Investigating different mechanisms for promoting the use of Solar Water Heaters in the Western Cape

by

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DECLARATION

I, Mogamat Riyaad Omer, confirm that this work submitted for assessment is my own and is expressed in my own words. Works of other authors in any form (ideas, equations, figures, text, tables, programmes etc) are properly acknowledged at the point of their use. A full list of the references employed is included.

Signed:………………………………………………

Date: ……………………………………………….

M.R Omer

DEDICATION

To my wife Shanaaz

To my parents Amienah and Akmal Omer

To my children Ahmad and Zakariah

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ABSTRACT

With increasing carbon emissions and decreasing energy resources, creating sustainable energy sources is crucial. According to the Department of Environmental Affairs and Planning, The Western Cape's electricity demand forms 31% of the Province's total energy demand. The objective of this research is to investigate mechanisms for implementing a large-scale Solar Water Heating (SWH) programme, aimed at reducing electricity demand in households, and achieve the renewable energy targets for the Western Cape.

The thesis provides an overview of the concepts and technologies around SWH, and their development and application, both globally and in South Africa, with the objectives of identifying barriers to be overcome and methods of incorporating "best practice" into Eskom's SWH programme. Mechanisms to promote the use of SWH are also considered.

The major barriers preventing the comprehensive adoption of SWH in the Western Cape are a

i) lack of awareness and access to finance,
ii) lack of quality equipment and
iii) lack of SWH installers.

The subsidy currently offered by Eskom has to date not significantly increased the amount of solar water heaters (SWHs) installed. One of the major barriers preventing the large-scale adoption of SWH is the large initial capital outlay required to purchase and install the unit. Researching ways of overcoming this hurdle involved creating a model to determine the optimal subsidy, which will reduce the payback period – the time it will take to recover the cost of installation and equipment through electricity savings. Currently the subsidy offered by Eskom is not sufficient to significantly increase the amount of solar water heaters (SWHs) installed. The incentive provided by Eskom requires that the SWH be SABS approved and that it should be installed with a load control device. The load control device has two functions, firstly to prevent the backup element from switching on during peak electricity consumption periods and secondly to maximise solar content. Funding of SWH projects using carbon trading is also considered to determine whether this is a feasible solution for the Western Cape.

The weather conditions in the Western Cape are ideal for the use of SWHs. The results of this study show that by subsidising the capital cost of SWHs, the payback period is shortened, making it more affordable for the middle to high-income groups. However, some SWH suppliers who have been SABS tested have increased the cost of their equipment, making the subsidy given by Eskom minimal. In addition, the number of companies importing the SWHs is increasing, and their prices have decreased− but they have not been SABS tested. Most of these companies do however conform to international standards and are becoming more affordable without the subsidy. It should be noted that imported SWHs need to be checked by customs officials to verify that the SWHs are sent from approved suppliers before being sold in South Africa

Training for installers of SWHs should be made a priority because even though a SWH system conforms to SABS and international standards, if the system is not installed correctly the solar industry will not be sustainable.

The current global concern about global warming, carbon emissions and sustainable and renewable energy makes this an ideal opportunity for implementing a SWH programme in the Western Cape. Eskom's SWH programme has stimulated the industry, and government intervention is now required to institute policy that will support and drive the initiatives. This study suggests recommendations for funding and implementation measure for the dissemination of SWHs to the general public.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ADEME	French agency for the environment and energy management
BEE	Black Economic Empowerment
CCT	City of Cape Town
CDM	Clean Development Mechanisms
CEF	Central energy fund
CO_2	Carbon Dioxide
CSIR	Centre for Scientific and Industrial Research
CTE	Spanish Technical Buildings Code "Código Técnico de la Edificación"
DBES	Department of Building and Engineering Services of Botswana
DBSA	Development Bank of South Africa
DME	Department of Minerals and Energy
DSM	Demand Side Management
DUE	Domestic Use of Energy conference
EREC	European Renewable Energy Council
ERI	Energy Research Institute
ERID	Eskom Research Innovation Department
ESCO	Energy Service Company
ESKOM	Electricity Supply Company of South Africa
EU	European Union
FSEC	Florida Solar Energy centre
GDP	Gross Domestic Product
GSR	Guaranteed Solar Results
HWC	Hot Water Cylinder
ICS	Integral Collector Storage
ISES	International Solar Energy Society
LEAP	Long-range Energy Alternatives Planning
NARES	National Agency of Renewable Energy Sources
NERSA	National Energy Regulator of South Africa

OCGT	Open Cycle Gas Turbines
PGWC	Provincial Government of the Western Cape
PV	Photovoltaic cells
QUALISOL	Quality Insurance Policy in France
REC	Renewable Energy Certificates
SABS	South African Bureau of Standards
SEA	Sustainable Energy Africa
SESSA	Sustainability Energy Society of Southern Africa
SETA	Sectoral Education and Training Authority
SWH	Solar Water Heating
TRNSYS	A transient system simulation program
TREC	Tradable Renewable Energy Certificate
UNDP	United Nations Development Program
VAT	Value Added Tax
WC	Western Cape
WEF	World Environment Fund

Exchange Rates

8.26 Yuan = 1 USD

R 8.50 (South African Rand) = 1 USD (United States Dollar)

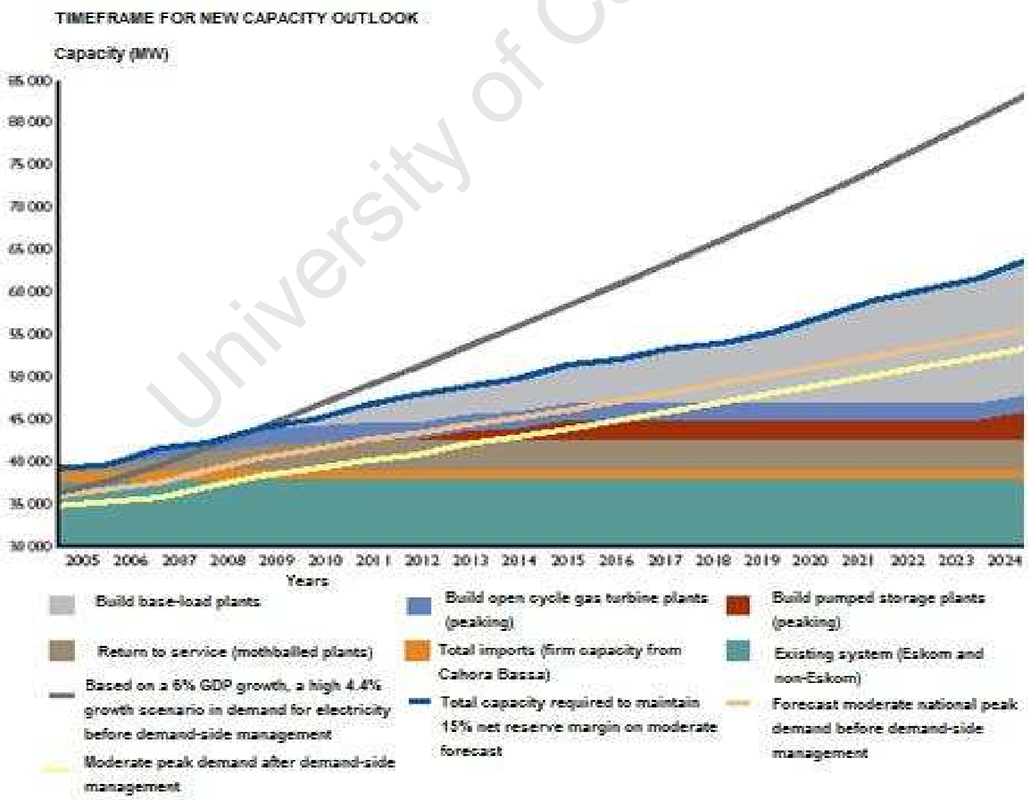
R 6.80 (South African Rand) = 1 AUS$ (Australian Dollar)

Chapter 1

DEFINITION OF THE PROBLEM

1.1. Background to the study

With the growth of South Africa's population and expanding economy, there is an increase in demand for electricity. Eskom supplies approximately 95% of South Africa's electricity. According to the Department of Environmental Affairs and Planning, the Western Cape's electricity demand forms 31% of the Province's total energy demand. The Provincial Government Western Cape (PGWC) expects that with current growth trends, by 2014 4200MW of electricity will be required to meet demand. The PGWC has outlined a plan to have 15% of this, i.e. 630MW, be from sustainable, renewable energy sources. Eskom has been identified as one of the key role players in their strategic planning. (Department of Environmental Affairs and Planning, 2008: [5]). Figure 1 shows the forecasted increased demand for electricity and the ability of the power utility Eskom to meet this demand.



(Eskom Annual Report, 2006: 54)

Figure 1. Graphical representation of timeframe for new capacity

1.1.1. An overview of renewable energy technologies in South Africa (SA)

Growing demands will require South Africa to consider more efficient use of energy and consider renewable energy as an alternative source of energy. The South African Government's White Paper on Renewable Energy Policy supports the establishment of Renewable Energy Technologies (RETs), targeting the provision of 10 000 GWh of electricity from renewable resources by 2013 (2003: 25). The current main renewable energy resources are wind, biomass, biogas, solar power, geothermal and wave. Currently there are two wind farms which have been built i.e. Klipheuwel and Darling wind farm and a third new 100MW wind farm at Koekenaap in the Vredendal area which should be completed in 2010. Solar power is another renewable source of energy and it refers to the generation of electricity using the sun's energy i.e. photovoltaic cells (PV) or concentrated thermal devices. Eskom is considering building a 100MW solar thermal energy plant in Upington. Currently in SA, photovoltaic systems are used mainly for telecoms towers, holiday homes and rural electrification. The National Energy Regulator of South Africa (NERSA) has sponsored the first solar-powered traffic lights in Cape Town and is planning to install more. Wave power, biogas and biomass are in their infancy stage and research is being done to realise their potential.

1.1.2. The need for renewable energy sources in the Western Cape

With diminishing biodiversity, worsening air pollution, increasing carbon emissions, decreasing energy resources, increasing road traffic and consequently increasing fuel demand, and international trade requirements regarding labelling, carbon disclosure and energy use, creating sustainable energy sources is imperative. The Western Cape (WC) has been experiencing power shortages, which resulted in electricity cuts and power outages. It is expected that electricity prices would increase as Eskom would be building new power stations. Currently, 61% of the carbon dioxide released from energy use within the Province comes from electricity production. The PGWC has announced that its strategic intent is to "develop a sustainable energy system that reduces its impact on people's health and the environment whilst contributing to long term sustainable economic development" (Department of Environmental Affairs and Planning, 2008: [20]).

1.1.3. The role of Solar Water Heating (SWH) in creating renewable energy sources

It is estimated that solar water heating can contribute to 23% of the Western Cape's renewable energy target.[1] In many households between 30% and 50% of electricity consumption can be attributed to heating water. With correctly sized and installed solar water heaters the electricity consumption for heating water can be reduced annually by between 50% and 75%. Figure 2 illustrates that the available solar radiation for South Africa is between 1 450kWh/m²/year and 1 950kWh/m²/year. Harnessing the sun's energy to heat water contributes to reducing greenhouse gas emissions and dependency on fossil fuels. Globally South Africa has the highest emissions per capita and per Gross Domestic Product (GDP).

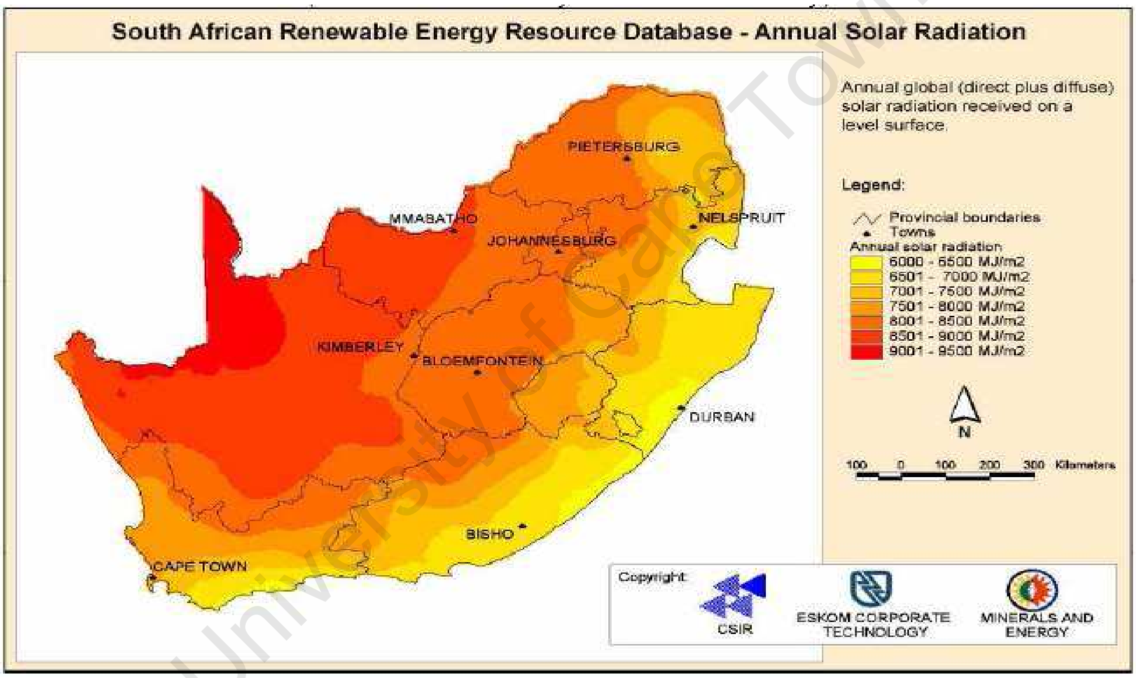


Figure 2. Annual direct and diffuse radiation for South Africa

(South African White Paper on the promotion of Renewable Energy, 2003: 21)

Eskom and the NERSA have collaborated with the Central Energy Fund (CEF), the Sustainability Energy Society of South Africa (SESSA), the Department of Minerals and Energy (DME) and several other organisations to develop the SWH programme.

[1] 1.4 -1.6 million solar water heaters if household size applications used.

1.2. Problem statement

Austin & Morris have established that SWHs are the least expensive means of heating water for domestic use on a life-cycle cost basis because solar energy is free (2005: 27). However, the capital cost of the equipment has made it less competitive compared to the low price of electricity.[2] Although the Western Cape experiences high levels of solar radiation, making it an ideal method of conserving energy and reducing heating costs, SWH is still not the preferred way of heating water.

The purpose of the study is to investigate mechanisms for implementing a solar water heating programme on a large scale, with the aim of reducing electricity demand in households, and achieve the renewable energy targets set for the Western Cape by government.

The study will attempt to answer the following questions:

1) What were the mechanisms used in other countries to promote the use of SWHs and which of those can be replicated to increase the number of SWH installed in the Western Cape?
2) How much energy is saved using SWHs, and how it will meet the hot water required by a medium sized urban home, taking into account estimates of seasonal variation and daily hot water demand?
3) What are the implications for establishing a Solar Water heating programme subsidy and will it work for low income groups?
4) What are the requirements (standards) for implementing such a programme?
5) Using the approximate energy saved in (kWh) for the Western Cape, what is the best subsidy to make it affordable for middle to high-income households?
6) What are the implications of using carbon trading for funding SWHs?

[2] South Africa's electricity is currently the cheapest in the world with its citizens paying about 28 cents per kWh. Finland, Sweden and Canada are next cheapest, at around 48 cents per kWh. But this was before Eskom was given the go ahead to increase its tariffs by 5.9 percent in the period between April 2007 to March 2008 and by 14.2 percent in its 2008/09 financial year. (Bridge, 2008)

1.2. Research Objectives

The objectives of this study are:

- to recommend an effective mechanism for heightening public awareness and promoting SWH on a large scale. This will be achieved by reviewing past work and examining the barriers to, and successes achieved, by SWH programmes, internationally and in South Africa.
- to develop a method to determine the approximate energy saving when heating water using SWHs as opposed to using conventional electricity, and
- to determine what the optimal subsidy and payback period would be for consumers to recoup capital costs by re-evaluating Eskom's current subsidy using a computer simulated model.

1.3. Methodology

The project will make use of logging data from a typical household's hot water and electricity consumption combined solar radiation data, which has been obtained from Eskom's research innovation department (ERID). Eskom ERID and SESSA are participants in a project to support solar hot water and energy demand side management and are currently monitoring 50 homes in various provinces. To provide comparative data, the results of the ERID/SESSA study will be compared to results obtained through a computer simulation model of a SWH system, created for this study. This model uses a mathematical model based on empirical equations.

1.4. Limitations of the study

The study will examine successful implementation programmes in other countries and see how it can be replicated or modified to suit South Africa's conditions. Unfortunately there is a general lack of accessible and reliable information on SWH in South Africa, especially in the Western Cape. The report uses web-based information to gain insight into international experience with regard to SWH implementation programmes.

In creating the computer simulation model, most calculations of SWH are based on the transient simulation program (TRNSYS), which has gained worldwide acceptance due to its modular construction and availability of the code in the public domain. Although a more advanced version of the software is available (TRNAUS), the author has not used this software as licensing is required and is beyond the scope of this thesis.

1.5. Exposition of the chapters

The study is divided into seven chapters. Chapter 1 provides an overview of renewable energy technologies, why the implementation thereof is crucial in the Western Cape, and the role of SWH in creating renewable energy sources. It outlines the purpose and methodology of the investigation. Chapter 2 discusses the various types of solar water heaters, the theoretical background to modelling a typical flat plate SWH and discusses the methodology for collecting the data on household consumptions.

Chapter 3 begins with a review of the development of SWHs in SA, and explores the success achieved in promoting the use of SWH in other countries. Chapter 4 discusses the different methods used to promote the use of SWHs in some of these countries, including financial incentives and creating market awareness. Chapter 5 discusses the computer model to determine electrical savings when using SWHs and the simple payback period. Chapter 6 discusses how carbon trading can be used to fund mass roll out of SWHs. Finally, Chapter 7 outlines conclusions and makes recommendations.

Chapter 2

THE FUNDAMENTALS OF SOLAR WATER HEATING

This chapter provides technical information on the various solar water heating technologies available.

Domestic solar water heaters consist of collectors− a blackened surface to absorb the radiant energy of the sun− and a storage tank to store the heated water. In layman's terms, a solar water heater is able to collect and store the sun's energy and use it to heat water. Various systems can be used to transfer the heat from the sun to heat the water, including:

1. Integral Collector Storage Systems,
2. Separate Collector Storage Systems, and Close coupled Collector Storage Systems,
3. Which can be further divided into:
    - Direct circulation systems,
    - Indirect circulation systems,
    - Active systems, and
    - Passive systems.

2.1. Integral Collector Storage Systems (ICS)

Integral collector storage systems, also known as ICS or *batch* systems. They normally have one or more black tanks or tubes in an insulated, glazed box as shown in figure 3. Cold water first passes through the integrated solar collector and storage tank, where it is heated. The water may be used or it flows to the conventional backup water heater, providing a reliable source of hot water. These ICSs work best in areas where temperatures rarely fall below freezing, and where large amounts of hot water are required in the evening such as camp sites, resorts and sports cloakrooms.

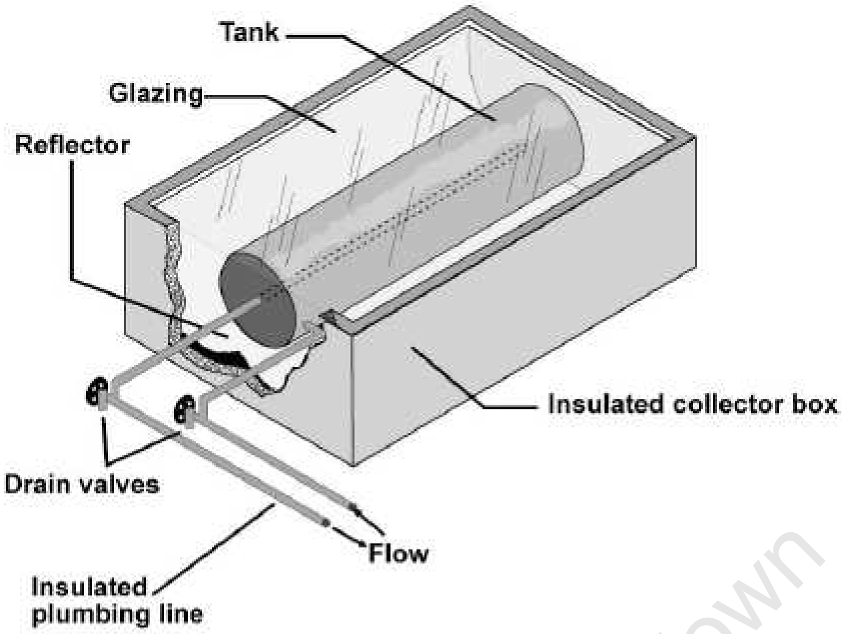


Figure 3. ICS or batch water system

(Source: Florida Solar Energy Center)

2.2. Separate Collector Storage Systems or Split Systems

The collector panels are the only thing visible on the roof in a separate collector system. The storage cylinder can be mounted at any desired location. Depending on the location of the cylinder, pumps and controllers may be required to regulate the flow of water between the cylinder and the collector. The collector feeds heated water to the Hot Water Cylinder (HWC). The HWC normally has an electric backup element which cuts in when the temperature drops below the set temperature. The backup element heats the water when there is not enough solar energy.

A separate collector and close coupled system may consist of two common types of collectors: flat-plate collectors, and evacuated tubes.

2.2.1. Glazed flat-plate collectors

Flat plate collectors are normally made up of thin plastic or metal pipes which are inside **glazed** glass to insulate and weather proof. The container houses the dark absorber plate, under one or more glass or plastic (polymer) covers as shown in figure 4. The transparent cover keeps out rain and reduces the cooling effect during the evening and low sunlight conditions. The covers are normally made of high strength material to withstand hail and prevent degradation due to prolonged exposure to ultra violet radiation.

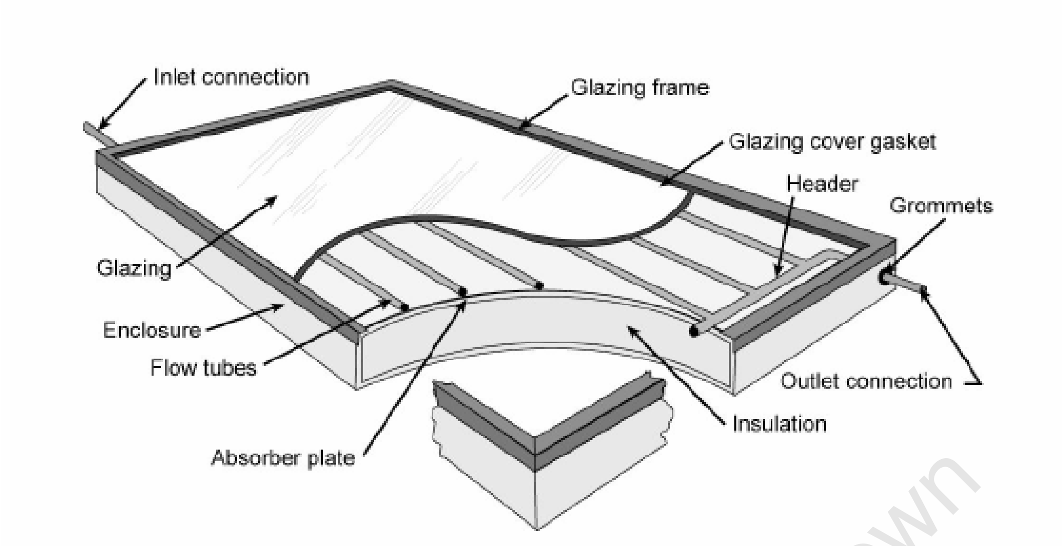


Figure 4. A typical glazed flat-plate collector

(*Source: Florida Solar Energy Center)*

As illustrated in figure 5 below, the air-gap provides a buffer between the absorber plate and glazed cover, insulating and trapping the incoming solar radiation. Heat loss is mainly due to radiation from the plate, air convection and direct contact with the outside air. By using glass as a glazing material, short wave radiation is allowed to pass through and long wave re-radiated heat is prevented, thus creating a greenhouse effect between the glass cover and the flow tubes.

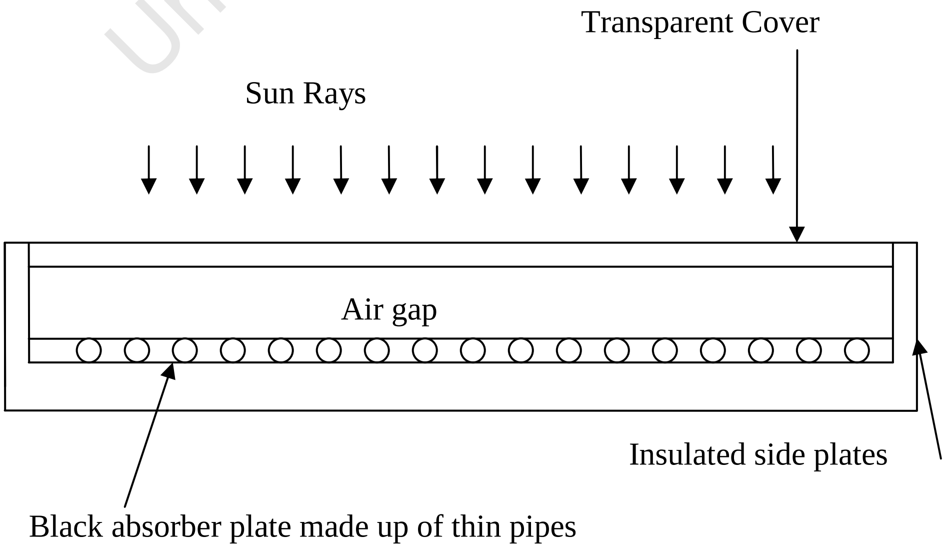


Figure 5. Cross-section of a typical flat-plate collector

The black absorber plate could have concentrating optical reflectors or fins to increase efficiency in heating the pipes containing the water. These additions influence the cost of the SWH.

2.2.2. Unglazed flat-plate collectors

Unglazed flat-plate collectors are typically used for heating swimming pools. They consist of dark absorber material, mainly fine polymer tubes, without a cover or enclosure as shown in figure 6.

Figure 6. Unglazed SWH used for heating a swimming pool

Source: Retscreen International Text book (Aquatherm Industries / NREL Pix)

Flat plate collectors are designed for applications requiring moderate temperatures below 80ºC. They use both beam and diffuse solar radiation, which are discussed further in Chapter 5.

2.2.3. *Evacuated-tube solar collectors*

Evacuated-tube solar collectors are made up of parallel rows of transparent toughened glass tubes. Each tube contains a glass outer tube and inner tube with a heat pipe attached to an absorber plate as illustrated in figure 7. The absorber plate absorbs the heat and transfers the heat to the heat pipe. Heat loss is prevented because of the vacuum created between the two inner and outer tubes. The heat transfer fluid can flow through the vacuum tubes or to a manifold which connects all the heat pipes.

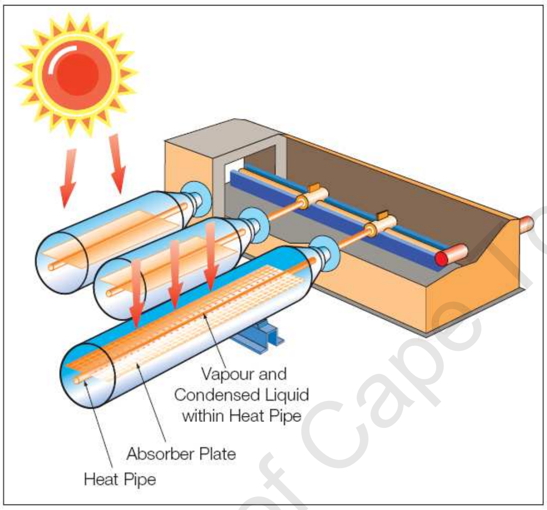


Figure 7. Illustration of an evacuated tube SWH system

Source: Retscreen International Text book (Natural-Resources-Canada)

Figure 8 shows how several tubes can be connected to a manifold to form a collector. Evacuated tubes are more efficient than normal flat plat collectors because they attain higher temperatures and emit low radiation.

Figure 8. Evacuated tubes

(Source: Sunpower)

2.3. Close-coupled collector storage systems

A Close-coupled system is a roof mounted solar hot water system which can be easily installed on tile, steel clad *or* flat roofs. It consists of the collector and an extra storage tank as shown in figure 9. No pumps or controller is required as the circulation of the hot water is achieved using the natural thermosyphon principle, *i.e.* direct circulation system.

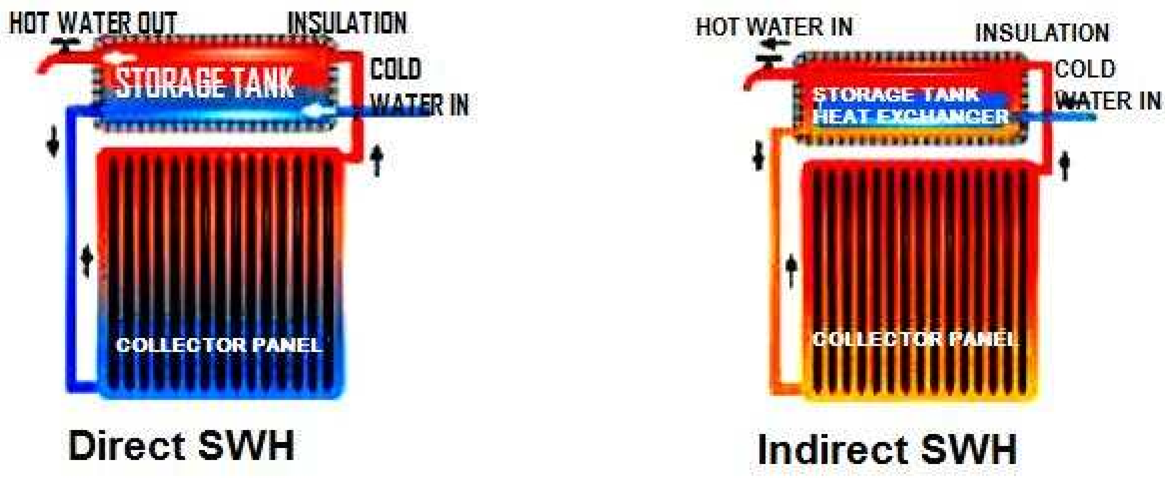
Figure 9. Typical flat plate SWH system

2.4. Direct circulation systems

A direct circulation system heats water directly from the sun and stores it in the tank. Direct systems are more efficient because they have low installation costs and have fewer components, making them easy to maintain. They work well in climates where ambient temperatures do not drop below 4°C.

2.5. Indirect circulation systems

The indirect system uses a heat exchanger to transfer heat from the solar collector to the water in the storage tank. The heat exchanger separates the potable water from the heating fluid such as glycol. The indirect system is mainly used in climate conditions where temperature drops below 4°C. It is also used in conditions where the water has chemicals in it, which are highly corrosive, or where high levels of lime. The indirect system is normally a closed loop pressurised system.



(Source: Solar Heating Canada)

Figure 10. Direct and indirect systems

2.6. Active System (pumped)

If the solar collector is higher than the storage tank, the cold water would have to be actively pumped into the SWH to circulate the water between the storage tank and the solar collector. The pump could be an AC or DC supply. In some cases photovoltaic cells are used to power the electric pump. The Active System is often used in large commercial and industrial applications because the size of the water tanks would make it difficult to install above the collector. The pump is either activated by temperature differential, light actuated or special computer software for large installations.

2.7. Passive Thermosyphon systems

Passive systems can be more reliable and normally last longer than active systems. The thermosyphon process is a convective process, where the water flows through the system due to the sun heating the water, causing it to rise as cooler water sinks. For the thermosyphon process to work, a collector must be installed below the storage tank so that warm water will rise into the tank. As illustrated in figure 11 the storage tank should be positioned at least 60 cm higher than the collector. The thermosyphon circulation flow may reverse on cold nights if the difference in height is too small between the storage tank and the collector. It could also have a non-return valve (NRV) installed to ensure that when a mixing tap is used, the pressure in the cold water is usually higher than the hot water pressure, and cold water can flow into the storage tank. The solar collector does act as a radiator at night and give off heat.

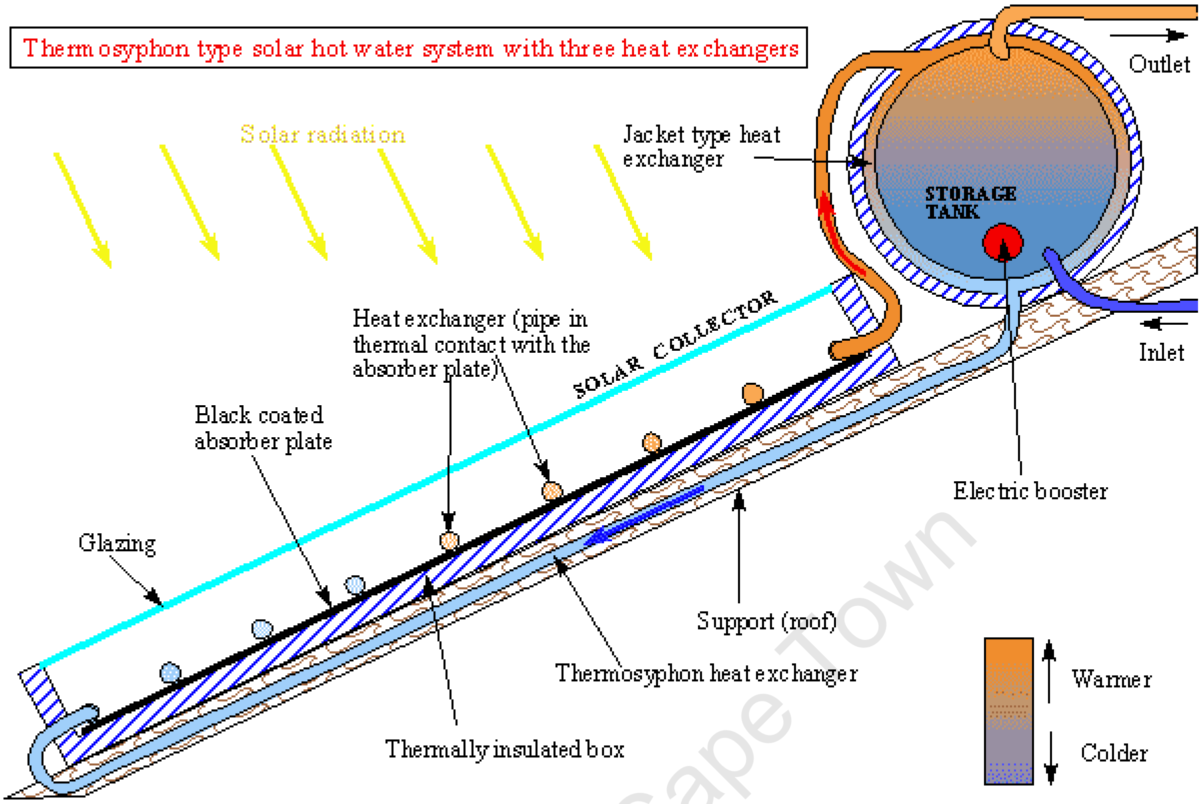


Figure 11. Illustration of the Thermosyphon effect

(Source: http://www.q-solar.com/)

2.8. Electrical backup

Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional hot water cylinders heaters usually have backup elements. A backup system may also be part of the solar systems, such as rooftop tanks with thermosyphon systems. The solar collector and tanks acts as a preheat system, where the water heated by the SWH system is fed into an existing hot water cylinder, which will normally have an electrical element. The preheated system has the advantage of making more stored hot water available. Figure 12 shows a schematic of a preheat system with a heat exchanger in case of an indirect circulation system under cold climate conditions.

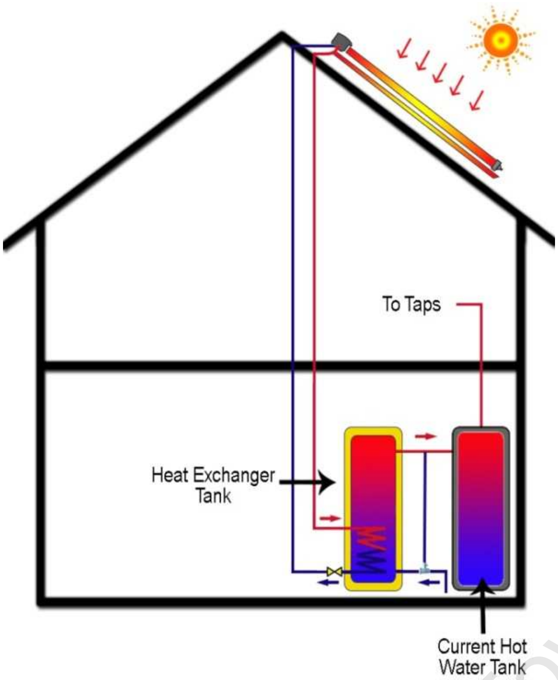


Figure 12. Schematic of a pre-heat system

(Source: Solar Heating Canada)

2.9. Collector Efficiency

Collector efficiency is used to determine the final thermal performance and sizing of equipment during installation. All suppliers of SWHs in South Africa must have their equipment tested at the South African Bureau of Standards (SABS). Refer to figure to 13 for the SABS test rig. The Eskom subsidy scheme uses the system's thermal efficiency as a determinant factor when calculating its subsidy.

Figure 13. Thermal efficiency test rig for complete SWH systems

(Source: SABS Pretoria)

Figure 14 graphically illustrates the thermal efficiency of the various types of SWH collectors.

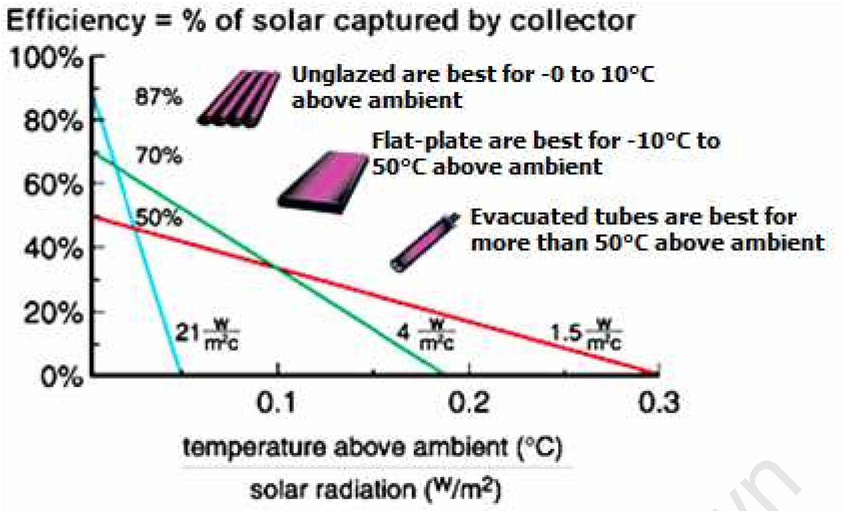


Figure 14. Graph illustrating the efficiency of the various types of SWH

(Source: WBGD solar water heating)

2.10. Collector orientation

The collector should ideally be installed facing true north at an angle to horizontal. Houses that have their roofs at the correct slope and orientated correctly can simply install the collector flat on the sloping roof. Some deviation either way from due north, and some variation in the angle of installation, will not make a great deal of difference to the performance of the SWH. (Suremann and Ledger, 2005: 43). However, on a flat roof, or if the unit is mounted on the ground, the collector will need a suitable frame for correct orientation. If there is no suitable north-facing pitched roof, a frame would have to be built to mount the SWH in the correct orientation as shown in figure 15.

Figure 15.Frame required for correct orientation

(Source: DUE conference [CEF Presentation])

Chapter 3

A REVIEW OF SOLAR WATER HEATING IN SOUTH AFRICA AND INTERNATIONALLY

This chapter presents a brief review of SWH in SA and internationally. The review is necessary to learn from the successes in overcoming the challenges when promoting SWH systems. This chapter will commence with a brief overview of the development of SWH in SA, and will examine international efforts to promote the use of SWHs. The estimated peak load reduction that could be achieved if SWHs are implemented on a large scale is also determined.

3.1. The development of Solar Water Heaters in SA

Solar water heaters have been designed and built since the 1930's in South Africa, making the country one of the leaders in SWH's early development and implementation. In 1956, Whillier contributed to solar energy work in SA by presenting several types of collector designs, performance curves, and an economical feasibility study (Eberhard, 1988).

During the period 1978-1983 there was widespread acceptance and installation of SWH because the government supported it through the Centre for Scientific and Industrial Research (CSIR). The CSIR developed effective communication strategies which motivated home owners to purchase SWHs either through home improvement loans or cash (Prasad, 2007). Karekezi and Ranja estimated that South Africa had more than 136 000 m^2 of installed SWH and a manufacturing history dating back to the 1970s. In 1977 there were approximately 85 manufacturers, distributors and installation companies for solar water heaters but only 59 companies remain by 1985 and 47 by January 1995 (Karekezi and Ranja, 1997). The SABS standard specification for SWHs was developed to improve the quality and reliability of the equipment. According to Stassen "at the end of 1985, only products of two local manufacturers complied with both the SABS standard specification for SWH (SABS 1307-1980) and the agreement certificate for solar systems." (Stassen, 1988).

In 1998 the total area of installed SWH in SA was estimated to be about 48 400m^2. The domestic SWH market in 2001 was estimated at 13 000 m^2/annum, which was approximately half of what it was 12 years ago, and market penetration was less than 1%. (Namibia. Ministry of Mines and Energy, 2005: 9).

From 1983 there was a sudden decline in the use of solar water heaters, which was mainly due to their high capital cost and the low c/kWh cost of electricity. Less than 1% of homes in South Africa had solar water heaters, although the weather conditions are favourable (DME, 1995: 164, 83). Another contributing factor was the lack of sustained government initiatives and standardisation, which led to the decline in product quality. One of the incidences that affected the solar water heater industry negatively occurred in 1982 during winter, when the temperature dropped to -4.2° C in Gauteng (Lukamaba-Muhiya, 2003). Most of the direct thermosyphon solar water heating systems failed, because they were incorrectly designed to withstand freezing temperatures. To prevent similar situations from occurring the standardisation of SWHs became important. The new standards, developed by the SABS, were the same for all the provinces. One of the criticisms raised by suppliers of SWHs was that the standard should differ for each province, as the weather conditions are different. For example, the size of hailstones in Gauteng is not the same as in the Western Cape.

Most solar water heater projects were targeted at subsidising domestic users. Austin and Morris (2005) have done extensive research on solar hot water supply to the low-income sector and registered their projects for Clean Development Mechanism (CDM) funding. Two well-known low-income SWH projects in the Western Cape are the Lwandle and Kuyasa projects. Lwandle is located in the Helderberg area in Cape Town, near Somerset West and houses consist of, amongst others, in former municipal hostels. The project started in 1999, where 295 units were installed. It was one of the largest low-income projects in SA and was completed in 2000. The project was not a success mainly because of three reasons:

1. No real community involvement;
2. No monitoring and maintenance contract was in place. Figure 16 shows the state of disrepair of some SWHs; and
3. Only some of the installed SWHs had electrical backup to heat the water during winter (Holm, 2005:35).

Figure 16. SWHs installed and not maintained

(Source: Steve Thorne Southern African SouthSouthNorth)

The City of Cape Town and the SouthSouthNorth organisation intend to retrofit 2 300 SWHs in Kuyasa, which is also a low income township in Khayelitsha. Funding of the project will come from CDM funding; already 10 houses were fitted with SWH as part of a pilot demonstration project. To complete the remaining SWH installation the City of Cape Town secured an additional R30-million from the national Department of Environmental Affairs and Tourism. The CDM funding is expected to cover about 15% of the expenses for this initiative (Jennings (b), 2007).

Most of the SWHs installed during the same period were to middle and high income households, because they could afford the high capital cost and to reduce their electricity costs. The amount of unglazed SWH systems for swimming pools has increased considerably while glazed SWH have stagnated. Most of the SWHs were funded via mortgage financing and, predominantly in the case of retrofits, supplier finance (Holm, 2005: 65-66).

In 2006 the SWH-500 project, funded jointly by the Central Energy Fund (CEF) and the United Nations Development Programme (UNDP), targeted the middle and high income sector for SWH installations. The project allowed for the subsiding of 500 solar water heating systems which were sold in the Cape Province, Gauteng and KwaZulu-Natal, on an equal split of 166 units a province over a six month period. The subsidy varied from R3 000 to R6 000 per unit, depending on the size of the unit and the date of purchase. Since the implementation of the programme in 2007 there was high interest in the SWH-500 project. In some of the provinces such as Gauteng, 167 SWH was sold within six weeks, but interest was slow in the Western Cape. The programme was seen as a test case in promoting SWH and the lessons learnt from it were used to implement the Eskom programme.

3.2. The current situation

With the current energy crises in South Africa, especially the Western Cape, new sources of electricity are being considered, including wind and gas turbines. The Western Cape has no coal and the only other sources of fuel are gas, diesel, and nuclear power. Eskom installed Open Cycle Gas Turbines (OCGT) mainly because the technology is readily available and has a lead-time of two to three years as opposed to the larger coal and nuclear stations that require 8 to 10 years lead time. The running costs of the OCGT are extremely high as they are designed to operate as peaking stations and for emergency situations but currently run as base load when the network is constrained. Nuclear power stations have a lead-time of approximately 10 years. Demand Side Management (DSM) can delay the need for such power stations by promoting electricity efficiency.

As part of South Africa's DSM programme, SWH is one of the mechanisms to reduce electricity demand. Eskom and the Central Energy Fund (CEF) have targeted the middle to high-income homes by providing a subsidy for the installation of SWHs. The programme is funded by the DSM fund, which is financed by a levy on the electricity tariffs, which is determined by the National Energy Regulator of South Africa (NERSA).

In June 2007 the Eskom Board approved an investment of R2,024 bn to provide a subsidy for SWHs over a 5 year period. This was a big step towards South Africa reaching its renewable energy targets. Commencing 1 December 2007, Eskom set a target to install one million solar water heaters over the next five years (Enslin, 2007). To achieve this objective the power utility must install 17 000 units per month. The implementation programme is an ambitious programme and is the largest implementation programme in the world The Eskom subsidy scheme, which is currently being implemented, forms part of the DSM programme. The

programme has been successful in some areas, but has been slow in getting SWHs sold using its subsidy scheme.
It has, however, created a huge interest amongst consumers. The main reason why consumers don't use the subsidy scheme because they believe the subsidy is not high enough.

Since the Eskom rollout, few SWH installation companies have been approved by Eskom. Those companies that have been approved increased their prices, resulting in the Eskom subsidy to consumers being negligible. Suppliers not on the Eskom-approved list are installing SWH at a much cheaper rate than those who are receiving the subsidy. The main reason for this is Eskom's quality control measures: the extra costs for load control equipment, the fact that the HWC must be a high pressure system, and must not be older than three years. One way of preventing such sudden increase in prices would be to increase the number of approved suppliers, which would create competition among suppliers.

The Eskom subsidy programme has also changed in a short period of time. In the initial stages of the programme the SWH supplier would have to give the discount to the customer upfront and then claim the money from Eskom. For various reasons, the suppliers were not happy with this format:

- they ran the risk of not receiving the subsidy if the installed system did not conform to Eskom's standards,
- delays in receiving the subsidy, and
- excessive and time-consuming paperwork to complete.
- certificate of compliance.

Currently, the customer pays for the complete SWH system upfront and claims the rebate, as shown in figure 17.

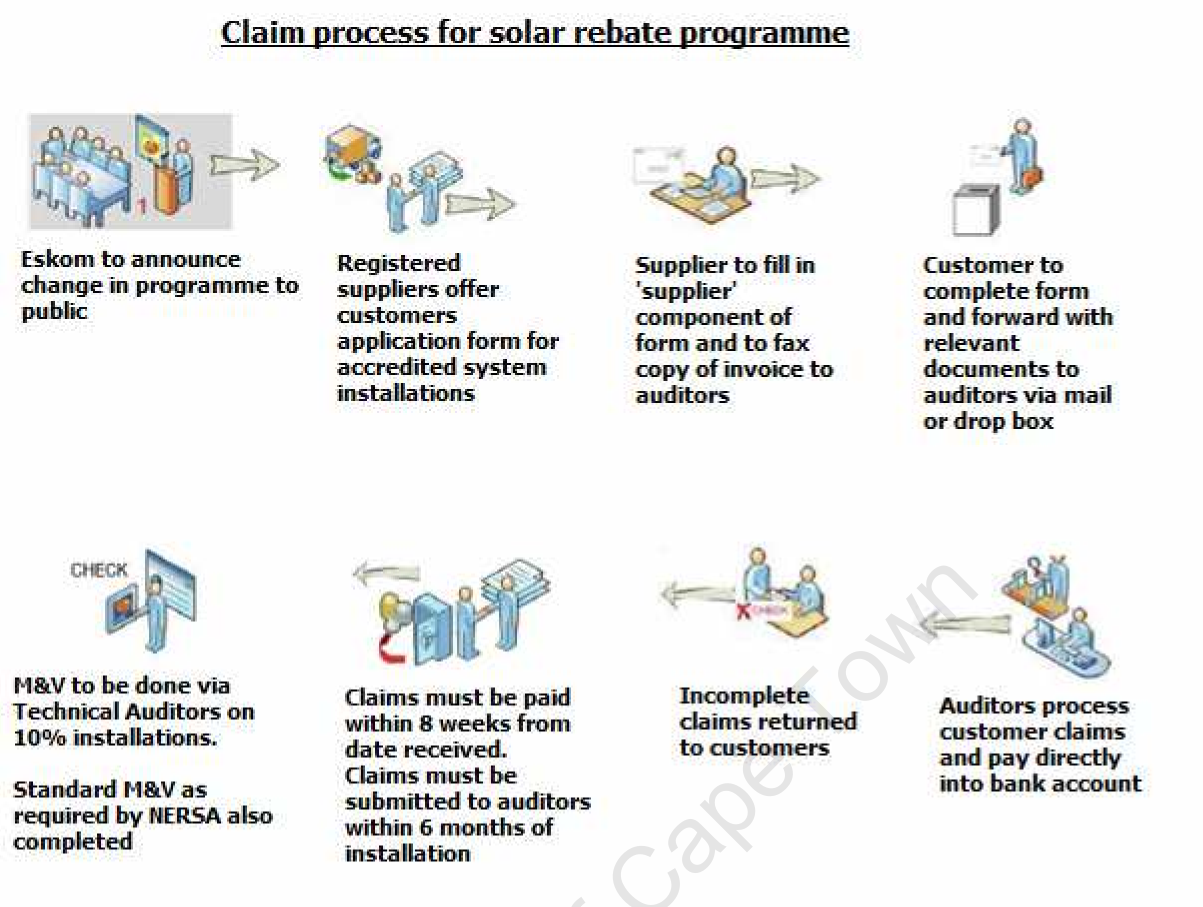


Figure 17. Claims process for Eskom solar rebate programme

(Source: Eskom solar water heating programme)

The capital cost of solar heaters is high− between R4 500 and R30 000. Although low-income households have the highest potential for electricity savings using SWH, the high capital cost makes it difficult to promote to this sector of the market. Another barrier for low income households is the ability to obtain bank loans. Therefore, the Eskom subsidy scheme targets the middle to high-income homes. SWH funding for low income homes will most likely be financed through the CDM.

A review of how other countries have successfully implemented their SWH programmes will provide information on mechanisms for implementing the SWH programme more efficiently in SA and the Western Cape in particular.

3.3. International SWH programmes

The steady expansion of the global market for SWH can primarily be attributed to an increasing concern over climate change and its associated problems. In other parts of the world, awareness of the benefits of SWH is growing, and developed and developing countries alike are increasingly adopting the technology. The European Union (EU) has consistently exceeded targets for SWH adoption, and many other nations have embraced it strongly. In Israel, approximately 80% of the residential buildings are equipped with solar thermal systems, and in Turkey, over 630,000 m^2 of SWH collectors are installed each year (Milton and Kaufman, 2005: 12). Countries like China has over 3 000 manufacturers servicing its domestic market (ESTIF, 2003).

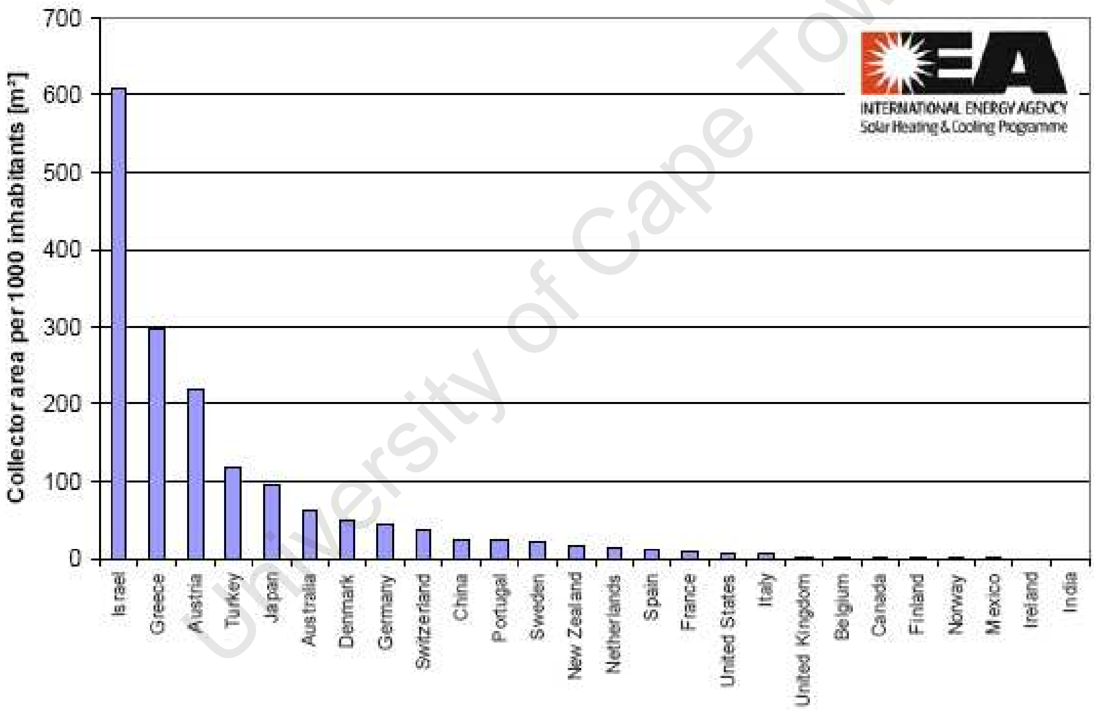


Figure 18. Bar graph collector area per 1 000 inhabitants per country (m^2)

(Source: International Energy Agency (IEA) W. Weiss, AEE INTEC (2001)

3.3.1. *Israel*

The bar graph in figure 18 shows that Israel has the most installed SWH per 1000 inhabitants mainly because of the law called the “Solar Law” which was introduced in 1974. It required that SWH be installed in all new buildings (including residential buildings, hotels and institutions, but not industrial buildings, workshops, hospitals or high-rise buildings). It has been estimated that over 80% of domestic homes have solar water heaters, representing over 1.3 million installations. The solar contribution is equivalent to 21% of the electricity used by the domestic sector, 5.2% of national electricity consumption and each year approximately 100 000 new domestic homes are constructed and fitted with SWHs (McChesney, 2005). This law encouraged the growth of the industry which resulted in the high-volume manufacture of SWH and created an economy of scale. The downside of the effect of compulsory installation was that the market was driven by building contractors who wanted to cut costs by pushing for low budget and low quality systems (East Harbour Management Services and Energy Library and Information Services, 2002: 34).

3.4. The progression of SWH in various countries

The growth rate of SWHs in a country is one the indicators of a successful roll out programme. A review of the aspects of various countries' incentives to promote the use of SWHs can inform South Africa's own SWH programmes. Some of the incentives are highlighted in table 1.

Country	Growth Rate (% pa)	Incentives
China	Over 20% for 3 years	Government – promotion, research and standards
Spain	19%	National Solar Obligation 2006
France	44% in 2002/3 134% in 2003/4	40% tax incentive > 50% in 2006
Australia	19% in 2003 11% in 2004	MREC Act 2000

Table 1. Growth rate of SWH in various countries

3.4.1. China

China's dominance in the SWH industry can largely be ascribed to the fact that they have replaced the flat plate collector with the evacuated tube solar collector. The process began in 1995 when the Chinese ensured that their technology had caught up with developed countries through research and development (Thompson, 2005). They instituted a renewable energy policy. By 2006, the coverage of solar energy water heaters in operation in China reached 90 million square meters, and the annual production capacity had exceeded 20 million square metres. Now over 95 percent of new SWH technologies are developed by China.

SWHs have become one of the most commercialised clean energy technologies in China, with nearly one in 10 households owning one (Xinhua News Agency, 2007). The high growth rate of SWHs and local competition amongst suppliers have resulted in a better quality SWH and a decrease in price. The high growth rate of SWH in China is not due to subsidies or low interest loans but because competition amongst manufacturers, which has caused price decreases. In 2006, five million SWH systems were produced by 3 000 manufacturers. In 2000, 70% of the manufactured SWHs were flat-plate and the balance was evacuated tube. In 2005, 10% of the manufactured SWHs were flat plate and balance evacuated tube. The manufacturing of evacuated tubes has grown to such an extent that individual companies are now exporting their products to obtain higher profits.

3.4.2. Spain

In Spain the "Solar obligations" government regulations required that the minimum share of the heating demand for new buildings and/ or buildings undergoing renovation use solar energy. The City of Barcelona was the first to enforce the regulation in 2000, which led to a dramatic increase in the use of SWHs. The regulation enjoyed the wide support of the public and decision makers. Therefore, the revision approved in 2006 increased the number of obligated buildings and improved the procedures, architectural integration and quality requirements. The revised solar obligations regulation was implemented under the Spanish Technical Buildings Code "Código Técnico de la Edificación" (CTE) that was passed in, 2006. It prescribes the installation of solar technology in new buildings and buildings undergoing renovation. (European Renewable Energy Council, 2007).

3.4.3. France

The Guaranteed Solar Results concept (GSR) was used in France as a response to the lack of confidence in the SWH performance in 1998. The GSR was a contractual arrangement between the client energy user and the SWH supplier/developer that wanted to guarantee the performance of a SWH installation. The client, through the GSR, was guaranteed that the SWH system would provide the hot water expected. If the installation did not conform and perform according to the standard set out in the guarantee, the client would be compensated financially for the failure. This removed any concerns about system maintenance and repair, as the onus remained on the contract provider to maintain the system so that it would perform to the agreed standard (McChesney, 2005).

In 1999, the French Agency for the Environment and Energy Management (ADEME) launched the “Helios” or “Plan Soleil”− a medium-term solar thermal development plan (six years), allowing for the rapid growth of SWH in France. It encouraged the purchase and use of solar systems by means of subsidies and financial aids. A quality insurance policy (QUALISOL) was initiated to improve quality of the product and installation. ADEME initiated a national communication campaign including a public toll-free phone number. (SOLMED II, 2007).

In 2005, the French government encouraged the purchase of solar systems with a tax rebate, and use of SWH began increasing significantly. The Tax reduction provided additional financial support for the SWH industry. Value Added Tax (VAT) was reduced from 19.6% to 5.5%, as well as the tax rebates until the end of 2002, which reduced material costs by up to 15%. In Jan 2006 the level of the tax break was raised to 50%. (Berner, 2006: 48).

3.4.4. Australia

The Renewable Energy (Electricity) Act 2000 allowed the Australian government to finance solar thermal systems by means of Renewable Energy Certificates (RECs). The incentives are confined to replacing electrical heating systems for domestic applications, new commercial applications, and systems where gas is not substituted.

Australia had experienced a boom in SWH installation because of government support for a Tradable Renewable Energy Certificate (TREC) system designed to reduce the amount of coal burned to generate electricity for domestic water heating. These TRECs were used to reduce the price of SWH systems. In 2003 SWH industry grew by 19% and in 2004, 11% but the growth rate has currently flattened out because the subsidy for the TREC has since declined. (Berner, 2006: 48). The TREC market was mainly financed by the electricity companies and bulk consumers such as ESCOs.

3.4.5. Tunisia

The growth of the Tunisian market was due to the World Environment Fund (WEF), a project financed by both the World Bank and Belgium, and run by the National Agency of Renewable Energy Sources (NARES). The project consists of granting a 35% subsidy of the investment cost of a SWH, thus making it more cost competitive than other systems using conventional energy sources. Figure 19 shows the growth of SWH market in Tunisia from 1985 to 2001. By the end of 2001, the number of installed SWH was estimated at 60 000 m². (Investment Promotion Unit Tunisia Sector of Renewable Energy Sources April 2002)

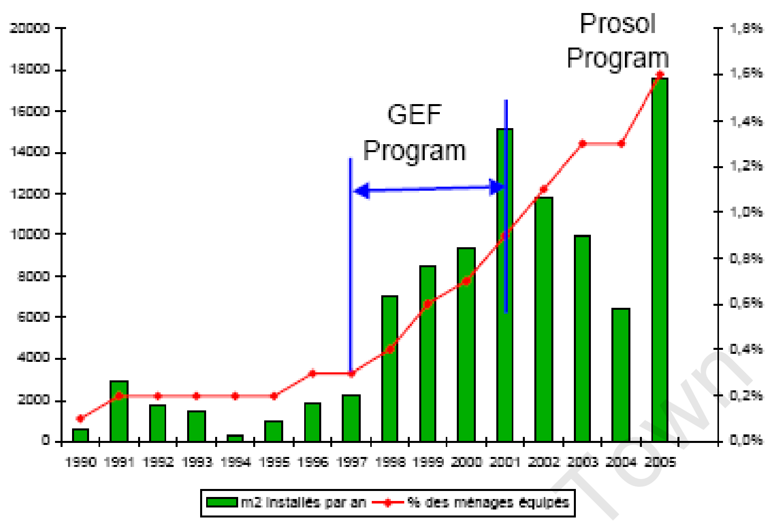


Figure 19. Growth of SWH market in Tunisia since 1985 – 2005

Source: Enerdata from ANME

Removing financial incentives too early may affect the market:

The Global Environment Facility (GEF) programme had stimulated demand from 1997 to 2001, with direct financial incentives, no custom duties, no VAT on SWH, provision of training, access to information, and quality assurance through standards. Subsidies were then discontinued. The PROSOL TUNISIA (Solar promotion for Tunisia), was implemented in February 2005. The discontinuation of subsidies had negatively impacted the sales of SWHs until the implementation of the new PROSOL. The main features of the PROSOL were:

- loans repayable over a 5-year term,
- repayments were done through utility bills,
- a capital cost subsidy for each SWH provided by the Tunisian Government.
- discounted interest rates on the loans i.e. the interest rates dropped from 13% to 7% due to the utility involvement. The interest rate subsidy facility would then be progressively phased out.

3.4.6. Botswana

The Botswana government promoted SWH in public institutions such as teacher housing, defence housing, government offices in rural towns and prisons. Some projects, such as Jwaneng Mines which installed 2 000 SWHs, were funded privately. There is still a lot of potential in both government buildings and private households in Botswana. This potential is not utilised because there is no legislation that encourages the installation of solar water heaters, particularly in government buildings. However, the Department of Building and Engineering Services (DBES) has taken a stand that for every building they supervise, a solar water heater (industrial or household) will be part of the package (Lukamba-Muhiya, 2003).

3.5. SWHs success in peak load reduction

One of the benefits of implementing a SWH programme is that it can shift electricity demand if all the hot water cylinders were electrically backed up. Research done by Tim Merrigan and Danny Parker from the Florida Solar Energy Centre (FSEC) found that electrical demand taken over at 15 minute intervals showed that normal electrical HWCs contributed approximately 1.1 kW of diversified demand to the utility during winter peak and at least 0.2 kW to the summer peak. Solar hot water systems exhibited the most desirable demand profile relative to a Florida utility. Peak loads with a 0.7 kW per household reduction in the winter and a minimum 0.2 kW per household reduction in the summer were experienced. These figures were calculated from research done over a two year period in 18 households in Florida (USA) from 1982 to 1984 (Merrigan and Parker, 1990).

Similarly McChesney found that in New Zealand on average, for every SWH that is installed, 0.5 kilowatts of peak demand per household is deferred from a utility's load. (2005: 53). According to Pandaram, after notch tests [3]were done by Eskom in 1997 the assumed peak demand reduction (after diversity) was 0.625 kW per household (which is close to what McChesney found in New Zealand of 0.5 kW of peak per household). (Pandaram, 2006: [1]).

According to Janisch the City of Cape Town has set targets for household penetration of solar water heaters of 10% by 2010 and 50% by 2020 in their energy strategy for 2006 (2007(a):

[3] Hot water load control tests used to calculate the change in electricity demand by switching off and on a group of hot water cylinders

[7]). His research into modelling in Long-range Energy Alternatives Planning (LEAP),[4] has shown that achieving SWH targets in Cape Town would result in a cumulative saving of more than 5.5 million MWh of electricity by 2024 and would reduce peak power demands by 385 MW in 2024. (Janisch, 2007(b): 10). With 50% penetration of SWH in the Western Cape it will equate to approximately 13% of Koeberg Nuclear power Station's capacity (238MW).

3.6. Conclusion

A brief overview of the Solar Water Heating programme in SA and internationally has been presented. South Africa is in the early stages of the SWH mass roll out, and a number of challenges have been identified. South Africa can benefit from the international experience with mass roll out of SWHs. Areas for improvements have been highlighted in this thesis.

International quality standards and the SABS for SWH have been developed to improve the manufacture quality of the SWH to build consumer confidence, but it should be noted that with improved quality comes increased costs. Raw material such as copper[5] has increased in price but with increased competition the price of SWH might stabilise or decrease.

This chapter has demonstrated that government should take the lead in promoting SWHs. Currently Eskom is driving the mass roll out. This is not the ideal situation, as the SWH programme is focused more on meeting our renewable energy targets rather than reducing electricity demand.

A growing number of South Africans are becoming environmentally conscious, and with media focusing on climate change the popularity of SWH will only improve.

The next chapter will discuss the common barriers to promoting SWH on a large scale.

[4] The LEAP modelling programme was developed by the Stockholm Environment Institute (SEI), Boston centre and used to evaluate energy development policies. It is an advanced software package for energy planning and climate change mitigation.

[5] The price of copper has increased four times during the period between October 2000 and October 2006

Chapter 4

PROMOTING THE USE OF SOLAR WATER HEATERS

This chapter discusses the various initiatives to promote the use of SWHs. Firstly it will highlight the common barriers to implementing SWH programmes, then review each barrier with various initiatives implemented by other countries to overcome these. Finally, its application in a South African context will be considered, particularly in the Western Cape.

Some of the most common barriers to promoting SWH on a large scale are listed below and will be discussed in more detail:

1. High capital cost. Lack of accessible finance and investment.
2. Standards and certification in the manufacturing and installation of SWHs.
3. Training for designers and installers by recognised training intuitions such as energy Sectoral Education and Training Authority (SETA) and tertiary institutions.
4. General lack of awareness and confidence in SWH technology.
5. Acceptance into government policy and planning.
6. Production volume restrictions.
7. Lack of coherence within industry.

4.1. Reducing high capital cost

Reducing the capital costs is one of the main barriers to the promotion of SWHs. Prospective customers are always comparing the cost of a normal electrical hot water cylinder to SWHs. Under normal circumstances it will always be the standard hot water cylinder that is chosen, as the initial capital outlay is considerably less than SWHs. With special funding such as subsidies, low interest loans and tax incentives, SWHs become very competitive. Each of these funding mechanisms will be explored in more detail.

4.1.1. Subsidies and low interest loans

Financial institutions such as banks could be subsidised to provide low interest loans or develop finance mechanisms for easier pay back. According to Afrane-Okese (2005), even with 30% capital subsidy on SWHs in the State of Karnataka in India, it could not entice new manufacturers or potential clients. With the introduction of low interest subsidies, it enticed banks to finance SWH programmes, which lead to a growth of manufacturers from less than 6 to 60 in 2005. In the early stages of SWH development in South Africa most installations were financed by home loans and cash for the middle to high income homes, therefore it will not be difficult to implement such a loan scheme again.

An added benefit of involving Eskom and financial institutions in funding SWHs is that the quality will improve, as manufacturers will have to work closely with these institutions in order for their systems to be qualified under the SWH programme. Currently there are a few banks offering personal loans for the installation of SWHs but there are no financial institutions providing interest-free loans or providing a highly reduced interest rate.

In the United States, some of the states have a policy that they will subsidise the interest rate by granting half of the loan at 0% interest. Therefore, the total interest from the borrowers' perspective will be half the interest rate obtained from their financial institutions (Afrane-Okese, 2005).

4.1.2. Tax exemptions

Chapter 3 shows that tax exemptions can encourage the installation of SWHs. In France the SWH market had increased steadily since 2003. 2005 saw a dramatic rise in SWH installations because the government encouraged the purchase of SWH systems using a tax rebate. Buyers were able to deduct 40% of the material costs from income tax which could be a significant advantage over the subsidy system as there is no need to wait for approval from a grant-providing authority before installing.

In South Africa the tax incentive system can also be implemented as it would be the same as completing the Income tax form to claim for money given to charity or for having a retirement annuity. The Finance minister of South Africa, Trevor Manuel, announced some steps towards addressing this issue where businesses and individuals are encouraged to invest in renewable energy. Section 12B of the Income Tax Act provides some tax relief for the generation of electricity from renewable energies such as, wind, sunlight, micro hydro and biomass comprising organic wastes, landfill gas or plants.

Another tax incentive could be a tax relief for the manufacturers and importers of SWH systems since there are not enough manufacturers to meet the demand for SWHs. The target set by Eskom is 17 000 installations per month. In order to keep up with demand for SWHs it would be cheaper and easier to import the SWH panels and raw material. By providing a tax exemption for the SWH companies supply will catch up with demand.

4.1.3. ESCOs and Solar Water Heaters

An energy service company (ESCO) identifies and evaluates energy-saving opportunities. ESCOs can help fund SWH projects for industrial units, commercial complexes, hospitals and governmental buildings, among others. The ESCO will guarantee that savings would meet or exceed annual payments to cover all project costs such as the "Guaranteed Solar Results" scheme applied in some European countries. If the savings do not materialise, the ESCO will have to pay the difference and not the client or the company implementing the project. ESCO services are guaranteed through implementation, monitoring, measurement and verification.

Figure 20 illustrates a flow diagram for possible funding using an ESCO. According to Volschenk (2007), banks may finance credit sales to clients or may enable manufacturers to operate as ESCOs. He explains that these two initiatives have the advantage that manufacturers gain access to more clients and may gain financially through the income from clients, either through interest or from service fees. In a service company model most of the risk is carried by the ESCO, and not by the bank.

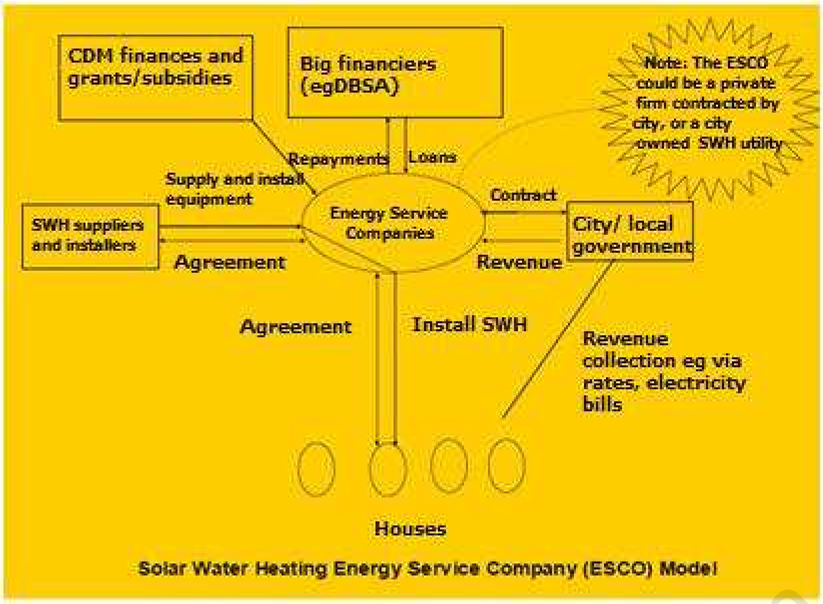


Figure 20. Flow diagram of possible funding of SWH Energy Services Company Model

(Source: Sustainable Energy Africa)

Figure 20 illustrates a flow diagram of possible funding using ESCOs. Using the Model developed by the Sustainable Energy Africa (SEA), ESCO can be financed by big financiers such as the Development Bank of South Africa (DBSA). The Bank could provide the ESCOs with low interest, long term loan to make loan repayments easier. The ESCO can secure funding by obtaining CDM funding, grants or subsidies from Eskom.

The ESCO will have an agreement with the SWH Company, to supply and install solar water heaters. An ESCO could be a developer for an energy-efficient, low carbon footprint housing development. The home owners will pay the ESCO a monthly fee to pay off their system, or the total cost of the SWH system could be included in the home loan. In the case of a government initiative such as the Kuyasa project the municipality will enter into a contract agreement with the ESCO to have the SWHs installed, and the money will be recouped though electricity bills or revenue collection.

The City Council can use the project as a marketing and awareness tool to show how well a solar water heating programme can work.

4.2. Quality assurance standards for SWHs

In the past the SWH industry was not regulated and many "fly by night" manufacturers were selling inferior products. Due to this lack of regulation the SWH industry suffered due to loss of confidence in the technology. Standards have since been developed to ensure that solar water heaters are manufactured to operate in South African conditions and that they are installed correctly.

Local manufacturers will have to conform to SABS standards and imported SWHs will have had to pass international SWH standards.

4.2.1. SABS standards implementation in SA

The SABS Standards have been written so that the SWH performance is aligned to South Africa's climatic conditions. There are two standards:

1. the SANS 2005-1307, which caters for both mechanical and thermal testing with emphasis on compliance to building regulations; and
2. the SANS 6211-1, which is a thermal outdoor test.

For a SWH supplier to be accredited the system should comply with the following standards as shown in Table 2.

	SANS NUMBER	DESCRIPTION/TITLE
1	SANS 1307:2005 (SABS 1307)	Residential solar water heaters
2	SANS 6210:1992 (SABS SM 1210)	Residential solar water heaters – Mechanical qualification
3	SANS 6211-1: (or part 2)	Residential solar water heaters Part 1: Thermal performance using outdoor test method (part 2 is an indoor test method)
4	SANS 60335-2:2000 (SABS 1307)	Safety of household and similar electrical appliances – Safety Part 1: General requirements
5	SANS 151: 2002	Fixed Electrical storage water heaters

Table 2. SABS standards required for a SWH supplier to be accredited

(Source: Eskom SWH training manual)

The total cost for testing in 2007 is shown in table 3.

Test	Price
Mechanical Strength Test SANS 1210:1992	R 21 750
Thermal – Outdoor test SANS 6211-1:2003	R 14 800
Total per Unit	**R 36 550**

Table 3. Testing cost of SWHs

(Source: DUE Conference 2007 (SABS Presentation)p.34)

According to a presentation done by the SABS at the Domestic Use of Energy conference (DUE) in 2007, the commercial testing cost per unit is R36 550. During the CEF 500 programme the testing was subsidised at R 7 250 per unit. With support from SABS, the SWH industry will ensure that quality standards are upheld. Suppliers can obtain a test certificate which is valid for 12 months. There is also a test to get the mark of approval which is valid for three years.

Solar Water Heater manufacturers have to submit two identical units because one is mounted on a rigid movable stand and the second is mounted on a test rig. The duration of the test is approximately one month. The testing laboratory produces a test report (not SABS approval). The test report is used as part of Eskom's subsidy programme. The SABS currently has an inventory list of suppliers who want their SWH systems tested, but this has a three-month backlog.

Should a supplier wish to import SWHs and have them SABS approved, a factory visit by SABS staff is required, which will be the importer's expense. To prevent the importing of inferior SWH collectors custom officials should work together with the SABS for inspectors to check imported consignments before they are released. A list of internationally approved suppliers could be made and only SWH supplied from these manufacturers will be accepted into South Africa

In future the building regulations will require that all SWHs installed need be SABS tested. Systems which have not been SABS will not be covered by the home owners' insurance policy.

All tanks would at minimum be tested in accordance with the SANS 60335, which will be controlled by the building regulations. Once the installation standards become regulated then all other standards will become regulated.

4.2.2. International standards

Solar water heater manufacturers normally manufacture their SWHs to the International Standards for Quality Assurance ISO 9001:2000. The manufactured SWHs are expected to have their performance tested and certified according to ISO. The ISO standards cover all solar water heaters, electric boilers and solar panels.

The SWHs are tested according to the following international standards:

- ISO 9459-1 SDWH Performance Rating using Indoor Test Methods
- ISO 9459-2 SDWH Performance Test for Solar Only System

The collector's performance is certified by ISO 9806-1 and the collector's reliability is certified by ISO 9806-2-3 (Eurostar-Solar).

The thermal performance test procedures are based on:

- ISO 9806-1:1994, Test methods for solar collectors – Part 1: Thermal performance of glazed liquid heating collectors including pressure drop, International Organization for Standardization, Geneva, Switzerland.
- ISO 9806-2:1995, Test Methods for solar collectors – Part 2: Qualification test procedure, International Organization for Standardization, Geneva, Switzerland.
- ISO 9806-3:1995, Test methods for solar collectors – Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop, International Organization for Standardization, Geneva, Switzerland.

- ANSI/ASHRAE[6] Standard 93-1986, "Methods of Testing to Determine the Thermal Performance of Solar Collectors," The American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

(Source solar-rating.org)

Countries that have adopted the ISO Procedures are:

- Australia-ISO 9459-4
- Europe-ISO 9459-5
- China-ISO 9459-2 (simplified)
- USA-ISO 9459-1 and ISO 9459-4
- Taiwan, Korea, Japan –ISO 9459-2 (modified)

Source (Solar Thermal Energy Laboratory, The University of New South Wales)

4.3. Training and support

Training is important for the development of the SWH industry. A code of practice is being drafted with the SABS and The Sector Education and Training Authority of South Africa (SETA), which is a government organisation that manages learnership programmes. The programme combines theory at a college or training centre with relevant practical training. Each training module is assessed against a set of occupational standards that have been agreed by the SABS and relevant industry stakeholders. The training will allow the SWH industry to assess the competency and skill levels of workers. The competency level can then act as financial incentives which are related to their salary grade.

Training can act as support for Black Economic Empowerment (BEE) companies, black technicians and entrepreneurs, who should be encouraged to set up SWH companies. After initial support the BEE companies can gain technical and managerial experience so that they can compete in the market. (Prasad and Visagie, 2006: 4).

Tshwane North College has been contracted by CEF to develop the training manuals and has been allocated to the Cape Province, Gauteng and KwaZulu-Natal to train installers, but most manufacturers have their own in-house training programmes or use contracted installers.

[6] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

The accrediting authority should ensure that the correct people are given recognition for their work done in the solar industry. There is also a need for formal qualification to enhance accountability for quality of installation work and establish a minimum expertise requirement.

Currently installers are required to be registered with an SABS approved SWH supplier for the complete system to receive the Eskom subsidy. Bad installation of SWHs can cause consumers to lose confidence and cause the failure of the SWH industry.

4.4. Creating awareness

Internationally, it has been found that the major barriers to implement a solar water heating programme is that there is a general lack of awareness amongst the public and government, which results in ineffective policies and a lack of motivation to change. The following steps could be taken to create awareness of the benefits of installing SWHs:

- Brochures, websites and multimedia could be developed to demonstrate the effectiveness of using solar water is and explain the different types of funding mechanisms.
- Regular workshops could be held with engineers, architects and plumbing associations. These workshops would allow for networking, advertisement for the various solar technologies, and updates on the latest information in the Solar Water industry.
- Use visible support from key political and social figures to elevate the status of SWH through demonstration, workshops, radio and TV talks where the key figure portrays support for SWH.

4.5. Government policy actions (by-law)

In Israel the “Solar law” which was an amalgamation of different legislative measures in the 1980’s, allowed for the planning and building law required for the installation of solar water heaters for all new buildings (including residential buildings, hotels and institutions, but not industrial buildings, workshops, hospitals or high-rise buildings). This facilitated the installation of solar water heaters into more than 80% of domestic homes.

The City of Cape Town proposed bylaw (refer to Appendix II), based on that developed by Israel, which would apply to all new buildings in Cape Town. Under the proposed bylaw, most new buildings and those undergoing renovations will be required to meet at least 60 percent of their water heating requirements with solar heaters. It will also apply to all additions to existing buildings which will require the use of hot water (e.g. bathrooms, bedrooms with en-suite bathrooms and kitchen extensions). The bylaw will be phased in to give the municipality, industry, building contractors, architects and others time to prepare. There is currently a lack of supportive legislation and there is not enough legal capacity to enforce the bylaw. The current solar water heater suppliers do not have enough capacity to support the bylaw.

4.6. Production volume restrictions

Currently, there is a production volume restriction because there are not enough local manufacturers to meet the future demand for SWH. As mentioned before, there are few SABS approved manufacturers in South Africa and they will not be able to supply enough SWH in the short period of five years. Importing of SWHs would be the next option. To ensure that the industry is regulated and inferior products are not imported they would have to be SABS approved or conform to the ISO standards. The importers of SWH systems will benefit if they use approved SWHs because they can participate in Eskom's subsidy scheme.

Importing SWHs will not have a negative effect on the job market for the Solar Water Industry. In fact more employment will be created because the prices of SWHs will drop due to increased competition thus creating a bigger market and therefore more installers will be required. Coupled with certified training programmes this can have a positive effect on employment and promote entrepreneurship and economic growth.

4.7. Creating coherence

It is important to have coherence in the SWH industry. The Sustainability Energy Society of South Africa (SESSA) has played a leading role in streamlining the renewable energy industry. SESSA was founded in 1964 as a non-profit organisation and is one of 50 National Sections of the International Solar Energy Society (ISES). ISES has members in over 100 countries and SESSA is the African office of ISES.

SESSA has recently established a SWH division and its function is to keep a register of members who consistently maintain a high standard for their products and installations.

SESSA also provides informal education and training. SESSA has played a supportive role in the CEF 500 programmes and is currently closely involved with the Eskom subsidy scheme.

4.8. Conclusion

In most of the literature consulted there are common barriers to the implementation of SWHs. For the SWH heating programme to be effective there has to be a partnership between government and industry to address the issues mentioned in this chapter. Government's responsibility is to meet the national environmental and energy policy. Government can provide financial assistance through tax incentives and reducing import duties. By speeding up the implementation of the SWH bylaw, it will compel the building industry to accept it as a hot water heating technology. Industry will be forced to incorporate SWHs in their designs.
To prevent the import of inferior SWHs, custom officials should notify the relevant authorities to inspect the imported products. Systems which are sold without SABS tests might be considered as illegal and will not be covered by their home owners' insurance policy.

This chapter has also highlighted the role ESCOs can play in the disseminating SWHs by working together with the building industry and financial institutions to make SWHs affordable.

Chapter 5

MODELLING OF SOLAR WATER HEATERS

This chapter presents an overview of the modelling process to determine the optimal subsidy to reduce the payback period. The chapter starts with an explanation of the basic factors which must be taken into account when modelling performance, then the data from the computer simulation model is compared to actual data collected through Eskom's SWH programmes, and finally the optimal subsidy is calculated.

5.1. The modeling process

A model was developed in Excel using the hourly global radiation data for Cape Town to calculate the average demand savings per household. A comparison of the theoretical data input with actual solar data can provide a better estimation and improve confidence in the results of the process.

The author modelled the performance of the SWH as a simple solar collector and cylinder into which radiant energy from the sun heats a solar collector, which supplies preheated water to an existing hot water cylinder. It was not possible to accurately model the SWH performance due to the different manufacturers of SWH units, the size, orientation of the SWH unit, the amount of cloud cover experienced in a particular location, and the way the hot water is used. Each of these factors influences the performance of SWH and will be discussed in this chapter. The aim is not to accurately model SWH but to get a relatively accurate estimated value which will give a fair picture of the expected savings that can be achieved if solar energy is used to heat water as opposed to conventional electricity.

5.2. Hourly Global Radiation data for Cape Town

The amount of solar radiation reaching the outside of the earth's atmosphere equals 1 367 W/m² and is known as the solar constant. Solar Irradiance hits the surface of the earth in two forms: beam (Gb) and diffuse (Gd). The beam component comes directly as irradiance from the sun, while the diffuse component reaches the earth indirectly and is scattered or reflected from the atmosphere or cloud cover. In this way the formula for total irradiance on a surface is G = Gb + Gd (University of Strathclyde, Energy Research Unit [ESRU]).

The amount of energy delivered to a SWH system on a particular day is dependent on the amount of incident solar radiation and is usually measured with a pyranometer. Research done by Muhlenbruch and Tegen at the Energy Research Institute at the University of Cape Town compiled a solar radiation database for South Africa, which could be used by solar installation designers.

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	0	0	0	0	0	0	0	0	0	0	0	0
6	52	18	2	0	0	0	0	0	0	9	41	64
7	215	153	75	18	1	0	0	8	42	116	192	225
8	413	348	251	134	59	34	47	97	182	293	388	418
9	598	538	444	298	190	143	166	241	346	476	576	599
10	763	712	610	447	316	262	291	374	485	620	739	751
11	892	835	737	558	416	352	381	471	595	745	859	872
12	964	906	799	621	470	395	432	524	659	813	922	940
13	965	916	802	620	472	397	441	524	670	824	927	958
14	914	855	743	568	424	352	394	479	621	776	868	899
15	797	742	625	463	329	265	301	384	511	657	758	796
16	638	580	455	312	198	149	177	247	367	503	606	642
17	444	378	262	143	63	37	49	99	194	314	414	454
18	234	168	74	17	1	0	0	7	40	123	208	251
19	58	20	1	0	0	0	0	0	0	8	45	73
20	0	0	0	0	0	0	0	0	0	0	0	0
Average Total per day	**7947**	**7169**	**5880**	**4199**	**2939**	**2386**	**2679**	**3455**	**4712**	**6277**	**7543**	**7942**

Table 4. Hourly global radiation for Cape Town for the whole year (Wh/m²)

(Muhlenbruch-Tegen, 1988)

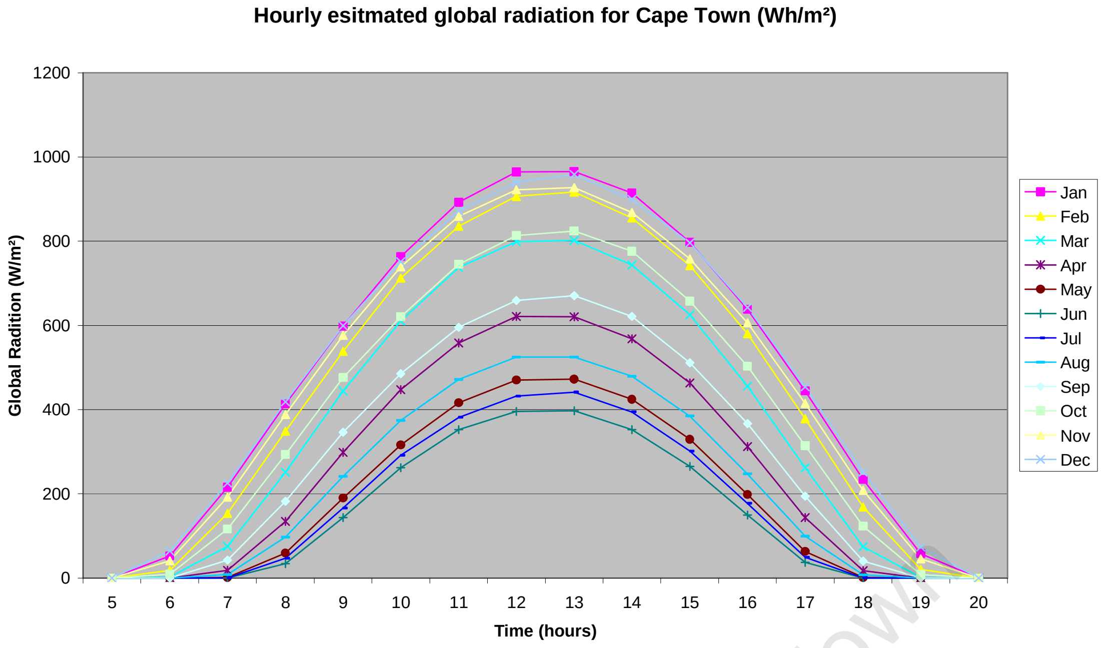


Figure 21. Graph of hourly estimated global radiation for Cape Town

Data obtained from tests done by Eskom show that the solar radiation differed slightly as illustrated in figure 21, showing a graph for the month of April. Although there is a difference in the mean estimated data and the actual data the author will use the estimated solar radiation data for estimating the energy savings expected in Cape Town. Eskom's test unit would have been setup similarly to that in figure 22.

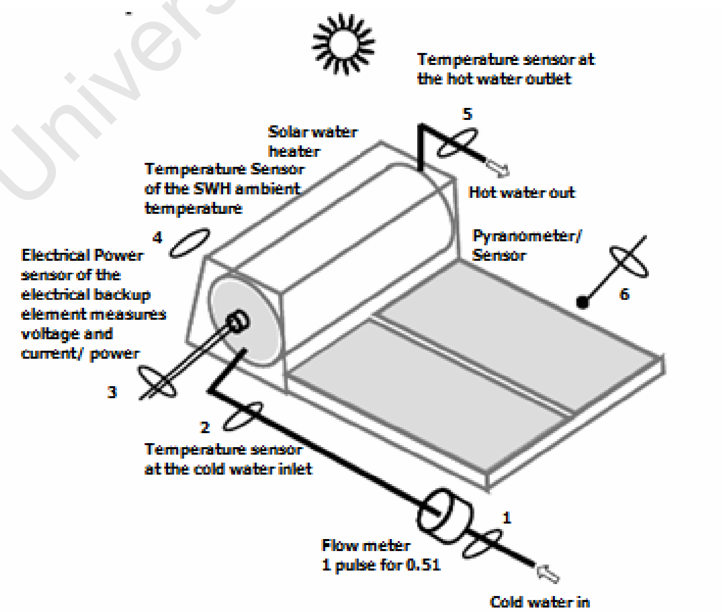


Figure 22. Typical SWH testing setup for monitoring

Source: (Dintchev, O.D, 2007)

When comparing data obtained from Eskom and the estimated Solar radiation data there is a clear difference between the mean and the estimated data. However if we take a typical day, like the 4th of April, there is a close relationship with the estimated solar radiation data for the month of April.

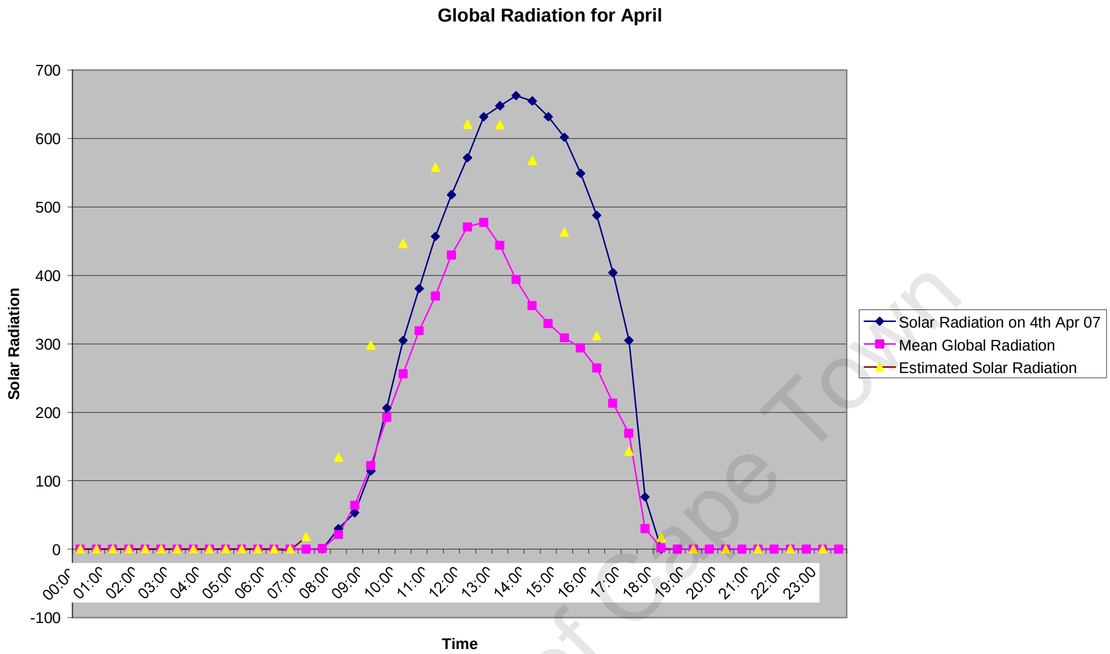


Figure 23. Global Radiation for April 2007

When comparing the data for January 2007, the actual global radiation and the mean global radiation compare closely but the estimated solar radiation data does not. The reason for this is that the solar radiation is related to weather patterns and seasonal variations which differ annually. By averaging out the data a more accurate estimation is obtained for calculation purposes.

It would therefore be better to use the mean solar radiation data for the month than an individual day of actual solar radiation data for the month when calculating estimated savings. Solar companies use an average solar radiation value for the whole year which does not reflect the true savings i.e. refer to Appendix III for calculations used by Solardome SA. A more accurate method would be to use the mean solar radiation data.

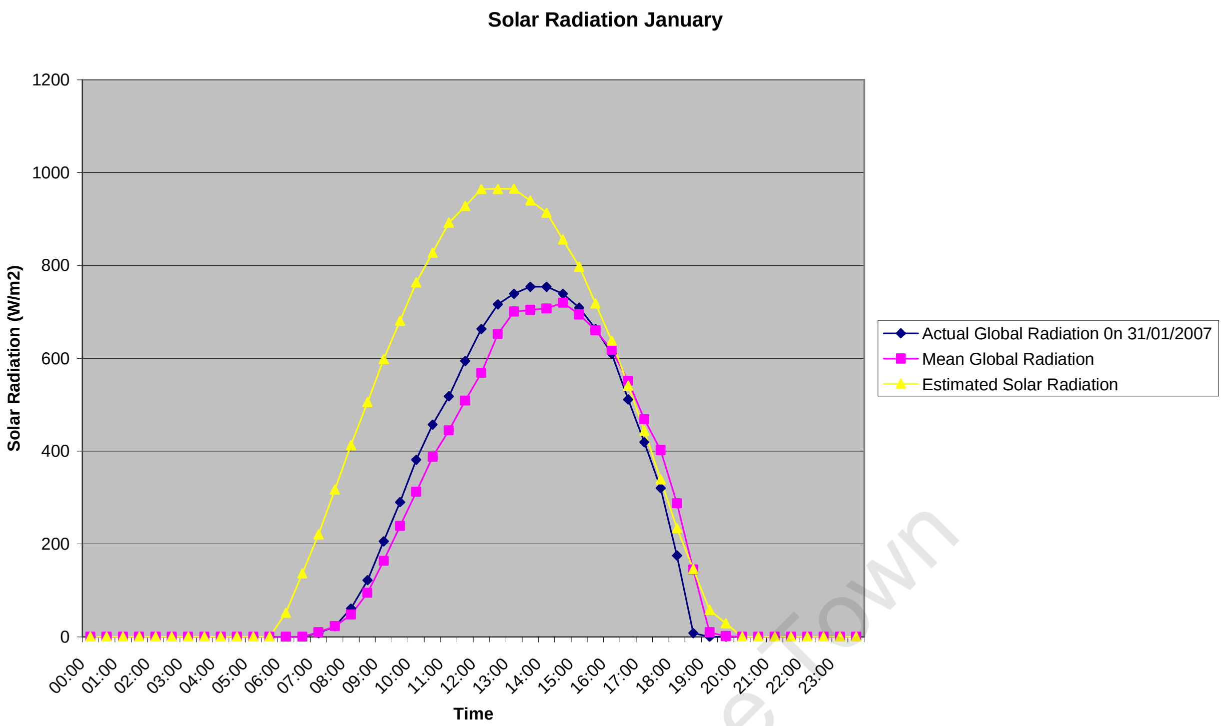


Figure 24. Global Radiation for January 2007

5.3. Daily hot water consumption

Hot water consumption varies for every household and depends on the number of people living in the house. The following questions are normally asked:

a) How many people live in the house?

b) Do they shower in the morning and bath at night?

c) When does their clothing and dishes get washed?

SWH installers usually allow 50 to 100 litres per person per day. However, it is generally accepted that in an average household, each person uses approximately 50 litres of hot water per day. (Tasol Solar, 2008)

The daily hot water consumption patterns for an average household and energy required to maintain the hot water varies. For example the average hot water temperature that a human body can handle is between 36 °C and 42°C, therefore the set temperature of the hot water systems is important. More hot water is used if the set temperature of the HWC is at 45°C versus being set at 60°C, because the mixture of hot and cold water determines how much hot water is consumed. The SWH provides preheated water to the HWC inside the home. With electricity backup the consumer still saves because the preheated water temperature is higher than using cold water directly from the mains. (Beute and Delport, 2006).

5.4. Sizing a SWH water system and collector

To determine the size of a SWH system, the installer has to calculate the total collector area and the storage volume so that most of the hot water supplied will meet all the household hot water requirements. It is important to select and invest in the correctly sized system because over-sizing will be costly and under-sizing will not produce the savings expected.

The first step to saving electricity is to size the hot water system according to the household daily usage, which will allow for a single reheat period per day during overcast weather conditions. By sizing the hot water cylinder and collector correctly the backup electrical element will not be on continuously to keep up with hot water demand. A rule of thumb used by most SWH installers is that one square metre of the solar heat collector will heat about 100 litres of water, depending on orientation and location. The daily consumption of hot water will differ from person to person according to individual taste; however, the average daily consumption could be as follows:

ACTIVITY	CONSUMPTION
Bathing:	50 - 60 litres per bath
Wash basin:	5 litres per person per day
Showering:	20 - 30 litres per shower
Dishwasher:	1 – 2 litres per meal served
Hand washing:	3 litres per meal served

Table 5. Calculated average consumption per average household:

(Source: Total solar website)

When sizing for a household of four people then:

Daily hot water requirement:

50 litres (1 bath) + 60 litres (3 showers) = (110 litres)

Hand basins:

5 litres per person per day = (20 litres)

Dish washing (assume 2 meals at home daily)

3 litres per meal = (4 x 3 x 2 = 24 litres)

Add heat loss due to cold water

(mixing and standing losses @ ±20%) =244 litres x 200000 (48.8 litres)

No washing machine added

Total hot water requirement @ 60ºC = 200 litres per day

Remember: Extra volume makes allowance for cloudy days.

(Source: Tasolsolar website)

5.5. Logged data for a typical flat plate SWH

Logged data for a typical flat plate SWH in the Western Cape. The graph below shows all the data for a particular day.

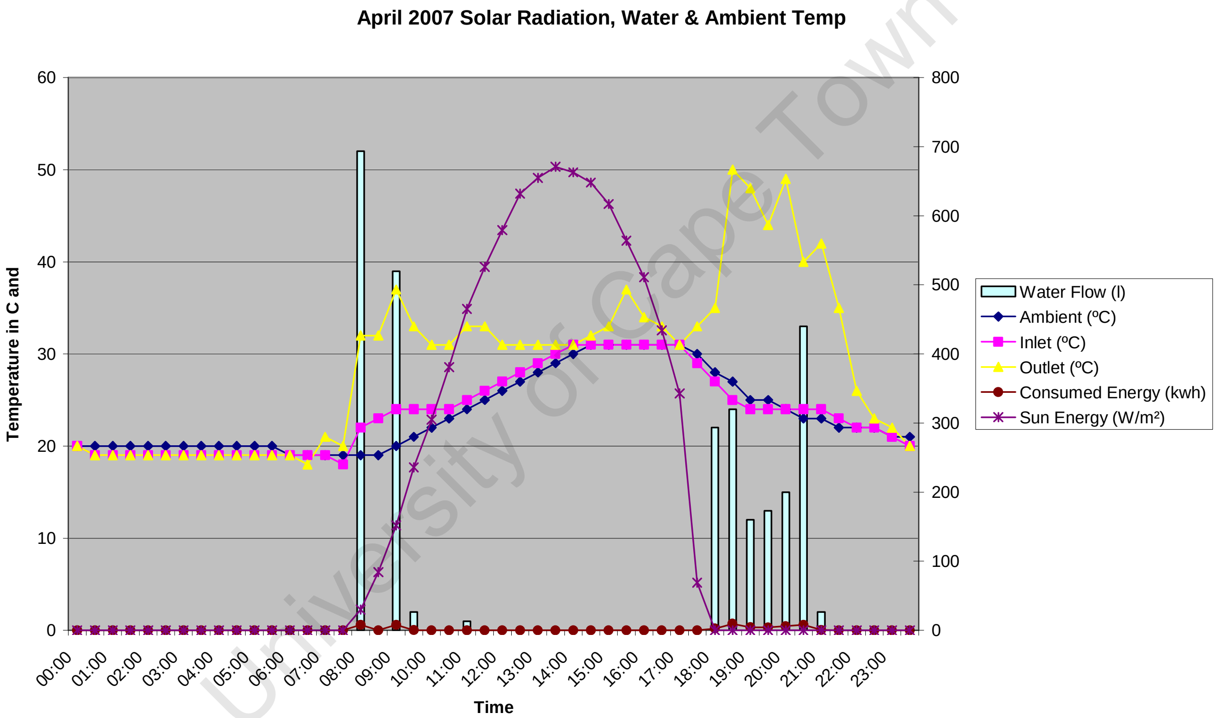


Figure 25. Graph showing all the data that was being monitored

(Source: Data for graph obtained from Eskom Research Department)

Figure 25 illustrates that the high hot water consumption occurs in the morning and evening. Hot water consumption is high mainly due to people taking showers, therefore the hot water temperature does not drop significantly. The electrical element switched on three times for a short period proving that SWH does save electricity as well as reduce electricity demand.

5.6. Computer simulation model for flat plate SWH

Previous assessments of energy reduction were usually based on f-chart predictions (Duffie and Beckman, 1991) of monthly performance and are based on average temperature and radiation values for the given month. Most simulations and calculations of SWH are based on the transient simulation programme (TRNSYS). TRNSYS is a simulation programme developed at the University of Wisconsin Solar Energy Laboratory. TRNSYS has gained worldwide acceptance as a result of its modular construction and due to the availability of the code in the public domain. The modular nature of the code means that it can be readily extended to include new energy devices and systems.

To develop a simulation package suitable for Australian solar water heating products, the Solar Thermal Energy Laboratory at the University of New South Wales has extended the TRNSYS code. It includes many of the unique features that have been developed by Australian water heater manufacturers. The modified code is referred to as TRNAUS. (Morrison and Tran, 1992).

The author has not used this software as licensing is required to use it and is beyond the scope of this thesis.

5.7. Theoretical background to modeling of a typical flat plate SWH

5.7.1. Computer simulation model for flat plate SWH

The sun path varies across the sky, determining the amount of solar radiation reaching the earth’s atmosphere. The sun path also varies with seasons as well as where the solar water collector located on the earth. The sun’s position is described by its elevation above the horizon, altitude, and by its bearing from the true north, azimuth. As shown in Figure 26 which is the sun path for countries in the northern hemisphere, which is different for South Africa in the southern hemisphere. It is important to place a SWH collector in a northerly direction to gain maximum exposure to the sun path. In summer, the sun path slopes at 45º and in winter at 30º. Most installers use 35º to the horizontal due north to maximize the use of the solar radiation during winter.

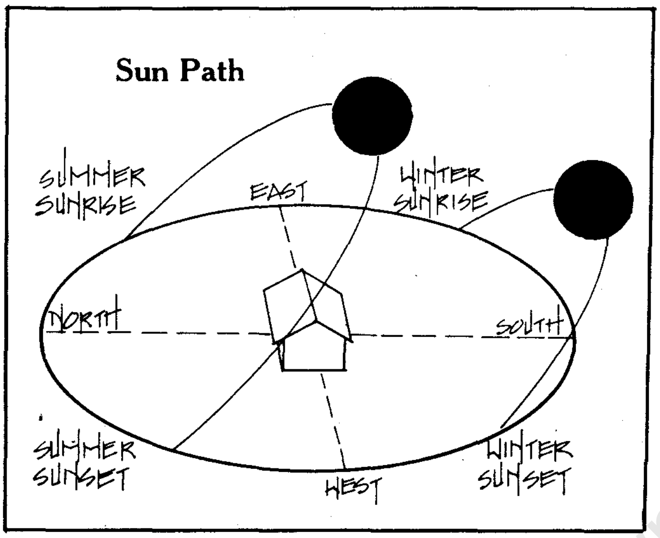


Figure 26. Sun path for countries in the northern Hemisphere

(Source: Bainbridge, 1981)

5.7.2. Orientation SWH

The slope angle (β) of any collector is defined as the angle between the plane of the collector and the horizontal. The azimuth angle (γ) is defined as the displacement angle between the projection on the horizontal plane of the normal to the collector surface due north. The incidence angle (θ) is the angle between the direct radiation on a surface and normal to that surface. For maximum direct radiation, the incidences angle should be a minimum. Figure 27 shows these various angles. (Bari, 2000).

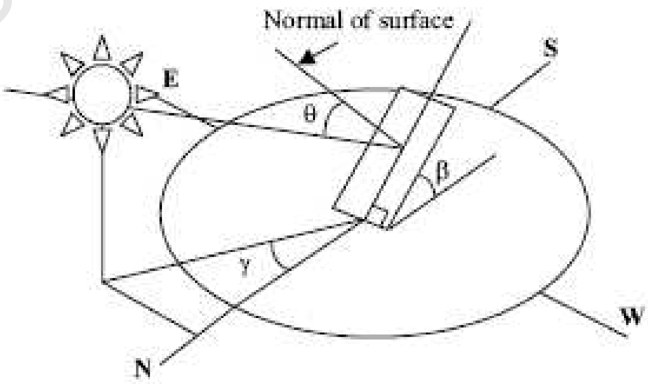


Figure 27. Major Angles in solar application

(Source: Bainbridge 1981)

It is important to install a SWH collector in the correct collector orientation and inclination. In the southern hemisphere like Cape Town, the collectors should face true north. If the collector cannot be installed facing north, an orientation facing slightly west is more advantageous than east, due to higher ambient temperatures in the afternoon.

A deviation of 45° east or west will have no major effect on the collector efficiency. However, deviations greater than this will require extra square metres of collectors to compensate for solar losses.

Before installing a SWH, an area for the collector must be selected and sun angles and shadowing must be considered. The solar altitude at a point on earth is the vertical angle between the sun and the horizontal plane. Sun angles are used to predict shading patterns that can cause obstructions. When a solar collector area is shaded it would be better to have no collector at all. If shading is experienced between 09h00 and 15h00, then another position should be located. A simple rule of thumb used by installers when calculating shadowing from obstacles during winter position the solar collector twice the distance away from the obstacle, at the actual height of the obstacle. This is true for areas of higher latitudes such as Cape Town.

Partial shading by chimneys, television antennas on buildings during sunshine hours is acceptable, provided that it does not exceed 10% of the area. Shading from newly erected buildings should be checked and if system performance is affected, relocation of the SWH may be necessary. *(Tasol Solar installation guide).*

5.7.3. Performance of SWHs

The performance of SWH not only depends on the solar energy absorbed by the collector, but also on factors such as thermal energy lost from the collector to the surroundings by conduction, convection and infrared radiation, tube spacing inside the collector, the geometry of the collector, material properties etc. Bari found in his study of SWH in Malaysia that most of the collectors were incorrectly installed and they received 10-35% less radiation than a properly installed collector and in some extreme cases they received as little as 50%. (Bari, 2001: 1206).

5.7.4. Collector aperture area

To determine the optimum collector area, the installer first has to determine the household's hot water needs. From the information the installer would refer to Table 6 to find the correct flat plate collector aperture. It is normally safer to design a system which is slightly larger than the minimum specification but when over-sizing, the payback period increases as a larger collector costs more and the efficiency of the system drops.

Household Size	Hot water cylinder size	Flat Plate Collector Aperture
1 person	100 Litre	1.3 m^2
2-3 persons	150 Litre	2.1 m^2
4 to 5 persons	200 Litre	2.9 m^2
5 or more persons	300 Litre	5.2 m^2

Table 6. Minimum flat plate collector size per household

5.8. Theoretical Modelling of SWH

A basic solar collector consists of a collector plate which absorbs solar energy, creating heat. In order to maximise the quantity of solar energy collected by the collector it should have a high:

(a) Absorption value: dictates how well the collector absorbs solar radiation to heat the water.

(r) Reflectance value: is the reflectance factor which represents the reflected heat from the collector.

(t) Transmission value: allowing full irradiance to fall on surface

Materials used in solar collectors have three characteristics when used in relation to solar energy. These three characteristics are:

Transmission (t), Absorption (a) and Reflectance (r)

For a given material the total of these characteristics should equal 1. **(t + a + r = 1)**

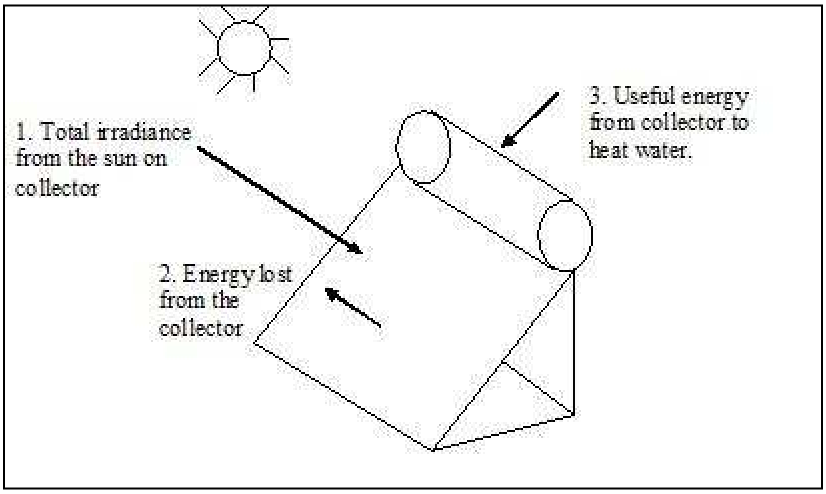


Figure 28. Energy balance used to model SWH performance

Useful energy from collector to heat water =

Total irradiance (energy) from the sun on collector - Energy lost from the collector.

This is basically the efficiency of the collector:

$$\frac{\text{Useful energy from collector to heat water}}{\text{Total irradiance (energy) from the sun on collector}}$$

Collector efficiency will be tested by the South African Bureau of Standards and for the purpose of the exercise we assumed the efficiency to be 60% which will account for the loss energy lost from the collector.

The irradiance G (Wh/m²) from the sun is given by the following heat equation:

$$G = \frac{Hc \times Sh \times Ce \times (\text{delta } Tw)}{3.6 \times A}$$

G = total irradiance (Wh/m²)

A = area of solar collector (m²)

Tw = temperature of water in the collector plate

Ta = ambient air temperature (K)

Ce = Collector Efficiency (60%)

Sh =Specific Heat of Water (4.2 kJ/kg.K)

Hc = Hot water cylinder size (litres)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Cold Water	26	25.5	24.5	20	16.5	14	13.5	14.5	16.5	20	23	25	℃
Ambient Temp	21.8	22.1	19.4	17.3	16.8	15.2	14.2	14.5	15.5	17.5	19.4	20.8	℃

Table 7. Cold water temperature and ambient temperature

To calculate the temperature profile for a SWH at 60% efficiency with no hot water draw-off, the above formula was used iteratively to calculate the approximate maximum temperature of the water in the collector. The first iteration uses the ambient temperature as the temperature of the water and heated up by the sun to find the next iteration. A profile was developed for each month of the year using the hourly global radiation (Wh/m²) for Cape Town, as shown in Table 8. The graph in figure 29 represents the calculated performance of a 150 litre hot water cylinder with a collector area of 2.1 m².

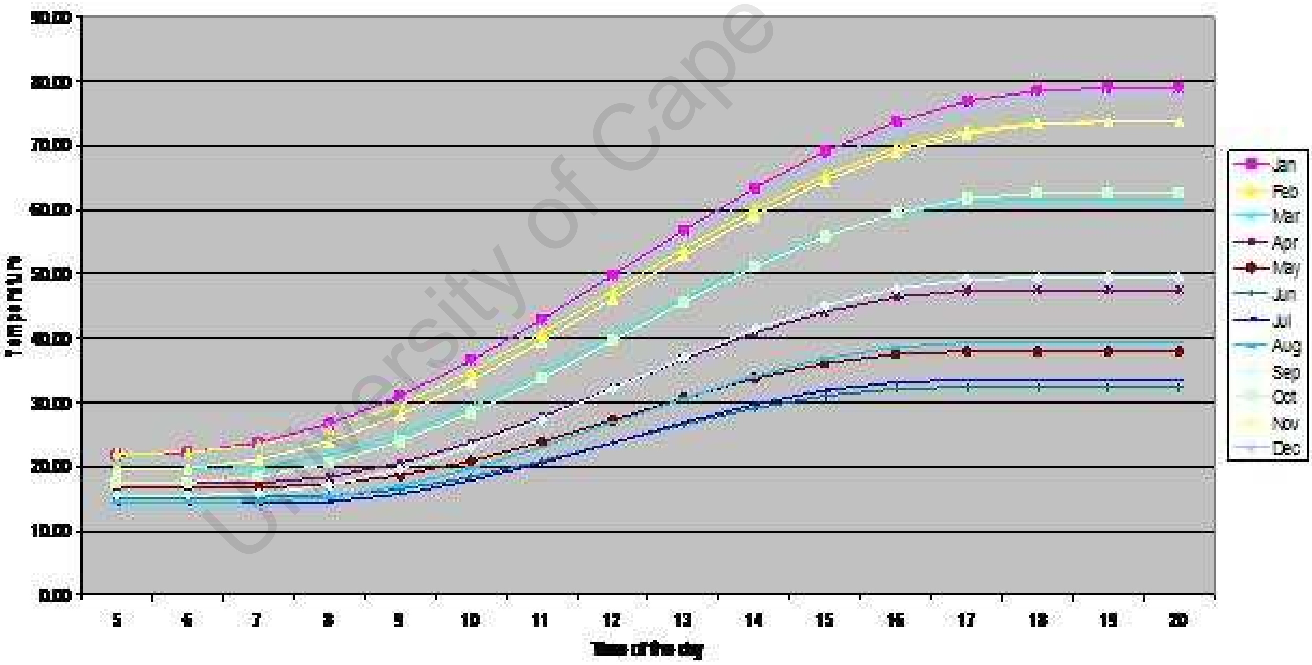


Figure 29. Temperature profile of solar water heater with no draw off

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total kWh per month	246.4	200.7	182.3	126.0	91.1	71.6	83.0	107.1	141.1	194.6	226.3	246.2
Assuming 60% efficiency	147.8	120.4	109.4	75.6	54.7	42.9	49.8	64.3	84.8	116.8	135.8	147.7

Table 8. Total kWh savings per month at 60% efficiency

The total cost for supplying and installing SWH varies depending on the type of panel and manufacturer. The cost in table 9 is used as an illustration to calculate the approximate total cost.

Hot water cylinder size	Collector Aperture	Collector Cost	Installation Cost	Total Cost
100 litre	1.3 m²	R 5,985.07	R 3,800.00	R 9,785.07
150 litre	2.1 m²	R 4,319.97	R 3,800.00	R 8,119.97
200 litre	2.9 m²	R 5,252.64	R 3,800.00	R 9,052.64
300 litre	5.2 m²	R 8,964.90	R 4,000.00	R 12,964.90

Table 9. Approximate total cost for supplying and installing of SWH

(Source: Solardome SA, 2007)

To calculate the approximate Rand savings per month the cost of electricity was assumed to be 50c/kWh in 2007, as shown in Table 10.

	Jan	Feb	Mar	Apr	May	Jun
100 l	R 96.08	R 78.29	R 71.09	R 49.13	R 35.53	R 27.92
150 l	R 155.20	R 126.46	R 114.84	R 79.36	R 57.40	R 45.10
200 l	R 214.33	R 174.64	R 158.58	R 109.59	R 79.26	R 62.27
300 l	R 384.32	R 313.14	R 284.36	R 196.51	R 142.13	R 111.66

	Jul	Aug	Sep	Oct	Nov	Dec
100 l	R 32.39	R 41.77	R 55.13	R 75.89	R 88.25	R 96.02
150 l	R 52.32	R 67.48	R 89.06	R 122.59	R 142.56	R 155.11
200 l	R 72.25	R 93.18	R 122.98	R 169.29	R 196.87	R 214.20
300 l	R 129.56	R 167.08	R 220.52	R 303.56	R 353.01	R 384.08

Table 10. Approximate Rand savings per month

Assuming that the cost of electricity to be 50c/kWh in 2007:

Note that there is some saving in electricity in winter i.e. (June, July and August)

The total savings per annum is shown in table 11, which does not take into account that the unit price of electricity increases annually.

Year	Total Savings per annum
100 l	R 747.48
150 l	R 1,207.47
200 l	R 1,667.46
300 l	R 2,989.93

Table 11. Total Savings per annum

The simple payback period is calculated by dividing the initial cost divided by the savings per month. By providing a subsidy between R4 000 and R5 000 the payback period has reduced from 5 to 2.5 years as shown in Table 12.

Subsidy	R 0	R 2,000	R 3,000	R 4,000	R 5,000	R 6,000
100 litre SWH System	13.1	10.4	9.1	7.7	6.4	5.1
150 litre SWH System	6.7	5.1	4.2	3.4	2.6	1.8
200 litre SWH System	5.4	4.2	3.6	3.0	2.4	1.8
300 litre SWH System	4.3	3.7	3.3	3.0	2.7	2.3

Table 12. Simple payback period with subsidy

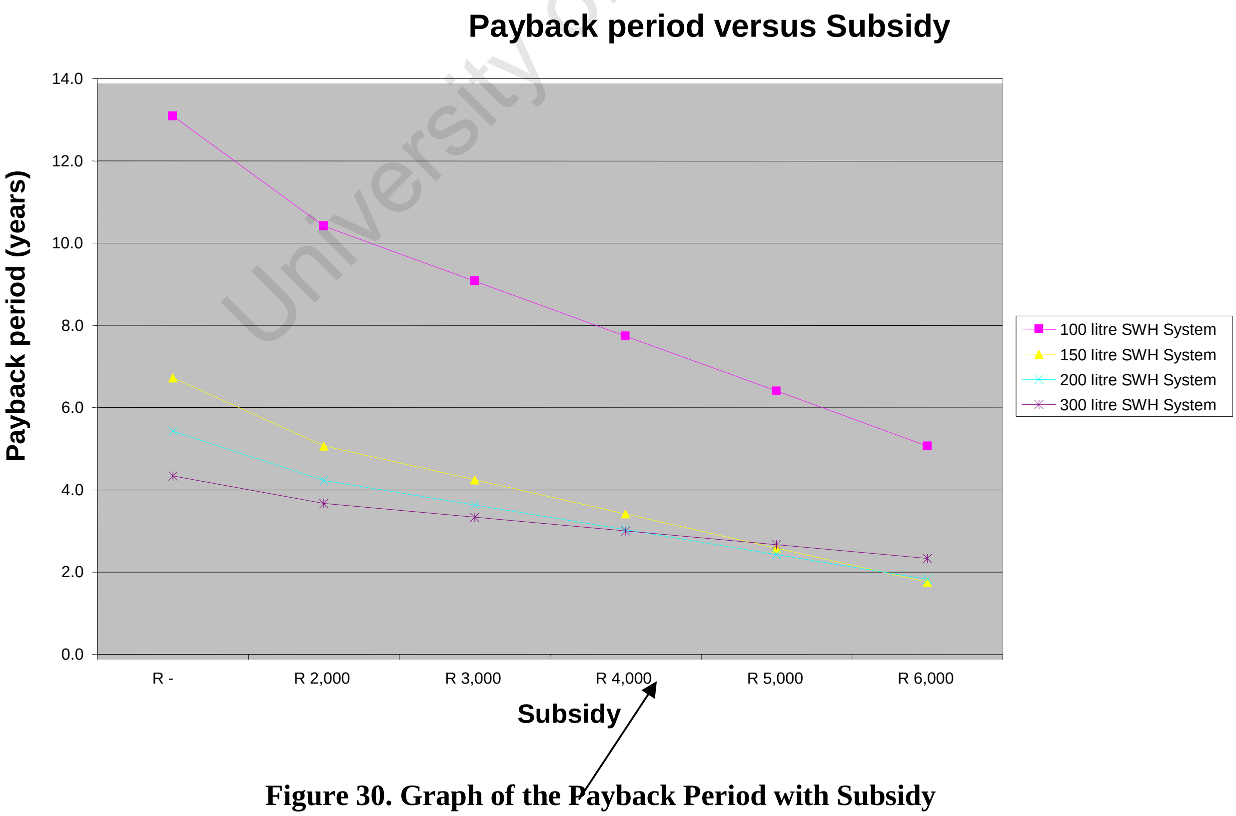


Figure 30. Graph of the Payback Period with Subsidy

By providing a subsidy of R4 300 the payback period would be approximately 2.7 years.

5.9. Conclusion

Most homeowners and businesses look for a simple payback period of three years but figure 30 shows that the payback without a subsidy is normally five years and more dependent on the hot water usage, price of electricity and type of solar water heating system.

SWHs are not competitive in price with the normal hot water cylinder because of the high capital cost. However, if loan repayments are made over five years with low interest rates then SWHs will become competitive as the home owner will now be saving on electricity costs.

Generally there is a lack of confidence in the economic performance, quality and long term reliability of SWHs. To change this, suppliers of SWHs need to backup or provide proof of savings and reliability. From the different websites consulted to calculate the approximate savings expected, many used the same $kWh/m^2/year$ for all regions, which is incorrect. It would be better for suppliers to have a demonstration unit in a normal house or on their premises to see how effective their SWH is. Using actual data will give the prospective client confidence in the SWH technology.

Chapter 6

USING CARBON TRADING TO FUND SWHs

This chapter discusses how solar water heaters can be funded using carbon trading. The first section provides an overview of carbon trading and how it is traded. The second section discusses how carbon trading can fund SWH projects.

6.1. What is Carbon Trading?

Global greenhouse emissions increased by 70% from 1990, with CO_2 being the largest contributor has increased by 80%. South Africa generates most of is electricity using low grade coal, which is a major contributor of CO_2 emissions. To reduce carbon emissions the Kyoto Protocol was signed in Kyoto, Japan, in December 1997, by various countries including the European Union (EU), Australia, Japan, India and South Africa, but excluding the United States of America (USA). Under this protocol the member countries will try to reduce the CO_2 levels from its 1990 levels by 5.2% by 2012. The agreement was implemented in 2007, with a 40 Euro per tonne of CO_2 penalty, which could be increase to 100 Euro per tonne. The ratio for carbon trading is one Carbon Credit is equivalent to one tonne of CO_2.

The signatories of the Kyoto protocol are divided into two categories: developed countries, which are referred to as Annex I countries and developing countries, the Non Annex I countries. Non Annex I countries do not have greenhouse gas emission reduction can participate in the CDM process. (See below for details)

6.2. How are Carbon Credits (CCs) traded?

The Chicago Climate Exchange, The European Climate Exchange and the Sydney Futures Exchange, which opened in 2007, are stock exchanges that can trade in carbon credits. Here carbon futures can be traded on new projects. Trading can also be conducted on the open market. It is estimated that China and India will be the biggest seller of CCs while Japan and Europe will be the biggest buyers of CCs. Financial investors are buying credits now at a cheaper rate and plan to sell them when the Europeans are unable to meet their target of reducing the emission levels by 2012.

Only companies that meet the United Nations Framework Convention on Climate Changes (UNFCCC) norms and take up new technologies will be entitled to sell carbon credits. Table 13 shows the carbon market per **TonCO_2** in 2005.

Carbon Market Programme	Approx. \$/Ton CO_2 (Summer 2005)	Approx. R/Ton CO_2 Assume \$1 = R8.50 (Summer 2005)
Clean Development Mechanism (CDM)	\$5 to \$10	R 42.5 to R85
European Union Emission Trading System (EU ETS)	\$20 to \$30	R 170 to R255
Retail and other voluntary markets	\$3 to \$15	R 25.5 to R127.5

Table 13. Carbon Market price per TonCO_2

(Source: Point Carbon)

6.3. Reduction and trading mechanisms

The Kyoto Protocol provides for three mechanisms that enable developed countries with quantified emission limitation and reduction commitments to acquire greenhouse gas reduction credits. These mechanisms are Joint Implementation (JI), Clean Development Mechanism (CDM) and International Emission Trading (IET). (Copperwiki–Carbon Credits,2008)

- Under JI, a developed country with relatively higher costs of domestic greenhouse reduction would set up a project in another developed country, which has a relatively low cost.
- Under CDM, a developed country can take up a greenhouse gas reduction project activity in a developing country where the cost of GHG reduction project activities is usually much lower. The developed country would be given credits for meeting its emission reduction targets, while the developing country would receive the capital and clean technology to implement the project.
- Under IET mechanism, countries can trade in the international carbon credit market. Countries with surplus credits can sell the same to countries with quantified emission limitation and reduction commitments under the Kyoto Protocol. (Carbon Friendly, 2007)

6.4. Carbon Credit Certification

Getting carbon credits certified for Kyoto is a lengthy and complex process. There are four stages of CDM approval.

- The first stage is at the domestic level, where the project gets approved by Designated National Authority (DNA).
- After DNA's Approval, the project is sent to the United Nations Framework Convention on Climate Changes (UNFCCC).
- After this, the executive board of UNFCCC reviews the project. The project gets evaluated on every front and is then registered under UNFCCC only if it meets all the norms.
- Thereafter, certification is done for the reduction in emission and credits are issued.

6.5. Renewable energy in the Western Cape

It is estimated that South Africa produces 1.8 percent of the world's total greenhouse gas emissions, making it one of the top 20 worst-offending nations. (Salgado, 2008) Recently there has been regular media coverage of environmental issues such as global warming and its impact on South Africa. According to the PGWC's integrated energy strategy (2007: 7), residences consume 9% of all the energy in the Western Cape, producing 15% of the provinces carbon emissions. Only 65% of rural households and 85% of urban households are electrified. In the domestic sector, the urban medium-high income households are the largest consumers of electricity.

It is estimated that if 15% of the electric hot water cylinders are replaced with SWH by 2024, cumulative savings of almost R670 Million would accrue. (South Africa: PGWC Department of Environmental affairs and Development Planning, 2007: 7).

The first internationally-registered CDM project in South Africa was the Kuyasa project, which was developed by a non-governmental organisation (NGO) SouthSouthNorth (SSN) for the City of Cape Town. There are now 11 registered projects in South Africa, six of which involve JSE-listed entities. A total of 53 South African projects have been submitted for approval. (Salgado, 2008)

6.6. Annual CO_2 reductions per household and CDM funding

Table 14 Calculated overall annual CO_2 reductions per household using SWHs and CDM funding that could be obtained.

Number of SWH installed	SWH to be installed per month for 5 years	Peak demand reduction (MW)	Energy Saving (GWh/yr)	Energy Savings in Rands per year assuming (50c/kWh)	Carbon reduction potential (1000 tons/ CO_2/yr)	Funding from CDM at a price at $5 per tonne (Assume R7.50 per $)
76000	1267	47.5	167.2	R 83 million	197.6	R 7,410,000
114000	1900	71.25	250.8	R 125 million	296.4	R11,115,000
380000	6333	237.5	836	R 418 million	988	R 37,050,000
570000	9500	356.25	1254	R 627 million	1482	R 55,575,000
760000	12667	475	1672	R 836 million	1976	R 74,100,000
900000	15000	562.5	1980	R 990 million	2340	R 87,750,000

Assumptions (from Eskom DSM estimates)

Peak demand reduction (after diversity)	0.625	kW/household
Energy: Savings	2200	kWh/system/year
Tons **CO_2** saved per system:	2.6	tons/year

Table 14. CO_2 reductions in relation to potential CDM funding

Disseminating SWHs in South Africa addresses three major concerns:

1. Reducing peak load at a time when electricity generation cannot always meet demand,
2. Reducing greenhouse gas (GHG) emissions.
3 At the household level, SWHs save electricity cost in the long term.

Table 14 illustrates that the average funding or subsidy from CDM for a SWH installation will be R973.68, which is not enough to reduce the payback period for the home owner. However, if 380 000 SWHs are installed it will result in a saving of 237.5 MW peak demand. It would therefore be ideal if the Eskom DSM fund is added to the CDM fund to make the subsidy substantial.

6.7. The Tradable Renewable Energy Certificate (TREC) system

Tradable Renewable Energy Certificate (TREC) originated in Australia with the aim of reducing the amount of coal burned to generate electricity. The TRECs were used to reduce the price of renewable energy systems where 1 TREC is equal to1 MWh.

Renewable Energy Certificates (RECs) are electronic certificates that are available on the public registry of information relating to the operation of the Australian Government's Mandatory Renewable Energy Target scheme (MRET) internet website (www.rec-registry.gov.au). The REC is a electronic form of currency and its price is negotiated. The Renewable Energy Regulator is not responsible for monitoring or setting REC prices.

Electricity retailers and purchases of wholesale electricity, called liable parties, have to surrender sufficient RECs to meet their targets each year, or pay a fine of 40 Australian Dollars per REC (AUS$40/REC) should they fall short of their target, which is approximately R270/MWh. (Solahart Website, 2008).

For a SWH to be eligible for RECs, the unit must be installed on or after 1 April 2001, either replace an existing electric water heater that has been installed at the same location for over one year; or replace an electric-boosted SWH that has been installed at the same location for over one year; or be installed in a new building. Typically, a SWH in Australia will be eligible for between 14 and 43 RECs, depending on the location and system type. Certificates for SWHs can only be claimed once for each installation (equivalent to ten years' displacement of electricity). Registration costs AUS$20, approximately R136 and must take place within 12 months of the SWH installation date. A framework exists for Agents to register (bundled) SWHs in the case of a building developer or ESCOs.

6.8. Possible savings from the TREC system

Research done by Greg Austin (2004) on TRECs in Developing Countries showed that this system could easily work in South Africa. In Appendix II there is an example of how TREC could be calculated. The example below is using the assumed values in the first exercise for comparison purposes.

Assuming a collector savings is 2.2 MWh/System/year then for 10 years the total saving is 22 MWh since 1 MWh = 1 TREC therefore 22MWh is quivalent to 22 TRECs.

Assuming the cost of 1 TREC = R 170/MWh then 22 TRECs = R 3,740 per SWH.

(Austin, G. 2004)

6.9. Conclusion

It is important that all renewable energy projects should source international funding from corporations in the developed world looking to secure carbon credits, while South Africa has the opportunity to make use of carbon credits and before this form of funding ends.

The current funding through CDM is not enough at $5 USD. To make the subsidy meaningful the actual cost should between $25-$30 USD to reduce the capital cost. One drawback is that CDM funds are volatile as the cost of carbon credits is dependent on the trade price. However, the TREC system should work well in South Africa. Companies such as SASOL and Eskom would be buying RECs since they are the largest CO_2 polluters.

Funding using carbon trading is a long and difficult process mainly because the public sector lacks the flexibility, technical skill and market experience to successfully manage CDM projects.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Global warming affects the entire world. With increasing carbon emissions and dwindling energy resources, creating sustainable energy sources is crucial. According to the Department of Environmental Affairs and Planning, The Western Cape's electricity demand forms 31% of the Province's total energy demand. Currently, 61% of the CO_2 released from energy use within the Province comes from electricity production. The province's electricity demand is expected to grow from 249.621 GJ in 2004 to 420 million GJ in 2024. The Provincial Government of the Western Cape (PGWC) estimates that with current growth trends, by 2014 4 200MW of electricity will be required to meet demand (Department of Environmental Affairs and Planning, 2008: [4]).

In 2003, the South African government's White Paper on Renewable Energy Policy supported the establishment of renewable energy technologies. In line with this, the PGWC has outlined a plan to have 15% of this, i.e. 630MW, be from sustainable, renewable energy sources. Eskom has been identified as one of the key role players in their strategic planning. (Department of Environmental Affairs and Planning, 2008: [5]).

This research explored mechanisms for implementing a large-scale solar water heating programme in South Africa, which would address three major concerns:

1. Reducing peak load at a time when electricity generation cannot always meet demand,
2. Reducing greenhouse gas (GHG) emissions.
3. At the household level, SWHs save electricity cost in the long term.

Chapter 2 explored the concepts and technologies around SWH, and their development and application, both globally and in South Africa, to find ways of promoting SWH on a large scale in the WC. It explored the role of the country's electricity provider, Eskom, in endorsing and sponsoring the use of SWH and found that although South Africa has been involved in the solar industry from the 1930's, the application and utilisation of the technology never really took off. This could mainly be attributed to the following factors:

- the low price of conventional electricity, as opposed to the large capital outlay initially required for SWHs,
- no SABS standards, and
- lack of government policy to drive the initiative.

Various programmes have been initiated in an attempt to stimulate the industry. The Solar 500 programme created interest in the market, but it focused mainly on the high to middle-income households. The CDM projects such as the Kuyasa and Lwandle SWH ventures focused on low-income homes, and showed that CDM funding is possible, but should be managed correctly. The current global concern about global warming, carbon emissions and sustainable and renewable energy makes this an ideal opportunity for implementing a SWH programme in the Western Cape. The weather conditions in this province are conducive to such a programme, and will result in electricity savings as well as meet the Province's renewable energy targets. However, government intervention is needed to institute policy that will support and drive initiatives such as the solar by-law.

Since the Eskom SWH rollout, there have not been many SWHs installed using the Eskom subsidy. In a short period, it has created a huge interest in SWH but has not had many sales using the subsidy scheme. Eskom's stringent testing requirements and set standards have resulted in a small number of companies receiving approval for SWH installation in the Western Cape. As approved installers, they increased their prices, making the Eskom subsidy negligible.

However, suppliers *not* on the subsidy scheme are struggling to keep up with demand for SWHs because they can provide the technology at a *cheaper* price. A review of international SWH schemes showed that interventions are needed to promote and encourage its use, including government intercession and participation, increased competition, tax incentives, building confidence in the industry and the Renewable Energy Act. It was also established that SWH has played a critical role in reducing electricity demand in other countries, proving that it can be used as part of the Eskom DSM programme.

Chapter 3 provided technical information on the various SWH technologies. Eskom supports the high pressure units with a pressure higher than 100kPa SWH system. The system must be SABS approved and the electrical element should not have a power rating bigger than 2kW. The hot water cylinder must be fitted with a timer or load control device. Unfortunately these standards resulted in a cost increase, making purchasing SWHs prohibitively expensive to the public.

Chapter 4 discusses the various initiatives to promote the use of SWHs. The findings have shown that standards and certification are important to regulate the SWH industry and prevent inferior-quality products affecting consumer confidence. Proper training and recognition of training received is required to build capacity and create jobs, which can have a positive influence on the Western Cape's economy.

Internationally, the major barrier to implementing SWH programmes is a general lack of awareness amongst the public and government, which results in ineffective policies and a lack of motivation to change. This can be overcome by creating awareness through brochures, websites, television, workshops, expos and exhibitions for professionals and artisans such as engineers, architects and plumbers. Prominent entertainment and political figures can also lend their support to the movement. However, the biggest influence in promoting the use of SWHs in South Africa will be the implementation of the Solar Bylaw to drive and enforce change.

Another obstacle to implementing a large-scale SWH programme is the high initial capital outlay, varying from R11 000 to R30 000, with Eskom-provided subsidies of between R3 000 and R6 000. The capital cost can be reduced through subsidies, low interest loans from financial institutions, tax exemptions and using ESCO to finance and install the SWHs. One of the objectives of this study was to create a model whereby a figure for a "minimum subsidy" could be reached. This modelling process is described in Chapter 5, where it was established that the minimum subsidy is R4 300, based on the assumptions made. The payback period (time taken to recoup the initial capital input) declines from five years to three years with the subsidy. It has also shown that if SWH suppliers use actual measurements for calculating electricity savings they will have a better rule of thumb based on actual electricity consumption.

Chapter 6 provides an overview of the carbon trading mechanism and how it can be used for funding SWH projects. Few projects have managed to use CDM funding but it is still a relatively new concept. From the basic calculations made we see that CDM funding is not really financially viable because of its market-based trading and competition with larger Non-Annexure 1 countries for CER credits.

7.2 Recommendations

Based on the findings of this study, it is recommended that the following steps be taken to ensure a successful SWH implementation plan:

7.2.1 Creating an awareness of SWH

Create an awareness of SWH through advertisements on radio, television, internet, printed media and brochures. The information provided must also highlight pilot projects, reasons for their success, and their contribution to the environment.

The marketing approach must focus on promoting sustainability, energy efficiency, renewable sources of energy and encouraging South Africans to take responsibility for their energy consumption.

Site visits for the media will enable them to see firsthand how SWHs work, must be organised with a consumer, interviews on savings, highlighting the positive aspects of SWH. With ongoing investment, the accumulated learning will spark new ideas, and increase knowledge and technical expertise.

Regular workshops should be held for architects, engineers, and plumbers' association networks. The dissemination of information could piggy-back on existing information networks as much as possible.

7.2.2 Funding of SWHs

Since SWHs displaces the electricity used by the consumer the electricity supplier can provide funding for the capital cost of the SWH unit, the electricity or municipal account of the consumer can be used to pay off the equipment.

Financial institutions can provide low interest loans such as home loans or private loans to finance the installation of SWHs. ESCOs can provide leasing schemes for large projects such as the "Guaranteed Solar Results" scheme that was applied in some European countries.

Government should provide subsidies to SWH manufactures through tax incentives or reduced cost of raw material used in the manufacturing process.

7.2.3 Building consumer confidence through quality assurance

Building consumer confidence would require that the SWH be SABS approved or made to internationally accepted standards and specifications, such as the International Organisation for Standardisation (ISO) and European National (EN) standards.

Training should be provided for installers of SWHs at colleges and technical schools to ensure accreditation and competence. SWH suppliers should also provide training for installers so that correct installation of their product is ensured (accredited installers). The suppliers will have a list of accredited installers which they will only use and the complete installation can be guaranteed.

SESSA can play an important role in receiving feedback from the users about the performance and quality of the SWH, and discipline those who promote inferior products. Action must be taken against suppliers and installers who do not adhere to standards and provides inferior products.

Housing delivery should be integrated with energy conservation. Architects and developers should offer SWH as an option when providing quotes for new homes. Therefore, they should be made aware of life-cycle costs and benefits of SWH versus electric hot water cylinders.

7.2.4 Supporting capacity building in the industry

Government and SESSA should provide technical assistance to promote the local manufacture of solar water heaters. The demand for SWH will increase, therefore to keep up with supply more manufactures and installers are required. With an increased number of manufacturers, there will be more competition, which will reduce the cost of SWHs.

Reducing the cost of raw materials and providing loans for start-up companies will increase the number of SWH suppliers. Education and training should be provided by SESSA and government to train local manufacturers to produce and market their SWHs. The following steps should be put in place to increase the number of local manufacturers of SWHs:

- Regular solar water heating workshops and training should be organised.
- Joint ventures should be established with SWH manufacturing companies, locally and internationally.
- Avenues should be provided for technology transfer.
- Training for architects and engineers at tertiary level is important, so that they can realise the benefits of introducing SWH in their designs and projects.

The training manuals should be made freely available so that it can be downloaded or printed in book form and distributed to all SWH companies. Training should be accredited with the relevant SETA.

7.2.5 Target markets for SWH

The target market for SWHs should be new homes and extensions to existing homes. It is cheaper to install SWHs in new projects where large numbers of homes are being built in the same location. Having a plumber onsite and ordering SWH panels in bulk delivery and transport costs are reduced. The SWHs will be part of the mortgage bond and no extra loans will be required. Retrofits on older established homes cost nearly twice as much, mainly because the old hot water cylinders are not compatible with the solar water heating panels.

7.3 Summary

The major barriers to the comprehensive adoption of SWH in the Western Cape are a lack of awareness and access to finance. The subsidy currently offered by Eskom has to date not significantly increased the amount of SWHs installed. Overcoming these barriers entails a multi-pronged approach:

- Creating awareness of the benefits of installing a SWH system;
- Building consumer confidence through quality assurance;
- Enhancing affordability of the technology by providing subsidies in conjunction with loans from financial institutions;

- Dialogue and engagement between stakeholders, including Eskom, provincial and government departments and civil society; and
- Implementation of the solar by-law to drive and enforce change.

It is envisaged that with awareness and education, financial incentives, dialogue and engagement between all stakeholders including NERSA, the Department of Minerals and Energy, Eskom, other provincial and government departments, civil society, and key role players in the energy sector, the application of SWH technology in the Western Cape will ensure safe, healthy and affordable energy and address the crucial environmental challenges confronting the Province.

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APPENDICES

APPENDIX I
TREC FUNDING FOR A LOW-INCOME HOME

Calculation based on SWH modeling for low-income houses:

According to work done by AGAMA a 1.4 m^2 100-litre SWH collector offsets 1.16 MWh electricity per annum (in Cape Town) which over 10 years is equivalent to 11.6 TRECs (compare against 10-64 in Australia). If their findings are extrapolated from 100-litre to 220-litre system, this is equivalent to 25.5 TRECs (2.55 MWh/annum over 10 years – compare with Australian figures)

Example: finance available for 100-litre close-coupled SWH in Cape Town:

11.6 TRECs @ R175/TREC = R2,030

Example: finance available for 220-litre close-coupled SWH in Cape Town:

25.5 TRECs @ R175/TREC = R4,462

The actual value would vary according to size, and location

Total value of SWH TRECs in SA:

69,400,000 @ R175/TREC = R12.1 billion

Tank Size	Electrical Energy Consumption (MWh/a)			
	Zone 1	2	3	4
400L	5.9	5.1	5.9	6.1
300L	4.3	3.6	4.3	4.4
220L	2.7	2.3	2.7	2.7

Source: Agama Presentation

APPENDIX II

CITY OF CAPE TOWN SOLAR WATER HEATERS BY-LAW

Draft 10

To regulate the incorporation of solar water heaters for the production of sanitary hot water in buildings in the City of Cape Town; and to provide for matters connected therewith.

1. Definitions

In this By-law, unless the context indicates otherwise -

"aperture area " means the area in a collector cover through which unconcentrated solar radiant energy is admitted to the absorber as defined in SANS 1307;

"**authorised official**" means the Chief Building Inspector or a person delegated to perform this function;

"building" means a building as defined in section 1 of the National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977);

"City" means the City of Cape Town as established by the City of Cape Town Establishment Notice as published in the Western Cape Provincial Notice No. 479 dated 22 September 2000;

"Developer" means the person or organisation which is building or developing a property with a view to sale or rent when completed;

"domestic solar water heater" means a solar water heater used by a single family household

"permanent shading" means shading caused by existing buildings, mountains, unsuitable orientation or other similar obstacles;

"Notice of Exemption" means a formal document signed by an authorised official setting out the manner and conditions of exemption of a particular building from the requirements of this By-law;

"Owner" means the person who has legal claim to a building or property by virtue of title deeds or other legally accepted documents;

"permanent shading" means shading caused by unsuitable orientation or by existing buildings, mountains, and other similar obstacles;

"solar collectors" means a device that contains or incorporates an absorber and a means for transferring thermal energy from the absorber to a fluid passing through it as defined in the SANS 1307;

"solar contribution" means the energy input to hot water tank from solar collectors;

"solar water heater" (SWH) means a complete operating system that uses energy from the sun to produce hot water comprising one or more collectors and hot water tanks, and all the necessary interconnecting pipes and functional components as defined in the SANS 1307.

Objectives
a. To improve energy security and improve energy risk management;
b. To reduce the use of electricity;
c. To reduce the national contribution to environmental impacts associated with the burning of fossil fuels, such as carbon dioxide ($C0_2$), sulphur dioxide ($S0_2$) and nitrous oxide emissions ($N0_3$);
d. To improve the quality of life through the provision of hot water;e. To create jobs in the solar water heater industry.

3. *Scope*

a. This By-law applies to all new buildings in the City other than those exempted in subsection (c.).
b. This By-law applies to all additions to existing buildings which will require the use of hot water (eg bathroom, bedroom with en-suite bathroom and kitchen extensions) other than those exempted in subsection (c.).
c. This By-law does not apply to the following cases:
   i. Buildings used only for industrial purposes where hot water requirements exceed that which can be reasonably obtained through solar water heating;
   ii. Any privately funded residential building of which the extent is less than 100 m2 (including garage space)
d. The City shall be authorised to exempt buildings or parts of buildings from the obligations of this By-law if there are valid reasons for such an exemption, such as :–
   i. Historical Buildings;
   ii. Buildings in areas which, due to permanent shading, are not able to have solar water heating.
e. Multi-storey buildings are required to have as much solar water heating as can be technically and economically accommodated by the structure and may apply for a Notice of Exemption for the hot water requirements not able to be served.
f. No Notice of Exemption will be valid unless given in writing over the signature of an authorised official.

4. Requirements for building plan approval

(1) An application for a building permission must disclose a description of he solar water heater, showing compliance with this By-law.

(2) The description shall, as a minimum, contain the following information:

(a) Manufacturer's name, trade name or trade mark;

(b) model number;

(c) aperture area;

.

(d) freeze resistant or not freeze resistant;

(e) for domestic solar water heating, a signed declaration on compliance of the solar water heater with SANS 1307 from manufacturer or distributor. The declaration shall include the rated daily output according to SANS 6211-1 or SANS 6211-2;

(f) for a solar water heater not within the scope of SANS 1307 (larger systems), until a national standard is available for commercial systems, a calculation of the estimated solar contribution to the hot water production must be done using realistic collector performance data and a reliable calculation tool for the solar water heater. The minimum estimated solar contribution shall be 50%. When calculating the solar contribution values for hot water consumptions given in Annexure A can be used; and

(g) the name of the installer and the installing company.

5 Required standards for solar water heater, installation and installer

(1) Domestic solar water heaters and its sub-components shall comply with SANS 1307, and compliance has to be declared in terms of section 4(2)(e).

(2) Larger solar water heating systems not covered by SANS 1307 shall, in a specific case, should be able to provide a solar contribution of at least 50% of the estimated energy consumption for the total production of sanitary hot water including also losses from tank. This shall be shown by a calculation according to section 4(2)(f). Dispensation from this requirement may be given be Building Authorities for very high buildings not having the necessary roof area for solar collectors.

(3) The solar collector shall be oriented in such a way that to attain optimum performance -

(a) it faces ±90° north;

(b) the angle between the collector plane and horizontal is between 15 and 50°;

(4) The installation of the solar water heater shall be done according to national codes of practise SANS 10106.

(5) A manufacturer shall give a 5 year warranty declaration on the solar water heater.

(6) A service contract shall be concluded between the installer and the owner of the solar water heater concerning the maintenance of the system.

(7) A service contract shall include, as a minimum -

(a) commitment from installer to perform a commissioning check within one month after installation, handing over the commissioning check list according to national code of practise SANS 10106 to the owner. This commissioning check shall be included in the price of the system; and

(b) commitment from installer to perform an annual service check at a reasonable fixed price stated in the contract, for a period of at least the two first years.

6 Appearance and design

(1) The City may require changes in the proposed design and appearance in order to minimise the visual impact of the solar water heater.

(2) Geysers shall be installed within the roof space or internally where possible, to address aesthetic and insulation concerns, particularly in aesthetically sensitive contexts, such as –

(a) on graded buildings;
(b) buildings older than 60 years; and
(c) in heritage areas.

7 Owner's obligations

(1) The owner of a building on which a solar water heater is installed is responsible for compliance with this By-law.

(2) The owner of the solar water heater is responsible for maintenance and repairs necessary for the system to work properly and with the best results.

8 Inspection

(1) The City may require an owner of a building to provide any information to give effect to this By-law.

(2) If such information is not provided within the time stated in the request, the City may carry out an inspection of the building to check compliance with the requirements of this By-law.

9 Prohibitions

Prohibitions in this By-law shall include the following:

(a) Installing a solar water heater system in contravention to requirements in this By-law;

(b) Failure to maintain the solar water heater system according to requirements in this By-law;

(c) Failure or refusal to provide information or give access to buildings as stated in section 8.

10 Compliance notices

(1) When a City official finds that a provision of this By-law is contravened by an applicant or that a condition has arisen that has the potential to lead to a contravention of this By-law, such authorised official may issue a compliance notice to the applicant or the person in charge of the solar water heater.

(2) A notice issued in terms of subsection (1) must state-

(a) the provision of the By-law that has been contravened or will be contravened if the condition is allowed to continue;

(b) the measures that must be taken to rectify the condition; and

(c) the time period in which the notice must be complied with.

(3) If a person on whom notice was served in terms of subsection (2), fails to comply with the requirements of the notice, the City Manager may take such steps as may be necessary to rectify the condition at the cost of the applicant or person in charge of the solar water heater.

11 Offences and penalties

A person who contravenes a provision of this By-law, or fails to comply to a condition or notice legally issued in terms of this By-law, is guilty of an offence and on conviction liable to the payment of a fine.

12 Application to new building permissions

(1) All applications for building permissions received by the authorities of the building plans department of the City after 1st of September 2006 must comply with this By-law.

(2) This By-law is called the City of Cape Town: Solar Water Heaters By-law, 2006.

ANNEXURE A

Estimation of consumption

Knowledge about the hot water consumption is needed when estimating/calculating the solar contribution from the solar water heater.
Values from table 1 below can be used for estimation of the hot water usage if not known from previous years or otherwise.

Table 1: Estimation of hot water usage in different preliminary cases, to be adapted

Case	Amount of hot water used Per day	Unit
individual households Hi/Middle income sector Low income sector	 50 25	 litres/person litres/person
apartments	30	litres/person
hospitals and clinics	60	litres/bed
old people's homes	40	litres/person
day schools	5	litres/pupil
factories and workshops	20	litres/person
offices	5	litres/person
camp sites	60	litres/site (occupied)
hotels	100	litres/bedroom (occupied)
college	30	litres/student
laundries	5	litres/kilo of clothes
restaurants	8	litres/meal (sold)

APPENDIX III
CALCULATING THE APPROXIMATE SAVINGS

(Extract from Solardome SA website)

"According to data made available by the South African Weather Bureau, the total solar radiation normal to a plate surface orientated true north for the Cape Town area is approximately 2017kWh per m² per year."(Solardome SA)

Assuming the collector has an efficiency of 65% then a collector with a surface area of 1m² will annually produce (2017kWh x 0.65 Efficiency) 1311.05 kWh into the hot water cylinder.

Currently Eskom sells electricity at ± 50c / kWh.

Based on this figures above the annual savings are as follows::

Hot water cylinder size	Collector with surface Area	savings per annum
100 l	1.3 m²	R852.08
150 l	2.1 m²	R1376.60
200 l	2.9 m²	R1901.02
300 l	2 x 2.6 m²	R3408.73

Example:

200 litre copper system with 2.9 m² collector @ ± R10 600

Installation cost @ ± R2500

Total cost = ± R13 100 and saving annually is R1 901.02 thus in this case the payback period is 7 years.

Generally the payback time of a solar thermal system varies which would usually takes between 3-7 years depending on the type of system installed and the hot water usage patterns. The price of electricity is increasing constantly and these increases will occur more frequently in the future as Eskom needs to upgrade its infrastructure to accommodate the ever increasing demand for electricity.

Source: Solardome SA.

APPENDIX IV

ESKOM'S APPROVED SUPPLIERS LIST

(source Eskom DSM website)

Participating Supplier	Contact Details	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying incentive (to be taken off overall cost)	SABS
Atlantic Solar	Regional contact number: 086 136 3749 info@atlanticsolar.co.za	Western Cape	Dura-Line 200 Vaal 200 Litre Flat plate Indirect Thermo Siphon	R12 517,00	R1900,00 - R2200,00	R2166,67	Test Report
			Dura-Line 300 Vaal Thermo Siphon 300 Litre Flat Plate Indirect Thermo Siphon	R19 937,00	R1900,00 - R2200,00	R2858,19	Test Report
Alt E Technologies	Regional contact numbers: Eastern Cape: 082 776 1503 Gauteng: 082 994 7001 Kwazulu-Natal: 083 412 2718 Western Cape: Till 1/3/2008: 021 511 9504 After 1/3/2008 021 461 3160	Eastern Cape Gauteng KwaZulu-Natal Western Cape	Ksh201 Giordano Indirect 175 Litre Flat Plate Direct Thermo Siphon	R15 276,00 – R21 204,00 Depending on roof type.	R3910,20 – R4366,20	R2388,19	Test Report
			Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	R22 287,00 – R28 215,00 Depending on roof type.	R3910,20 – R4366,20	R4452,63	Test Report
Frantel Distribution	Regional contact number: 012 804 6664 frantel@absamail.co.za	Coastal Areas	Frantel JP – B2 150 Litre Flat plate Direct Pumped	R13 330,00	R1800,00 - R5300,00	R2314,72	Test Report

Participating Supplier	Contact Details	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying incentive (to be taken off overall cost)	SABS
Home Comfort	Regional contact number: 0861 114 169	Gauteng Free State Western Cape (incl. Garden Route)	Dura-Line 200 Vaal 200 Litre Flat plate Indirect Thermo Siphon	R12 517,00	R1900,00 - R2200,00	R2166,67	Test Report
			Dura-Line 300 Vaal Thermo Siphon 300 Litre Flat Plate Indirect Thermo Siphon	R19 937,00	R1900,00 - R2200,00	R2858,19	Test Report
Pronto Plumbing t/a Solar Pro	Regional contact number: 021 761 7602	Western Cape	Solarpro DT 200D Thermo Siphon 200 Litre Flat Plate Direct	R 10 384,00	R3200,00 - R3500,00	R3390,69	Test Report
Solar Beam	Regional office: 031 563 9585 solarbeam@netactive.co.za	KwaZulu-Natal	SBG Direct Thermosiphon 200 Litre Direct	R10 500,00 – R11 500,00 Depending on close coupled or in-roof installation	Installed cost, excluding electrical CoC and timer	R2500,83	Test Report
			SBG Direct Thermosiphon 300 Litre Direct	R15 500,00 – R16 500,00 Depending on close coupled or in-roof installation	Installed cost, excluding electrical CoC and timer	R3943,89	Test Report

Participating Supplier	Contact Details	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying incentive (to be taken off overall cost)	SABS
			SBG Direct Thermosiphon 300 Litre Indirect	R16 500,00 – R17 500,00 Depending on close coupled or in-roof installation	Installed cost, excluding electrical CoC and timer	R3100,55	Test Report
Solar Heat Exchangers	Regional office: 086 11 solar (086 11 76527) info@solarheat.co.za	Gauteng	Ksh201 Giordano Indirect 175 Litre Flat Plate Direct Thermo Siphon	R15 276,00 – R21 204,00 Depending on roof type.	R3910,20 - R4366,20	R2388,19	Test Report
			Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	R22 287,00 – R28 215,00 Depending on roof type.	R3910,20 - R4366,20	R4452,63	Test Report
Tasol Solar	National contact number: 086 111 3078 Johan@tasolsolar.co.za www.tasolsolar.co.za	Gauteng Eastern Cape	Tasol HPS104 150 Litre Evacuated tube Direct Pumped	R 10 744,50	R1000,00 - R2000,00	R1912,91	Test Report
			Tasol AKH20 200 Litre Evacuated tube Indirect Thermo Siphon	R 11 934,64	R2000,00 - R3000,00	R 1869,72	Test Report

APPENDIX V
ENERGY UNITS CONVERSION TABLE

Energy Units Conversion Table

To / From	Joule	Gigajoule	Tetrajoule	Toe	kWh	GWh
Joule	1	10^{-9}	10^{-12}	$2.4x10^{-12}$	$2.8x10^{-7}$	$2.8x10^{-13}$
Gigajoule	10^{9}	1	10^{-3}	$2.4x10^{-2}$	278	$278x10^{-6}$
Tetrajoule	10^{12}	10^{3}	1	24	$2.8x10^{5}$	$2.8x10^{-1}$
Toe	$42x10^{9}$	42	$42x10^{-3}$	1	$12x10^{4}$	$12x10^{-3}$
kWh	$36x10^{5}$	$36x10^{-4}$	$36x10^{-7}$	$8.3x10^{-6}$	1	10^{-6}
GWh	$36x10^{11}$	$36x10^{2}$	$36x10^{-1}$	83	10^{6}	1

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Source: South Africa. Department of Minerals and Energy, 2003: vi