Eskom's morning and evening peak demand periods. Reducing electricity consumption for water heating and cooking at these times would assist the municipality to manage peak electricity demand and help reduce its carbon footprint. The Housing Strategy notes that the following:

> In the light of the current electricity supply crisis, as well as the need to reduce carbon footprint, it is proposed that this be reduced to 350 KWh per month, also because this will enable low income households – which on average only consume about 250 KWh per month – to increase their consumption to 350 KWh per month. The trade-off in energy consumption between richer and poorer households is consistent with a pro-poor approach, on which this housing strategy is based, and also enables a limit on the contribution of electricity usage by residential estates to the carbon footprint of the municipal area
> (Stellenbosch Municipality, 2008: 35).

Installing both a gas stove and SWH would save about 529kWh per month per household. If all the 17 000 houses classified as middle-to-high income household were to install both a gas stove and a SWH this would result in a saving of about 8.9 million kWh per month on geysers and stoves. This would be enough to supply more than 25 000 housing units per month if they consume 350 kWh per month. In other words, Stellenbosch could double in size without requiring more electricity from Eskom.

5.7 Role of municipality

Local authorities in South Africa are the implementation or delivery arm of national government (Abrahams 2003). They are responsible for translating national policies into action. This means that local authorities are crucial for the implementation of sustainable development in South

Africa. This role is defined in the White Paper on Local Government as working in a community "to find sustainable ways to meet their social, economic and material needs and improve the quality of their lives" (RSA, 1998:17). This gives local authorities an active role in the pursuit of economic and social development (Nel and Binns 2003). Local authorities use the integrated development planning and local economic development (LED) as the basis for their development.

Local authorities have to be aware that in their quest for development, there is no single solution: there are several possible solutions and there is a need to involve the community in identifying them (Simon 2003). Local authorities influence the way development takes place in their territories. Stellenbosch municipality, in partnership with Stellenbosch University, has an initiative known as "Reinventing Stellenbosch" through which the municipality is changing the way development takes place in its area (Stellenbosch Municipality, 2008). It is incorporating the concept of sustainability in the following areas:

- energy supply and demand management;
- water supply and demand management;
- waste recycling;
- greening;
- public transport;
- local economic development; and
- capability building for sustainable living (Stellenbosch Municipality, 2008: 13).

In terms of energy supply and demand management the focus needs to be on energy efficiency and the introduction of renewable energy sources.

The situation described above means that Stellenbosch Municipality has an opportunity to begin implementing energy efficiency measures and introducing renewable energy sources. The question is, How can the municipality begin implementation?

5.8 Energy efficiency and renewable energy

The quickest way to introduce energy efficiency and renewable energy is to make it mandatory for new buildings. Considering that Stellenbosch Municipality has to meet the 10% energy constraint imposed by Eskom, this option of making this apply only to new building seems problematic. It appears that the solution lies in introducing mandatory regulations that require retrofitting of SWHs and gas stoves in existing households, beginning with middle-to-high income households.

5.9 Chapter Summary

Stellenbosch is a growing town that, like any other urban area, is faced with the challenges associated with urban growth. The major challenge is the provision of housing: Stellenbosch has a housing shortage which presents itself through informal structures, backyard dwellers and overcrowding. Stellenbosch relies on electricity generated from coal which is supplied from Eskom. Energy demand is expected to treble by 2025; currently it is almost peaking.

Stellenbosch municipality together with Stellenbosch University are partners in an initiative known as "Reinventing Stellenbosch" through which the municipality is shifting the way development takes place in its area (Stellenbosch Municipality, 2008). The idea is to adopt the concept of sustainability. With regard to energy supply and demand management, the municipality has identified energy efficiency and the introduction of renewable energy sources as the best options for achieving sustainability. The quickest way to introduce energy efficiency and renewable energy is to make it mandatory for new buildings. However, because this ignores existing buildings, it appears that the solution lies in introducing mandatory regulations that require retrofitting of SWHs and gas stoves in existing households, beginning with middle-to-high income households.

Chapter 6

Research Findings

6.1 Introduction

This chapter presents research findings that address the research objectives identified in Chapter 1, namely to investigate the opportunities and barriers to municipal-initiated energy-efficient programmes, and to investigate financing mechanisms that can be used by a municipality to promote the use of SWHs and LPG stoves in middle-to-high income households. The energy savings and environmental benefits are also demonstrated.

6.2 Summary of Stellenbosch Context

Stellenbosch is a small town that is likely to double in size over the next 20years. It covers an area of about 900 square kilometres. The population and economy are expected to grow steadily. There is a housing shortage and presents itself through informal structures and backyard dwellers and overcrowding in the formal units. Electricity is supplied and distributed by Eskom to the rural areas of Jamestown, Raithby, Kylemore and Klapmuts; the municipality distributes to the other areas. Electricity supply has almost peaked and demand is expected to grow by 4% annually until 2025. The residential sector is made up of electrified and non -electrified households. Water heating in electrified households is by electric geyser and by electric stove in low-income households. On average the electrified middle-to-high income household consumes about 774kWh of electricity monthly. The residential sector presents an opportunity for implementing the twin solution of energy efficiency and renewable energy by promoting the use of SWHs and LP Gas stoves by middle-to-high income households.

6.3 National Energy Eefficiency

Traditionally, the increasing demand for energy in South Africa has been met by increasing the supply. Having realized that energy efficiency could help to meet the higher energy demand, South Africa is investigating energy efficiency to address power supply problems. The South African government is leading the energy efficiency drive. Energy efficiency has been identified as an economically viable way of reducing energy consumption and reducing greenhouse gas emissions. Energy efficiency interventions focus on the residential, commercial and industrial sectors. Energy efficiency is now a national priority.

6.4 Energy efficiency Programmes

The DoE has a National Energy Efficiency Campaign, “Save It”, to encourage South Africans to save electricity. In addition, the DoE and Eskom launched the “49 Million Initiative” in March 2011. This initiative encourages South Africans from all sectors to work together to save electricity by taking action, even if these are only through small steps – such as switching off appliances that are not in use. This initiative focuses on both no- to low-cost measures, and medium- to high-cost technologies that South Africans can use.

6.4.1 National Solar Water Heating Programme

The National Solar Water Heating Programme is part of Eskom’s IDM programme, and is aimed at demand-side management. The government has set a target of 1 million SWHs by 2014. The main goals are to reduce electricity demand and to assist in meeting the renewable energy target of 10 000 GWh by 2013. This programme is supported by a SWH rebate. Eskom announced a reduction in the rebate at the end of April 2011. The reason for this was that the rebate had served its purpose of stimulating the market. While the rebate has stimulated the market, it has been criticised for being focused on low-income households and not on the middle-to-high high income households that actually consume more electricity (Weber, 2011). Under the programme

60 000 systems have been installed, resulting in an energy saving of about 16MW (Eskom, 2011).

6.4.2 The use of LP Gas for energy efficiency

There were about 5 324 785 households using electric stoves in South Africa in 2008 (DOE, 2009:12). The residential market for the replacement of existing electric stoves is similar to that for replacing electric geysers: it consists of low-income, middle-income and upper-income households. In addition there are segments for the new built market and the electric stove replacement market (following stove failure). LPG in the residential sector is mainly used for cooking and outdoor living applications, although its use for space heating and water heating has recently gained in popularity (Robertson 2010). LPG use has been increasing in South Africa as consumers seek alternative fuels to reduce reliance on electricity. The LPG market has been growing by between 8% and 12% annually (Munro, 2007). LPG suppliers foresee this trend continuing, for the following reasons:

- Government is making efforts to make LPG an essential source of energy for low-income households;
- there is a limited supply of electricity; and
- increasing electricity tariffs are forcing lifestyle changes, especially in high-income households (Munro, 2010; Robertson, 2010; Van Wyk, 2011).

In addition there is a change in policy direction as far as LPG is concerned. The price of LPG for domestic use prices has been regulated since July 2010. This has addressed the issue of artificially inflated prices by some LPG retailers: consumers now know the price they should pay for LPG (Van Wyk 2011). The Energy Minister has also announced plans to come up with an LPG Strategy. The aim of the strategy is to encourage the use of LPG as an alternative to electricity (Peters, 2011).

This is a welcome development as it would ease the pressure on the national grid; LPG suppliers note that an increase in demand combined with supply constraints has led to LPG shortages, particularly in winter. In order to meet the expected growth in demand (if there is no investment in new local refining) the LPG industry may have to import LPG plants (Munro, 2010; Robertson, 2011; Van Wyk 2011).

One of the barriers of LPG adoption in the residential sector is the high cost of the gas equipment (Munro, 2010; Van Wyk, 2011). In addition there is a perception that LPG is dangerous. This perception is, however, changing as consumers become more informed about LPG and its safe use (Munro, 2010).

6.4.3 Energy Efficiency in Stellenbosch

The municipality is aware that its electricity supply is almost peaking. It has begun efforts to implement energy efficiency and renewable energy. One of the steps that the municipality has taken is to meet with big electricity consumers and request them to reduce electricity consumption. Another measure is the replacement of mercury vapour streetlights with high-pressure sodium streetlights, which are more efficient. All new property developments have to prove that they will save 10% of the building's electricity requirement through various energy efficiency measures. In the residential sector the building needs to meet the requirements of SANS 204 – 1: 2008 which provides for passive building design and the installation of SWH systems. The provision reads as follows:

> Solar water heating systems shall be installed, unless it can be proven by a competent person that it is not technically feasible…. The hot water services of all new buildings shall be heated using devices and equipment which provide a minimum of 50% of the heating energy via solar energy (RSA, 2008: 6).

This means that new residential buildings need to install SWH systems. It should be noted that this is not a municipal decision, but a requirement by the Electric Engineering Services Department (Zwane, 2009). This means that municipal councils do not need to pass a by-law requiring new buildings to install SWHs, as the Electrical Engineering Services Department requires this as part of ensuring energy efficiency in buildings.

Long-term energy-efficiency plans include ripple control and smart metering (Koegelenberg, 2010). The approach by the municipality seems to be based on the view that the easiest way to reduce electricity demand is through energy efficiency measures that do not require SWH; their view is that it is easier to design new builds with energy-efficient features rather than to retrofit existing buildings.

The municipality has also commenced consultations with service providers to explore wind power and photovoltaic power as a step towards the adoption of renewable energy. The municipality is, however handicapped by a shortage of staff when it comes to implementing energy-efficiency projects. It also has no Energy Officer/Manager dedicated to energy management and it lacks the necessary financial resources. The municipality's energy-efficiency efforts ignore existing buildings in general and residential buildings in particular.

Another barrier to energy efficiency is that this is viewed as a threat to municipal electricity sales. This ignores economies of scale as the municipality would still be able to sell the electricity from the energy efficiency savings. The municipality needs to view energy efficiency as a way of managing growth in energy demand and reducing peak demand (Janisch, 2011; Van Wyk 2011).

The municipality has two routes that it can follow to promote the use of SWHs and gas stoves. One is legislation and the other is financing mechanisms. The point of departure for this thesis is that one should envisage a time when the municipality will require all middle-to-high income households to install energy efficient appliances.

6.5 Solar Water Heater Financing Mechanisms

One of the barriers to introducing energy efficient technologies such as SWH is the high upfront cost. Affordability is an issue in South Africa, the cost of SWHs needs to come down if SWH uptake is to improve (Janisch, 2011; Van Wyk 2011). Financing mechanisms are a way of reducing high upfront costs, thereby encouraging consumers to adopt energy-efficient technologies. A number of companies have realised the value of financing mechanisms and have programmes aimed at reducing upfront costs for solar water heaters. The programmes are based on the idea of monthly instalments towards the purchase of solar water heaters rather than one lump sum payment. In order to avoid reinventing the wheel, the research into this option began by investigating mechanisms already in use in South Africa. Some of these are discussed below.

6.5.1 Solarent

Solarent is a solar rent-to-own program. Solarent rents out the SWH to the customer over a five-year period (60 months). At the end of the rental period, the customer can opt to return the SWH to Solarent or purchase the SWH. The purchase price works out as 5% of the total monthly instalments paid to Solarent over the rental period. The customer pays a once-off installation fee, after which the SWH is installed. The customer then pays a monthly rental over five years which is escalated by 5% per year. The rental agreements also cover maintenance costs (Van Wyk **2011**). Table 6.1 below shows the Solarent monthly payments for various SWH systems. It was difficult to establish the market penetration rate since the programme was barely a year old at the time of writing.

Table 6.1: Solarent monthly payments

SWH System	Installation fee	Monthly repayment over 60 months escalated by 5% per year
150L	R 1 999 (Close couple) R 3 500 (Split system)	R249
200L	R 1 999 (Close couple) R 3 500 (Split system)	R299
300L	R 2 500 (Close couple)	R379

Source: Adapted from Solarent, 2011

Table 6.1 shows that monthly rental payments range between R 249 and R 379 for the different systems. Solarent targets middle-income households with an electricity bill of at least R 1 000 per month. Since its inception in June /July 2010 it has been operating in Cape Town and has recently expanded to include Gauteng. According to Van Wyk (2011), since the rental programme began about 85% of their sales have been through the Solarent programme; the remaining 15% are cash sales (Van Wyk, 2011).

When compared to electric geysers purchased under the same terms, electric geysers would be slightly cheaper. Table 6.2 shows the monthly rental payments for electric geysers.

Table 6.2: Monthly rental payments for electric geysers

Electric geyser	Cost of Electric geyser	Monthly repayment over 60 months escalated by 5% per year
150L	R 14 850	R 247
200L	R 16 780	R 279
300L	R 20 620	R 344

Source : Adapted from Plumb Boyz, 2012; Winelands Plumbing, 2012

6.5.5 Teljoy Green Credit

Teljoy Green Credit offers consumers the opportunity to purchase a SWH on credit. The consumer applies for funding based on a quote supplied by the sales team. It should be noted that the quote excludes the Eskom rebate. The customer pays low monthly instalments over a four-year period (48 months), escalated by 15% per year. The Green Credit accounts for about 55% of Teljoy's sales (Ross, 2011). Table 6.3 below shows Teljoy Green Credit monthly instalments for the various SWH systems.

Table 6.3: Teljoy Green Credit monthly instalments for SWH systems

SWH system	Cost of SWH net of rebate	Monthly instalments
100L	R 13 821.00	R 414.00
150L	R 15 822.39	R 469.00
200L	R 17 377.00	R 512.00
250L	R 18 850.00	R 575.00
250L	R 22 118.98	R 645.00
300L	R 25 100.00	R 728.00
300L	R 25 789.00	R 746.00

Source: Teljoy, 2011

Table 6.3 shows that under the green credit scheme, consumers pay monthly instalments ranging between R414 and R750 for the various SWH systems.

When compared to electric geysers purchased under the same terms, electric geysers would be cheaper. Table 6.4 shows the monthly instalments for electric geysers over 48 months.

Table 6.4: Monthly instalments for electric geysers

Electric geyser	Cost of electric geyser	Monthly instalments
100L	R 12 740	R 265
150L	R 14 850	R 310
200L	R 16 780	R 350
250L	R 18 750	R 390
300L	R 20 620	R 430

Source: Adapted from Plumb Boyz, 2012; Winelands Plumbing, 2012; Mcgyver Plumbing,2012

6.6 Municipal Financing Mechanisms

Solar water heaters have been identified as a "low hanging fruit" in South Africa. The problem is this: How can the uptake of solar water heaters best be promoted? Several approaches have been considered. One suggestion is that local authorities should treat this as the provision of a service, and that SWHs should be installed as part of the municipal-owned infrastructure for which the building owner pays a monthly rate (SEA, 2009). The idea behind this suggestion is to reduce the initial cost to the customer by spreading payments over a long period of time. Financial mechanisms that are currently being used to promote SWH have produced different results in different countries. The rebate that is used in South Africa has not had much impact on the residential market.

One of the reasons why the rebate has not been effective is that it does not overcome the cost barrier since consumers have to purchase the SWH first and then make a claim for reimbursement. In addition there is a time delay between the time the claim is laid and the time payment is made. Innovative financing mechanisms are being investigated as a way of overcoming the barrier of high initial costs.

Although there is a general consensus that financing mechanisms could assist in increasing the uptake of energy-efficient technologies, various concerns have been raised with regard to municipal financing mechanisms. One of the concerns is that municipalities do not have the capacity or the business skills to operate as a business (Janisch, 2011). Another concern is that existing legislation such as the Municipal Finance Management Act (RSA, 2003) and National Credit Act (RSA, 2005) forbids municipalities from carrying out certain functions, such as issuing loans (Janisch, 2011; Tshaka, 2011). In order to avoid problems associated with the Municipal Finance Management Act, some municipalities are opting to start by improving internal energy efficiency, focusing initially on smart metering, on the energy efficiency of municipal buildings, and on street lighting (Tshaka, 2011). Instead of financing energy-efficient projects on their own, municipalities are exploring other possibilities, such as improved marketing, launching awareness campaigns, introducing more consumer-friendly billing systems and facilitating concession loans from development banks (Janisch, 2011; Van Wyk, 2011). While all these concerns are valid, they also give municipalities an excuse for doing nothing to address their energy issues. Municipalities should consider ways of getting around these problems and should take action to initiate energy efficiency programmes. Municipalities such as NMBMM and eThekwini have initiated SWH programmes that are funded by the CEF.

6.6.1 Marketing role

One of the suggestions is that the municipality could use social marketing to promote solar water heaters and LPG stoves in Stellenbosch (Thompson, 2011). Social marketing is non-conventional marketing, in that it involves behaviour change with the goal of achieving individual or societal benefit. In this case, electricity used for water heating and cooking is generated from coal-powered stations and causes greenhouse gas emissions. Middle-to-high income households could be persuaded to change their behaviour by pointing to the contribution they could make to reducing greenhouse gases and the benefit to the environment. .The appeal would not be based simply on financial savings. Social marketing would be relevant in this case since the marketing of SWHs and LPG stoves involves behavioural changes that benefit both the society and individual. Social marketing could be used by to share success stories, thereby influencing households to adopt energy efficient technologies.

Du Toit (2010) carried out an experiment in Stellenbosch, where SWHs were installed in one household in Kayamandi and another household in Cloetesville. The SWH systems generated interest in the technology and many people in these neighbourhoods requested more information about SWH from the households using the SWHs. This experiment raised awareness and proved the value of demonstration projects (Du Toit, 2010).

Although this was carried out in low-income households, demonstration projects can also be applied to middle-to-high income households. The municipality could use such demonstration projects to raise awareness. In the case of middle-to-high income households, the municipality could identify opinion leaders and install SWHs at their houses, thereby influencing people's opinions and behaviour.

In addition to marketing, the municipality could work with insurance companies as far as the replacement of broken electric geysers is concerned. A recent study by Kritzinger, (2011b) showed that some insurance companies have started programmes to replace SWHs with electric geysers. The municipality could approach these companies and agree on a mechanism to avoid this. Such an agreement would be beneficial to the municipality as it would contribute to peak demand reduction (Kritzinger, 2011b).

6.6.2 A targeted SWH Approach

Since the Stellenbosch municipality lacks the financial resources to fund a programme, the municipality could approach companies like Solarent and Teljoy which can supply SWHs and arrange the necessary finance. The municipality has access to information about the households that consume most electricity. The idea is to target these consumers and use the municipality's billing system for SWH instalments. An initiative that involves the municipality and commercial companies is likely to be trusted, thereby making buy-in easier (Ross, 2011; Van Wyk, 2011). This also makes the programme more credible, as it would not be offering anything new.

6.6.3 The Financial case for SWHs and LPG stoves

One of the biggest challenges that municipalities face when initiating energy efficiency programmes is getting finance to fund their projects. One route that a municipality can take is to follow municipalities that have approached the CEF for funding. The researcher considered a scenario similar to that implemented by NMMBM, where the municipality comes up with a billing system and the CEF provides funding for both SWHs and LPG stoves over a six-year period at an interest rate of 10%. The following assumptions were made.

Table 6.5: Assumptions for 300L SWHs and LPG stoves financed over six years

Cost of SWH	R 14 000-00
Cost of LPG stove	R 6000-00
Cost of electric geyser	R 17 970-00
Cost of electric stove	R 4000-00
Monthly electricity cost for SWH	R 110-00
Monthly electricity cost of electric geyser	R 379-00
Monthly electricity cost of electric stove	R 147-60
Monthly electricity cost LPG stove	R 0
Electricity cost escalation rate 25% in year two and 15% from year three	

Source: Author, 2011 Adapted from Winelands Plumbing, 2011; Defy, 2011, Blue Flame Hardware and Gas, 2011; Sun Tank, 2011.

Table 6.6: Financed SWH and LPG stove

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Electric Geyser																				
Financed payment	2,928	3,194	3,485	3,801	4,147	4,524	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity cost	4,548	5,168	5,873	6,674	7,584	8,618	9,793	11,129	12,646	14,371	16,330	18,557	21,088	23,963	27,231	30,944	35,164	39,959	45,408	51,600
Electric Stove																				
Financed payment	672	733	800	872	952	1,038														
Electricity cost	1,771	2,013	2,287	2,599	2,953	3,356	3,814	4,334	4,925	5,597	6,360	7,227	8,213	9,332	10,605	12,051	13,694	15,562	17,684	20,095
Total Annual	9,919	11,108	12,444	13,947	15,636	17,536	13,607	15,463	17,571	19,967	22,690	25,784	29,300	33,296	37,836	42,995	48,858	55,521	63,092	71,695
Total cumulative	9,919	21,027	33,472	47,418	63,054	80,591	94,198	109,661	127,232	147,199	169,889	195,673	224,973	258,269	296,105	339,100	387,959	443,480	506,572	578,267
SWH																				
Financed payment	2,328	2,540	2,771	3,022	3,297	3,597	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity costs	1,320	1,500	1,705	1,937	2,201	2,501	2,842	3,230	3,670	4,171	4,740	5,386	6,120	6,955	7,903	8,981	10,206	11,598	13,179	14,976
Gas Stove																				
Financed payment	996	1,087	1,185	1,293	1,411	1,539	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total annual	4,644	5,126	5,660	6,252	6,909	7,637	2,842	3,230	3,670	4,171	4,740	5,386	6,120	6,955	7,903	8,981	10,206	11,598	13,179	14,976
Total cumulative	4,644	9,770	10,787	11,913	13,161	14,546	10,479	6,072	6,900	7,841	8,911	10,126	11,506	13,075	14,858	16,885	19,187	21,804	24,777	28,155
Savings from choosing a SWH and gas stove																				
Savings	5,275	5,982	6,784	7,694	8,727	9,899	10,765	12,233	13,901	15,796	17,950	20,398	23,180	26,341	29,933	34,014	38,653	43,923	49,913	56,719
Cumulative savings	5,275	11,257	22,685	35,506	49,893	66,045	83,719	103,588	120,331	139,358	160,979	185,548	213,467	245,194	281,247	322,216	368,772	421,676	481,795	550,112

Source: Author’s table, 2011

Table 6.6 shows that when financed over a six-year period, SWHs and LPG stoves become affordable and that in the long run it will be beneficial for a household to invest in these energy-efficient technologies.

6.6.4 Leasing of SWHs and gas stoves

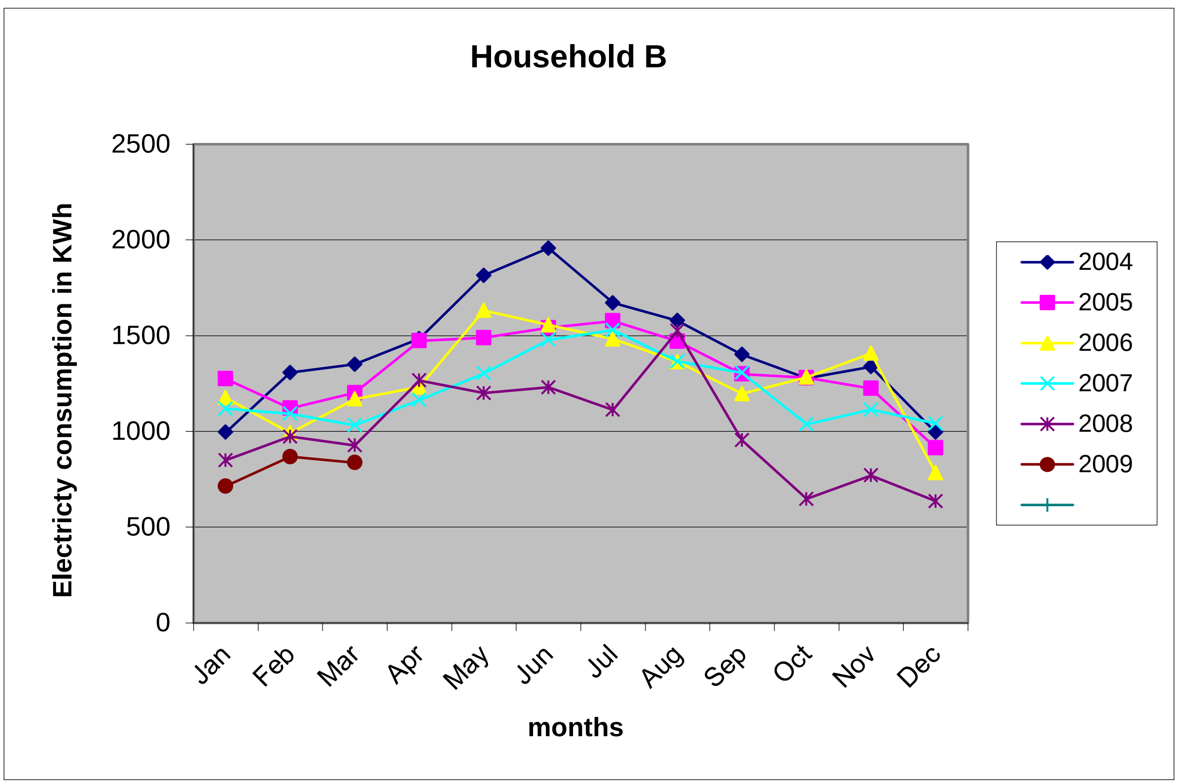
Another option the municipality could consider is to source funds from international development institutions that offer low-interest loans. The researcher considered a scenario where the municipality obtains a low interest loan which enables it to lease SWHs and gas stoves to consumers over a 20-year period, escalated at 5% per year. In this case the municipality could set up a Special Purpose Vehicle (SPV) to own the SWHs and gas stoves and lease them to consumers. The monthly repayments for a household that adopts both a SWH and a gas stove would be R 133.74 amounting to R 1604.88 per annum (Refer to Appendix 5).

The problem likely to be associated with such a programme is that it combines SWH and LPG industry players and might be difficult to administer. Another issue is that households might not be prepared to enter into 20-year lease agreements; these could, however, be reduced to five-year leases which would be subject to renewal. In addition if a consumer were to default on repayments, the equipment could be removed, leaving the household without the appliances.

6.7 Energy savings from SWHs and gas stoves

With regard to energy savings from energy-efficient technologies, it was noted that consumers are generally not aware of the savings that could be obtained from SWH (Van Wyk, 2011; Thompson, 2011). The researcher identified two current SWH users who agreed to share their energy consumption data to demonstrate the impact of energy-efficient technologies on consumption. The data from household A had too many information gaps as the household did not keep proper record of consumption. Household B, on the other hand, kept a proper record from January 2004 to March 2009. The household installed a SWH in March 2007, a gas stove in October 2008 and an under-counter geyser in the kitchen, and it uses CFLs for lighting. Figure 6.1 below shows household B's electricity consumption pattern for January 2004 to March 2009

Figure 6.1: Household B electricity consumption Jan 2004 – March 2009



Source: Adapted from interview data, 2009

If we take 2004 as the baseline, Figure 6.1 shows that as the household adopted more energy efficient technologies, energy consumption decreased.

A SWH reduces energy consumption for the household. According to Eskom a 150L SWH replaces about 4.5kWh of electricity daily (Eskom, 2009:1). Using a simple ratio, electricity savings from various SWHs are as shown in table 6.4 below. Electricity savings from a gas stove are also shown in table 6.4.

Table 6.7: Electricity savings from different SWHs and gas stove

SWH by size	Daily savings	Monthly savings	Annual savings
150L	4.5kWh	135kWh	1 620kWh
250L	7.5kWh	225kWh	2 700kWh
300L	9kWh	270kWh	3 240kWh
Gas stove	-	148.2kWh	1 778.4kWh

Source: Author, 2011

Table 6.5 shows daily, monthly and annual electricity savings from each system as well as savings from a gas stove. Assuming all middle-to-high income households install a SWH and a gas stove, each household would save about 5014kWh annually. For all the 17 000 middle-to-high income households in Stellenbosch this would amount to about 85million kWh. This would be enough to power more than 20 000 housing units if the new builds were to consume about 350kWh monthly. This would enable the municipality to double in size without requiring more electricity from the national grid.

6.8 The environmental Impact of a SWH

There are environmental benefits associated with SWH usage. For a 150L SWH the annual environmental benefits are shown in table 6.6.

Table 6.8: Environmental benefits of 150 L SWH

Resource saved/ Emission avoided	Saving per kWh	Approximate annual saving
Water	1.26 litres	2.07 kilolitres
Coal	0.5kg	821kg
Ash	0.28g	460g
SO_2	8.79g	14.4kg
NOx	3.87g	6.4kg
CO_2	0.96kg	1.6 tonnes

Source: Adapted from Eskom, 2009:1

Based on the daily electricity savings in table 6.4, Table 6.7 shows the approximate resource savings/emissions avoided per SWH system.

Table 6.9: Approximate Resource saving/emission

Resource saved/ Emission avoided	Approximate annual saving - 250L SWH	Approximate saving over 20 years – 250L SWH	Approximate annual saving - 300L SWH	Approximate saving over 20years – 300L SWH
Water	3.45 kilolitres	69 kilolitres	4.14 kilolitres	82.8 kilolitres
Coal	1.37 tonnes	27.4 tonnes	1.6 tonnes	32 tonnes
Ash	767g	15.34 kg	920g	18.4 kg
SO_2	24.08kg	481.6 kg	28.8kg	576 kg
NOx	10.6kg	212 kg	12.8kg	256 kg
CO_2	2.6 tonnes	52 tonnes	3.2 tonnes	64 tonnes

Source: Author, 2011

By promoting SWHs the municipality would significantly reduce the amount of harmful emissions that contribute to global warming. If 17 000 250 L SWHs were installed the annual CO_2 emissions avoided would amount to 44 200 tonnes. Given that carbon credits are between

USD10 and USD40 per tonne, (The Jatropha Organization of South Africa, 2011) the annual potential income from carbon credits for the 17000 units would be between USD442 000 and USD1.768 million, without taking into account administration costs. Similar calculations can be done for different sizes of SWHs.

6.9 Conclusion

Sustainable development is a worldwide challenge because economic development and its associated growths trends perpetuate anthropogenic resource use that has negative consequences for the environment. The shift towards sustainable development is necessary to ensure equitable resource distribution and environmental protection. Energy is an important resource that has implications for future sustainable development. The current energy system is based on fossil fuels; however, these produce GHG emissions that contribute to climate change. A transition to sustainable energy systems based on renewable energy sources is necessary for sustainable development.

Sustainable urban growth is an integral part of the goal of achieving worldwide sustainable development. Urban growth presents new challenges as far as resource use is concerned. Urban areas consume a lot of energy and are responsible for a considerable proportion of GHG emissions. Cities and towns can influence how resources such as energy are generated and used in their localities through various strategies to reduce energy consumption, increase energy efficiency and meet their energy needs through renewable energy systems.

Sustainable energy can be implemented via the twin solution of energy efficiency and renewable energy sources. Energy efficiency is considered the "low hanging fruit" because it is "the best energy resource": it is commercially viable, it allows for financial savings due to decreased energy consumption, and it is a way to shift the world towards sustainability. In addition organisations and households can implement it immediately. The literature on this subject highlights the need for end-use energy efficiency based on the idea of compounding efficiency losses during energy conversions. Limitations to energy efficiency as well as unintended consequences of energy efficiency were noted.

Technologies that are available to implement end-use energy efficiency and the introduction of renewable energy were identified. A range of possible options for retrofitting residential and commercial buildings were discussed to indicate how end-use energy efficiency can facilitate sustainable energy use. These included energy-efficient options for water heating systems and cooking end-uses.

Energy efficiency necessitates behaviour change: consumers need to shift from current equipment to energy-efficient appliances. Various techniques can be used to encourage the shift to energy-efficient equipment, such as SWHs. These included awareness campaigns to persuade people to act, positive motivational techniques such as the use of financial incentives, and coercive measure such as regulations that force people to act under duress.

Local authorities have begun to introduce energy-efficiency measures and renewable energy technologies in their areas as a way of reducing GHG emissions and reducing energy consumption. This is based on the view that locally designed programs provide cost-effective ways of achieving sustainability goals. If countries are to move towards a sustainable energy path, cities and towns are important partners in the process. Local authorities are using various municipal financing mechanisms in a bid to assist in the transition to sustainable energy use. In their efforts to make the transition to sustainable energy use, local authorities have begun by focussing on "low hanging fruits" such as SWHs. International and local authorities are promoting SWHs, and taking their local context into account.

Local authorities can play an important role in assisting a nation to meet the goals of sustainability. Municipalities do not have to wait for national government to take the lead but can play a leading role in the search for local renewable energy sources and energy efficiency.

Energy-efficiency measures that make sense in South Africa should focus on reducing peak electricity demand and managing growth in demand. These include measures to reduce electricity use in the residential sector by looking at water, space, cooking, appliances and lightning. Water heating has been identified as the major contributor of electricity usage in a household. Recent studies have shown that a SWH can reduce household electricity demand, especially during the evening peak. SWH technology is mature technology that has been used successfully internationally, and it is available in South Africa.

In addition to SWH there are also applications for LPG that can help reduce electricity peak demand, such as LPG heaters and stoves. For a household there are definite financial savings and environmental benefits to using energy-efficient technologies. A major constraint to the adoption of energy-efficient technologies is the high upfront cost of SWHs and the high cost of LPG equipment such as heaters and stoves. Financing mechanisms that spread repayments over a period of time overcome this barrier, making it more affordable for households to adopt energy-efficient technologies such as SWHs and LPG stoves.

6.10 Chapter Summary

Energy efficiency is a national priority. There are various programmes that encourage South Africans from all sectors to save electricity. Stellenbosch municipality has begun to put in place measures to save electricity. These efforts focus on internal energy efficiency and new builds in the residential sector. Technologies that have been used for energy efficiency include SWH and LPG gas equipment such as stoves. A major barrier to the adoption of these technologies is their high initial cost. Financing mechanisms which spread repayments over a period of time make these technologies affordable and can be used to persuade households to adopt them.

Although Stellenbosch municipality has placed energy efficiency on its agenda, it does not have a lead official or champion driving energy management. In addition the municipality does not have the financial resources to implement energy efficiency. It could, however, obtain funding from international sources. Stellenbosch municipality has the potential to use energy efficiency (particularly through the introduction of SWH and gas stoves in the residential sector) to overcome energy constraints on future development.

Chapter 7

Conclusion and recommendations

7.1 Introduction

This chapter gives a summary of the research findings and makes recommendations for Stellenbosch municipality.

7.2 Summary of research findings

Sustainable development is a worldwide challenge because economic development and its associated growths trends perpetuate anthropogenic resource use that has negative consequences for the environment. A shift towards sustainable development is necessary to ensure equitable resource distribution and environmental protection. Energy is an important resource and has implications for future sustainable development.

Stellenbosch municipality has chosen to shift the way development takes place within its boundaries. In terms of energy, the municipality has placed energy efficiency and renewable energy high on its agenda. The municipality however has only begun to take steps towards translating this rhetoric into action. It has chosen to begin with internal energy efficiency measures, requesting large consumers to reduce their consumption and focusing on new builds in the residential sector that have to prove that they have put in place measures to save 10% of energy consumption. However, the new builds in the residential sector constitute a small portion of the total number of buildings, and this means that efforts should also to focus on existing buildings.

This study showed that a household that adopts energy efficient technologies by installing SWH and a LPG stove can significantly reduce energy consumption. In addition, there are financing mechanisms that can help to reduce the high upfront costs of SWH and LPG equipment, such as stoves. These mechanisms would give households the option of spreading repayments over a long period of time, thereby overcoming the barrier of high initial costs. They can be used to encourage households that are first-cost sensitive to adopt energy-efficient technologies. In order to support an energy efficiency programme, the municipality needs to obtain funding from international sources. There are, however, a number of steps that the municipality should to follow in order to reduce energy consumption, such as promoting energy efficiency and renewable energy technologies.

7.3 Research limitations

The research objective was to show that Stellenbosch Municipality can overcome energy constraints on future development through promoting energy efficiency, particularly with regard to SWHs and gas stoves. In addition, the study sought to highlight financial mechanisms that the municipality could use. Although these objectives were met there were some limitations that affected the quality of the study. These limitations had to do with access to information, resources and time frame.

7.3.1 Access to information

The policy direction taken at national level influences what happens at local level. In terms of national energy-efficiency policy, the researcher could not obtain information from major energy-efficiency players such as Eskom, the CEF, the National Energy Efficiency Agency (NEEA), the DoE, and the Southern African Association for Energy Efficiency (SAEE) and the South African Local Government Association (SALGA). In the case of Eskom, the researcher first called the head office and was referred to a provincial office. When the provincial office was approached they declined to release information on the grounds that they needed head office's approval. Although the provincial office requested the researcher to send in questions, they still referred the matter to head office before any response could be issued. The researcher made numerous attempts to get a response via telephone and email but on each occasion was told to exercise patience since head office had not yet responded. In addition gatekeepers played a role in making access to senior managers in an organisation difficult. In the end the researcher resorted to SDA to obtain information. If the researcher had been able to conduct face to face interviews the outcome might have been different.

In the cases of NEEA, DoE, SALGA and the SAEE the researcher made initial contact by telephone and was requested to forward questions via email. After the questions had been sent it was difficult to make arrangements for interviews as the respondents were not available. After numerous attempts to try and arrange telephonic interviews, the researcher asked the respondents to send in their responses electronically, but there was still no response. If the researcher had conducted face to face interviews the outcome would have been positive, that is assuming that the organizations would have granted face-to-face interviews.

The researcher's inability to contact the above-mentioned organisations meant that the researcher relied on secondary data which might have been outdated in so far as policy direction was concerned. In addition organisations such as NEEA and SALGA could have shed some light on the role South African municipalities are playing in promoting energy efficiency and renewable energy technologies.

It was also difficult to get information from municipalities. Officials were cooperative only to a certain point; if the researcher continued to request more information, in some cases the response was that no further assistance could be offered. Although there was a SWH project in Cloetesville, the municipality insisted that they were not involved in any way in the project. Efforts to speak to the project's contractor were unsuccessful as the contractor had been suspended.

In the case of the Nelson Mandela Bay Metro Municipality, the researcher was given information regarding the SWH programme for low-income houses and not the programme for which information had been requested. This resulted in information gaps that could sometimes be covered by SDA in order to meet deadlines. It should however be noted that in some cases, such as the Nelson Mandela Bay Metro Municipality case study, the researcher could not resort to SDA as the project is still being implemented and there is little available information .

7.3.2 Resources

This study was constrained by the limits of the available budget. The collection of data required telephonic interviews and personal meetings with interviewees. Substantial financial resources were needed to meet the cost of fuel expenses and telephone bills. As a self-sponsored student this was a big challenge which at times required huge financial sacrifices from the family. Personal interviews outside Cape Town required substantial amounts of money to cover airfares and accommodation costs, and the researcher could not meet these due to budgetary constraints. This resulted in face-to-face interviews being conducted with respondents in Stellenbosch and Cape Town. The researcher was forced to rely on telephone interviews for respondents outside Cape Town. This however often resulted in no response being obtained, leading to information gaps in the study.

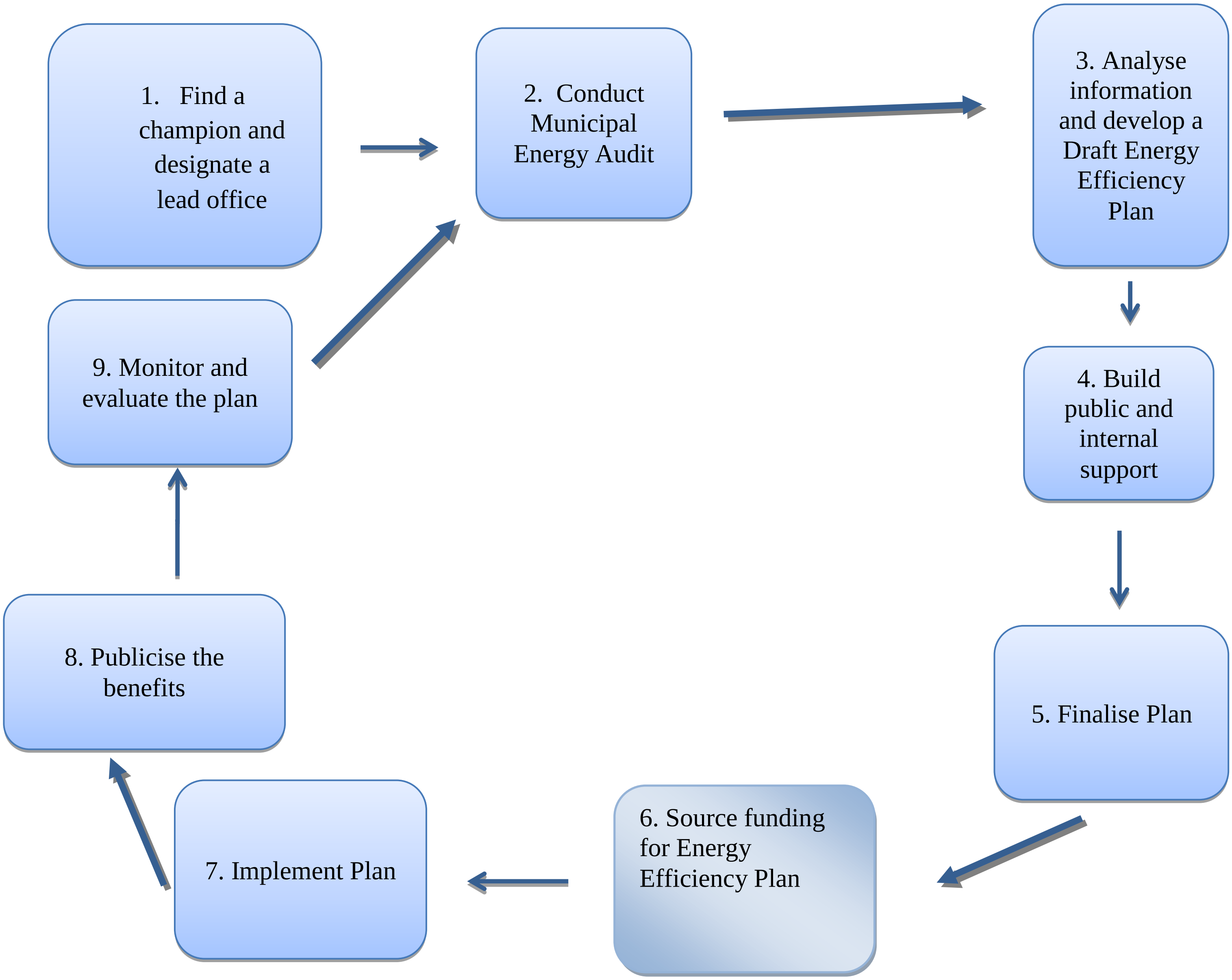
7.3.3 Time frame

As the study was time-bound with deadlines for the submission of the report, the information collection process had to be stopped when the deadlines were drawing near in order to allow time for data analysis and report writing. However, even if more time had been given, there is no guarantee that obstacles could have been overcome, since the researcher had little control over the release of information. This also resulted in information gaps that affected the quality of information, especially in cases where one could not use secondary data.

7.4 Recommendations

Based on the research findings, the researcher came up with a nine-step planning process, adapted from ICLEI (2009) that the municipality could follow. The flow chart below shows the planning process.

Figure 7.1: Nine step planning process



Source: Adapted from ICLEI, 2009

7.4.1 Finding a champion and designating a leading office

A champion is a person with the power, commitment and charisma to will play the important role of in gaining buy-in and convincing people to shift from the business–as–usual method to embracing new ways of thinking leading to innovative solutions. Considering the diverse groups within Stellenbosch, what might be needed are champions who can influence the various groups, such as staff, political leaders and consumers.

Energy is a vital concern for every municipal department and it is important that any initiative should have the support of all departments. However, direction and leadership needs to come from one leading department or office. This office needs to be one which will gain general support within the municipality and it must have has the motivation and capacity to do the work. In the case of Stellenbosch municipality, the lead office could be the Municipal Manager's office as this is likely to gain the necessary support from other departments and should have strength and capacity to do the work.

7.4.2 Conducting a municipal energy audit

Before the municipality can take action to reduce energy consumption it must gather information about energy consumption within the municipality and also make projections regarding future energy needs. The energy audit should investigate which sectors consume most energy so that they can be targeted for energy efficiency. Once the municipality has the information it can then come up with a plan for reducing energy consumption.

7.4.3 Analyse data and develop a draft energy efficiency plan

After gathering information, the municipality needs to identify critical issues in each sector and draft an energy efficiency plan that details the measures, projects and programmes that will bring the greatest benefit.

7.4.4 Build public and internal support

This step is important: this is an ongoing process which needs to be continued throughout the development and implementation phases. It is important to engage with and educate the public, municipal staff, and political leaders on the purpose of the plan and its benefits.

7.4.5 Finalise plan

After the participation process there will be a great deal of input to the draft plan. The municipality must identify priority projects and adopt a final plan.

The plan should be comprehensive, with clear objectives, and should focus on all possible energy-efficiency measures, ranging from no-cost or low-cost measures to medium- and high-cost strategies.

7.4.6 Source funding for an energy efficiency plan

It was noted that the municipality does not have the financial resources to fund energy efficiency programmes. It needs to obtain funding from international sources to enable the implementation of its plan. This applies particularly the medium- to high-cost energy efficiency projects in the residential sector.

7.4.7 Implement Plan

The municipality noted that it lacked the capacity to implement its own plans by itself. The researcher recommends that the municipality sets up a Special Purpose Vehicle (SPV) to spearhead the implementation process.

7.4.8 Publicise benefits

Once the plan is set in motion, the municipality needs to publicise the benefits of programmes and projects. There is a need to use the various media to communicate the benefits to the public in order to build trust and credibility.

7.4.9 Monitor and evaluate plan

Monitoring and evaluation is an important part of the process as it helps track progress, identify strengths and weaknesses, improve the planning process and it enables strategic decisions to be made.

7.5 Conclusion

The main issue hindering the municipality from initiating an energy efficiency programme is the idea that energy efficiency would be a threat to municipal finances, which depend to a significant extent on electricity sales. Even though it appears that the shift to energy efficiency could address energy constraints in the Stellenbosch municipality, the system is geared towards meeting energy demand in the conventional way and protecting municipal finances through the sale of electricity. There is need for awareness programmes to change the perceptions of municipal officials so that energy efficiency is no longer seen as a threat to municipal finances: the focus should shift to viewing energy efficiency as a way of managing energy demand and reducing peak electricity demand. Such a shift in perception is needed if the system is to come up with new and innovative solutions to deal with energy constraints.

One such intervention would be the promotion of SWH and LPG stoves in the middle-to-high income households in Stellenbosch. By taking this route, Stellenbosch municipality would be able to overcome the energy constraints on future development; it would be able to grow while containing growth in energy demand.

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Appendices

Appendix 1: Panel of Experts meeting participants

Frank Spencer (Chair/ facilitator)	Alt – e Technologies
Helmut Hertzog	Atlantic Solar
Stuart Llyod	Atlantic Solar
Wouter Roggen	City of Cape Town
Carl Wesselink	South African Export Development Fund
Joseph Hames	Stellenbosch Municipality
Duncan Palmer	University of Stellenbosch
Dr. Ben Sebitosi	University of Stellenbosch
Prof. Mark Swilling	University of Stellenbosch
Jaco Du Toit	University of Stellenbosch(Student)
Thumakele Gosa	University of Stellenbosch(Student)
Ben Mokheseng	University of Stellenbosch(Student)
Christine Nyabadza	University of Stellenbosch(Student)

Appendix 2: Interviews

LPG Industry Interviews

Name	Organization	Position	Venue	Transcript	Recorded
Kevin Robertson	LPGSASA	Communications Manager	Telephone	No	Yes

SWH Industry Interviews

Name	Organization	Position	Venue	Transcript	Recorded
Andrew Janisch	Sustainable Energy Africa	Project Manager	Cape Town	No	No
Arno Van Wyk and Corrine Geldenhuys	Solarent	Shareholder and Marketing Manager	Cape Town	No	Yes
Herman Weber	Kwikot	Technical Director	Telephone	No	Yes
Robin Thomson	SESSA	Technical Specialist	Telephone	No	Yes
Sandiswa Tshaka	South African Cities Network	Project Manager	Telephone	No	No

Stellenbosch Municipality Interviews

Name	Position	Venue	Transcript	Recorded
Joseph Hames	Manager Operations & Planning: Electrical Engineering Services	Stellenbosch	No	No
Nombulelo Zwane	Head: Planning and Design: Electrical Engineering Services	Stellenbosch	No	No
Floris Koegelenberg	Loss Control Manager: Electrical Engineering Services	Stellenbosch	No	No
Yeki Mosomothane	Manager: Stakeholder Relations Office of the Municipal Manager	Stellenbosch	No	No

Appendix 3: E-mail Correspondence

Name	Organization	Position	E-mail address
Neil Ross	Teljoy	Director and Financial Manager	NRoss@teljoy.co.za
Arno Van Wyk	Solarent	Shareholder	arno@solarent.com
Andrew Janisch	Sustainable Energy Africa	Project Manager	andrew@sustainable.org.za
Robin Thomson	SESSA	Technical Specialist	robin.thomson@sessa.org.za
Thomas Dresel	SolarRegion Freiburg	Project Executive	Thomas.Dresel@stadt.freiburg.de
Liam May	Nelson Mandela Metro Municipality	-	lmay@mandelametro.gov.za
Robert Veith	Alt – e Technologies	Sales Representative	robert@alt-e.co.za
Karin Kritzinger	Green Cape	Project Manager	karin.kritzinger@gmail.com
Nombulelo Zwane	Stellenbosch Municipality	Head: Planning and Design: Electrical Engineering Services	NombuleloM@stellenbosch.org
Lorraine Van Wyk	Easigas	Marketing and CSC Manager	Lorraine.VanWyk@easigas.com
Jacques Schippers	Totalgaz Southern Africa	Marketing Manager	Jacques.Schippers@totalgaz.co.za
Kevin Munro	Afrox	Manager - Hospitality Gases	Kevin.Munro@afrox.linde.com
Rosa Botha	Exact Gas	-	admin@exactgas.co.za

Appendix 4: Confirmation letter

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jou kennisvennoot • your knowledge partner

20 April 2011

TO WHOM IT MAY CONCERN

This serves to confirm that CHRISTINE NYABADZA (student number 15539830) is a registered MPhil Sustainable Development Planning & Management student at Stellenbosch University. As partial fulfillment of the requirements for this degree programme, she is undertaking research for a thesis on the topic *Overcoming energy constraints on future development through energy efficiency: Retrofitting of solar water heaters and gas stoves in middle/high income households*.

The objectives of her study are to investigate:

- the possibility of Stellenbosch Municipality overcoming energy constraints through energy efficiency; and
- possible financing mechanisms that can be used by the Municipality to promote solar water heaters and gas stoves.

It will be highly appreciated if you will be able to grant Ms Nyabadza an interview during which certain aspects of the research will be covered.

Please contact me should you have any queries.

Yours sincerely

Mark Swilling (Prof.)
PROGRAMME CO-ORDINATOR: SUSTAINABLE DEVELOPMENT

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School of Public Leadership
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Appendix 5: Justification for SWH and LPG stove leasing

Leasing equipment is a common business practice and is used a way to finance equipment purchases. The lease term can be short - term such as months, medium - term for example three to five years and long - term up to 30years. The following assumptions were made in determining the lease amount;

Cost of SWH	R 14 000-00
Cost of LPG stove	R 6 000-00
Residual value	R 0
Interest rate 5% per annum	

The calculation of the lease charge would be as follows:

i. The discounted residual value is given by

$$Residual\ value\ \times\ present\ value\ factor^{1}\ at\ 5\%\ interest\ over\ 20\ years$$

ii. The monthly lease payment will be based on the difference between the current cost and the discounted residual value.

iii. The present value involving the amount in (ii) is given by

$$\frac{difference\ between\ the\ current\ cost\ and\ the\ discounted\ residual\ value}{present\ value\ factor\ annuity^{2}\ at\ 5\%\ interest\ over\ 20\ years}$$

With a residual value of zero the monthly lease payment will be based on the current cost of R 20 000.

The annual lease payment per month for 20 years will be

$\frac{R20\ 000}{12.462}$ = R 1 604.88 *per annum*.

This translates into a repayment of R 133.74 per month.

[1] The present value factor (PVF) is obtained from Table A-3 in Lovemore and Brummer, 2003
[2] The present value factor annuity (PVFA) is obtained from Table A- 4 in Lovemore and Brummer, 2003