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An assessment of financial incentives for encouraging South Africa's domestic solar water heater market

by

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Thesis presented for the degree of Master of Science

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It is without doubt that I have many people to thank for allowing me to write this thesis, because this thesis has shown me how much trust it requires to be able to finish such a laborious study with the same idealism as was required to initiate it. I say this not to reflect on the difficulty of the task, but to thank those who contributed to the broad subject at hand whether they were, or were not, referenced in this thesis. More importantly than thanks to colleagues, friends and family, however, I hope that this thesis can contribute to the broad academic field of sustainable energy in some way.

A special thanks must go to my supervisor Dr. Harald Winkler, who has, I hope, learned to accept my lack of academic poise as a valuable naivety. For your role as my supervisor, I would like to thank you for your academic guidance, and the effort you put into helping me to make my deadlines.

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DECLARATION

I, Alistair Henry Stewart, submit this half-dissertation in partial fulfilment of the requirements for the degree of Master of Science

I know the meaning of plagiarism and declare that all the work in this document, except for that which is properly acknowledged, is my own.

Signed:

Alistair Henry Stewart
12 April 2009

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ABSTRACT

SA has a demand for domestic hot water, which is supplied by a number of different technologies. For a number of reasons, including health reasons and versatility, Government has encouraged the demand for electricity to meet domestic requirements. But currently there is a shortage of electricity supply, with negative impacts for the development of SA.

Solar water heating (SWH) is a renewable energy technology that could relieve some of the demand for electricity, and the aim of this study is to assess which types of national financial incentive programmes should be implemented in order to encourage the use of SWH systems in households, within the context of SA's energy policy and the current electricity crisis. However, only hybrid SWH technologies were considered, due to a lack of information.

A review of literature shows that domestic SWH technology use is uncommon, resulting from households preferring other technologies for reasons of cost and convenience.

The modelling of current and hypothetical scenarios of energy consumption for domestic water heating show that the increased use of hybrid SWH technology would benefit SA's sustainable development. A literature review was used to identify the barriers stopping these benefits from being translated into the domestic sector.

A literature review of energy policy documents confirmed SA's commitment to sustainable development and introduced a number of developments intended to reduce the barriers to renewable energy technologies. Investment incentives and set-asides were identified as potential financial incentive options for SA.

A literature review of the SWH market identified the existing structures and capacity of expertise, and identified options for reducing SWH barriers.

A criteria analysis was performed on a set-aside option and investment incentive options, which included a direct subsidy, an income tax deduction, and an interest rate subsidy. The criteria used for this analysis were derived from this study and a report of international experiences, and the analysis provided an assessment of the suitability of each of these financial incentives.

The assessment resulted in the recommendation that a direct subsidy programme be implemented, possibly using a system of Tradable Renewable Energy Certificates (TRECs), which could allow for compatibility with developments that could enhance the success of the programme.

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1 Introduction

1.1 Hot water demand in SA

South Africa's population may not need domestic hot water for cleaning or washing purposes, however, there is undoubtedly a demand for domestic hot water. The reasons for this include the benefits of improved sanitation and comfort, as well as the fact that the availability of hot water has become a 'norm' in modern households.

Each household's demand for domestic hot water is related to a number of factors, which include cost and availability factors, among others. This variation in demand is as a result of the numerous technologies that are available to heat water, each with its own advantages and disadvantages. These technologies are:

- Fossil (and fossil-fuel derived) fuel stoves (e.g. LPG, paraffin, coal, electric)
- Biomass and converted fuel combustion stoves (e.g. fire-wood, charcoal, ethanol-gel)
- Mains-supplied geysers (from various energy sources, e.g. natural gas, electricity)
- SWH systems (which use renewable solar energy, but may also have mains-supplied backup energy sources)

Data from the 2001 national Census, and other research, gives us a reasonably good picture of what the hot water demands are for certain types of households, which are differentiated according to whether they have high or low incomes, and whether they are electrified or not.

Low income, unelectrified households make up 32.1% of SA's 11 205 705 households (Winkler et al, 2006:120). It is typical for these households to use cheap technologies like fossil-fuel, biomass and converted fuel stoves to heat water as and when they need it. This is partly because energy costs can be met by cash-in-hand, partly because of the unavailability of other fuel sources, and partly due to the expense involved in buying energy appliances. These technologies have negative side-effects, such as health hazards associated with the local pollution, and health and property risks associated with accidental fires. Often these health hazards can offset the benefits gained by the improved sanitary conditions provided by hot water. The time that it takes to prepare hot water using these methods also makes this process inconvenient. On average, low income, unelectrified, households each required approximately 1.09 GJ of useful energy in 2001 (Winkler 2006:119;188) for water heating purposes.

Low income, electrified, households make up 21.0% of SA's households (Winkler et al, 2006:120). These households typically use electrical appliances to heat water as well as those

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that use cost-effective technologies like fossil and converted fuel appliances. This is because, while it is generally cheaper and safer to buy and use electricity than fossil or converted fuels, electrical appliances that are specifically designed for heating water are relatively expensive. On average, low income, electrified, households each required approximately 2.31 GJ of useful energy in 2001 (Winkler 2006:119) for water heating. Approximately 83.1% of this useful energy demand for this household type was electricity (Winkler 2006:119;188).

It is generally assumed that most low income households experience a 'suppressed demand' for hot water, due to the risks, costs and inconvenience involved in heating water manually. The specific useful energy contributions attributable to each of the various technologies used in low income households for water heating are difficult to determine, since the same technologies are often used for cooking, water heating, and even space-heating in some cases.

High income households make up the remaining 46.9% of SA's households (Winkler et al, 2006:120). Almost all households in this income category are electrified, and most of them can afford to use mains-fed fuel technologies to heat water, which are more convenient. Mains-fed gas geysers are uncommon due to South Africa's limited natural gas resources and infrastructure, and SWHs are uncommon due to their high capital cost. Holm states in his survey, that a typical household in South Africa has a 150 litre electric geyser with a 3kW element (Holm 2005:41), and the assumption here is that this refers to the high income households, although it may also refer to some low-income households. On average, high income, electrified, households each required 5.36 GJ of useful energy in 2001 (Winkler 2006:119) for water heating. Approximately 89.9% of this useful energy demand for this household type was provided by electricity (Winkler 2006:119;188), and it is assumed that this represents electricity consumption by geysers, while the remaining 10.1% was provided using other technologies.

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1.2 Supply issues

Two major developments in SA, as integral parts of the Reconstruction and Development Programme (RDP) of 1994, are likely to have affected the demand for domestic hot water and the technologies and fuels used for this service. These included improvements in clean water allocations per person and the increased electrification of households.

While the importance of access to clean water can be seen as a basic service, electrification was seen as strategically important for achieving national development objectives. The White

Paper on Energy Policy emphasized the importance of electrification as:

"Government recognises that household access to adequate energy services for cooking, heating, lighting and communication is a basic need. Whilst these needs can be met by various fuel-appliance combinations, government recognises that without access to electricity, a clean, convenient and desirable fuel, human development potential is ultimately constrained." (DME 1998:48)

Another significant development, which followed from the increased electrification of households, has been the introduction of free basic electricity for low income households.

The importance of electrification might have been justifiable, since at the time of the publication of the RDP, in 1994, there was substantial over-capacity of electricity generating capacity in SA, compared to the electricity demand. Table 1, below, shows how this over-capacity, shown as the reserve margin, has diminished since 1994. The table also shows the magnitude of peak electricity demand and new electricity connections for each year.

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Year	Max Capacity [MW]	Peak Demand [MW]	Reserve Margin	New Connections
1994	35 926	24 798	31.0%	435 756
1995	35 951	25 133	30.1%	478 767
1996	36 563	27 967	23.5%	453 995
1997	37 175	28 329	23.8%	499 311
1998	37 848	27 803	26.5%	427 426
1999	38 517	27 813	27.8%	443 290
2000	39 186	29 188	25.5%	397 019
2001	39 810	30 599	23.1%	336 918
2002	39 810	31 621	20.6%	338 572
2003	39 810	31 621	20.6%	298 791
2004	38 436	34 195	11.0%	248 451

Table 1 SA's electricity Generating Capacity and Demand
Source: (DME 2006:40)

So, while electrification has been an important strategy for SA's development, the capacity of South Africa to meet its electricity demands has become insufficient during periods of peak electricity demand, as shown by the table above.

This situation has become critical and since 2006 the national electricity utility, Eskom, has required occasional load shedding across the country. It is expected that, despite efforts to increase the electricity generating capacity (Kenny 2007), there will continue to be occasional shortages over the next few years.

While this shortage in peak electricity supply is due to the general growth of SA's aggregated electricity demand, domestic hot water provision by electric devices contributes to the problem in that domestic hot water demand is greatest during peak electricity demand periods (mornings and evenings, and particularly in winter). This means that there is some strategic benefit in dealing with these devices contributions to peak electricity demand.

1.3 Motivation for this study

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The previous sections have shown how the SA Government, through various developmental efforts, has encouraged the demand for electricity to meet domestic service requirements. These efforts have been made in order to promote the living standards of SA citizens, but it is likely that the effect of an insufficient electricity generating capacity will have a negative impact on the development of SA. Given this situation, it may be expected that governmental strategies implemented to achieve national development objectives will need to be revised to address the under-supply of electricity.

The aim of this study is contribute to the broader body of energy research by assessing which types of nationally implemented financial incentive programmes the SA Government, and in particular the Department of Minerals and Energy (DME), should consider implementing to encourage the use SWH systems in households, given the particular energy policy and SWH market environments.

At this point it is important to note that Eskom has implemented a SWH subsidy programme, at the beginning of 2008, and that this study might be redundant if Eskom's SWH subsidy programme was a success in terms of encouraging the SWH market. However, there may be some benefits gained from exploring a number of different financial incentives, even if the programme implemented by Eskom was a success.

1.4 Structure of this study

The structure of this study is set out so that the research chapters (Chapters 2 - 6) each answer a broad question that is necessary for understanding what the main factors are that govern the use of SWH technology in SA. The order of the chapters is set in such a way that each chapter, and the associated question, follows logically from the previous one.

Each research chapter is comprised of the question that is to be dealt with, a brief description of the methodologies that are to be used to answer the question, the research content of the chapter, and finally a conclusion that provides the answer to the question dealt with in that chapter.

Subsequent to the final research chapter, this study culminates in a conclusions and recommendation chapter, which summarises the findings of this study and answers the main question by this study: What financial incentives are the most suitable for SA to encourage its domestic SWH market?

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2 Domestic SWH systems

As the first research chapter, the question posed should be: What are domestic SWH systems and how do they compare with other domestic water heating technologies for households?

2.1 Methodology

The first part of the question posed in this chapter is answered by providing an overview of SWH technology. Information provided by a literature survey shall be presented to describe SWH technology generally, including the domestic system components and materials, while the details shall also be provided about the SWH systems installed currently in SA.

The second part of the question is answered by comparing SWH systems to the other technologies available, taking household concerns into account, such as Health and Safety, Cost Issues, Availability of Fuel, Convenience of Use and Reliability of Technology. These concerns are generally provided by a combination of a literature review and the author's own analysis. The provision of useful Cost Issue comparisons have been provided by simple calculations derived from data provided by the literature review.

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2.2 Overview of domestic SWH technology

This overview of domestic SWH technology in SA is split into two sections, the technology profile, which gives a broad description of the technology, and the SA profile, which gives a brief description of the prevalence of the technology in SA.

2.2.1 Technology Profile

SWH systems can be used for providing hot water to domestic households and swimming pools, commercial facilities, and some industrial processes. The SWH technology used for each application provides different temperatures of hot water, depending on the requirements of that application. Of all of these applications, this study concerns the domestic applications of SWH to heat water for washing and cleaning purposes. Hot water used for these purposes is normally required to be 40°C to 60°C.

SWH systems use energy available from solar radiation to heat water. Systems basically consist of three components, besides their water supply:

- A solar collector, which absorbs energy from solar radiation during the day. Collectors used for domestic SWH systems in SA are typically either glazed flat-plate collectors or evacuated tube collectors.
- A water storage tank, which contains a mixture of solar heated mains-supplied water. In hybrid systems, a backup heating component such as an electrical heating element may be included.
- A heat transfer system, which transfers the energy absorbed by the collector to the water in the water storage tank, either directly by water flowing back and forth between the collector and the storage tank, or indirectly using a heat exchange mechanism between the collector and the storage tank. Systems that use convection currents for heat flow are known as thermosyphon systems, while alternative systems use pumps.

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There are a number of different types of SWH systems available currently (DME 2002:8) that can meet domestic water heating requirements. They differ from each other in terms of their system components and may be listed as:

- Integral SWH Systems have their water storage and solar collector integrated into one another therefore no heat transfer system is required. These may be hand-filled or connected to a water supply system.
- Close-coupled SWH Systems are contained in a single constructed unit, although components are not integrated and do include a heat transfer system.
- Split collector/storage SWH Systems have the solar collector and the water storage tank located separately, therefore the heat transfer system is more elaborate and usually requires pumps.

Integral SWH systems are typically more cost-effective than close-coupled or split systems with smaller storage capacities. This is because the latter two systems have better insulation of the stored heated water, resulting in a reduction of standing heat losses. This also makes the latter two systems suitable for hybrid operation, where fuel supplies such as electricity or gas may be used to keep the stored water heated during periods where the solar heating contribution is unable to, although electricity is commonly used for backup heating in SA.

The thermal performance of a SWH system is dependent on each of the system components. The solar collector determines how much solar radiation is absorbed or reflected, and re-radiated into the atmosphere or transmitted to the heat transfer system. An estimate of SA's average annual output for glazed flat plate and evacuated tube collectors has been calculated to be 943 and 1 015 kWh/m^2 respectively (Holm 2005:Annexure J), based on international convention. The heat transfer system regulates the heat flow rate, affecting the performance of the collector, while the insulation on the heat transfer system limits heat loss. In indirect systems, the heat transfer system can also be affected by the efficiency of the heat exchange mechanism. Finally, the insulation on the water storage tank limits standing heat losses.

The technology that domestic SWH systems make use of is not complex, but the capital costs are large because of the expensive materials used to construct them, usually non-corroding metals and glass. But while the capital costs are high, SWH systems do have long operational life-spans (15 to 20 years), and the operating costs are low because besides occasional maintenance, the solar energy used to heat the water is free. In the case of hybrid SWH systems, the capital and operating fuel costs of the system will result in increased system costs.

2.2.2 SA Profile

SWH systems have been available in SA since the early 1970s, but their popularity has fluctuated, depending on various factors, which are important from a developmental aspect. Figure 2, below, shows estimated aggregates for total SWH collector area installed in SA, from 1975 until 2004. The total for domestic SWH systems is shown as the line "acc glaz", which stands for accumulated glazed collector area, while the line "acc unglaz" refers to unglazed collectors and is almost entirely accounted for by swimming pool water heating (Holm 2005:26).

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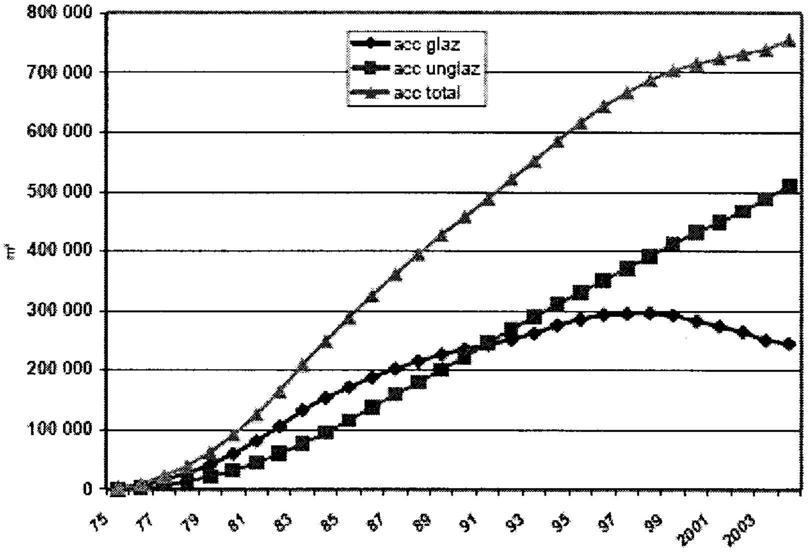

Figure 1. Graph of total installed solar collector area in SA

Source: (Holm 2005:29)

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Since collectors are essential components of SWH systems, the graph above illustrates how SWH systems have become less popular since their peak in 1997, when approximately 300 000 m^2 of glazed collectors were installed, until recently in 2004, when approximately 246 000 m^2 were installed.

More recently, evacuated tube collectors have become popular as an imported technology that compares well in terms of cost, locally, with glazed flat plate technologies. The current estimate (in 2008) of installed domestic SWH collector area is 330 000 m^2, according to the DME's website[1], but details of how this level was reached are not given.

It is difficult to translate this estimate of total installed collector area into a number of SWH systems installed. One report stated that an average domestic SWH system in SA should have a collector area of just over 4.5 m^2 to fulfil the households heating requirements (Holm 2005:46), although it is likely that most SWH systems are hybrids and require some backup heating for cold climate. If we assume that the total installed collector area is in fact 330 000 m^2, and if we assume that the average domestic SWH system has a collector area of between 2 and 4 m^2, then this implies that there are currently between 82 500 and 165 000 domestic SWH systems in SA, which we can resolve into a single compromise figure of 123 750 SWH systems.

Also, if we consider that there are approximately 11 million households in SA currently, which

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[1] www.dme.gov.za/energy/renew_solar.stm (at 31/7/2008)

was the total estimated by the 2001 Census, this implies a prevalence of SWH systems in approximately 1.1% of SA's households.

2.3 Comparison with other technologies

In order to consider what benefits there are to installing domestic SWH technology in households, it is important to compare this technology to all of the alternatives that are currently being used in SA. A review of the literature identifies the following technologies:

- Fossil (and fossil-fuel derived) fuel stoves (e.g. LPG, paraffin, coal, electric)
- Biomass and converted fuel combustion stoves (e.g. fire-wood, charcoal, ethanol-gel)
- Mains-supplied geysers (from various energy sources, e.g. natural gas, electricity)
- SWH systems (which use renewable solar energy, but may also have mains-supplied backup energy source)

The factors that influence the choice to use, and benefits of, each alternative technology are numerous, and a distinction can be made between the benefits to individual households, which is the responsibility of the household, and the benefits to society, for which the Government may be accountable, and it therefore may take steps to secure these benefits.

The following sections discuss the factors that are likely to be considered by households when choosing which technology to use, concluding with a section that deals with the economic, social and environmental factors that Government must explore before it may endorse a technology.

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2.3.1 Health and Safety

All combustion heating technologies besides gas geysers can be dangerous when used in households, and require constant supervision when in use because of the risk of accidental fires. Combustion technologies also result in associated emissions that may be detrimental to peoples' health, and the DME's White Paper on Renewable Energy has identified the need to reduce domestic combustion of coal and fuelwood (DME 2003a:37). Occurrences of poisoning have also resulted in infant deaths after ingesting paraffin (DME 1998:89). For these reasons, the safest combustion technologies used for domestic water heating tend to be those that use ethanol gel and gas fuels, and in particular gas geysers. But only electric and SWH technologies do not have associated emissions at household level and therefore they are the safest, although electricity use does also come with some risks, but these can usually be avoided.

2.3.2 Cost Issues

Cost issues are made up of initial costs and operating costs. Recent analyses give costs for some domestic water heating technologies along with their associated fuel costs, and these are given in the table below. The technology and fuel costs (Winkler 2006:110,127) are taken from years 2000 to 2005, with the fuelwood costs given by De Villiers & Matibe (2000:26), and these cost values have been adjusted to represent their equivalent value in Rands from the year 2000 (Winkler 2006:111). This method of adjusting the cost values is done to reflect real values, by compensating for inflation using the table of cost deflators given in Appendix A. Besides the cost values given, the same analysis (Winkler 2006) also gives the efficiency and lifespan values for the technology devices given.

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Technologies used for both water heating and cooking:				
Technology	**Capital Cost**	**Efficiency**	**Lifespan**	**Fuel Cost**
Coal Stove	R 4 060	25%	11 years	R3.20/GJ
Fuelwood Stove	R 687	25%	9 years	R28.24/GJ
Paraffin Stove	R 29	35%	3 years	R53.85/GJ
LPG Ring	R 193	53%	5 years	R115.50/GJ
Electric hot plate	R 178	65%	5 years	R41.41/GJ
Technologies used solely for domestic water heating:				
Technology	**Capital Cost**	**Efficiency**	**Lifespan**	**Fuel Cost**
LPG Geyser	R 3 749	84%	22 years	R115.50/GJ
Electric Geyser	R 1 686	70%	22 years	R41.41/GJ
SWH (integral)	R 5 045	100%	17 years	N/A

Table 2 Technology and fuel costs for domestic water heating

Sources: (Winkler 2006), own analysis

It should be noted that both technology and fuel costs will have changed, in real terms, from the values given in the table above, but corrections to these values are not in the scope of this study. With respect to individual values, there are a few notes that should be made about the table above. It is very likely that the capital cost of the coal stove in the table above is a high estimate, since makeshift devices may be much more cost-effective, and the fuel cost for fuelwood has not been included since it is not regulated in any way. Also, the heating capacity of the integral SWH is not given, and the value of 70% given for the efficiency of electric geysers should read 100%, since the former value actually refers to the thermal heat retention of the geyser, and not the percentage of energy transferred from the fuel to the water as for the other technologies.

The table above gives an estimate of technology cost for an integral SWH system, but not for hybrid SWH systems. Evaluating the cost of hybrid SWH technology is difficult because there are many different products available in the market, and studies that have dealt with cost issues have not dealt with performance issues thoroughly enough to draw reliable conclusions. For example, a report completed by De Villiers & Matibe (2000:6) compared the cost of a 200 litre electric geyser to a 200 litre hybrid SWH system, quoting one reference, but then quoted another reference that stated that the SWH component of hybrid systems can provide 90% of the energy requirements. This may have been applicable for the system mentioned previously, but the lack of performance details given makes it difficult to substantiate the claims.

Given the limited information found, relating to the costs and performances of hybrid SWH systems in SA, it is necessary to use information used in official Government reports that deal with SWH systems from a policy perspective. The assumption is that these documents rely on significant data in their analyses, or that they make realistic assumptions, whether they are stated or not. The most significant report completed recently that deals with the cost and performance issues of SWH systems is the DME's macro-economic report that was made of renewable energy technologies in SA (DME 2004:88-95). In this report it was the installed costs (in year 2003 Rands) for hybrid SWH systems were given as R13 000 (R10 400 system + R2 600 installation) with annual maintenance costs of R260 for high income households, while the installed costs of R7 500 (R6 000 system + R1 500 installation) and annual maintenance costs of R150 were given for systems suitable for all other households. The performance details given were that these systems can provide 60% of total energy requirements, with electricity providing the remaining 40%, although a discrepancy exists between these performance details and the assumptions already stated in the introduction of this report. This is that annual water heating energy requirements in the macro-economic report ranged from 13.6 GJ for low income households to 34.0 GJ for high income households, while the assumptions given in the introduction of this report were that electrified low income households required on average 2.31 GJ, and high income households 5.36 GJ. Ignoring this discrepancy, the table below gives the costs (in year 2000 Rands) associated with hybrid SWH systems as assumed for the macro-economic report, and using system lifespan of 17 years (EDRC 2000:6).

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Technology	SWH Capital Costs		Maintenance Costs (annual)	Efficiency	Lifespan	Fuel Cost
	System	Install.				
Hybrid SWH - High Income	R 8 421	R 2 105	R 211	100%	17 years	60% free solar 40% at R41.41/GJ
Hybrid SWH - Low Income	R 4 858	R 1 215	R 121	100%	17 years	60% free solar 40% at R41.41/GJ

Table 3 Table of technology and fuel costs for hybrid SWH systems

Sources: (DME 2004:88-95), (Winkler 2006), own analysis

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Using these cost values we can compare technology (yearly costs in 2000 Rands) costs for all of the water heating technologies mentioned so far. The results shown in the table below are calculated as:

1. Total system cost for each technology is the addition of capital costs and maintenance costs over the technology lifespan.
2. Annual fuel cost for each technology is made by multiplying fuel costs by each household type's useful energy requirements, as stated in the introduction, and then dividing by the technology's efficiency as a proportion of 1 (An efficiency of 100% is used for electric geysers).
3. Annual water heating cost for each technology is the sum of total system cost divided by the technology's lifespan and the annual fuel cost, for each household type.
4. See Appendix B for further details of the information used in deriving these values.

	Yearly Water Heating Cost for Typical Household Type		
Technology	**Low Income Unelectrified**	**Low Income Electrified**	**High Income**
Coal Stove	R 383	R 399	R 438
Fuelwood Stove	R 199	R 337	R 682
Paraffin Stove	R 177	R 365	R 834
LPG Ring	R 276	R 542	R 1 207
Electrified Hot Plate	N/A	R 183	R 377
LPG Geyser	R 308	R 476	R 895
Electric Geyser	N/A	R 172	R 299
SWH (Integral)	R 297	R 297	R 297
Hybrid SWH – High Income	N/A	N/A	R 919
Hybrid SWH – Low Income	N/A	R516	N/A

Table 4 Yearly water heating costs for various domestic technologies
Sources: (Winkler 2006), (DME 2004:88-95), own analysis

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The cost calculation above shows how integral SWH systems perform well for the high income households, but it is unclear what the heating capacity of these systems are, so no conclusions should be drawn about their performance. But the table does show how electric geysers are the cheapest means of providing hot water to high income households, while the purely electrical technologies are cheapest for low income electrified households, and paraffin is the cheapest technology for low income unelectrified households.

Despite the results of these calculations, SWH systems can be the cheapest option for households with particularly large hot water requirements, and some reports on hybrid SWH system performance give their solar contribution as higher than 60% of the fuel energy mix, which is what was used in this calculation. In fact, much of the recent literature about such systems state that SWH systems are more cost-effective than electric geysers, but this has yet to be shown conclusively.

2.3.3 Availability of Fuel

The ability of any household to meet its hot water demand is limited by its access to suitable technologies, and the fuels associated with them. Access to these fuels are usually created by markets that initially sell the technology devices to the households, while quantities of the associated fuels are sold from time to time, when required by those households. The availability of fuel is of particular importance because households usually opt for using a technology where the fuel has a secure supply, unless they use a number of technologies, or a hybrid technology. Each fuel type has its own set of availability issues, but these fuels may be split into two categories: those that have regulated or unregulated supply characteristics.

Fuels that are regulated are those that are delivered by markets, and these include fossil and processed fuels. The benefits of regulated fuels are that, since they are regulated, their pricing can be kept reasonably consistent while the aggregated fuel supply can usually be controlled to meet the demand. One example of the benefits produced by fuel supply regulation are the electrification programme and free basic electricity, which have been implemented by the public electricity corporation, Eskom. Another is the Government's zero-rating for VAT on illuminating paraffin sales, which was notified by the Minister of Finance in his Budget Speech in 2001. A problem associated with regulated fuels, though, is that the markets responsible for their distribution can have associated infrastructure limits, such as the electricity generating capacity shortages faced by Eskom, or limited fuel market penetration in rural areas.

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Unregulated fuels usually have their own individual supply issues. The most predominant fuels in this category that are used for domestic water heating are combustible bio-wastes, fuelwood and solar insolation. Supplies of these fuels vary over time, or periodically, and geographically according to location, and this makes the regulation of these fuels difficult. Of these unregulated fuels mentioned, though, solar insolation is unique in that it is free, variations are consistent, and the energy provision is relatively abundant across the country.

Since households are likely to choose which technology they shall use for domestic water heating from whichever associated fuels are available in their vicinity, households close to energy markets have more options available to them than the more isolated households. This disparity can be illustrated by comparing the options available in urban areas, where the energy markets are well represented, to rural areas where the markets are not so well represented and where energy poverty is greatest. This problem is one of those that energy policies try to deal with by the development of markets through public and private sector interaction, or other incentives, although this is only possible for fuels with regulated supplies.

2.3.4 Convenience of Use

The convenience of each technology used for domestic water heating can be categorised for the different income households and is, to some extent, a combination of the other factors.

Lower income households in SA necessarily prioritise food and clothing over hot water demand, which cannot be described as a basic necessity, therefore any spending on this service needs to be monitored and controlled. In these cases, convenience equate to the control of expenses. This is most simply achieved by manual water heating using the technologies and excess fuel remaining from more important services like cooking or space heating, if the technologies used for these are applicable. But SWH systems can potentially provide this hot water without the need to monitor fuel usage or supervision of the heating process, although these systems cannot produce hot water at all hours and there are limits to their heating capacities.

At the other end of the spectrum, higher income households can afford, and usually prefer, to use automated water heating technologies that result in a constantly available supply of hot water. This requires mains-fed fuel and water supplies, and the use of technologies such as gas or electric geysers, or hybrid SWH systems. The convenience of such systems is that there no time is taken up waiting for the water to heat up, and it is available at all hours of the day.

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2.3.5 Reliability of Technology

If we can gauge reliability of a technology by how long a system lasts, then the table above (Figure 3) gives that the geyser technologies and SWH systems are the most reliable, lasting 22 and 17 years, respectively, according to research done. In the case of SWH systems, there have been a number of incidents in SA where cold weather conditions, such as during some nights in the 1980s, have resulted in damage to a number of thermosyphon SWH systems. But indirect SWH systems can withstand freezing temperatures, since they incorporate a heat exchanger, and these are suitable for areas that experience such low temperatures.

But the reliability of a technology may also be determined by the reliability of the fuel source associated with that technology. This will affect all fuels occasionally, due to various reasons such as supply shortages or distribution failures, but SWH systems have an inherently unreliable, albeit consistent, energy source. This is because sunlight is only available for approximately half of each day and also because the sun moves throughout the day, and varies in intensity throughout the seasons of the year. The correctly calculated sizing and correct positioning of SWH systems can optimise the amount of useful sunlight available to the systems. But hybrid SWH systems, which also have an alternative fuel source, are commonly used to account for these variations in sunlight.

2.4 Conclusions

These conclusions answer the question: What are domestic SWH systems and how do they compare with other domestic water heating technologies, for households?

Domestic SWH systems are renewable energy devices connected to household water supplies that are installed to receive maximum sunlight. This sunlight is transferred to heat the water stored in the systems, which in turn is used by the households when required. There are a number of variations in SWH system design, and it may be concluded that the range of SWH systems can accommodate any climatic conditions that may be found in SA. Correctly sized systems can provide all of the hot water demands of the households that they supply, although policy documents seem to consider only hybrid SWH systems that require a 40% electrical backup heating component. Since SWH system performance and cost data are limited in SA, data provided by these policy documents have been used to complete this study with the result that this study cannot conclude on the impact of SWH systems in non-electrified households.

Currently, SA has approximately 123 750 SWH systems installed, which equates to a prevalence in SA households of approximately 1.1%, even though the technology has been available in SA since 1975.

Households are generally responsible for providing their own water heating technologies and the fuels associated with these. While hybrid SWH systems and electric geysers compare favourably to other technologies in terms of health and safety, availability of fuel, and reliability, other factors are more decisive in determining energy use patterns for electrified households. These factors are convenience and cost, and they affect high income households and low income households differently.

Low income households will often find it convenient to use the cheapest technology available to them that can also provide other services such as cooking and space heating. At the other end of the spectrum, high income households can usually afford to purchase whichever device provides the cheapest and most convenient solution, where convenience is represented by an automated device that provides hot water instantaneously.

Technology cost and convenience have been identified as the main reasons for households choosing technologies other than (electric) hybrid SWH technology to provide their hot water.

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3 The Sustainable Development of domestic water heating

The previous chapter showed that SWH systems did not provide significant benefits for households, so this chapter should answer the question: How would increased SWH system use benefit SA and why do households' choices of technology not reflect this?

3.1 Methodology

This chapter answers the question posed in three parts. Firstly, a literature review provides the details of SA's commitment to sustainable development and the measurable benefits that are offered by sustainable development through considerations to the economy, society and the environment.

Secondly, the impacts that may be associated with the highest levels of SWH prevalence are quantified. This is achieved by modelling the current use of energy for water heating, as the reference case, then modelling the use of energy that might be reflected if a maximum prevalence of SWH use was incorporated into the current energy use pattern, as the hypothetical scenario. The measurable benefits, identified as those benefits offered by sustainable development, can then be applied to the differences in energy use between the scenarios to evaluate what impacts are achievable.

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Thirdly, a literature review identifies a number of barriers that make it difficult for households to correlate their own interests with the interests of the state.

3.2 Factors of Sustainable Development

Domestic energy services such as cooking and space heating services could be described as basic needs and therefore may be considered to be more important than water heating. But, given that there is a general demand for domestic hot water, this energy service must also be addressed by the energy governance that regards the basic needs of households. As has already been discussed in this study so far, particularly with regard to domestic electrification, Government involvement in domestic energy provision has been geared to improve household safety, cost factors, and human potential, amongst other factors. According to the principles stated in SA's energy policy documents, and which will be reviewed in the next chapter, these benefits should be brought about through the implementation of sustainable development. Sustainable development is given by the National Environmental Management Act of 1998 as:

"the integration of social, economic and environmental factors into planning, implementation and evaluation of decisions to ensure that development serves present and future generations". (SA 1998:41)

Accordingly, the appropriate involvement of policy and Government should deal not only with economic and social factors, but also with environmental factors. SA's Energy Efficiency Strategy concerns all energy use, and therefore also domestic water heating, and it lists these sustainable development factors as (DME 2005:4-5):

Social sustainability

- Improving the health of the nation – by the reduction of harmful atmospheric emissions
- Job creation – this factor is self-explanatory
- Energy poverty alleviation – this can involves the provision of adequate affordable energy to communities

Environmental sustainability

- Reducing environmental pollution – this refers to the damaging impacts of pollution
- Reducing CO2 emissions – this refers to GHG emissions that contribute to climate change

Economic sustainability

- Improving industrial competitiveness – by maximising the energy use to energy cost ratio
- Enhancing energy security – protecting primary energy sources from supply disruptions
- Reducing the necessity for additional power generation capacity – this refers specifically to capacity issues such as the current electricity shortage

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Furthermore, the definition given above for sustainable development suggests a thorough approach to decision making, with the implication that the three steps, planning, implementation and evaluation are necessary for sustainable development. The recent publication of 'A National Framework for Sustainable Development' shows SA's commitment to sustainable development, and although it does not give explicit details for its implementation in the energy sector, it does discuss the introduction of sustainable development indicators for monitoring and evaluating SA's performance (DEAT 2008:10).

3.3 Indicators of Sustainable Development

To some extent, the performance of domestic water heating in SA may be provided, with regard to sustainable development, by quantifying the sustainable development factors given by the Energy Efficiency Strategy (2005), which have been listed above. While not all of these factors can be quantified, due to their nature or because of a lack of information available, a number of reports provide relevant information that may be used to generate sustainable development indicators.

A cost benefit analysis of domestic energy use, completed in 2002 (Winkler et al 2002), reported the external costs associated with fuels used to heat water domestically. These values were given in Rands for the year 1999, but are given in year 2000 Rands in Table 7 below. According to the report, the costs associated with local impacts are equated with illness and death due to local emissions, and burns and property damage due to accidental fires, while the costs associated with greenhouse gas (GHG) impacts are due to climate change and are estimated at R37/tCO2 (in 1999 Rands) for emissions.

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Fuel used:	**Local Impacts**	**GHG Impacts**
Electricity	2.8 R/GJ	11.6 R/GJ
Coal	5.1 R/GJ	4.2 R/GJ
Fuelwood	27.9 R/GJ	0 R/GJ
Paraffin	58.2 R/GJ	2.9 R/GJ
Gas	0 R/GJ	2.3 R/GJ

Table 5 External costs associated with domestic water heating
Source: (Winkler et al 2002), own analysis

We can see from this table how electrification might mitigate negative local impacts of domestic fuel usage, compared to the other fuels mentioned, but the use of SWH systems to provide hot water has no relative local or GHG impacts.

Other integrated aspects of sustainable development that have been mentioned are energy poverty alleviation and job creation. The macro-economic report (DME 2004) on SA's potential renewable energy markets gives numeric values for the impacts that new coal-fired (electricity generating) power stations and the installation of domestic SWH systems would have on these aspects. Values derived by this report are given in the table below, with costs adjusted to represent year 2000 Rands, while the assumed annual power outputs are also given to reflect the size of the developments that were considered. Also included are values for the effective impacts that the developments would have on Government revenue. Average values have been appended to this table for use in later calculations, but since these are not weighted according to the development sizes, they may be considered to be conservative estimates of the impacts.

Technology development	**Size of development** [GWh/a]	**Jobs created** [jobs/GWh]	**Value to Low Income hhs** [R/GWh]	**Impact on Gov Revenue** [R/GWh]
New coal-fired power stations	22 005	1.5	R 55 715	R 91 388
Hybrid SWH systems for:				
Low income households	2 232	3.8	R 73 477	R 130 376
Medium income households	1 339	3.3	R 67 961	R 117 999
High income households	930	2.8	R 63 441	R 107 527
Cluster housing	254	3.3	R 66 929	R 118 110
Traditional houses	159	3.3	R 69 182	R 119 497
(Average for SWH)		3.3	R 68 198	R 118 702

Table 6 Impacts of SWH and electrical generating developments
Sources: (DME 2004), own analysis

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These values show how domestic SWH technology compares favourably with electricity production, on all accounts, when the electricity is generated using coal-fired power stations, which is the cheapest and most common method of production in SA. Unfortunately, such values are not available for other household fuels.

Together, the information provided in this section can be used to address, quantitatively, the Sustainable Development factors given by the Energy Efficiency Strategy (2005) as shown in Table 8, below. Further to these factors, the 'Impact on Government Revenue' has also been identified, which will become important when considering the effects associated with financial incentives, and which this study will do.

Sustainable Development factors identified in the Energy Efficiency Strategy (2005)	**Quantified indicators identified in this study**
Improving the health of the nation	This factor can be represented by external costs due to local impacts.
Job creation	This factor has been identified for electric geyser and hybrid SWH technologies.
Energy poverty alleviation	This factor has been identified as the value to low income households, which has been identified for electric geyser and hybrid SWH technologies.
Reducing environmental pollution	This factor can be represented by external costs due to local and GHG impacts.
Reducing CO2 emissions	This factor may be represented by external costs due to GHG impacts, since CO2 and GHG emissions are equivalent in their association with climate change.
Improving industrial competitiveness	This factor has not been addressed in this study.
Enhancing energy security	This factor can be represented by hybrid SWH technology making use of a consistent supply of solar radiation, and simultaneously reducing the dependency on other fuels for a certain amount of energy.
Reducing the need for additional power generation capacity	This factor can be represented by hybrid SWH technology making use of an abundant supply of solar radiation, and simultaneously reducing the dependency on other fuels for a certain amount of energy.

Table 7 Relationships between sustainable development factors and indicators
Source: DME 2005, this study

Table 7 shows that the information given in Table 5 and Table 6 may be used as indicators for evaluating factors of sustainable development. And even though this information does not relate to all domestic water heating technologies, at least it shows that sustainable development factors may be evaluated to some extent, in order for Government to identify which strategy options should be used in the domestic energy markets to maximise sustainable development.

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3.4 The potential impacts of SWH

The material dealt with previously in this chapter can be applied to account for potential benefits that would be experienced by maximising the number of SWH installations in SA. This can be achieved by modelling domestic water heating in SA.

A reference scenario, based on research and qualified assumptions, may be constructed for typical household types and their current use of domestic energy for water heating. This scenario can then be compared to a hypothetical scenario, which has maximum SWH penetration in the domestic energy sector, to identify the potential impacts of domestic SWH technology.

It should be kept in mind, though, that as it was already mentioned in the previous section, the information given in relation to the factors of sustainable development does not refer to all domestic water heating technologies. Also, while other values used in the calculations in this section are based on a number of generalisations and assumptions, they may still be useful in representing the magnitude of the impacts that could be achieved by increased domestic SWH use.

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3.4.1 Reference Scenario

This scenario is a description of domestic water heating similar to that that was given in the introductory chapter. SA households are characterised as being either low income unelectrified, low income electrified, or high income electrified.

There are approximately 3 598 811 low income, unelectrified households in SA (Winkler et al, 2006:120). On average, they each required approximately 1.09 GJ of useful energy in 2001 (Winkler 2006:119;188) for water heating purposes, using combustion technologies, and usually cheap appliances. Research giving the breakdown of technologies used by these households has not been found, so data on household cooking (based on Census 2001 data) has been used to derive this breakdown, using the assumption that poor households can usually only afford to use one technology for both of these services. These results are shown below in Table 8.

Fuel used for domestic water heating	Estimated split for low income unelectrified households
Gas	5.1 %
Kerosene/paraffin	44 %
Wood	42.2 %
Coal	5.8 %
Other	2.9 %

Table 8 Table of typical fuel use estimated for low income households

Source: (Census 2001)

Low income, electrified, households make up 2 351 177 of SA's households (Winkler et al, 2006:120). These households typically use a combination of electrical appliances and combustion technologies, and usually cheap appliances to heat water. On average, low income, electrified, households each required approximately 2.31 GJ of useful energy in 2001 (Winkler 2006:119) for water heating. Approximately 83.1% of this useful energy demand was for electricity (derived from Winkler 2006:119;188), assumed to be evenly split between hot plate and geyser technologies, while the remainder of the energy demand is split as per Table 8 above.

High income households make up the remaining 5 255 717 of SA's households (Winkler et al, 2006:120), of which it is assumed that all are electrified. On average, high income, electrified households each required 5.36 GJ of useful energy in 2001 (Winkler 2006:119) for water heating. Approximately 89.9% of this useful energy demand for this household type was provided by electricity (Winkler 2006:119;188), the assumption being that this was using geyser technology.

These typical household characteristics, some of which have been assumed, give the following patterns of energy use for SA's domestic water heating, as shown in Table 9 below. See Appendix C for a breakdown of information used to derive these values.

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Water heating technology used	Fuel split for each household type	Annual domestic fuel demand [GJ/a]
Low income unelectrified households	(100 %)	(12 840 457)
Gas	5.1 %	377 467
Paraffin	44 %	4 931 400
Wood	42.2 %	6 621 523
Coal	5.8 %	910 067
Other	2.9%	-
Low income electrified households	(100 %)	(8 728 734)
Electricity – geysers	41.55 %	2 256 671
Electricity – hot plates	41.55 %	3 471 802
Gas	0.9 %	92 226
Paraffin	7.4 %	1 148 314
Wood	7.1 %	1 542 470
Coal	1 %	217 251
Other	0.5 %	-
High income electrified households	(100 %)	(25 325 410)
Electricity – geysers	89.9 %	25 325 410
Other	10.1 %	-

Table 9 Final energy demand for domestic water heating (Reference Scenario)
Sources: (Winkler 2006), (DME 2004), Census 2001, own analysis

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It is reasonably safe to assume that most of SA's 82 500 to 165 000 domestic SWH systems are installed in high income households, due to the high initial costs required for the systems, and that these households are reflected in the 10.1 % of high income households that use 'other' technologies to heat their water domestically. The implications for annual, aggregated, fuel demand have been calculated using relevant values provided previously in this study.

3.4.2 Hypothetical Scenario

This scenario relates to the current pattern of energy use in households for water heating, except for the incorporation of the maximum prevalence of SWH use. There have been a number of values given by different reports for the potential penetration of domestic SWH technology in the domestic water heating market, but each of these studies used its own methodologies, and it is difficult to find a consensus, or compromise, between them. It is therefore necessary to discuss these reports before applying the most appropriate methodology provided.

With regard to unelectrified households, a finding of this study's background literature survey is that there was very little literature that discusses the potential penetration of SWH technology in SA, and as such no values can be referenced in this regard. A couple of reasons can explain this lack of information. The first is that SWH systems are seen as being more applicable to households that experience larger domestic hot water requirements, since higher levels of demand improveses the cost effectiveness of the systems, and unelectrified households have the smallest hot water requirements. The second reason is that hybrid SWH technology is usually seen as an alternative fuel technology to electric geysers, which impacts only on electrified households. For these reasons, any assessment made of the impacts for unelectrified households would be pure speculation, and therefore this scenario will deal only with hybrid SWH penetration of electrified households.

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With regard to electrified households, the potential penetration of SWH systems into the domestic water heating market is given different levels in different reports. The most commonly referenced level of penetration was implied to be 100%, and the impact was given as an offset of 5 900 GWh of electricity demand (Fecher et al 2003), which was derived by assuming that 30% of total residential electricity demand, or 9 800 GWh, was attributable to water heating, and that 60% of this could be generated by the solar component of hybrid SWH systems. These values were also quoted as the potential of SWH systems in the DME's 2003 White Paper for Renewable Energy.

But a more thorough methodology was given in the DME's macro-economic report (DME 2004:88-94) of renewable energy technologies. This report uses 2001 Census data to identify the number of households with access to mains-water and grid-electricity are totalled up, excluding non-permanent or non-applicable structures such as informal dwellings, caravans and boats. As such, this number of household residences suitable for hybrid SWH sytems is given as 5 439 905 out of SA's 11 205 705 total households or 48.5%, in 2001. This gives a good indication of the maximum possible hybrid SWH penetration, but this level should still be reduced further to account for residences that cannot physically accommodate SWH systems, such as in apartment blocks with limited roof space. The report's calculations use penetration levels as 33% of these 5 439 905 households, presumably for reasons such as that just given, although it states that *"this percentage can be changed to reflect more pragmatic assessments of the number of houses that will ultimately incorporate SWH systems."* (DME 2004:92).

The report goes on to calculate that 4 914 GWh/a of electricity savings may be achieved by this level of hybrid SWH penetration, based on the assumption that hybrid SWH systems can deliver 60% of heating requirements. But as has already been mentioned in this study, there is a discrepancy over estimates of what each household's energy requirements are for water heating between the macro-economic report and the assumptions made at the beginning of this study.

It seems clear from the approach taken in the macro-economic report that the previous estimate of 5 900 GWh/a of electricity potentially saved is too optimistic. At the same time, the discrepancy between the household energy requirements assumed by this study, which are 2.31 to 5.36 GJ/a, and the estimates provided by the macro-economic report, 13.6 to 34.0 GJ/a, is too great to ignore. This study will deal with this discrepancy by making a few assumptions for this new scenario:

1) Penetration levels are 33% for the 5 439 905 households that are suitable for hybrid SWH systems, which are spread across all of the electrified household groups.
2) SWH systems incorporated in the hypothetical scenario satisfy the same demands for domestic hot water, without alleviating the suppressed demand for hot water in low income households.
3) The SWH systems that were included under "other" in the reference scenario remain undefined, except that these 123 750 (compromise of 82 500 to 165 000) SWH systems are subtracted from the number of households acquiring hybrid SWH systems in this scenario.

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These assumptions have been incorporated into Table 10, below, to reflect domestic energy use for water heating under the hypothetical scenario of maximum penetration of hybrid SWH. See Appendix C for a breakdown of information used to derive these values.

Water heating technology used	**Percentage of household type using each technology**	**Annual domestic fuel demand [GJ/a]**
Low income unelectrified households	**(100 %)**	**(12 840 457)**
Gas	5.1 %	377 467
Paraffin	44.0 %	4 931 400
Wood	42.2 %	6 621 523
Coal	5.8 %	910 067
Other	2.9%	N/A
Low income electrified households	**(100 %)**	**(9 554 834)**
Hybrid SWH	22.0 %	477 349 (electricity) 716 023 (solar)
Electricity – geysers	32.4 %	1 760 825
Electricity – hot plates	32.4 %	2 708 962
Gas	0.7 %	71 963
Paraffin	5.8 %	896 003
Wood	5.5 %	1 203 547
Coal	0.8 %	169 517
Other	0.4 %	N/A
High income electrified households	**(100 %)**	**(25 958 796)**
Hybrid SWH	22.0 %	2 475 908 (electricity) 3 713 863 (solar)
Electricity – geysers	70.1 %	19 760 803
Other	7.9 %	N/A

Table 10 Final energy demand for domestic water heating (Hypothetical Scenario)
Sources: (Winkler 2006), (DME 2004), Census 2001, own analysis

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This scenario results in a new domestic energy use pattern, shown in Table 10 above, which must be compared against the reference scenario and the differences can then be quantified to reflect the impacts of the hypothetical scenario. The results of this process are shown in Table 11 and Table 12, below, for the electrified household types, since there has only been significant information available for electric hybrid SWH systems and not straight SWH systems, and have been derived from tables of values given or derived previously in this study. It should be noted that the values used to derive the impacts due to electricity are based on new coal-fired power stations, but this is appropriate since most electricity generated in SA is in coal-fired power stations, and these are also the cheapest power stations to build and operate in SA (DME 2004:7).

Change in domestic fuel requirements for low income electrified households	
Fuel type	**(Hypothetical – Reference)**
Solar	716 023 GJ/a
Electricity	- 781 337 GJ/a
LPGas	- 20 263 GJ/a
Paraffin	- 252 311 GJ/a
Fuelwood	- 338 923 GJ/a
Coal	- 44 734 GJ/a
Associated impacts (derived for Sustainable Development factors)	
Factors	**(Hypothetical – Reference)**
External costs: local impacts	- 26 572 000 R/a
External costs: GHG impacts	- 10 042 000 R/a
Jobs created	331 jobs/a (add footnote: applies to elec and SWH only)
Value to low income households	1 472 000 R/a (add footnote: applies to elec and SWH only)
Impact on Government revenue	3 775 000 R/a (add footnote: applies to elec and SWH only)

Table 11 Potential impacts of electric hyrid SWH use in low income electrified households
Sources: (Winkler et al 2002), (DME 2004), own analysis

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We can see, from the table of impacts above, that the increased use of electric hybrid SWH systems results in favourable impacts for low income electrified households, from the reduction of external costs associated with conventional fuel use to improved job creation, value to low income households, and the additional factor of the impact on Government revenue. The table below shows that similar favourable impacts result for increased electric hybrid SWH systems in high income households, although the impacts are significantly improved for the factors of job creation, value to low income households, and the impact on Government revenue.

Change in domestic fuel requirements for high income households	
Fuel type	**(Hypothetical – Reference)**
Solar	3 713 863 GJ/a
Electricity	- 3 088 699 GJ/a
Associated impacts (derived for Sustainable Development factors)	
Factors	**(Hypothetical – Reference)**
External costs: local impacts	- 8 648 000 R/a
External costs: GHG impacts	- 35 829 000 R/a
Jobs created	2117 jobs/a
Value to low income households	22 552 000 R/a
Impact on Government revenue	44 048 000 R/a

Table 12 Potential impacts of electric hybrid SWH use in high income households
Sources: (Winkler et al 2002), (DME 2004), own analysis

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This exercise in modelling the potential impacts of the increased use of electric hybrid SWH technology in SA's electrified households indicates that it would contribute favourably to SA's sustainable development. However, there is still scope for the further development of sustainable development indicators, particularly for technologies other than coal-fired electricity generation and electric hybrid SWH technology.

3.5 Barriers facing SWH

Having gauged, in the previous section, that there are some relevant sustainable development benefits to be gained from the increased use of SWH technologies in domestic water heating, it is now important to identify which barriers exist that prevent this from happening. The reason for this is that, within the context of domestic water heating, these barriers can be seen as obstacles to progress along the lines of sustainable development.

The following barriers have been compiled from literature found in a number of sources, and this study. They have been categorised into investment barriers, technology barriers, barriers due to prevailing practice, and other barriers.

3.5.1 Investment Barriers

The overall cost of domestic SWH technology is a barrier for potential customers of SWH systems. Figure 5, given in the previous chapter, shows a comparison of annual domestic water heating costs attributable to the various available technologies, and in this comparison SWH is shown to not be cost-effective for any of the typical income-type households.

The high initial cost is also a barrier for potential customers of SWH systems. It has already been shown (as capital costs in Figure 3 and Figure 4) that the initial costs for SWH technology are higher than the alternative technologies. An implication of this is that households that do not have savings or large disposable incomes cannot afford the initial cost of the SWH system, even if they do have high water heating requirements, and will therefore purchase whichever one of the other alternatives suits best their specific circumstances.

3.5.2 Technology barriers

A brief history of SWH technology, provided in Holm's SWH market survey (2005), shows that SA has had a lot of experience with SWH systems since they first became widely available in the 1970s. In fact, South Africa has been involved with the early development of some SWH technologies. Currently, SA has a number of standards accredited with the South African Bureau of Standards (SABS), which cover a broad range of SWH requirements, from the mechanical testing of systems to the certification of SWH installers. These standards should provide some quality assurance for customers who purchase accredited SWH systems.

However, it was identified earlier in this study that there is a lack of widely acknowledged information about SWH system performance. This results in a large uncertainty about domestic SWH technology performance, which will have a negative affect on the demand for SWH systems, and therefore may be seen as a SWH performance barrier.

3.5.3 Barriers due to prevailing practice

This category of barrier is one of the most significant in SA, and the sources of these lie in the practices of both the public and private domains.

The public domain barrier is one of energy pricing regulation. The price of electricity, which is regulated by the National Energy Regulator (NERSA), is set at a level which does not reflect

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the total cost of meeting SA's electricity demands, either for the development of new power stations (DME 2004:8) that are required, or to include the external costs of the current electricity production (DME 2003a:27). Similarly, paraffin pricing benefits from a zero VAT rating. The concern with these pricing issues is that electrical and paraffin technologies have an unfair advantage over other technologies that may be even less harmful. This concern holds for domestic SWH technology and it may be seen as a barrier to SWH technology's competitiveness.

In the private domain, the inconsistent demand for SWH systems (shown in Figure 1) and the fact that there is significant spare SWH production capacity (Holm 2005:48) in SA, means that these SWH producers do not operate at optimum capacity. And since imports, which are affected by external cost factors, also contribute a portion of total SWH system supply in SA, there is a security of supply and demand barrier to the competitiveness of SWH systems in SA.

3.5.4 Other barriers

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The perceived usefulness of SWH technology is conflicting when seen from the perspectives of society on the whole and private households, and this can be shown easily by discussing these varying perspectives.

Society on the whole is concerned more in the requirements or effects of aggregated energy use in SA (e.g. in terms of sustainable development) than the specific requirements or effects of energy use in a single household. Therefore it will view the increased use of SWH technology as advantageous because it uses solar irradiation as a fuel source, which does not damage the environment, and because it can help to alleviate SA's demand for electricity, which is a priority at the moment.

Private households, on the other hand, will usually take their own specific needs into consideration. SWH technology cannot be considered to be versatile, because besides providing hot water, space heating applications are not ideal, and there are no other energy-related tasks that a SWH system can provide. This means that other technologies, such as electric, gas, paraffin, and biomass technologies, which are able to provide the means for lighting, water heating, space heating, and cooking, are likely to be prioritized above SWH technology. These implications are more severe for households with lower incomes, since they will usually buy household goods or devices according to priority. For households with higher incomes, the current national load-shedding of electricity is unlikely to affect domestic water heating much, since a typical household that has its hot water provided by an electric geyser is likely to have the geyser capacity to provide hot water for the period of time usually scheduled for rotational load-shedding.

The result of these concerns is that SWH technology is not likely to be seen as a priority in most households, despite the benefits to society, and since households usually choose their means for heating water themselves, it is likely that society will suffer to benefit individual households. This sacrifice may be seen as a lost opportunity to benefit society, and hence an opportunity barrier.

This barrier is, to some extent, only an acknowledgement of the existence of the other barriers, however it is possible to conceive that the public sector might wish to implement instruments at some stage to link the concerns of households and society.

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3.6 Conclusions

This chapter answers the question: How would increased SWH system use benefit SA and why do households' choices of technology not reflect this?

The benefits that SA may derive from the increased use of domestic SWH have been evaluated with respect to sustainable development, which is an important concept in the formulation of SA's policies and regulations, and which requires due consideration of social, economic and environmental factors.

A number of quantifiable social, economic and environmental indicators were identified by this study, and were shown to be useful in representing most of the major factors associated with sustainable development in SA. These indicators are:

- External costs associated with fuel usage, resulting in pollution damage to peoples' health and the environment, as well as accidental damage to property. These costs are carried by society and the environment.
- External costs associated with climate change, due to anthropogenic GHG emissions. These costs are carried by society and the environment.
- Poverty alleviation provided by developments' value to low income households.
- Job creation provided by developments.
- The effect on the economy by developments, which is provided by GDP growth.

These indicators were used, in conjunction with scenario modelling, to derive the sustainable development impacts that would result from the maximisation of electric hybrid SWH use in typical SA households. The result of this exercise was that the increased use of electric hybrid

SWH systems in SA households would contribute favourably to sustainable development in SA, for all of the indicators considered. Furthermore, the impact on Government revenue was also found to be favourable, and this has positive implications for the sustainability of any financial incentive programmes recommended by this study.

Before these sustainable development benefits may be realised, however, there are a number of barriers that may need be overcome. The barriers identified in this chapter were:

Investment Barriers:

- A total cost barrier results from SWH systems not being cost-effective compared to the other available technologies.
- A high initial cost barrier exists for SWH systems can be prohibitive for households, unless they have savings or access to personal financing.

Technology barriers:

- A performance barrier related to the relatively unknown performance of SWH technology.

Barriers due to prevailing practice:

- A competitiveness barrier exists, resulting from energy pricing regulation of electricity and paraffin in the public domain, which gives these fuels and their associated water heating technologies an advantage over SWH.
- A security of supply and demand barrier exists for the domestic SWH market in SA, resulting from an inconsistent local demand and from external supply factors, which determines that SWH production capacity is not optimised.

Other barriers:

- An opportunity barrier exists, resulting from the discrepancy between the factors of domestic water heating that are considered by private households and society as a whole, whereby the opportunity for sustainable development is superseded by the requirements of individual households.

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4 SA Energy Policy

The previous chapter dealt with SA's commitments towards sustainable development, the associated benefits that increased SWH use could achieve, and the barriers to these benefits. This chapter deals with the question: How do SA's energy policies address domestic SWH technology, as well as the barriers to and financial incentives for this technology?

4.1 Methodology

This chapter answers the question posed by reviewing energy policy, as provided by the DME, paying specific attention to documents that consider SWH, or renewable energy, technologies in order to understand the public sector's approach to developing the SWH market.

But before the energy policy documents are reviewed, it is important to understand some of SA's policy structures. This can be provided by a review of the documents that have defined the policy environment in SA generally, as well as those documents identified by the energy policy documents as being responsible for the conception of the energy policy documents.

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4.2 Policy environment

The Concise Oxford Dictionary (9th Edition) defines 'policy', amongst other things, as: "a course or principle of action adopted or proposed by a government, party, business or individual, etc" and "a document containing this". These are broad definitions of policy, but they do correlate with SA governance policy in that they outline governmental guidelines for addressing public concerns, while policy documents convey these guidelines.

But as in any society, SA policy has many concerns to address and in order to do this co-ordination is achieved by a certain level of regulation in the private sector, as well as a certain level of self-regulation in the public sector. Furthermore, concerns facing SA change over time, and existing policy must adapt to deal with the new concerns, either by applying the existing policy to new scenarios, or by superseding old policy with new relevant policy.

SA's policy environment has changed significantly since 1994, the year that heralded the end of Apartheid, and consequently numerous policy reforms were required. At the same time, South Africa's existing economy and infrastructure required some consistency throughout the reform process, and initial guidelines for this process were given in the Reconstruction and Development Programme (RDP 1994). The bearing of this document on energy concerns was predominantly the electrification of 2.5 million households by 2000, while the social and economic strategies embodied in energy policy still follow the guidelines given in these documents, according to the DME's White Paper on Renewable Energy (DME 2003a:7).

Another major development in SA has been the incorporation of the Constitution of South Africa (SA 1996), which is currently the highest set of laws in SA. As such, all policy must adhere first and foremost to the Constitution, although amendments may be made to this document. The Constitution also stipulates the jurisdiction and responsibilities of governance structures, which has implications on policy environments. And while the Constitution does not provide any relevant details on energy policy specifically, there are two broad policies reflected upon that do have a bearing on energy policy. The first is the inclusion of the Bill of Rights, which has some implications on which regulatory measures that may be adopted by energy policy. The second is the commitment that SA should

"... secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development." (SA 1996:6).

In fact, this second policy commitment of sustainable development is given as the motivation for the necessity of a White Paper on Energy Policy (DME 1998:3) in the latter document.

The DME is the administration responsible for national energy policy, while the documents that describe their policies are the White Papers on Energy Policy (DME 1998) and Renewable Energy Policy (DME 2003a). Along with other DME documents that are referred to therein, these collectively form the official body of national energy policy documents.

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4.3 Energy policy documents

The policy documents to be reviewed here cover a range of subjects other than SWH technology and may not be relevant to domestic SWH, therefore these subjects will not be dealt with unless they have specific relevance to general policy principles, renewable energy, domestic energy use or SWH technologies.

4.3.1 White Paper on Energy Policy (1998)

Produced by the DME, the White Paper on Energy Policy states that a national energy policy is required by the Constitution of SA (DME 1998:3), and gives the national context for energy policy, like other SA policies, as being part of the Government's macro-economic strategy of Growth, Employment and Redistribution (GEAR), as well as the social and economic strategies provided for in the Reconstruction and Development Programme (RDP). While GEAR emphasises the promotion of growth through exports and investments, and redistribution of wealth by the creation of jobs and reallocation of resources through the budget (DME 1998:7), the RDP provides a socio-economic programme of development that focuses mainly on the energy issue of electrification. Within this national context, the list of energy sector policy objectives are given as (DME 1998:8):

- Increasing access to affordable energy services.
- Improving energy governance.
- Stimulating economic development.
- Managing energy-related environmental and health impacts.
- Securing supply through diversity.

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The document addresses these objectives for each energy supply sector, which are listed as Electricity, Nuclear Energy, Oil and Gas (exploration and production), Liquid Fuels, Gas, Coal and Renewables. With regard to the specific fulfilment of these objectives in the domestic sector, the document commits Government to implementing measures that result in the progressive achievement of universal household access to electricity (DME 1998:48), and the promotion of low-smoke fuels and efficient combustion appliances in order to improve pollution from coal and wood use (DME 1998:78).

Besides fulfilling the objectives mentioned above, energy policy is also required to regard the effective management and development of SA's vast energy resources and infrastructure, as well as the regulation thereof. As a single broad subsection of the energy sector, though, renewable energy is relatively poorly represented in the document. This can partly be explained by the Government's approach to energy policy formulation, which the document gives as (DME 1998:18):

- Recognising problems;
- Identifying underlying problems;
- Identification of potential solutions to the problems, and choosing solutions based on analyses of their implications; and
- Monitor and evaluate the effects of the solutions, once the implementation of policy has commenced.

This approach favours centralised energy systems that are already well developed in SA, due to the requirements necessary for recognising problems, assessing the implications of potential solutions, and structures available for monitoring implemented policy. In contrast to the developed, centralised energy systems in SA, policy and governmental structures for renewable energy systems are relatively underdeveloped.

But, in mitigation of this fact, the document does identify the following challenges to renewable energy that policy should deal with:

- Ensuring the implementation of economically feasible technologies and applications.
- Ensuring the investment of an equitable level of national resources according to their potential, compared with other energy supply options.
- Dealing with constraints to their development.

In order to address these challenges facing renewable energy, Government has committed to providing the following (DME 1998:80-81):

- Support for development, demonstration and implementation for small and large-scale applications, including SWH systems.
- Support for applications in specific markets based on researched priorities.
- Development and implementation of standards, guidelines and codes of practice for the correct use of technologies.
- Establishment of suitable information systems of renewable energy statistics, assistance with the dissemination thereof.

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The document also provides criteria for the establishment of Integrated Energy Planning (IEP), which includes linking planning to sustainable development concerns, the macro-economic strategy, and supply and demand issues (DME 1998:82-83). Another development, which forms part of the IEP, is Integrated Resource Planning (IRP), which is required before any large investment decisions may be implemented by energy suppliers or service providers, and comprehensively deals with the social, economic and environmental implications of those decisions (DME 1998:83). Although the document does not elaborate on the details of these developments, both the IEP and the IRP could highlight the advantages and disadvantages inherent in renewable energy projects, assuming that these projects are initiated.

As part of the energy policy document, the DME gives a list of its responsibilities to include the general governance of the energy sector, formulation of long-term integrated energy policies, communication with stakeholders, management of investigation and demonstration programmes, management of regional and international co-operation, and ensuring that appropriate institutions are established to achieve energy policy objectives (DME 1998:106-

107).

4.3.2 Baseline Study – solar energy in SA (2002)

This document was commissioned by the DME to provide a basis for solar thermal (SWH) and solar electric (photovoltaics) technologies in SA, which could then be utilised to aid in the formulating of a renewable energy strategy (DME 2002:ii). The document comprises of three sections that deal with estimates of solar radiation, a survey of the SWH industry in SA and a survey of the photovoltaic industry in SA, although the latter section is not relevant to this study and is therefore not considered.

The section that covers estimates of solar radiation gives average radiation for the major urban areas, Gauteng, Durban and Cape Town, as 5.79 kWh/m^2/day, when measured at an angle of 30° (DME 2002:15) from the horizontal, which is considered to be close to the optimal angle of incidence for solar radiation in SA.

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In its report of the SWH industry, this document gives descriptions and some information about the design considerations of SWH systems, and gives a description of SA's SWH technical standards, as provided for by the SABS, although some of these are now obsolete. It also gives an estimate of SA's total installed SWH energy production capacity, although this estimate is not very useful since it does not differentiate between domestic systems and swimming pool, commercial, industrial or agricultural systems. Another shortfall of this estimate of the installed SWH systems' energy production is that it considers only a very simple estimate of the maximum capacity, but not a realistic estimate of what the solar energy contribution to domestic water heating might be.

In terms of sustainable development, and the national development objectives for SA, this document gives the benefits that SA would experience from expanded use of SWH systems as follows (DME 2002:14):

- Increased job creation
- Reduction of expenditure on energy (this benefit is mentioned in connection with households, but only relates to fuel expenditure and not investment expenditure)
- Reduction in air pollution from coal, wood or paraffin burning stoves
- Improved environmental impact and GHG emissions

This document does not present any conclusions or recommendations for the SWH industry, but this is not unusual since it is predominantly an informative review of the industry. As a baseline report, though, it would have been useful if the document had presented more information about the performance of the SWH system types in SA, as well as methodologies and findings, in more detail, for the improved monitoring of the SWH industry.

4.3.3 Integrated Energy Plan for the Republic of South Africa (2003)

The Integrated Energy Plan is a significant document in energy policy following its mention in the White Paper on Energy Policy (1998), along with Integrated Resource Planning, in connection with energy planning based on sustainable development.

The document gives scenario modelling as the basis for its integrated energy plan (DME 2003b:5). In a simulation of SA's energy system, a baseline scenario of current energy trends has been projected into the future, as the reference scenario, and compared against a number of scenarios that correlate to the implementation of certain planned policies.

Amongst the findings of this document, there are no specific recommendations for renewable energy planning, as opposed to the reaffirmation of the predominant role of coal in the energy sector, over the next 20 years. But this is not surprising since the document lists the exclusion of environmental externalities, and job creation and social development factors as identifiable gaps in the analyses (DME 2003b:28). While these omissions are in opposition to the national priority of sustainable development, they are scheduled to be addressed in the second phase of the IEP programme, although there is no timeframe given in the document for this development.

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4.3.4 White Paper on Renewable Energy (2003)

The DME produced the White Paper on the Renewable Energy Policy of South Africa as a supplement to the White Paper on Energy Policy released in 1998 (DME 2003a:vii). The justification for this policy document is given as being an enforcement of clauses in The Bill of Rights, which state that our environment should be protected by the state, from, among other things, pollution and ecological degradation (DME 2003a:6). This justification is appropriate with regard to renewable energy because these sources of energy represent some of the most environmentally benign technologies.

The fact that this justification was omitted from the White Paper on Energy Policy (1998) in its consideration of renewable energy may seem strange, but it could be that awareness of the potential benefits of renewable energy has grown. It is also likely that this document and its implications are necessary to make optimise the use of new international financing and investment opportunities that have become available recently through the United Nations Framework Convention for Climate Change, which SA ratified in 1997 and hereby gained access. The document gives these as the Global Environmental Fund (GEF), which gives financial aid for climate change activities, and more recently (in 2002) the Kyoto Protocol, which provides a mechanism for securing foreign funding for development projects that reduce emissions of greenhouse gases (GHGs) (DME 2003a:10).

The document goes on to discuss a number of topics, such as the national context for energy policy, which is largely the same as in the White Paper on Energy Policy (1998), and the potential that renewable energy sources and technologies have in SA. With regards to SWH, these sections do not deal much with aspects of the specific technology except to state the (Fecher et al 2003) estimate of potential electricity savings due to hybrid SWH systems as 5 900 GWh/a (DME 2003a:22). The document also states that SWH would contribute favourably to demand-side management of electricity (DME 2003a:22), and that the household sector requires measures that replace electric geysers with solar water heaters (DME 2003a:36).

But while these statements constitute elements of possible energy strategy, the most significant contribution to energy policy contained in this document, and which makes up a large portion thereof, is the effective establishment of a list of key barriers to renewable energy use and the stated commitments by Government in response to these challenges. The key barriers to renewable energy are given by the document (DME 2003a:9), as shown in Table 13 below, with comments placed alongside to make comparisons between these barriers and the barriers identified in the previous chapter.

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Renewable energy barriers identified in the White Paper on Renewable Energy (2003):	**Comparison with domestic SWH barriers identified earlier in this study (Section 3.5):**
Many renewable energy technologies have higher capital costs compared to conventional technologies that make use of bulk energy supply.	This barrier is identical to the high initial cost barrier identified previously.
Implementation of renewable energy technologies only becomes profitable after relatively long periods.	This barrier is similar to the high overall cost barrier identified previously.
Consumer awareness of the benefits and opportunities is limited.	This barrier is similar to the SWH performance barrier identified previously.
Economic and social system of energy services is based on centralised development around conventional sources of energy, such as electricity generation, and gas and liquid fuel provision.	This barrier is similar to the security of supply and demand barrier identified previously, since they both address the relatively undeveloped system of decentralised energy services.
Financial, legal, regulatory and organisational barriers to implementing renewable energy technologies and develop emerging markets.	This barrier is similar to the competitiveness barrier identified previously, where conventional energy sources such as electricity and paraffin prices are kept low through regulatory measures.
Lack of open access to key infrastructure (although this does not apply for SWH).	N/A
Market power of utilities (which may be regarded as competition to renewable technologies).	This barrier was not discussed before.

Table 13 **Comparison of renewable energy and SWH barriers**
Source: (DME 2003a:9), this study

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The main difference between the barriers identified previously in this study, and the barriers given in this document, is that there is no mention in this document of the weak link between individual households' and society's view of domestic water heating, which was given earlier as an opportunity barrier.

In response to the barriers that need to be overcome, the document discusses the creation of an enabling environment for renewable energy technologies and markets, and commits Government to the implementation of goals, objectives and deliverables (DME 2003a:32-35), which have been transcribed or summarised in the two tables (Figure 12 and Figure 13) below.

Goal: Establishment of appropriate financial and fiscal instruments	
Objectives:	Deliverables:
The investment of equitable levels of national resources into renewable energy systems compared with other energy supply options.	Analyses of the current financial framework and barriers to implementation of renewable energy supplies.
The setting of targets for the allocation of national resources and international funding.	The investigation of appropriate financial and fiscal instruments or incentives.
Introduction of appropriate fiscal incentives for renewable energy supplies.	To clarify the role of the CEF in renewable energy initiatives.
The extension of existing financial structures to establish sustainability and financing mechanisms.	The monitoring and evaluation of effectiveness of financial incentive schemes.
To facilitate the creation of an investment climate for local and international investors.	

Table 14 Energy policy goals, objectives and deliverables (financial)
Source: (DME 2003a:32-35)

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Besides the general development requirements that are given, in the table above, regarding financial incentives, the document gives further details on what incentives or mechanisms might be considered, such as budgetary allocations, subsidies, levies or tax rebates. It states that the most effective instruments for promoting renewable energy development have been investment incentives, production incentives and set-asides (DME 2003a:27-28). The two instruments of these that could be applied to SWH technology are investment incentives, which could be direct subsidies or tax credits, and set-asides, which entail the supplies of a predetermined quantities of renewable energy awarded to tendering energy generators and who may receive financial support. The document states that whichever options are implemented will be based on a macro-economic report and the outcome given in a Renewable Energy Strategy (DME 2003a:29). It was also mentioned that Tradable Renewable Energy Certificates (TRECs) could speed up the commercialisation of renewable energy technologies by allowing "green" energy to be purchased at a premium, thereby somewhat alleviating the need for financial assistance.

Goal: Development of an effective legislative system to promote renewable energy	
Objectives:	Deliverables:
Development of an appropriate legal and regulatory framework for pricing and tariff structures	The phasing in of regulations requiring tariffs to reflect full cost accounting, including environmental externalities.
	The establishment of clear solar radiation rights for property owners to prevent structural interference from neighbouring properties.
Goal: Development of renewable energy technology levels	
Objectives:	Deliverables:
The development of appropriate technology standards, guidelines and codes of practice.	The establishment of standards, and certification, for the design, installation and performance of systems.
The promotion of research, development and local manufacture of technologies.	The revision of Government tenders to include standards for renewable energy technologies.
	The monitoring of research to identify additional investigations and demonstration projects.
	To identify appropriate public/private partnerships for the promotion of renewable energy.
	To identify increased areas of international cooperation, including skills transfer.
	To integrate renewable energy R&D into the proposed National Energy Research Institute.
Goal: Raising the public awareness of benefits and opportunities for renewable energy	
Objectives:	Deliverables:
To promote the benefits provided renewable energy supply.	The development of standards for training programmes by the SA Qualifications Authority (SAQA).
To increase the government's knowledge of renewable energy.	Training on renewable energy for stakeholders, funded by the Energy Sector Education and Training Authority (ESETA).
To improve communication and interaction between national, provincial and local Government institutions.	Awareness raising and marketing campaigns for stakeholders.
	The establishment of a renewable energy centre, or network of centres.

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Table 15 **Energy policy goals, objectives and deliverables (other)**
Source: (DME 2003a:32-35)

These goals, objectives and deliverables that were given in the tables above form part of

Government's integrated approach to policy making, which takes account of cross-cutting issues. The document discusses these issues in depth (DME 2003a:35-40), but these implications are contained in the commitments or form part of the practical constraints on implementation, and as such are not in the scope of this study.

The biggest single contribution by this document, although it is not a commitment, is the target given for renewable energy supply as:

"10 000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. This is approximately 4% (1667 MW) of the estimated electricity demand (41539 MW) by 2013."

"This is in addition to the estimated existing (in 2000) renewable energy contribution of 115,278 GWh/annum (mainly fuelwood and waste) (Hughes et al, 2000). More efficient conversion of wood and waste for power generation will contribute to the target." (DME 2003a:25)

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While this target provides some scope for speculation, in terms of what the target actually means, how it will be implemented, or how significant the level of the target actually is, the creation of this target at least provides a benchmark in time, and hence establishes the need for a scheduled programme of implementation and monitoring capacity. The document acknowledges this by committing to an assessment of the document in 2009, presumably by Government and renewable energy stakeholders, with the possibility of a revision in the light of progress made towards the 2013 target (DME 2003a:29).

4.3.5 Economic and Financial Calculations and Modelling for the Renewable Energy Strategy Formulation (2004)

This document has also been referred to as the DME's macro-economic report elsewhere in this study.

This document is an economic and financial analysis aimed at assisting the DME in finding the optimal balance of renewable energy technologies that should be implemented in SA to reach the 10 000 GWh per annum target set by the White Paper on Renewable Energy (2003), based on the objective of least cost. It also deals with the implementation of another 4 000 GWh of renewable energy per annum, relating to a World Bank, DME and National Energy

Regulator (NER) initiative, although this is a subsidiary objective. The report follows the policy parameters given in the energy White Papers (of 1998 and 2003), in that it takes into account implications for indicators of national development and also includes contributions from CERs associated with CDM projects, which can typically be associated with renewable energy implementation projects.

The methodology used in this report, for finding the most cost effective method of renewable energy supply, was to derive supply curves for particular methods of renewable energy generation, in Rands versus kWhs generated, for the following technologies:

- Hydroelectric
- Biomass (from pulp and paper, and from sugar bagasse combustion)
- Landfill gas (combustion)
- Wind turbines
- SWH (residential and commercial)

These supply curves could then be compared against the cheapest electricity production method available currently, which is given as R 0.2526 per kWh for new coal-fired power stations (DME 2004:8), to indicate what subsidy level would be required to level their costs. The rationale behind this methodology is that while the national electricity utility currently purchases power from Independent Power Producers (IPPs) at approximately R0.10/kWh, this cost should rise to R0.2526/kWh as SA electricity demand reaches production capacity and new power stations need to be built (DME 2004:45). The analysis of findings in this report were performed by using what is described as a partial general equilibrium econometric model, that incorporates the SA Social Accounting Matrix (SAM), and which assessed the impacts on national development indicators such as employment creation, low income household incomes, and gross domestic product (DME 2004:6).

As with any modelling procedure, a number of assumptions were made in this report, including assumptions about macro-economic characteristics, such as discount rates, and technology characteristics, such as performance and cost. Technology generating costs, which were made up of annualised capital costs, operational costs and external costs were included for the technologies considered, along with any likely reductions in technology cost that may result from the increased implementation. Specifically with regard to the analysis of residential SWH technology, there is one assumed characteristic whose validity is questionable. The level of the average household's energy demand for hot water heating, made by the report, has already been discussed in this study. The calculation of this energy demand, from values given in the report (DME 2004:92), implies consumption of 13.6 GJ/a for low income households and 34.0 GJ/a for high income households, and this is much

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higher than findings by other studies. This may be explained by the fact that the report derives its household energy demand using a number of assumed variables, and does not include a factor for diversity.

Another assumption made in this document was that substantial revenue can be generated through the sale of CERs (Certified Emissions Reductions) from registered CDM (Clean Development Mechanism) projects, according to the rules of the Kyoto Protocol. CERs are awarded for each ton of CO2 emissions avoided by the use of renewable energy instead of conventional fossil fuel technologies. This rate of revenue was determined to be $3.50/CER at an exchange rate of R8/$ (DME 2004:36), which amounts to R28/CER in 2004 Rands, and equivalent to R21.74/CER in 2000 Rands. Estimates of the total CER revenue, given in this document for domestic SWH technology, however, should be ignored since these estimates have been based on the questionable estimates of household energy requirements for domestic water heating.

The findings of the report highlight a number of technologies and applications that should be promoted by the Government in order to achieve the 10 000 GWh/a target that was set in the Renewable Energy White Paper at the least cost to the energy producers. Amongst these technologies is included 930 GWh/a of residential SWH systems installed in high income households (DME 2004:table 88), which would require some subsidy or incentive, but which is shown have associated benefits for SA's GDP, low income household incomes, and job creation, when compared against new coal-fired power stations.

But while this report makes many conclusions, it does not suggest a particular programme for renewable energy implementation. This omission may be due to some practical issues, associated with implementation, that still need to be clarified by policy. Although it is not mentioned in the report, one reason to avoid implementing projects on the basis of least cost to energy producer is that while the other technologies can be compared against the cost of generating electricity from new coal-fired power stations (at R 0.2526/kWh), as IPPs of electricity, SWH system costs need to be compared by the individual households that install them against retail prices of electricity. For this reason, the main contribution of the report may be seen for the derivation of supply curves and the application of macro-economic accounting tools used for the report, although the methodology should be improved and validated to ensure accurate assumptions and to incorporate implementation options, such as subsidy or incentive options for the renewable energy technologies.

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4.3.6 Energy Efficiency Strategy of the Republic of South Africa (2005)

This document was prepared by the DME in recognition of the usefulness of energy efficiency as a cost effective measure in contributing towards sustainable development in SA, coinciding with a Demand Side Management programme being developed by the national electricity utility, Eskom (DME 2005:1).

Energy efficiency is the proportion of energy consumed in a process that is actually useful. The benefits of energy efficiency is therefore related to less wastage of energy, and the goals of the strategy presented by this document are given according to the component factors of sustainable development as (DME 2005:4-5):

Social sustainability

- Improvement of the health of the nation
- Job creation
- Alleviation of energy poverty

Environmental sustainability

- Reduction of environmental pollution
- Reduction of CO2 emissions

Economic sustainability

- Improvement of industrial competitiveness
- Enhancing energy security
- Reducing the necessity for additional power generation capacity

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The document gives details of the strategy by dealing with various sectors of society, and the section that relates to domestic SWH technology is the one that considers the residential sector. In this section the strategy proposed is that a target for final energy consumption by the residential sector in 2015 should be 10% below projected levels, which are based on projecting final energy consumption values for 2000 according to expected growth (DME 2005:12;15). One measure that the document gives as being required for households is that SWH systems should replace electric geysers, which may be funded by Eskom's DSM Fund (DME 2005:37-38).

Despite this suggestion of using the DSM Fund to support the funding of SWH, the document generally expects the costs of the energy efficiency measures to be borne by the beneficiaries of the measures, although there may be other financing mechanisms available, such as CDM (DME 2005:21). Also, the creation of a more formal framework for Energy Service Companies (ESCo), in terms of approving methodologies and accrediting performance standards and skills training, is given by the document as a role for the DME (DME 2005:22), and this should aid the implementation of energy efficiency measures in certain projects.

In the consideration of this document, it is somewhat unusual for the replacement of electric geysers with SWH systems to be suggested as an energy efficiency measure, since it is in fact a fuel switch, but the contribution of SWH technology to the sustainability goals mentioned above have been shown earlier in this study. Also, it is unlikely that solar energy contributions to the residential sector's energy consumption in 2015 are likely to be considered, due to benign nature of solar radiation as a fuel, therefore SWH can help achieve the target set for the residential sector.

4.3.7 Tradable Renewable Energy Certificate System Feasibility (2007)

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This document discusses, in further detail, the Tradable Renewable Energy Certificate (TREC) System that was mentioned in the Renewable Energy White Paper (2003), in connection with accelerating renewable energy commercialisation. Although in the White Paper it mentioned that TRECs could be used to help finance renewable energy production by pricing this "green" energy at a premium, this document states that the TREC system is not a financing mechanism, but rather a monitoring system for renewable energy production that could provide useful in enabling support mechanisms that encourage renewable energy production (DME 2007:3).

The TREC system can be understood by considering the life-cycle of a single TREC. The document describes this as (DME 2007:11-12) a three step process:

- Issue: A certificate is issued to represent 1MWh of renewable energy produced from a certain technology.
- Transfer: The certificate is registered to a single party and ownership may be transferred to another party.
- Redemption: The certificate is redeemed by the final owning party when it is transferred to their redemption account, which represents their environmental performance, or obligations within a regulatory system.

The document suggests that a TREC system implemented in SA should be based on the framework provided by Europe's Association of Issuing Bodies (AIB), and gives a plan for the implementation of the TREC system (DME 2007:3). Among the organisational developments provided by the plan is the creation of a national TREC Issuing Body (IB), which could be either a DME approved Non-profit Organisation (NPO) or a governmental agency, and which would be governed by market representatives and the DME. This TREC IB would then appoint a Production Registrar (PR), who would verify the compliance of the energy producing devices, an Auditing Body (AB) that would audit the devices' fulfilment of conditions for continued registration, and a Central Monitoring Office (CMO) that would operate a database of TREC certificates and accounts.

4.4 Conclusions

This chapter answered the question: How do SA's energy policies address domestic SWH technology, as well as the barriers to and financial incentives for this technology?

Energy policy reviewed in this study has spanned ten years, beginning with the White Paper on Energy Policy (1998), where policy regarding well established and predominantly centralised energy sources was detailed, but lacked detail when regarding decentralised or less established energy producers. The IEP's omission of sustainable development factors in 2003, suggests that energy strategy favoured economic development and energy poverty alleviation up until that point, through the supply of cheap established energy supplies, rather than sustainable development.

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SA's ratification of the Kyoto Protocol, in 2002, and the White Paper on Renewable Energy (2003), however, marked the beginning of a new era in the energy policy regime. Both of these commitments prioritised sustainable development, and policy developments, as given by the policy documents since 2003, have continued to explore options that can help to achieve the target contribution for renewable energy supply, which is given in the White Paper on Renewable Energy as:

"10 000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels." (DME 2003a:25)

Along with stating the DME's commitment to renewable energy, the White Paper on Renewable Energy (2003) identified a number of barriers to the increased use of renewable technologies, and provided details of further commitments and deliverables for relieving these barriers. The barriers dealt with in this document covered each of the barriers that were identified in the previous chapter of this study, except for the necessity to link individual households' and society's domestic water heating requirements. And while this barrier may be seen as an acknowledgement of the existence of other barriers, it may also be seen as an opportunity barrier that could be dealt with by the introduction of policy instruments, or mechanisms, such as financial incentives.

The policy documents suggest some options, in terms of financial instruments or mechanisms that may be used, which include:

- Prioritised technologies identified by a macro-economic report should be included in a Renewable Energy Strategy and could receive financial support (DME 2003a:29). The financial incentives that could be considered, which are relevant for domestic SWH technology, are investment incentives and set-asides (DME 2003a:27-28). A macro-economic report was published in 2004, but the Renewable Energy Strategy is still forthcoming.
- Two other financing mechanisms that may be used to finance domestic SWH systems are the DSM Fund and CDM (DME 2005:21). The DSM Fund would be accessible since SWH systems can help to reduce peak electricity demand contributions associated with electric geysers, and currently Eskom has a domestic SWH subsidy programme, which is discussed more in the following chapter. CDM can help to finance SWH systems by reducing CO2 emissions and contributing to sustainable development, and some details of SA's experiences will also be discussed in the following chapter.
- The TREC System is a system for monitoring renewable energy production, which may be useful in enabling support mechanisms (DME 2007:3), such as financial incentives, and its feasibility is currently under investigation.

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5 Local domestic SWH market

The previous chapter reviewed SA's energy policy approach to the development of the SWH market. This study also needs to consider the suitability of developments to encourage the SWH market, therefore this chapter answers the question: What public and private structures govern the supply and demand of domestic SWH technology in SA?

5.1 Methodology

This chapter requires an extensive literature review to identify the most significant structures in the SWH market, but this task has been simplified by the review previously made of policy documents and the availability of Holm's (2005) SWH market survey. These two sources of information have been used, along with the author's own analysis of the market, to provide a guiding, and bounded, representation of the entire SWH market.

This representation of the SWH market is then used, along with information provided by the literature reviewed, to describe the significant elements in the SWH market, and the relationships between the elements that create the market structures.

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5.2 Representation of the SWH market

The previous chapters have covered a number of aspects regarding SWH technology for domestic use, the policy documents have clearly established that existing Government structures will be used, first and foremost, to achieve the objectives given above. Since operational structures, and likewise their capacity, in governance cannot be ignored in this study, it therefore follows that public and private structures should likewise be considered, since operational governance is largely integrated into both public and private sectors. With this in mind, it is therefore essential to gain an understanding of the SWH market and the determining structures therein.

SA's domestic SWH market is made up by a complicated set of relationships, some of which may have greater influence than others. To ensure that our understanding of this market is inclusive of those relationships with the greatest influence, it is important to understand the relevant market concepts, and also to distinguish between and describe the common elements of the market.

The Concise Oxford English Dictionary (9th Edition) defines a market in a number of ways, with the most applicable for our purposes being 'the trade in a specified commodity'. Using this definition and applying it to the commodity of domestic SWH technology, we could consider the boundary of the SWH market to include only those trade relationships that actually involve the transfer of SWH hardware. This narrow definition of the SWH market is shown diagrammatically in the figure below, with the external market structures and alternative technologies to SWH shown as being external to the market.

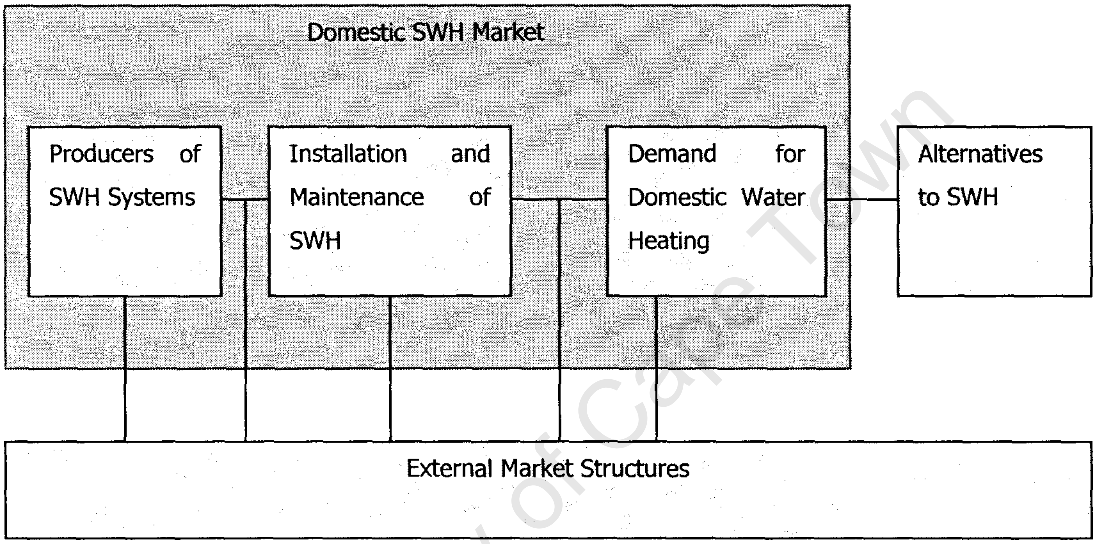

Figure 2 Simple diagrammatic representation of the SWH market

Source: this study

This view of the SWH market was similar to the one used in the DME's 2004 macro-economic report. In that report, the annualised cost of the system was compared against the annualised cost of electric geyser technology, in conjunction with coal powered electricity generation and external factor costs, to estimate the level of subsidy that would be required to equate total costs for SWH and electric geyser technologies.

But this narrow definition of the SWH market does not have the kind of depth of resolution that is required to account for non-conformities in each of these groupings. For example, the 'Demand for Domestic Water Heating' grouping does not differentiate between private households and property developers. This can be seen as a problem when we consider that, while private households can buy a SWH system based on their hot water requirements and budget limits, property developers would in many cases require the services of a consultant to plan for the inclusion of SWH systems. This problem alone identifies the need to view the SWH market in more detail to understand it.

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One way of dealing with the problems that arise when we view the SWH market under the narrow definition is to use a broader definition for the SWH market, which includes any other elements that have specific interest in the SWH market. Therefore this chapter will also include descriptions of elements that contribute to make up external market structures.

5.3 Elements of the SWH market

An effort has been made to provide information on all significant and distinct elements of the SWH market, describing their functions within the market as well as other pertinent information that may be useful in understanding their roles.

5.3.1 Producers of SWH systems

Producers of SWH systems may be subdivided into manufacturers, suppliers and retailers, but will be considered as a single element in this study.

From an economic perspective, market principles should regulate the price of SWH systems, since producers of SWH systems compete with other producers for business by minimizing the selling price of each SWH system, while still making a profit in the short or long term.

In 2004, it was estimated that there was 339% spare capacity for the production of glazed systems, without increasing work shifts or including the increased capacity for importing stock into account (Holm 2005:27). This can be combined with the estimated returns from manufactured and installed SWH systems (Holm 2005:33), which are shown in the table below, to illustrate what cost reductions would be possible if this 339% spare capacity was replaced by a four-fold increase in demand for SWH systems.

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	Proportion of total SWH cost	Estimated adjustment corresponding to four-fold increase of demand for SWH
Manufacturer material	31.2 %	31.2 %
Manufacturer labour	16 %	4 %
Cost of premises	2 %	0.5 %
Overheads	4.2 %	4.2 %
Promotion	2.4 %	0.6 %
Return (profit)	17 %	17 %
Distributor	9.2 %	9.2 %
Install/maintenance	18 %	18 %
totals	100 %	84.7 %

Table 16 Components of estimated returns for installed SWH systems
Source: (Holm 2005:33)

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The adjusted values shown in the right hand column of the table, shown above, have been derived by dividing the components associated with overcapacity by four. The resulting implication is that SWH system costs may be reduced by 15.3 %. Further cost reductions may be achieved by automation or by improving efficiency of manufacture, factors normally associated with economies of scale.

5.3.2 Proprietors of SWH Systems

Proprietors of SWH systems are those individuals or groups that buy complete or component SWH systems for inclusion in their residences, whether they plan to reside there or not. This can be seen as a group consisting of two separate elements, private households and property developers, since the considerations of these two elements differ to a large extent.

5.3.2.1 Private Households

Private households can either purchase their dwelling units along with SWH systems already incorporated, or they can install new or replacement SWH systems. It is unlikely that households who rent their homes would either be permitted to, or interested in, installing SWH systems, except under special agreements.

Market principles dictate that private households will pay less money, rather than more, to purchase the SWH system of their choice.

Due to high initial capital costs of SWH, it is usually only medium to high income households that can afford to install SWH systems.

5.3.2.2 Property Developers

Property developers are groups, or individuals, that build or renovate dwelling units to sell or lease to private households upon completion. It is typical for property developers to include some form of domestic water heating technology in these residences. But since the property developer would in many cases be unfamiliar with the specific hot water requirements of the households that the units would ultimately be allocated to, SWH systems would usually be sized and installed according to specifications, which would often require the involvement of a SWH consultant to some extent.

There are different types of property developers, such as commercial developers who take on projects to profit financially, and special interest developers groups that include donor organisations or the Government who fund projects not to make a profit, but to address social or environmental concerns, such as better hygiene, lower running costs, reduced pollution and local job creation (Holm 2005:37). In special interest projects, single-discipline consultants or NGOs typically approach donor organisations, motivated by social or environmental concerns, for project funding (Holm 2005:34). Government involvement to integrate SWH in the social housing delivery process requires much policy work (Austin & Morris, 2004:24).

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Market principles dictate that property developers will pay less money, rather than more, to purchase the SWH system of their choice.

Considering the planning which is necessary property development, which usually increases according to the size of the development, it can be understood that a lack of awareness regarding SWH opportunities could result in their non-inclusion at the planning stage, and this could result in their becoming too costly to include at a later stage.

5.3.3 Operators of SWH systems

This element includes both installers and maintainers, since these entities are likely to provide the same services and require the same tools and operational knowledge as each other. Operators of SWH systems are required to replace SWH system components occasionally, therefore some of these operators may be divisions of SWH producing companies.

Market principles dictate that operators of SWH systems compete with other operators for business by minimizing the cost, to proprietors, of installation or maintenance of each SWH system, while still making a profit in the short or long term.

Installation and maintenance costs for SWH systems vary depending on the design of the proposed system, with costs increasing in accordance with the complexity of the system. Maintenance costs would increase if replacement components were difficult for the operator to obtain, such as if a producer of non-standard SWH systems and components went out of business.

5.3.4 SWH Consultants and NGOs

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SWH consultants and NGOs are those organisations that develop and retain special knowledge of the SWH market elements, or of the relationships between those elements, thereby creating a role for themselves in projects where their expertise or experience is required.

Far from being entirely dependant on the other elements of the market for their involvement in new projects, SWH consultants and NGOs may approach donor organisations for funding of temporary SWH projects, using their knowledge of social or environmental issues to motivate for the initiation of the projects (Holm 2005:34). Such projects may be for the subsidised housing sector, or contributions to policy formation, amongst others.

5.3.5 Alternatives to SWH

Alternatives to SWH are constituted by the alternative technologies, and associated fuels, that are used for domestic water heating.

Alternatives to SWH technology are included in the domestic SWH market under the broad definition of the market because they have an effect on the SWH market, but not the narrow definition because they do not involve any trade of SWH technology or information. These alternative technologies affect the SWH market by trying to reduce the demand for SWH systems by satisfying as large a demand for domestic water heating as possible by their own use. The one exception to these rules is in the case of the electricity utility, Eskom, which has initiated a subsidy programme for SWH systems, but this shall be dealt with at a later stage.

These alternative technologies have already been dealt with in depth in this study, and therefore this element of the SWH market does not need to be elaborated upon.

5.3.6 External Market Structures

External market structures have been incorporated as the elements of the broader SWH market that introduce external factors into the market that are not provided by the elements described thus far. Also, although SWH promotions do have an effect on the market, they shall not be defined as constituting the external market structures of the SWH market, because they are temporary structures and they shall be dealt with in a separate section.

For the purposes of this study, the external market structures shall be constituted of the following elements: Government, public entities and private entities.

5.3.6.1 Government

SA's Government is responsible for looking after the public's interests according to rules given in the Constitution (1996), and the amendments thereof. In order for SA's Government to carry out its duties, various taxes, levies, duties and surcharges are imposed on businesses, organisations and individuals. The Constitution defines the various spheres of Government as national, provincial and local Government (SA 1996:Chapter 14).

National governance of the energy sector is carried out by the DME, although interaction with other Government departments and institutions is required. According to the White Paper on Renewable Energy Policy, the DME has the following functions, regarding renewable energy, within its jurisdiction and budget (DME 2003a:41-42):

- Development of policy, strategy, action plans, legislation, regulations and enforcement.
- Coordination.
- Dissemination of information.
- Monitoring, auditing and review.
- Monitoring of publicly funded research development.
- Promote capacity building and empowerment.

Apart from these duties, and the implementation of developments given in the energy White Papers, the DME has also developed some international partnerships, such as the Global

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Village Energy Partnership and the Renewable Energy and Energy Efficiency Partnership[2], which can provide funding for sustainable development projects. In terms of the provision of access to funding for renewable energy projects, the DME has established the Renewable Energy Finance and Subsidy Office (REFSO), which offers advice on financing options and manages the awarding of subsidies[3].

The role of provincial and local Government is given by the White Paper on Energy Policy (1998), regarding energy governance in general, as a limited one that deals with energy supply and use (DME 1998:107), matters which are concerned with energy service delivery. Although provincial and local governments have a limited role in energy governance, they may be instrumental in the development of the energy sector, as illustrated by the City of Cape Town's target for SWH penetration as 10% of households (CCT 2006:53) by 2010.

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5.3.6.2 Public Entities

This section is made up of organs of state and public corporations that have been created by Acts of Parliament in order to fulfil certain mandates as required by the public interest. They may be recipients of funding for the development of the SWH market, or they may provide a service within the market. In each case, these entities will be described briefly, and their current and potential roles discussed.

The Central Energy Fund (CEF) is a private company but is governed by the CEF Act, and reports to the Minister of Minerals and Energy and the Minister of Finance. Its role, besides managing oil and gas assets belonging to the SA Government, is to search for and encourage the development of energy sources. The CEF group is made up of seven operating subsidiaries, which include[4]:

- The South African National Energy Research Institute (SANERI) focuses on energy research and development.
- The Energy Development Corporation (EDC) invests in renewable and alternative energy through involvements in commercial, developmental and social projects.

The CEF's role in the SWH market has been to stimulate it by its involvements in SWH projects. Two examples of CEF's involvement in the SWH market include a subsidy project, known as the CEF SWH500 project, where 500 SWH systems were made available to

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[2] From www.dme.gov.za/energy/renewable.stm on 19/06/2008

[3] From www.dme.gov.za/energy/refso.htm on 19/06/2008

[4] From www.cef.org.za on 13/03/2008

households in three provinces, and its involvement in procuring a SWH test rig for the SA Bureau of Standards (SABS) that has led to a simplification of system testing for quality certification (CEF 2007).

Eskom is a public corporation, established under the Eskom Conversion Act in 2001, with the Minister of Public Enterprises as its executive authority[5]. Eskom is SA's national electricity producer, and since electricity is the energy carrier used to power electric geysers, it contributes to this competing technology to SWH.

But Eskom is also the main implementing agent of DSM[6] and, given the current electricity generating capacity issues and the ability of SWH systems to reduce electricity demand, it has implemented a SWH subsidy programme. Details of this programme are given later in this chapter.

The National Energy Regulator of South Africa (NERSA) was established under the National Energy Regulator Act, 2004[7]. Currently, NERSA has regulatory mandates regarding gas, petroleum and electricity supplies, with no particular interests in the renewable energy sector. But under its role as electricity regulator, it approves a DSM component of the electricity tariff[8], part of which is currently used to fund Eskom's SWH subsidy programme.

The South African Bureau of Standards (SABS) is a statutory body established under the Standards Act, 1945, which publishes technical standards for manufactured products and provides compliance testing as a service[9]. These services include quality assurance for SWH systems, with the relevant standards being:

- SANS 1307:2005 – domestic SWH systems
- SANS 6210:1992 – domestic SWH systems; mechanical qualification tests
- SANS 6211:2003 – domestic SWH systems; thermal performance tests
- SANS 10106:2006 – code of practice for SWH installation
- SABS 151:2002 – fixed electric storage water heaters

Until recently, the standard set for SWH systems involved a difficult procedure, but the recent commissioning of a SWH test rig at Pretoria's SABS (CEF 2007), the first in Africa, has allowed for much less time consuming performance testing. And there is a registered unit standard on

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[5] From www.eskom.co.za on 19/06/2008

[6] From www.cef.org.za on 13/03/2008

[7] From www.nersa.org.za on 13/03/2008

[8] From www.cef.org.za on 13/03/2008

[9] From www.sabs.org on 19/06/2008

a NQF level 3 that has been accepted by the South African Qualifications Authority. The unit standard relates to the installation of solar water heater systems. The code of practice and the NQF unit standard will form the basis of the training within the project. Currently the training material is being designed to assist in the process of training new and current solar water heater installers[10].

The South African Revenue Service (SARS) was established under the South African Revenue Service Act 34 of 1997, and provides the country with the services of revenue collection (all national taxes, duties and levies), customs regulation policing (import/export regulation), and administration of trade agreements[11] (e.g. free trade with SADC and EU). SARS operates according to a regime set by the National Treasury, and reports to the Minister of Finance. As the national revenue collection service, SARS's activities in the SWH market should represent the income required for governmental expenditure in the market, subject to policy concerns.

Statistics South Africa (STATSSA) was established under the Statistics Act, 1999, and is responsible for providing data about the economic, demographic, social and environmental situation in SA[12]. Data provided by the 2001 Census, which was carried out by STATSSA, has been referenced on a number of occasions in this study, and these illustrate the importance of accurate data in research. Unfortunately, the 2005 SWH market survey highlighted that STATSSA did not have renewable energy statistics, and this was identified as an impediment to assessing progress towards the Renewable Energy White Paper's national target of 10 000 GWh/a of renewable energy by 2013 (Holm 2005:26). Policy development in relation to renewable energy should rectify this to some extent. The next Census is scheduled to be carried out in 2011 (STATSSA 2007:9) and this would also provide an opportunity to gather further data on renewable energy, specifically SWH installations.

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5.3.6.3 Private interest

The private interest element consists of groups or organisations that enter the SWH market in order to achieve certain ends, and their effects on the SWH market may be intended or not. They may operate similarly to the public interest element, in that they benefit society at large but without the same constraints on their conduct, or they may be competitors to SWH technology, investors hoping to make profits, etc.

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[10] From www.cef.org.za/content/view/7/25/ on 23/07/2008

[11] From www.sars.gov.za on 17/06/2008

[12] From www.statssa.gov.za on 17/06/2008

5.4 Promotion of SWH systems

Promotions are temporary structures within the SWH market, and as such, they have an effect on the market. They are made up of one or more elements of the SWH market, which may be called promoters. Promoters usually have specific objectives with in the market, which they attempt to achieve by applying funds or providing knowledge in order to stimulate certain market activities, believing that these can achieve their objectives.

The recent survey of the SWH market (Holm 2005) provides a list and some details of promotions that have been implemented, or have been planned for implementation, in the last few years. Usually these promotions have involved the installation of fully-subsidised SWH system installations in low income housing schemes, or the subsidisation of a limited number of SWH systems available on a voluntary basis to targeted groups of the public. These promotions have usually been initiated to benefit the recipients of the SWH systems, but also to raise public awareness about SWH technology, learn about such SWH projects, and to stimulate activity generally in the SWH market.

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Two promotions that are of greater interest to this study than the other promotions, though, are the Kuyasa project, because of its registration as a CDM project, and the Eskom subsidy programme that has been initiated as a DSM initiative to reduce peak electricity use.

5.4.1 Kuyasa CDM project

The Kuyasa CDM project is located in Khayelitsha, Cape Town, and consists of the implementation of a number of energy, and particularly electricity, saving measures in 2309 Government subsidised low income houses. These measures comprise the retrofitting of ceiling insulation, energy efficient lighting and hybrid SWH systems with electrical backup heating, and qualify under the regulations of CDM because they reduce CO2 emissions that would normally have been expected, and that would contribute to global climate change. But because hot water supply and ceiling insulation had not been incorporated into the houses' original design, the registration of this project as a CDM project has required the provision of a case for the suppressed demand for energy services (SSN 2004).

Stakeholders participating in this project are the Kuyasa community, the City of Cape Town as the local governing authority, and SouthSouthNorth (SSN) as the specialist energy consultant. Financing is being provided by a number of sources, which include a poverty alleviation grant from the Department of Environmental Affairs and Tourism, and approximately 30% of capital costs from carbon income generated from the CDM activities (Bredenkamp 2007). This carbon income is to be provided by 6 580 metric tonnes of CO2e/a emission reductions[13].

The progress of the project has been slow, however, due to problems in securing the funding. Despite the implementation of 10 pilot installations in 2003, and the registration of the project on the 25th of August 2005 with the UNFCCC[14], the Kuyasa project has only recently, in late 2007, begun full implementation of the project (Bredenkamp 2007).

Other financing problems have also been experienced. Due to the small size of the project, and its registration as a Small-Scale CDM project, the Kuyasa project's income earned through carbon financing has been negated by the cost of the registration process's requirements and the cost of selling the CERs on the international market[15]. But this project has been used as a learning experience, and there may be some developments that similar projects could take advantage of to make better use of international carbon markets.

It has been suggested that the registration of a number of projects, similar to the Kuyasa project, could be registered under a different kind of CDM project known as a "programme of activities" (Winkler & van Es 2007:31), which would account for much greater CO2 emission reductions. And this would therefore make the cost of registration a much less significant portion of the capital costs. Also, considering that this CDM "programme of activities" could possibly be implemented in projects totalling 2 to 3 million RDP households (Winkler & van Es 2007:31), the establishment of a Sustainable Housing Facility (SHF) could be used to provide funds for new projects, while completed projects reinvest in the SHF through the generation of CERs[16].

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5.4.2 Eskom DSM subsidy programme

General information about Eskom's subsidy programme has been provided on Eskom's website[17], although there is no mention of how long the programme will last or what, if any, specific targets have been set. It is likely, as is typical with voluntary participatory

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[13] From http://cdm.unfccc.int/Projects/DB/DNV-CUK1121165382.34/view on 14/10/2008

[14] From http://cdm.unfccc.int/Projects/DB/DNV-CUK1121165382.34/view on 14/10/2008

[15] From www.savingenergy.co.za/content/efficient_lowcost_housing.php on 14/10/2008

[16] From www.savingenergy.co.za/content/efficient_lowcost_housing.php on 14/10/2008

[17] From www.eskomdsm.co.za/?q=Solar_water_heating_Read_more on 14/10/2008

programmes such as this, that the performance and implications of this programme will be evaluated at predetermined benchmarks.

This subsidy programme is available to any households looking to purchase SWH systems. The programme also involves a number of approved SWH suppliers and installers, a number of technical auditors to monitor and verify that the process is adhered to, and Eskom as the implementing agent who must report on the impact of the subsidy programme to NERSA. Each of these participants has a role in the subsidy process:

- Households must choose an approved SWH system (see Appendix E for details as given on 14/10/2008) from an approved supplier that is suitable for their requirements in terms of their likely hot water demand, their location's ambient temperature range and water supply type.
- Approved suppliers must advise households on the type of system appropriate for their requirements and provide for the correct installation of the chosen system by a registered installer. Selected systems will be installed with monitoring devices to determine the performance of these systems.
- Technical auditors will inspect a selection of households to verify that the SWH system registered was correctly installed.
- At the time of the SWH purchase, a subsidy claim form is given to the customer by the supplier, and the amount of the subsidy is paid to the household by Eskom within eight weeks of the submission of this claim form. As the implementing agency for the subsidy, Eskom is also responsible for the general administration of the programme, although these details are not provided.
- As was mentioned earlier in this study, Eskom receives funding for DSM measures from a component of the electricity tariff, which is approved by NERSA, and as such, Eskom must account for its expenditure on DSM measures by reporting these to NERSA.

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This programme ensures quality assurance of the SWH systems by only including SABS approved systems with comprehensive guarantees of at least five years, and which are supplied by SWH suppliers that are registered with the Sustainable Energy Society of South Africa's (SESSA) Solar Water Heating Division.

The programme qualifies as a DSM programme in that each SWH system installed must have a timer control or ripple control installed, if it has a electric backup heating component, which disables electrical operation during peak electricity demand periods, although override switches are also incorporated. Electric geysers must also be disabled, in households that receive the subsidy.

While it is uncertain what the impact of this subsidy programme will be, a recent report suggested that the uptake of SWH systems within this programme was slow due to the relatively large cost of SWH systems compared to electric geysers, despite the favourable contribution of the subsidy (vd Merwe 2008), which is between 14% and 31% of the capital cost of the approved SWH systems (reflected in Appendix E).

5.5 Conclusions

This chapter answers the question: What public and private structures govern the supply and demand of domestic SWH technology in SA?

The supply chain that forms the core of the domestic SWH market is made up of SWH system producers, installers and maintainers, who provide SWH equipment and services to households that represent the demand for SWH systems. Both the supply and demand for domestic SWH systems can be characterised simply.

The supply of domestic SWH systems in SA began in the mid-1970s, being met by local manufacturers, or by the importation of systems. Despite the age of the market, it has not experienced consistent growth, and currently the prevalence of domestic SWH systems in SA households is only about 1.1%. To some extent, this inconsistent growth contributes to the high cost of SWH systems, and it has been shown in this study that these costs may be reduced by 15% or more if the demand for SWH systems was more consistent or exceeded current supply capacity.

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The current demand for domestic SWH systems in SA can generally be described in two ways:

- By individual households purchasing a SWH as their preferred choice of technology for heating water.
- By groups or organisations that subsidise and install subsidised SWH systems in low income housing projects to achieve developmental or environmental objectives. These are generally initiated by specialist SWH or sustainable development consultants that secure donor or public funding for the projects.

Besides this supply chain, a further number of market elements have been identified in this study that contribute to, and have an impact on, the market in the following ways:

Financing mechanisms:

- There is currently an Eskom DSM subsidy programme available for approved systems, which provides direct subsidies for between 14% and 30% of the total system cost. Financing for this programme originates from a DSM levy component in the retail cost of electricity. Households are responsible for claiming the subsidy after they purchase an approved system.
- Local and regional Governments may provide grant funding for development projects under their mandate of service delivery. This type of funding is suitable for low income housing projects.
- The Kuyasa CDM project has been used to develop a methodology for acquiring foreign funding for SWH systems using the CDM. This would be suitable for some low income housing projects.

Quality assurance:

- SESSA's SWH division is currently seen by some as an authority on the SWH industry in SA.
- IOPSA is an important organisation with regard to the installation and maintenance of SWH systems.
- The SABS provides a number of standards for SWH systems, ranging from the materials used in manufacturing, to correct system installation.

Competition:

- Competition to SWH technology is provided by alternative water heating devices as well as their associated fuel supplies, which is mainly due to cost factors. Government has used policy to keep regulated, conventional fuel prices low, in the past, to reduce poor households' spending on energy, with the result that these technologies may have an unfair advantage compared to SWH.

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6 Financial incentives

This chapter answers the question: What financial incentive options are suitable for SA to encourage its domestic SWH market, and how well are they likely to perform?

6.1 Methodology

The research provided previously in this study contributes to a body of research, which may be referred to in order to answer the question posed above. The methodology used to answer this question may be described as a criteria analysis, and this is performed in a stepped process, which may be given as:

1. The financial incentives options that are going to be considered by this study must each be identified from the research provided by this study.
2. A set of criteria should be identified from the research provided by this study, in order to ensure that each financial incentive is dealt with systematically, and not chosen only on the basis of its strengths, or disregarded only on the basis of its weaknesses.
3. The financial incentives should each be analysed according to this set of criteria, in order to make comparisons between them simpler. A simple scorecard will be used to record each option's performance for each criterion.
4. Conclusions should be made about what financial incentives are the most suitable for SA to encourage its domestic SWH market.

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6.2 Identification of financial incentive options

SA has had some experience with SWH promotions recently, although most of these promotions have been relatively small projects that have provided a limited number of subsidies targeted at public services, public servants or low income households. On a larger scale, a financial incentive programme has recently been launched by Eskom, at the beginning of 2008, to subsidise the cost of SABS approved domestic SWH systems, in an effort to achieve DSM objectives.

Government involvement in these promotions has usually been in the allocation of funding for their implementation by public entities, such as the CEF and Eskom, since the promotions have fallen within the mandates of these public entities. The commitment involved in a long term financial incentive programme, however, is likely to require more direct involvement in its implementation and operation, especially if an objective of the programme is to support the implementation of the DME's energy policy. But these issues should be addressed when regarding each financial incentive option.

Three types of incentive where suggested by the White Paper on Renewable Energy (2003), investment incentives, production incentives and set-asides. The two of these, which may be applied to domestic SWH technologies are investment incentives, which could be direct subsidies or tax credits, and set-asides, which entail the supplies of a predetermined quantities of renewable energy awarded to tendering energy generators and who may receive financial support. Each of these two applicable incentive categories should be considered for the possibilities that they permit.

Considering firstly the investment incentive options available, the Government has a number of options available to it to help make SWH systems more attractive to households, including:

- Direct subsidies – households apply for the subsidy when an approved SWH system is purchased and installed
- Income Tax deductions – homeowners may deduct a certain amount of their approved SWH system's capital cost from their income tax returns
- Interest rate subsidy – households effectively receive a low interest, or interest free, loan to purchase a SWH system, which they pay off over a set period of time by making regular payments

Similar investment incentives have been implemented in other countries, and therefore there exists experience in each of these programmes.

In the second instance, set-asides may be considered by the Government as another type of incentive for domestic SWH systems. These entail the supply of predetermined quantities of renewable energy supply, to come from SWH systems, awarded to tendering energy generators who may receive financial support. It is likely that these set-asides would target large housing projects where there is a collective demand for water heating technology, and may be implemented according to regional criteria, or in replicable projects in order to maximise positive impacts and minimize complications.

It may be possible for Government to implement a combination of investment incentives and set-asides, although this would be dependent upon the circumstances of the incentives considered, and on national resource constraints.

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In summary, the financial incentive options that will be analysed in this chapter are:

1a Direct subsidies
1b Income tax deductions
1c Interest rate subsidies
2 Set-asides

6.3 Criteria for the analysis of financial incentives

Many different aspects of domestic SWH technology in SA have been researched throughout this study. Each of these aspects was motivated by a question raised. In order to address these aspects comprehensively, they should be represented within the criteria for analysis. The following summary presents these aspects according to the chapter in which they were previously discussed:

- Chapter 2 reviewed SWH technology's current role as a service provider to households, and identified that cost and convenience factors distinguished individual households' attitudes towards SWH. As such, cost and convenience for households should be included in the criteria analysis.
- Chapter 3 reviewed the potential contribution of SWH technology to aspects of sustainable development, which were determined to be positive, and identified a number of barriers that constrained the increased use of SWH systems in households. In order to address these issues, sustainable development indicators should be evaluated within the context of the financial incentives considered, thereby representing the implications of the financial incentive options. Furthermore, the likely effects of the financial incentives on relieving barriers should be included in the criteria analysis.
- Chapter 4 reviewed SWH technology's access to public resources as constrained by energy policy, as well as the policies' identification of barriers, and steps required for relieving those barriers. To address these, the criteria analysis should consider how well the financial incentives correspond to the energy policy and funding opportunities identified in the energy policy documents.
- Chapter 5 reviewed the current domestic SWH market environment, identifying elements and relationships that make up the market structures. Since the state of the market is the motivation for this study, as well as a major constraint for any proposed measures, the basic structure of the financial incentive options should be identified and reflected against elements and relationships of the market that are relevant to them.

Besides these, there are other aspects of importance to the effective implementation of

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financial incentive programmes for domestic SWH technology. One report of such international case studies is provided by an international cooperation agency, the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), which focuses primarily on sustainable development (Hack 2006:iv) issues. In this report, assessments are made of a number of international domestic SWH programmes, based on the following criteria (Hack 2006:8):

- Transaction cost for applicants. This can be rephrased as the user-friendliness of the programme towards the direct recipients of the incentive.
- Transaction costs for promoter. These are the programme's operating costs, such as for administration and monitoring.
- Market orientation. This refers to the programme's applicability to the SWH market elements, which can be illustrated by the understanding that the public and the private sector are motivated by different objectives.
- Adjustment to country specific conditions. This refers to the programme's applicability to other institutional frameworks, such as the tax and legal frameworks.
- Credibility and reliability. These relate to the actual and perceived likelihood of the applicants being awarded the incentive offered they have applied for.
- Sustainability. This refers to the sustainability issues related to the programme, such as its duration and system of phasing out at the end of the programme's life. To avoid confusion with the concept of sustainable development, this aspect will be referred to as Programme Continuity.
- Efficiency/Cost-benefit ratio. This refers to the success of the programme with respect to achieving certain goals or benchmarks.
- Assessment scheme. This is the actual method of monitoring the success of the programme.

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A number of these criteria refer directly to the operational performance of programmes, and as such they would be inapplicable to a feasibility assessment of SA's incentive options such as this study. Instead, these criteria can be used as a guide for establishing a number of appropriate criteria, such as:

- Transaction costs for applicants could be viewed, along with Credibility and reliability, as the convenience of the programme to applicants.
- Transaction costs for promoters could be considered, along with Market orientation and Adjustments to country specific conditions, instead as the burden of the financial incentive to the market.
- Programme Continuity and the Assessment scheme should each be considered, although they should deal with likely impacts associated with the programme.

Each of the appropriate criteria identified above should be included in the criteria analysis of the financial incentive options. In summary, the following criteria will be considered (Each of these criteria assessments will be scored on the graded scale [-2,-1,0,1,2], with -2 representing very negative effects, and 2 representing very positive effects):

- Structure of the programme. Aspects of the basic workings of the programme should be highlighted and explained. This criterion is largely descriptive, providing details that will subsequently be assessed, and therefore it does not require a scoring.
- Capacity and Policy Issues. The workings of the programme should discussed in terms of their use of existing capacity, and their general burden on the SWH market. Scoring: A score of –2 should represent a severe lack of capacity for implementation or severe inappropriateness within energy policy, and vice-versa for a score of 2. (This combination of capacity and policy issues should not create problems of conflict, since these issues should be linked.)
- Programme Funding. The likely sources of funding, and how applicable they are to the programme, in terms of logic and within the context of energy policy, should be discussed. Scoring: A score of –2 should represent the severe inappropriateness of the funding in relation to the impacts derived from the programme, and vice-versa for a score of 2.
- Programme Continuity. The programme limits should be discussed to identify important aspects relating to its operations. Scoring: A score of –2 should represent severe problems in the continuity of the programme, and vice-versa for a score of 2.
- Cost and Convenience to Households. Aspects of the programme that impact on households should be discussed. Scoring: A score of –2 should represent a severe lack of cost and convenience benefits for the households targeted by the programme, and vice-versa for a score of 2.
- Impact on Public Sector. This provides an assessment of the likely performance of programme by linking sustainable development benefits to the cost of the programme. Scoring: A score of –2 should represent a severe mismatch between the benefits and the costs of the programme, and vice-versa for a score of 2.
- Impact on Barriers. There should be some consideration of what the programme is likely to have on overcoming barriers that were identified in Chapter 3 of this study. Scoring: A score of –2 should represent a severe mismatch between the benefits of the programme and the likely impact on reducing barriers to the domestic SWH market, and vice-versa for a score of 2.

The use of this scoring system is to introduce an element of objectivity and accountability into the comparison between the financial incentive options when considering each criterion. The criteria to be analysed are not weighted according to their importance relative to the other criteria, and therefore the results of the scoring system should not be seen as a reflection of

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the best available option

6.4 Criteria Analysis of financial incentive options

The criteria analysis that follows is a combination of qualitative and quantitative analyses, with references to information provided or derived earlier in this study.

6.4.1 Direct subsidies

Aspects of a direct subsidy programme are likely to resemble the implementation plan of Eskom's DSM programme, although there are some further possibilities and constraints that would be imposed by the SWH market and energy policy.

6.4.1.1 Structure of the programme

The main points that would represent such a programme are given in the table below, along with descriptions of how these main points are likely to be implemented, details of which have been derived from the literature provided in this study.

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Structure of the direct subsidy programme:	**Description of the likely structural implementation:**
Overall responsibility for the programme.	The DME would be responsible for oversight of the programme, securing the funding that would be required to subsidise an increased demand for SWH systems, and also for setting the subsidy levels according to a set of principles that should be established.
Administration of the programme.	The DME would also be responsible for the appointment of whichever organisation is contracted to provide the administration for the project. This administrator would probably be responsible for awarding the subsidies to SWH buyers, for which it would be reimbursed by the DME. The administrator would therefore also be required to keep a database of all programme related transactions.
Independent monitoring of the SWH installations.	Independent agencies should be contracted to verify the validity of a random sample of subsidy applications by checking that installations are correct, and correctly installed, as well as monitoring some of these systems to track their performance in relation to household hot water demand. There are currently a number of authorised Measurement and Verification teams in SA, that perform similar tasks for energy efficiency projects. These matters should be reported upon, periodically, to ensure transparency as well as for the DME to readjust their subsidy levels.
Application for subsidy.	Any person that buys an approved, with a fixed maintenance plan, may apply for a prescribed subsidy amount from the programme administrator after the installation is completed, which should be received by the applicant within a certain period of time.
Eligibility of SWH systems.	Any domestic SWH may qualify for the subsidy if the system and installation are certified to the appropriate SABS standards, and have a five-year guarantee. Each system should also have an appropriate performance rating, which should be tested, to ensure that it has a certain minimum solar heating capability.

Table 17 Structure and description of the direct subsidy programme

Source: this study

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Should it be the case that the TREC System is implemented, the functions provided by the administrator and the independent agencies responsible for monitoring and verification would be taken over by the relevant TREC System elements. Also, the renewable energy that is likely to be produced by the SWH systems over the first five years of their operation may be awarded TRECs, which the DME could agree to buy at set prices that reflect a partial subsidy of the total SWH system cost.

6.4.1.2 Capacity and Policy Issues

Implementation of the TREC System is likely to require some organisational capacity work, but the benefit of this system is that it can be extended to benefit energy systems other than domestic water heating.

In the event that the TREC System is not implemented, a new organisation fulfilling the role of programme administrator might need to be introduced. however there is already some experience available, in this regard, from the existing DSM subsidy programme.

Scoring: Since it is the case that existing organisational infrastructure may be exploited to implement the programme, this assessment scores a 1. This score would not be affected by the introduction of the TREC System, for the reason given above.

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6.4.1.3 Programme Funding

Funding for this programme could realistically be garnered from a number of sources:

- Funds earmarked for Eskom's DSM subsidy programme could be reallocated to this programme if SWH system installation requirements included DSM measures. This would mean a 14% to 31% contribution towards the cost of the system. For simplicity of calculation, we will use a single compromise value of (31+14)/2 = 22.5%.
- Furthermore, there could be some account taken of the historical disadvantage that SWH systems have had in competing against electric geysers, due to the effectively subsidised retail price of electricity. This funding could be sourced from the levy of 2c/kWh that has been set for electricity produced from non-renewable sources, since it is expected that this levy will raise R2 billion in 2008/2009, and R4 billion annually thereafter (Manuel 2008). This funding proposal would be acceptable on the grounds that renewable energy, like conventional energy in the past, is a priority for SA's development, as long as the money collected from the levy was not already earmarked for addressing environmental externalities. If this money were available

for the subsidy programme, it might take the form of a 15% system subsidy, to account for possible cost reductions in SWH system production that have been derived in this study.

- Other sources of funding may be made available, at the discretion of parliament.

Scoring: The sources of funding listed are appropriate for this programme, therefore this assessment scores a 2.

6.4.1.4 Programme Continuity

Such a subsidy programme would have favourable continuity aspects, with regards to the setting of subsidy levels and its phasing out. Both sources of funding may be adjusted yearly to reflect:

- DSM benefits, which are likely to reduce since households with the largest hot water demands are likely to take up the subsidy faster than other households, and
- possible SWH production cost reductions, which should also be reduced due to the increased demand for SWH systems resulting from the subsidy.

Scoring: Due to the simplicity of the dynamics involved, this assessment scores a 2.

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6.4.1.5 Cost and Convenience to Households

The approximately 37.5% that this subsidy programme would contribute to the total SWH system cost is likely to prove attractive, particularly to low income and high income households that have large hot water demands. And the inconvenience of applying for the subsidy should pose little problem if the subsidy is awarded within 8 weeks of the application, as in the case of Eskom's DSM subsidy programme.

The 37.5% subsidy applied to the SWH system costs (given in Table 3) results in impacts for households, as given in Table 18 below. This table shows the initial capital costs that are required for the purchasing of the hybrid SWH system, the amount of the subsidy to be reimbursed to the household, and how this reflects in terms of equal yearly costs over the life of the system. All costs are in year 2000 Rands.

Household type	Capital costs	Capital cost breakdown		Equivalent yearly costs
		Subsidy	Remainder	
High income	R 10 526	R 3 158	R 7 368	R 733
Low income	R 6 073	R 1 822	R 4 251	R 409

Table 18 Impacts of a direct subsidy on hybrid SWH technology and fuel costs

Source: this study

Scoring: The values given in the table above show substantial reductions in the cost of the hybrid SWH systems, however a comparison of these costs with other domestic water heating technologies show that the subsidy does not make the SWH systems the cheapest technology available, based on this study's cost assumptions. This means that only those households that have higher than typical demands for hot water will benefit financially from this programme. This, together with the convenience of the application process, determines that this assessment scores a 1.

6.4.1.6 Impact on Public Sector

This programme is applicable to all electrified households, including both low income and high income households, therefore the sustainable development impacts associated with it are shown by Table 11 and Table 12.

These impacts are related to a maximising of hybrid SWH use in households, and may be associated with total subsidies of R3 158 for 1 154 808 high income households, and R1 822 for 516 611 low income households, although the eventual programme phase-out does mean that these subsidies will become less over time. Ignoring the phasing out of the programme, and the subsidy may be broken down further into DSM and non-DSM contributions, which are differentiated according to their funding sources, and totals for these are given in Table 19 below.

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Subsidy component	Total subsidy for low income households	Total subsidy for high income households	Total subsidy for all households
DSM component	R 564 716 478	R 2 188 057 263	R 2 752 773 741
Non-DSM component	R 376 477 652	R 1 458 704 842	R 1 835 182 494
Total for all components	R 941 194 130	R 3 646 762 105	R 4 587 956 235

Table 19 Estimated maximum costs for the direct subsidy programme

Source: this study

The implication for this funding, when considering only the reduction of demand for electricity (these reductions are shown in Table 11 and Table 12), is that low income electricity demand is effectively being bought for R1 205 for each GJ/a, or restated as R71/GJ over the 17 year life of a hybrid SWH system. Similarly, high income electricity demand is effectively being bought for R69/GJ. These returns are slightly more than the costs given (in Table 2) for electricity.

A similar exercise may be performed to compare the expenditure of this funding against the external cost impacts, and the impact on Government spending (using Table 11 and Table 12). This calculation determines that every Rand spent on funding in low income households results in the reduction of local external costs by R0.48, the reduction of GHG external costs by R0.18, and adds R0.07 to Government revenue, over the 17 years of the hybrid SWH systems' lives. Similarly, every Rand spent on funding in high income households results in the reduction of local external costs by R0.04, the reduction of GHG external costs by R0.17, and adds R0.21 to Government revenue, over the 17 years of the hybrid SWH systems' lives. This analysis shows that the financial returns are approximately equal to half of the funding spent on subsidies, for the public sector.

The impacts on jobs and value to low income households will not be calculated here, but have been shown to be positive earlier in this study (in Table 11 and Table 12).

Scoring: This analysis of the impact of a direct subsidy programme on the public sector indicates that approximately half of the spending on subsidies would be returned to the public sector through reduced external costs and increasing the Government's revenue. And simultaneously the programme would purchase the demand for domestic electricity at a slightly inflated price. The performance of the programme, in terms of sustainable development, however, would be positive, and therefore this assessment scores a 1.

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6.4.1.7 Impact on Barriers

A direct subsidy programme can benefit the SWH market by relieving some of the barriers facing SWH technology:

Investment Barrier:

- The subsidy contribution means that SWH systems become more competitive when compared to non-renewable energy alternatives.
- If the subsidy can be awarded within eight weeks of the application being made, as it is in the Eskom subsidy programme, then this will have a positive effect on interest payable on a loan amounting to 37.5% of the systems costs, as well as for households with small savings, improving access to this energy service.

Barriers due to prevailing practice:

- This programme is likely to contribute to the improvement of structures, mechanisms and opportunities for decentralised energy supply through the building of organisational capacity in the renewable energy sector, especially if the TREC System is implemented.
- The increased attractiveness of SWH technology cost should increase demand for the technology, leading to production cost reductions, which have been estimated at 15%.

Other barriers:

- The programme provides a bridge between what is good for households and what is good for SA, with regard to water heating technologies, based on sustainable development.

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Scoring: This programme is likely to have a positive impact on the reduction of most of the barriers identified in Chapter 3, and this assessment scores a 1.

6.4.2 Income Tax deductions

Income tax deductions have been implemented in a number of foreign countries, which include Greece and France (Hack 2006:4), and the structure of this financial incentive option for SA has been based on some aspects of these foreign programmes. This kind of financial incentive programme allows tax-payers more choice of how to invest some of their tax contributions.

6.4.2.1 Structure of the programme

The main points that would represent such a programme are given in the table below, along with descriptions of how these main points are likely to be implemented, which has been derived from the literature provided in this study.

Structure of the income tax deduction programme:	**Description of the likely structural implementation:**
1. Overall responsibility, and decision-making.	The amount of the tax deduction is limited to certain limit each year, and is determined collaboratively by the DME and the Department of Finance.
2. Administration of the programme.	The tax revenue collector, which in SA's case is SARS, would be responsible for correlating this receipt with a similar receipt provided by the SWH producer, to verify the authenticity of the claim of the tax deduction.
3. Application process.	Households may remove an amount of taxable income from their income tax returns at the end of the tax year if they provide a receipt for purchase of an approved SWH system, which accounts for that amount. For the highest income tax category, 40% (SARS 2008a:19), the deduction would amount to a saving of 40% on the capital cost of the SWH system, although there may be a limit set on the value of the tax deduction.
4. SWH systems eligible.	Any domestic SWH may qualify for the subsidy if the system and installation are certified to the appropriate SABS standards, and have a five-year guarantee. Each system should also have an appropriate performance rating, which should be tested, to ensure that it has a certain minimum solar heating capability.

Table 20 Structure and description of the income tax deduction programme
Source: this study

6.4.2.2 Capacity and Policy Issues

The benefit of such a programme is that it is such a simple system to implement. In SA, there is already a precedent set, whereby tax deductions of a certain limit may be made when that amount of money is given to approved public benefit organisations (SARS 2008b). This has the result that the programme imposes little burden on existing capacity in the SHW market, although it does require some operational capacity building within SARS.

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Scoring: Due to the existing capacity available for this programme, this assessment scores a 2.

6.4.2.3 Programme Funding

Funding for this kind of programme is derived from the public sector in lost earnings, which could be rationalised according to the projected take-up of the tax deduction incentive to be replaced by a portion of the 2c/kWh levy that has been set for electricity produced from non-renewable sources, since it is expected that this levy will raise R2 billion in 2008/2009, and R4 billion annually thereafter (Manuel 2008). This funding proposal would be acceptable on the grounds that renewable energy, like conventional energy in the past, is a priority for SA's development, as long as the money collected from the levy was not already earmarked for addressing environmental externalities.

The use of an income tax deduction programme will mean that only high income individuals, and by implication only high income households, will benefit from the programme. This could lead to a number of questions about the legitimacy of the programme. But if it is considered that high income households predominantly use electricity to heat water, which results in high GHG external costs (shown in Table 12) that affect all and not only local households, it may be possible to rationalise the applicability of this funding.

Scoring: The benefits derived from the programme funding may be applicable to the funding source, but there may be questions surrounding the fact that the programme only targets high income households, and therefore this assessment scores a 1.

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6.4.2.4 Programme Continuity

The continuity of this programme, in terms of its being phased out, would be determined by the DME and the Department of Finance, according to predetermined programme benchmarks. Any adjustments made to the programme would be required to be at the beginning of each financial year, or else SWH sales could fluctuate unnecessarily.

Scoring: This programme would require the anticipation of annual participation in the programme in order to protect annual budgets. This would be difficult to achieve, therefore this assessment scores a -1.

6.4.2.5 Cost and Convenience to Households

This kind of programme is predominantly applicable to high income individuals, and by implication high income households, since the subsidy amount awarded in a tax deduction programme is allocated through a reduction of income tax. The lowest income households are not required to pay income tax, and other low income households generally pay little income tax and would therefore receive relatively small financial benefits from the programme.

For high income individuals, the effective percentage of the SWH subsidy is approximately equal to their maximum income tax level, up to a limit set for the cost of the SWH system. For our purposes, we may assume that this limit is R8 421.05. The effective subsidy value may be derived in the following way:

1. Suppose that an individual earned X + Y amount of income, where X represents the highest income tax threshold. The individual would pay the required income tax on X, and 40% of Y.
2. If the individual purchased an approved SWH system for R8 421.05, then they would be allowed to deduct R8 421.05 from their taxable income, X + Y, if they provided a valid receipt for the SWH system.
3. Now their income tax would be the required tax on X, and 40% of (Y – R8 421.05).
4. The difference in income tax before and after the tax deduction can be calculated as (the tax on X) + 0.4(Y) – [(the tax on X) + 0.4(Y – R8 421.05)] = - 0.4(R8 421.05)
5. The result is a reduction of income tax by, and an effective subsidy of, R3 368.42

In the case studied above, and using cost information from Table 3, the equivalent yearly costs of the SWH system have been calculated to be R720.84.

Scoring: The values given in the example above show substantial reductions in the cost of the hybrid SWH systems for high income households, although these only apply to households consisting of individuals in the highest income tax bracket. Any other households would receive a smaller amount of tax credits. A comparison of these costs with other domestic water heating technologies, however, shows that the income tax deduction does not make the SWH systems the cheapest technology available. This means that only those households that have higher than typical demands for hot water will benefit financially from this programme, therefore this assessment scores a 1.

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6.4.2.6 Impact on Public Sector

This programme is applicable to high income households, and therefore the sustainable development impacts associated with it are shown in Table 12.

These impacts are related to a maximising of hybrid SWH use in high income households, and may be associated with tax credit levels of up to R3 368.42 for 1 154 808 high income households, which would equates to a tax credits up to R 3 889 879 579.

The implication funding, when considering only the reduction of demand for electricity (as shown in Table 12), is that high income household electricity demand is effectively being bought for up to R1 259 for each GJ/a, or restated as R74/GJ over the 17 year life of a hybrid SWH system. These minimum returns are more than the cost given (in Table 2) for electricity.

A similar exercise may be performed to compare the expenditure of this funding against the external cost impacts, and the impact on Government spending (using Table 12). This calculation determines that every Rand credited in high income households results in the reduction of local external costs by at least R0.04, the reduction of GHG external costs by at least R0.16, and adds R0.19 to Government revenue, over the 17 years of the hybrid SWH systems' lives. This analysis shows that these minimum financial returns are less than the funding spent on subsidies, for the public sector.

The impacts on jobs and value to low income households will not be calculated here, but have been shown to be positive earlier in this study (in Table 12).

Scoring: This analysis of the impacts of a tax deduction programme on the public sector indicates that a high level of the tax credits awarded may not be returned to the public sector. The performance of the programme, in terms of sustainable development, however, would be positive, and therefore this assessment scores a 0.

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6.4.2.7 Impact on Barriers

This programme should also have some effect in relieving the barriers to SWH technology:

Investment Barrier:

- The tax deduction contribution means that SWH systems become attractive for higher income households, in terms of overall cost, when compared to non-renewable energy alternatives.

Barriers due to prevailing practice:

- The increased attractiveness of SWH technology cost should increase demand for the technology, leading to production cost reductions, which have been estimated at 15%. However, there may be some expected inconsistencies in the timing of orders for SWH systems, due to the deadline for tax returns, that result from job insecurity or when people calculate their tax returns, which could slow down the rate of predicted production cost reductions.

Scoring: This programme is likely to have a positive impact on the reduction of only a few of the barriers identified in Chapter 3, therefore this assessment scores a 0.

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6.4.3 Interest rate subsidies

An interest rate subsidy programme is a programme that is designed particularly for low income households, as it particularly addresses the problem associated with SWH technology which is the high initial capital cost. A similar programme has been implemented in Tunisia (Hack 2006:5).

6.4.3.1 Structure of the programme

The main points that would represent such a programme are given in the table below, along with descriptions of how these main points are likely to be implemented, which has been derived from the literature provided in this study.

Structure of the interest rate subsidy programme:	**Description of the likely structural implementation:**
1. Overall responsibility for programme.	The DME would be responsible for securing the funding that is required for making loans available to households to help finance SWH systems, although these loans would not be made directly available to households.
2. Administration of funds.	Instead, banks are likely to make these loans available to SWH producers, who in turn would set up contracts with households to pay the bank back for the systems in instalments. The funding secured by the DME would go towards paying the interest accruing on the bank loans. This chain of financing is similar to the system currently in place in Tunisia (Hack 2006:29), although in their programme the instalment payments are made to the national energy utility.
3. Participation of households.	Households would be able to pay for the approved SWH system of their choice in monthly instalments to the SWH producer over five years, although there would have to be some deposit paid initially, to cover installation and some system costs.
4. Eligibility of SWH systems.	Any domestic SWH may qualify for the subsidy if the system and installation are certified to the appropriate SABS standards, and have a five-year guarantee. Each system should also have an appropriate performance rating, which should be tested, to ensure that it has a certain minimum solar heating capability.

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Table 21 Structure and description of the interest rate subsidy programme

Source: (Hack 2006), this study

6.4.3.2 Capacity an Policy Issues

This programme could be implemented with little or no need for new organisations or agencies to be created, although the implementation of the chain of financing would require a fair amount of capacity building within existing structures to deal with new relationships and new tasks. The extent of this capacity building is unknown.

Scoring: Due to the necessity for an unknown quantity of capacity building, this assessment scores a -1.

6.4.3.3 Programme Funding

This funding could be sourced from the levy of 2c/kWh that has been set for electricity produced from non-renewable sources, since it is expected that this levy will raise R2 billion in 2008/2009, and R4 billion annually thereafter (Manuel 2008). This funding proposal would be acceptable on the grounds that renewable energy, like conventional energy in the past, is a priority for SA's development, as long as the money collected from the levy was not already earmarked for addressing environmental externalities. If this money were available for this programme, the interest rates offered by the banks for the management of the financing should be negotiated.

An interest rate subsidy is likely to improve household access to SWH systems, and thereby aid the positive impacts that are associated with the technology. But the required programme funding is likely to fluctuate depending on the agreed interest rates, which in turn are dependent on the Reserve Bank's lending rate. Such fluctuations could negatively influence the relationship between the funding and the benefits thereby derived.

Scoring: The possibility of a unstable relationship developing between programme funding and the benefits thereby derived means that the funding may be inappropriate for the type of programme, and this assessment scores a 0.

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6.4.3.4 Programme Continuity

This programme has a number of issues, which have been mentioned, that would need to be addressed before it could be feasible. The chain of financing that makes the programme possible is made up of a number of distinctive relationships, which are not typical, so there may be a number of issues, and operating protocols, that would need to be worked out and adhered to. These issues might not be so difficult to deal with, however, since similar problems should have been addressed in Tunisia's implementation of a similar programme. What may be more problematic, though, are the problems that derive from the lengthy household's payment period, which is given as five years to coincide with typical guarantee periods for SWH systems. These problems include what to do with SWH systems when households default on instalment payments, and how the DME can plan the eventual phasing out of the interest rate subsidy, while still being committed to the programme for another 5 years at least.

Scoring: This programme would require the accurate anticipation of household participation and interest levels to enable the five year plus funding commitment period, which could pose serious problems, therefore this assessment scores a -2.

6.4.3.5 Cost and Convenience to Households

Households are likely to benefit from such a programme for a number of reasons. Low income households would otherwise probably not have had access to low interest loans, making the purchasing of SWH systems prohibitive. The main benefit that all households could receive from this programme is convenience, in that they could evaluate how much they currently pay for their water heating service, and directly compare this against the instalment plan associated with a suitable SWH system.

The cost arrangements for this programme requires the participating households to pay and initial deposit, for the installation of the SWH system, and then the payment of the balance in monthly instalments over five years. Cost information provided earlier in this study (in Table 3) has been rearranged, in Table 22 below, to reflect this payment scheme. Note that energy costs have not been included, and should be considered separately.

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Household type	Initial payment (for installation costs)	Monthly instalments over five years
High income	R 2 105.26	R 200.13
Low income	R 1 214.58	R 115.26

Table 22 Hybrid SWH costs for the interest rate subsidy programme
Source: this study

Scoring: This programme benefits households, particularly low income households, by providing a convenient financing plan for SWH systems. However, there are no total cost reductions made, therefore this assessment scores a -1.

6.4.3.6 Impact on Public Sector

The costs that such a subsidy would require from public funding may be derived as follows:

1. Banks would lend an amount of money, PV, equal to the present value of a SWH system on the condition that they received interest, r, annually on whatever amount was outstanding. If regular, equal instalment payments were made over n years, then it may be shown that the annual contributions of these instalments, C, are required to be $\mathbf{C = (r.PV)/[1 - (1 + r)^{-n}]}$ (Ross et al 2003:144)
2. The difference between the sum of these annual contributions over five years and the present value of the SWH system gives the cost required by public funding, R, as $$\mathbf{R = 5C - PV}$$

Using these calculations and assuming that r = 0.05, n = 5, it can be shown that the public sector funding required for an interest rate subsidy on the system and maintenance costs (using costs from Table 3) of a hybrid SWH system is R1 859.69 for high income households, and R1 071.02 for low income households. These calculations are shown in Appendix D.

Since this programme is applicable to high and low income households, the sustainable development impacts associated with it are shown in Table 11 and Table 12.

The implication for this funding, when considering only the reduction of demand for electricity (as shown in Table 11), is that low income electricity demand is effectively being bought for R708 for each GJ/a, or restated as R42/GJ over the 17 year life of a hybrid SWH system. Similarly, high income electricity demand is effectively being bought for R41/GJ. These returns are approximately equal to the cost given (in Table 2) for electricity.

A similar exercise may be performed to compare the expenditure of this funding against the external cost impacts, and the impact on Government spending (using Table 11 and Table 12). This calculation determines that every Rand spent in low income households results in the reduction of local external costs by R0.82, the reduction of GHG external costs by R0.31, and adds R0.12 to Government revenue, over the 17 years of the hybrid SWH systems' lives. Similarly, every Rand spent on funding in high income households results in the reduction of local external costs by R0.07, the reduction of GHG external costs by R0.28, and adds R0.35 to Government revenue, over the 17 years of the hybrid SWH systems' lives. This analysis shows that the financial returns in the public sector are approximately equal to the funding spent on subsidies.

The impacts on jobs and value to low income households will not be calculated here, but

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have been shown to be positive earlier in this study (in Table 11 and Table 12).

Scoring: This analysis of the impact of a direct subsidy programme on the public sector indicates that approximately all of the spending on subsidies would be returned to the public sector through reduced external costs and increasing the Government's revenue. And simultaneously the programme would purchase the demand for domestic electricity at a good price. The performance of the programme, in terms of sustainable development, would also be positive, and therefore this assessment scores a 2.

6.4.3.7 Impact on Barriers

This programme can also benefit the SWH market generally by relieving some of the barriers facing SWH technology:

Investment Barriers:

- The financing mechanism provided by this programme effectively removes the high initial capital cost barrier, helping to improve access to SWH systems as a energy service provder.

Technology barriers:

- This programme would be very effective for households in creating awareness of how SWH systems compare against each other, and with other technologies, in terms of performance and economics due to its uncomplicated financing plan.

Barriers due to prevailing practice:

- This programme would be useful in allowing SWH technology to be compared more directly against other technologies. In this way, the SWH market could be developed without changing consumer perceptions to a great extent.
- By introducing a financing scheme, the result of this programme would be to increase the availability and demand for SWH systems, and thereby also contribute to the reduction of production costs for the systems by up to 15%, as was estimated in the previous chapter.

Scoring: This programme is likely to have a positive impact on the reduction of most of the barriers identified in Chapter 3, and this assessment scores a 1.

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6.4.4 Set-asides

Set-asides are a different kind of incentive, which do not rely on individual households to choose to invest in SWH technology, but entail the supply of predetermined quantities of renewable energy, to be installed in targeted households, by tendering energy generators who may receive financial support.

6.4.4.1 Structure of the programme

The main points that would represent such a programme are given in the table below, along with descriptions of how these main points are likely to be implemented, which has been derived from the literature provided in this study.

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Structure of the set-asides programme:	**Description of the likely structural implementation:**
1. Overall responsibility, allocation of project initiation funding and operational oversight.	The DME would be responsible for ensuring that the required funding is available to initiate projects, and for the oversight of operations in order to achieve certain levels of installed SWH capacity.
2. Administration of operations.	A public entity, such as the CEF, together with local authorities might be responsible for the identification and operation of specific projects.
3. Project implementation.	Project implementing companies, such as the ESCos that are currently used to implement energy efficiency projects under Eskom's DSM activities, would undertake the installation of SWH systems in targeted large-scale housing developments.
4. Independent monitoring of projects.	Independent monitoring agencies, such as the authorised M&V teams that currently verify energy efficiency projects under Eskom's DSM activities, may be used to monitor and verify the renewable energy produced by these projects.
5. External funding.	The securing of external funding sources for these projects, such as CDM, GEF or developmental financing, would be required before they are implemented.
6. Participation of households.	With each project the involvement of the recipients of the SWH systems would have to be considered, but in most cases this is likely to be addressed by a contractual agreement between the public entity operator of the project, or the local authority and the recipient household, whereby the SWH system is partly subsidised, and partly paid for in instalments over the five years that cover the system's guarantee. SWH system subsidies would be provided for by the external funding sources mentioned under the previous point.
7. Eligibility of SWH systems.	A range of SWH systems may be offered to recipient households, as long as the systems and installations are certified to the appropriate SABS standards, and have a five-year guarantee. Each system should also have an appropriate performance rating, which should be tested, to ensure that it has a certain minimum solar heating capability.

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Table 23 Structure and description of the set-asides programme

Source: this study

6.4.4.2 Capacity and Policy Issues

Such set-asides could be implemented using a number of organisations and structures that are already in place and have already gained relevant experience in such activities, although there may need to be further discussion between these stakeholders to formalise the boundaries of responsibility between them, and hereby determine weaknesses in this approach to implementation. One outcome resulting from this type of implementation of projects is that households pay back a portion of the SWH system costs to an effective SWH utility provider, and the impacts of this should be further explored to determine if this utility provider should be replicated locally, regionally, or should only be created as a single national utility.

Scoring: Due to the necessity for capacity building, and the requirement for formalising the programme's functional roles, this assessment scores a -1.

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6.4.4.3 Programme Funding

Funding sources for such projects are likely to be numerous, but have specific relevance to the projects:

- There would be a large sum required to initiate project operations, which might be placed in a fund such as the SHF, which has already been identified for this purpose earlier in this study. This funding would not ultimately contribute to any subsidies, but would be replaced in the SHF by external funding sources and payments made by the recipients of the SWH systems participating in the project. The DME would be responsible for this funding, This funding could be sourced from the levy of 2c/kWh that has been set for electricity produced from non-renewable sources, since it is expected that this levy will raise R2 billion in 2008/2009, and R4 billion annually thereafter (Manuel 2008). This funding proposal would be acceptable on the grounds that renewable energy, like conventional energy in the past, is a priority for SA's development, as long as the money collected from the levy was not already earmarked for addressing environmental externalities. Otherwise, some other funding should be made available for these purposes.
- External funding would be secured for each project based on specific criteria, such as CDM financing resulting from sustainable development and reduced GHG emissions. This funding would be placed in the fund that provided the initial capital to replace a portion of that spent.

- Instalment payments owed by the recipients of the SWH systems would also be placed in the fund that provided the initial capital to replace the remaining portion of that spent.

Scoring: Each project would be required to secure its own funding from an appropriate external source, and the risk present in each project could be minimised to protect the initial capital fund, therefore this assessment scores a 2.

6.4.4.4 Programme Continuity

The continuity of operation for such a set-aside programme is likely to be ensured, since each of the projects implemented should ultimately provide a positive cash flow into the initial capital fund. But there should be a number of adaptation, phasing out or escalation options that should be considered to deal with the following possible eventualities:

- Certain project activities highlight inefficiency in the programme's operating protocol.
- All projects identified are considered to be too risky to implement.
- New projects are identified, but no initial capital funds are available.

Scoring: If the eventualities listed above were provided for, this programme could adapt to suit requirements, therefore this assessment scores a 2.

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6.4.4.5 Cost and Convenience to Households

Low income households are likely to be exclusively targeted by this programme initially, since external funding is more likely to be made available for these households and also because low income subsidised housing developments represent the most easily accessible large-scale housing developments in SA currently. Higher income households may benefit at a later stage from projects that may be identified, or indirectly from spin-off projects that use the same implementing companies during lulls in project activities or from similar financing mechanisms that become initiated by the private sector. This study has already identified and discussed the convenience that households would experience from choosing SWH systems based on their performance and the level of instalment payments.

Participating households are likely to receive subsidised SWH systems, and be responsible for the paying the balance of the SWH system cost in monthly instalments over five years. Subsidy levels would vary from project to project, depending on the external funding secured.

Scoring: This programme benefits households through its convenience. However, there are no estimates available for the anticipated SWH system cost benefits, therefore this assessment scores a N/A.

6.4.4.6 Impact on Public Sector

Scoring: Any funding provided by the public sector would need to be justified for each project implemented, and would vary for different projects, therefore the impacts on the public sector cannot be commented at this stage, therefore this assessment scores a N/A.

6.4.4.7 Impact on Barriers

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This programme is likely to have a number of benefits for sustainable development. Given the derivation of impacts, in terms of the sustainable development indicators that were evaluated in chapter 3 for the maximum use of domestic SWH technology, it may be expected that the set-aside programme would have a favourable impact on the low income household sector. It has also been identified, however, that there could be some impacts on the higher income household sector, from later developments in the programme or from spin-offs. This programme can also benefit the SWH market generally by relieving some of the barriers facing SWH technology:

Investment Barriers:

- The SWH systems provided by this programme would be cost effective for the households that receive them, compared to other technologies, due to subsidy contribution.
- The financing mechanism provided by this programme effectively removes the initial capital cost barrier, helping to improve access to SWH systems as an energy service provider for the low income households that are included in the programme.

Technology barriers:

- This programme would be very effective for households in creating awareness of how SWH systems compare against each other, and with other technologies, in terms of performance and economics due to its uncomplicated financing plan.

Barriers due to prevailing practice:

- This programme is likely to secure the funding required for the projects implemented, based on the biases that favour conventional technologies despite their associated environmental concerns.

- The effect that this programme will have on the cost of SWH systems on the open market is likely to depend on the continuity of demand provided by the implementation of projects. But this should become well regulated in the medium term, due to the limited availability of initial capital in the fund, which is likely to result in reductions to SWH production costs.

Other barriers:

- This programme would be very effective for participating households in creating awareness of how systems compare to each other, and to other technologies, financially due to its uncomplicated and accessible financing plan.

Scoring: This programme is likely to have a positive impact on the reduction of most of the barriers identified in Chapter 3, and this assessment scores a 1.

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6.4.5 Scorecard for the financial incentive options

The tabulated results of the scoring that was carried out throughout the criteria analysis of the financial incentive options, is given in the table below. Each of these criteria assessments are scored on the graded scale [-2,-1,0,1,2], with -2 representing very negative effects, and 2 representing very positive effects.

	Direct subsidy	**Tax deduction**	**Interest rate subsidy**	**Set-aside**
Capacity and policy issues	1	2	-1	-1
Programme funding	2	1	0	2
Programme Continuity	2	-1	-2	2
Cost and convenience to households	1	1	-1	N/A
Impact on public sector	1	0	2	N/A
Impact on barriers	1	0	1	1

Table 24 Scorecard for the criteria analysis of the financial incentive options
Source: this study

This scorecard provides a useful summary of the criteria analysis performed on financial incentive options.

The direct subsidy performs well for all of the criteria, reflecting consistently positive results, but performing slightly better in the Programme Funding and Programme Continuity criteria. Relative to the other financial incentive options, the direct subsidy performs as well as any other option for all of the criteria, except for Capacity and Policy Issues, and Impact on Public Sector. However, it scores only slightly lower for these criteria.

The tax deduction's performance over the range of criteria varies from a good positive score for Capacity and Policy Issues, to a slightly negative score for Programme Continuity. Relative to the other financial incentive options, the tax deduction's scores are average, being neither the highest nor the lowest for each criteria, except for Capacity and Policy Issues, where it scores higher than the other options.

For the interest rate subsidy, the scores attained for the criteria also vary, from its most positive score for Impact on Public Sector, to its most negative score for Programme Continuity. Relative to the other financial incentive options, the interest rate subsidy probably is the least consistent, scoring the highest for Impact on Public Sector (outright) and Impact on Barriers (tied with others), while scoring as low, or lower than any other option for the remaining four criteria.

The set-aside did not have scores for the Cost and Convenience to households, and Impact on Public Sector criteria, and since these criteria have not been analysed, they should not be regarded in either a positive or a negative light. However, prior to any recommendations on the implementation of a set-aside, these criteria should be analysed. Ignoring these un-scored criteria, the set-aside option scores highest on the Programme Funding and Programme Continuity criteria, while it has its lowest score for Capacity and Policy Issues. Relative to the other financial incentive options, the set-aside performs as well on each of the analysed criteria as any other option, except for Capacity and Policy Issues where it scores lowest (tied with another).

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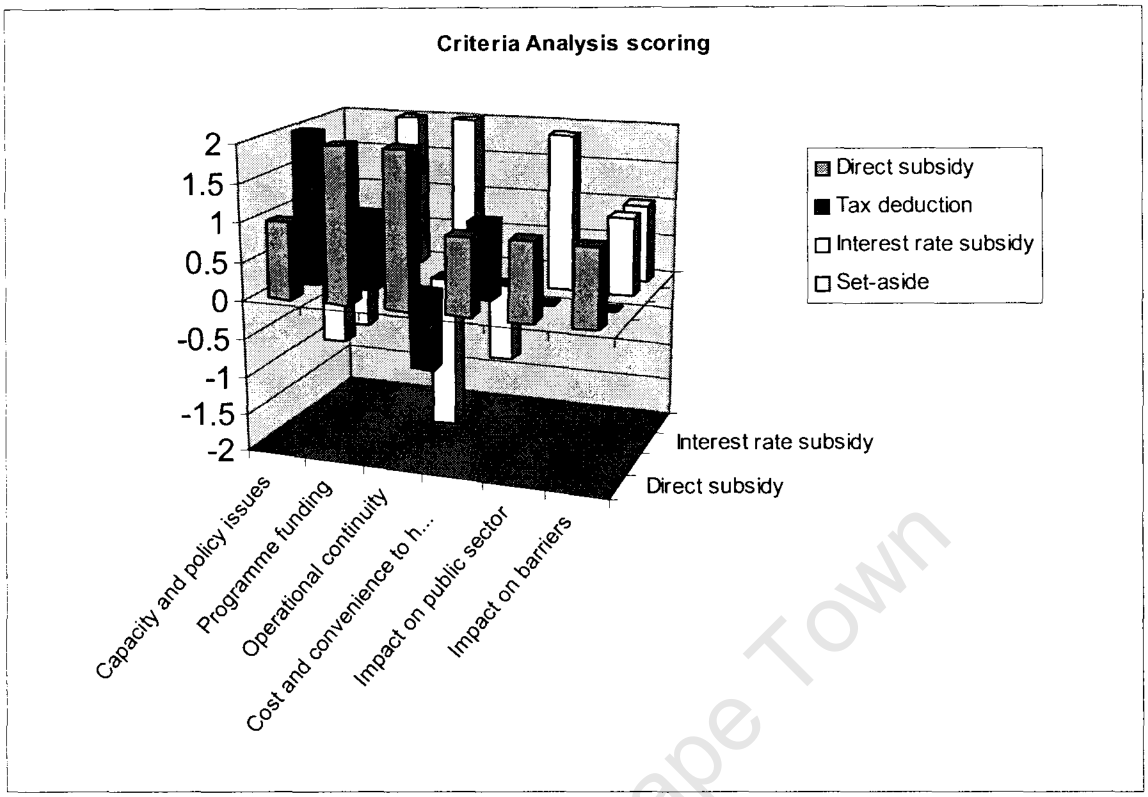

Figure 3 **Graphical representation of the criteria analysis scorecard**
Source: this study

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These results may also be neatly represented by a three-dimensional graph, as shown above in Figure 3, which shows visually how the financial options fared in the criteria analysis.

6.5 Conclusions

These conclusions answer the main question posed by this study, which is: What financial incentive options are suitable for SA to encourage its domestic SWH market, and how well are they likely to perform?

A number of financial incentives options were identified that could be considered as suitable options under SA's energy policy regime, and these were:

1a Direct subsidies
1b Income tax deductions
1c Interest rate subsidies
2 Set-asides

In order to assess these options, a number of criteria were used to perform a criteria analysis on these financial incentive options, using research documented earlier in this study to make generalisations about what features might characterise the implementation of such options. The findings of these criteria analyses man be summarised, and the options weighed up, to determine which options are the most suitable.

Experience gained in Eskom's DSM programme might be used to implement a similar direct subsidy programme, but with greater benefits to households that participate. The subsidy is provided to households when they purchase their SWH system. Existing market elements and structures could predominantly be used to implement the system, but it may be implemented more simply by incorporating the TREC System, especially if this financing option becomes available to other renewable energy technology markets. Funding sources for this programme would be relevant to the benefits resulting from this spending, and their finite limits would create a natural phase-out of the programme eventually. The incentive would be suitable for most households, but benefit those with large hot water demands the most, thereby having a generally good impact on sustainable development indicators. The programme would also have a good impact on the reduction of all the identified barriers to the SWH market. Relative to the other financial incentive options, the direct subsidy performs as well as any other option for all of the criteria analysed, except for Capacity and Policy Issues, and Impact on Public Sector criteria. However, it scores only slightly lower for these.

The tax deduction incentive option would involve individuals claiming a tax deduction for their SWH systems by providing a receipt along with their income tax return, at the end of the financial year. The implementation of such a programme would be smooth, since donations to registered charities are already tax deductible, and its phasing out could be easily achieved as performance benchmarks are achieved. Funding might be difficult to rationalise from a policy point of view though. The incentive would only be applicable to the higher income earners, but it would still have positive impacts on sustainable development indicators, since high income households generally have greater hot water requirements. This programme would also help to reduce barriers felt by the SWH market, although these impacts would be weak in terms of reducing the initial capital cost of SWH systems and in terms of the provision of system performance reports. Relative to the other financial incentive options, the tax deduction's scores for the criteria analysed are average, being neither the highest nor the lowest for each criteria, except for Capacity and Policy Issues, where it scores higher than the other options.

An interest rate subsidy programme would be likely to be implemented by banks offering loans to SWH producers for SWH systems that are then purchased by households with a deposit and instalment payments to the bank over a number of years. The subsidy would be

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paid to the banks to account for the interest, or a portion thereof, accruing on the loans. While there might be no need for any new organisations or agencies to be created to implement this programme, there would need to be some capacity building within the existing structures. Funding could be secured for this kind of programme, but it would need to be rationalised, and there could be problems with the manageability of operations, since the level of the subsidy needs to be determined for a number of years to come, while application levels could grow beyond funding capabilities. All households could benefit from such a programme, which would provide SWH systems with a very attractive financing plan, although the high overall cost of SWH systems compared to other technologies would mean a further subsidy is required on the capital cost of the systems. Also, another problem associated with this programme is what would become of SWH systems if households default on their instalment payments. If a number of SWH systems were identified that did compare well, financially, against other water heating technologies for the different household types, then it is likely that the positive impacts associated with sustainable development indicators would be maximised. This incentive could also have very good impacts on the reduction of barriers to the SWH market. Relative to the other financial incentive options, the interest rate subsidy probably has the least consistent scores for the criteria analysis, scoring the highest for Impact on Public Sector (outright) and Impact on Barriers (tied with others) criteria, while scoring as low, or lower than any other option for the remaining [four] criteria.

Set-asides are likely to be implemented by a new market structure, which still needs to be formalised, in a number of projects. Households targeted in these projects would purchase subsidised SWH systems in instalment payments from an effective SWH service utility. Funding for such a programme would be enabled by the creation of a financing facility, by external funding sources identified for each of the projects, and by the instalment payments made by households receiving the SWH systems. A number of issues need to be addressed to ensure that the programme's continuity is manageable, but these issues should not be prohibitive, and ultimately each project undertaken would be financially self-sufficient. The programme would be likely to target low income households and positive impacts associated with increased SWH use, as they were evaluated earlier as sustainable development indicators. But a number of developments could make the high income household sector accessible to this programme, directly, or indirectly through spin-off projects. The reductions in SWH market barriers associated with this programme should be very good as the number of projects implemented increase. Relative to the other financial incentive options, the set-aside performs as well on each of the criteria analysed as any other option, except for Capacity and Policy Issues where it scores lowest (tied with another).

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7 Conclusions and Recommendations

This study has answered a number of questions that relate to domestic SWH technology in SA, and in the previous chapter, assessments were made of the financial incentive options that might be suitable for encouraging SA's domestic SWH market. This chapter will need to incorporate these findings to answer the main question of this study: What financial incentives are the most suitable for SA to encourage its domestic SWH market?

The financial incentive options that were assessed in the previous chapter were:

1a Direct subsidies
1b Income tax deductions
1c Interest rate subsidies
2 Set-asides

The criteria analysis that provided the assessment of these options gives enough detail of how such options might be implemented to achieve the greatest benefits, and identifies a number of crucial issues.

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The direct subsidy programme provides a simple financial incentive option that performs well in all criteria of the criteria analysis (see Table 24), and also relative to the other incentive options. The implementation of the programme involves an option of whether to incorporate the TREC System into the structure of the programme, and although this does not affect its performance in the criteria analysis, it could be made available as a financing system for other renewable energy technologies, and this could in turn lead to lower administrative costs.

Besides scoring averagely on the criteria analysis, relative to the other incentive options, the income tax deduction programme scored low on the criteria: Programme Continuity, Impact on Public Sector, and Impact on Barriers (See Table 24). These were due to the following reasons, respectively:

- The level of deduction could only be set at the beginning of the financial year, and this could lead to problems in terms of anticipating participation in the programme.
- The benefits to the public sector did not quite justify the spending.
- The impact on the reduction of SWH market barriers were limited, due to the programme's targeting of only high income households.

The interest rate subsidy performed relatively inconsistently on the criteria analysis, compared to the other options, and attained low scores on the criteria: Capacity and Policy

Issues, Programme Continuity, and Cost and Convenience to Households (See Table 24). These were due to the following reasons, respectively:

- There would be a need for new working relationships and capacity building.
- The lengthy funding commitment period (assumed to be 5 years) would introduce problems.
- Participating households would not see a direct reduction of the SWH system cost.

The set-asides scored well on the criteria analysis, compared to the other options, but badly on Capacity and Policy Issues (See Table 24), which was due to the need for further understanding of such a programme as well as the need for capacity building. Furthermore, the criteria of Cost and Convenience to Households, and Impact on Public Sector were not assessed due to the undeterminable nature of the programme.

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While these reflections on the weaknesses of the financial incentive options give a good indication of how difficult they would be to implement successfully, it is also important to look at how successful the options are likely to be, in terms of generating household participation. This is most easily done by comparing the scores of each option for the Cost and Convenience to Households criterion, since it was identified in Chapter 2 that cost and convenience were the two criteria that influenced households' choice of domestic water heating technology the most. Looking at Table 24, the direct subsidy and the tax deduction scored highest for this criterion, while the set-aside did not receive a score due to determinability issues.

Together, the issues considered above lead to the conclusion that a direct subsidy programme would provide the best option currently for SA. Therefore it is the recommendation of this study that this programme should be implemented, according to the success of Eskom's DSM subsidy programme. Furthermore, it is recommended that the TREC System should be considered for incorporation into the operating structure of the direct subsidy programme, especially if the direct subsidy programme is extended to other renewable energy technologies, for the following reasons:

- The functionality of the TREC System is regarded to have good compatibility aspects, and may be extended to other renewable energy markets, which could have the effect of reducing administration costs.
- The compatibility aspect of the TREC System could allow for other financial incentive options to be developed and implemented along-side the direct subsidy programme.

One of the conclusions and implications of this study, which does not specifically form part of the recommendations, however, is that further research might lead to the adaptation of this direct subsidy programme, to include an interest rate subsidy component or to combine it with set-asides. From the findings of the criteria analysis, the implications of such adaptations could have the impact of reducing more barriers to SWH technology, such as the high initial cost of SWH systems, and of introducing more financing options for SWH. Such possible developments illustrate that a direct subsidy programme may still be considered as a versatile solution.

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Appendices:

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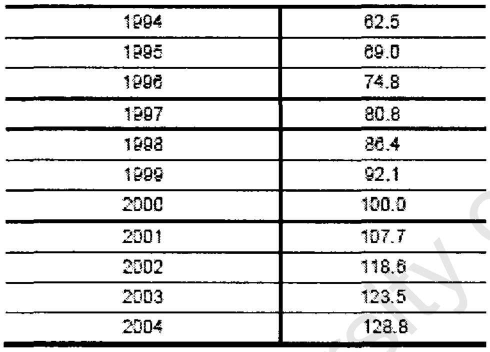
Appendix A – Cost deflators

The table (Winkler 2006:111) below gives values for cost deflators for the years 1994 until 2004. It may be used to convert the nominal value of an item, priced for any of these years, to an equivalent nominal value in base year 2000 Rands. It is used to remove the effects of inflation from commodity prices, making it possible to compare those commodities' real prices, which are given for the base year 2000.

Nominal prices are adjusted to real prices, for the base year 2000, by dividing the price of the commodity by the cost deflator associated with the year in which the price was quoted, and then by multiplying this quotient by 100.

Table 6.5: Cost deflators based on Gross Value Added

Sources: (SARB 2005; SSA 2004b)



1994	62.5
1995	69.0
1996	74.8
1997	80.8
1998	86.4
1999	92.1
2000	100.0
2001	107.7
2002	118.6
2003	123.5
2004	128.8

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Appendix B – Calculation of yearly costs for domestic water heating

Yearly cost calculations referred to in this study have been calculated using information and assumptions given in previously in the study.

The tables below represent the spreadsheet tables (and associated information and assumptions) that were used to derive values for Table 4.

Tech	Tech cost	Instal. Cost	Total capital cost	Maint. Cost	Lifetime [yrs]	Total system cost
Coal Stove			4060	0	11	4060
Fuelwood Stove			687	0	9	687
Paraffin Stove			29	0	3	29
LPG Ring			193	0	5	193
Electric Hot Plate			178	0	5	178
LPG Geyser			3479	0	22	3479
Electric Geyser			1686	0	22	1686
SWH (Integral)			5045	0	17	5045
Hybrid SWH - High Income	8421.053	2105.263	10526	211	17	14113
Hybrid SWH - Low Income	4858.3	1214.575	6073	121	17	8130

Table of domestic water heating technology device costs

University of Cape Town

Tech	Lifetime [yrs]	Tech eff.	Fuel unit cost R/GJ	Total household fuel cost		
				low income unelectrified	low income electrified	high income
Coal Stove	11	0.25	3.20334262	13.96657	29.59889	68.67966574
Fuelwood Stove	9	0.25	28.24	123.1264	260.9376	605.4656
Paraffin Stove	3	0.35	53.8532962	167.7146	355.4318	824.7247646
LPG Ring	5	0.53	115.506035	237.5501	503.432	1168.136508
Electric Hot Plate	5	0.65	41.4113278	69.44361	147.1695	341.4841797
LPG Geyser	22	0.84	115.506035	149.8828	317.6416	737.0385109
Electric Geyser	22	1	41.4113278	45.13835	95.66017	221.9647168
SWH (Integral)	17	1	0	0	0	0
Hybrid SWH - High Income	17	1	16.5645311	18.05534	38.26407	88.78588672
Hybrid SWH - Low Income	17	1	16.5645311	18.05534	38.26407	88.78588672

Table of domestic water heating technology fuel costs

		Total household fuel cost			Yearly water heating cost		
Tech	Total system cost	low income unelectrified	low income electrified	high income	low income unelectrified	low income electrified	high income
Coal Stove	4060	13.96657	29.5988858	68.67967	383.0575	398.6897949	437.7705748
Fuelwood Stove	687	123.1264	260.9376	605.4656	199.4597	337.2709333	681.7989333
Paraffin Stove	29	167.7146	355.431755	824.7248	177.3812	365.0984215	834.3914312
LPG Ring	193	237.5501	503.431965	1168.137	276.1501	542.0319651	1206.736508
Electric Hot Plate	178	69.44361	147.169488	341.4842	-	182.7694879	377.0841797
LPG Geyser	3479	149.8828	317.641597	737.0385	308.0192	475.7779607	895.1748745
Electric Geyser	1686	45.13835	95.6601671	221.9647	-	172.2965308	298.6010804
SWH (Integral)	5045	0	0	0	296.7647	296.7647059	296.7647059
Hybrid SWH - High Income	14113	18.05534	38.2640669	88.78589	-	868.4405374	918.9623573
Hybrid SWH - Low Income	8130	18.05534	38.2640669	88.78589	-	516.499361	567.0211808

Table of domestic water heating costs

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Appendix C – Calculation of the aggregated energy required for domestic water heating

The tables below represent the spreadsheet tables (and associated information and assumptions) that were used to derive values that were given in Table 9 and Table 10, for the reference and hypothetical scenarios, respectively.

Household Type and fuel	% of households	No. of households	Useful energy demand GJ/a	Tech eff.	Fuel demand GJ/a
Low income unelectrified	(100)	(3598811)	(1.09GJ/a/hh)		(12840457.24)
gas	5.1	183539	200057.51	0.53	377467
kerosene	44	1583477	1725989.9	0.35	4931399.8
wood	42.2	1518698	1655380.8	0.25	6621523.28
coal	5.8	208731	227516.79	0.25	910067.16
other	2.9	104366	113758.94	-	-
low income electrified	(100)	(2351177)	(2.31GJ/a/hh)		(8728734.302)
electricity - gesyer	41.55	976914	2256671.3	1	2256671.34
electricity - hot plate	41.55	976914	2256671.3	0.65	3471802.062
gas	0.9	21160	48879.6	0.53	92225.66038
kerosene	7.4	173987	401909.97	0.35	1148314.2
wood	7.1	166934	385617.54	0.25	1542470.16
coal	1	23512	54312.72	0.25	217250.88
other	0.5	11756	27156.36	-	-
High income electrified	(100)	(5255717)	(5.36GJ/a/hh)		(25325410.4)
Electricity - geyser	89.9	4724890	25325410	1	25325410.4
other	10.1	530827	2845232.7	-	-

Table of energy use for domestic water heating (Reference scenario)

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Household Type and fuel	% of households	No. of households	Useful energy demand GJ/a	Tech eff.	Fuel demand GJ/a
Low income unelectrified	**(100)**	**(3598811)**	**(1.09GJ/a/hh)**		**(12840457.24)**
gas	5.1	183539	200057.51	0.53	377467
kerosene	44	1583477	1725989.9	0.35	4931399.8
wood	42.2	1518698	1655380.8	0.25	6621523.28
coal	5.8	208731	227516.79	0.25	910067.16
other	2.9	104366	113758.94	-	-
low income electrified	**(100)**	**(2351177)**	**(2.31GJ/a/hh)**		**(8004188.345)**
Hybrid SWH	22.0	516611	1193371.4	(composite) 1	1193371.41
electricity - gesyer	32.4	762262	1760825.2	1	1760825.22
electricity - hot plate	32.4	762262	1760825.2	0.65	2708961.877
gas	0.7	16511	38140.41	0.53	71963.03774
kerosene	5.8	135758	313600.98	0.35	896002.8
wood	5.5	130254	300886.74	0.25	1203546.96
coal	0.8	18346	42379.26	0.25	169517.04
other	0.4	9173	21189.63	-	-
High income electrified	**(100.0)**	**(5255717)**	**(5.36GJ/a/hh)**		**(25950574)**
Hybrid SWH	22.0	1154808	6189770.9	(composite) 1	6189770.88
Other	7.9	414192	2220069.1	-	-

Table of energy use for domestic water heating (Hypothetical scenario)

Use of the term 'composite' in the table above relates to the use of two systems of heating, solar and backup electrical, which are used with hybrid SWH systems.

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Appendix D – Calculation of the income tax subsidy contributions

The tables below reflect the spreadsheet tables used to calculate the interest rate subsidy contributions, which the public sector would need to provide for low income electrified and high income households that participate in the programme. Also given in the tables are worked examples of how the annual household and public sector contributions, combined as C, go towards paying off the loans that are provided by the banks.

Subsidy contributions:

PV =	6915.43
interest rate (r) =	0.05
years (n) =	5
C =	1597.29
5C - PV =	1071.02

Worked example of loan repayments:

Amount owed	Amount owed (with interest)	year	payments	remainder
6915.43	7261.202	0	1597.29	5663.911
5663.911	5947.107	1	1597.29	4349.817
4349.817	4567.308	2	1597.29	2970.018
2970.018	3118.519	3	1597.29	1521.229
1521.229	1597.29	4	1597.29	5.23E-12

Table of interest rate subsidy contributions for low income electrified households

Subsidy contributions:

PV =	12007.74
interest rate (r) =	0.05
years (n) =	5
C =	2773.485
5C - PV =	1859.687

Worked example of loan repayments:

Amount owed	Amount owed (with interest)	year	payments	remainder
12007.74	12608.13	0	2773.485	9834.642
9834.642	10326.37	1	2773.485	7552.888
7552.888	7930.533	2	2773.485	5157.048
5157.048	5414.9	3	2773.485	2641.415
2641.415	2773.485	4	2773.485	4.55E-12

Table of interest rate subsidy contributions for high income households

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Appendix E – Approved SWH systems

(Approved systems eligible for Eskom's DSM subsidy programme[18])

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[18] From www.eskomdsm.co.za/?q=Solar water heating Read more on 14/10/2008

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
tlantic Solar egional contact number: 36 136 3749 fo@atlanticsolar.co.za	Western Cape	Dura-Line 200 Vaal 200 Litre Flat plate Indirect Thermo Siphon	R12 517,00	R1900,00 - R2200,00	**R2166**	Test Report
		Dura-Line 300 Vaal Thermo Siphon 300 Litre Flat Plate Indirect Thermo Siphon	R19 937,00	R1900,00 - R2200,00	**R2858**	Test Report
t E Technologies egional contact numbers: astern Cape: 32 776 1503 auteng: 33 302 9870 wazulu-Natal: 33 412 2718 estern Cape: 21 511 9504	Eastern Cape Gauteng KwaZulu-Natal Western Cape	SHE Solar Heat system 200 Litre Flat Plate Indirect Thermosiphon	From R15 276,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2519**	Test Report
		Ksh201 Giordano Indirect 175 Litre Flat Plate Thermo Siphon	From R18 924,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2388**	**SABS Mark Approval***
		Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	From R26 562,00 Depending on roof type.	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R4452**	**SABS Mark Approval***

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Note: All prices are estimates, final prices are to be determined between the supplier and customer.

articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
osolar CC egional office: 39 682 0103 39 682 1454 adarc@ispace.co.za	Kwa-Zulu Natal Eastern Cape	SHE Solar Heat system 200 Litre Flat Plate Indirect Thermosiphon	From R15 276,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2519**	Test Report
		Ksh201 Giordano Indirect 175 Litre Flat Plate Thermo Siphon	From R18 924,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2388**	**SABS Mark Approval***
		Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	From R26 562,00 Depending on roof type.	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R4452**	**SABS Mark Approval***
nervision ational office: 36 111 1270 ww.enervision.co.za foswh@enervision.co.za	Gauteng Kwa-Zulu Natal Western Cape	Vision 3.96 Litre Heat Exchanger 250 Litre thermal capacity Evacuated Tube Indirect Thermo Siphon	R13 000,00	R4150, 00 – R5350,00 Incl labour and timer but excludes CoC)	**R3975**	Test Report
rantel Distribution egional contact number: 2 804 6664 antel@absamail.co.za	Coastal Areas	Frantel JP – B2 150 Litre Flat plate Direct Pumped	R13 330,00	R1800,00 - R5300,00	**R2314**	Test Report

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
reen Power egional Contact Number: 44 873 4606 fo@green-power.co.za	Western Cape (Garden Route)	GP-CW-150-KIT Forced Circulation 150 Litre Evacuated tube Direct Pumped	R11 000.00 – R12 500.00	R2500,00 - R4000,00	**R2471**	Test Report
		GP-CW-200-KIT Direct 200 Litre Evacuated tube Direct Pumped	R14 250.00 – R15 500.00	R2500,00 - R4000,00	**R3664**	Test Report
		GP-SPA-150-KIT 150 Litre Evacuated tube Direct Pumped	R10 260,00	R2500,00 - R4000,00	**R3780**	Test Report
egional Distributors		GP-SPA-200-KIT 200 Litre Evacuated tube Direct Pumped	R18 500,00	R3100,00 – R4200,00	**R4371**	Test Report
ett Irrigation & Plumbing upplies(Pips) 44 533 0040 on@pipsupplies.com						

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Note: All prices are estimates, final prices are to be determined between the supplier and customer.

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
ome Comfort egional contact number: 361 114 169 fo@homecomfort.co.za ww.homecomfort.co.za	Coastal	GP-CW-150-KIT Forced Circulation 150 Litre Evacuated tube Direct Pumped	R11 000,00 – R12 500,00	R2500,00 - R4000,00	**R2471**	Test Report
	Coastal	GP-CW-200-KIT Direct 200 Litre Evacuated tube Direct Pumped	R14 250.00 – R15 500.00	R2500,00 - R4000,00	**R3664**	Test Report
	National	Dura-Line 200 Vaal 200 Litre Flat plate Indirect Thermo Siphon	R12 517,00	R1900,00 - R2200,00	**R2166**	Test Report
	National	Dura-Line 300 Vaal Thermo Siphon 300 Litre Flat Plate Indirect Thermo Siphon	R19 937,00	R1900,00 - R2200,00	**R2858**	Test Report
udu Design (Pty) Ltd egional contact number: 1 706 2157 fo@hudu.co.za ww.hudu.co.za	Gauteng	250 Litre Integrated geyser 2.35 Litre heat exchanger 250 Litre thermal capacity Evacuated Tube Indirect Thermo Siphon	R 20 178,00	R 4560,00	**R3047**	Test Report

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
J Taylor Contracting egional office: 21) 761 9006 fo@ljtaylor.co.za	Western Cape	Solardome SA 200 Litre Flat Plate Direct Thermo Siphon	R17 200,00	R2500,00 - R5500,00	**R3422**	Test Report
		Solardome SA 300 Litre Flat Plate Direct Thermo Siphon	R21 845,00	R3500,00 – R6500,00	**R4925**	Test Report
		Solardome SA 200 Litre Flat Plate Indirect Thermo Siphon	R18 200,00	R2500,00 – R5500,00	**R2778**	Test Report
		Solardome SA 300 Litre Flat Plate Indirect Thermo Siphon	R23 000,00	R2500,00 – R5500,00	**R4098**	Test Report
axlite egional contact number: 1 622 2827 3 442 0467	Gauteng Mpumalanga	WaterLite H_2O 150 150 Litre Evacuated Tube Indirect Thermo Siphon	R14 000,00 – R15 200,00	R2850,00 – R4000,00	**R2548**	Test Report

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
33 377 3496 ax 086 519 3933 evor@maxlite.co.za ww.waterLite.co.za		WaterLite H_2O 200 200 Litre Evacuated Tube Indirect Thermo Siphon	R16 500,00 – R17 900,00	R2850,00 – R4000,00	**R3289**	Test Report
icrosolar South Africa ational office: 11) 918 1800/9 ww.mikrosolar.co.za ales@mikrosolar.co.za	Gauteng KwaZulu-Natal Western Cape	MICROSOLAR M60VTHE 3.5 Litre heat exchanger 264 Litre thermal capacity Evacuated Tube Indirect Thermo Siphon	R16 580,00	R2500,00 - R3000,00	**R2711**	Test Report
ronto Plumbing t/a Solar Pro egional contact number: 21 761 7602 ww.solarpro.co.za ave@delta-t.co.za *egional Distributors*	Western Cape	Solarpro DT 200D Thermo Siphon 200 Litre Flat Plate Direct	R11 686,00	R1900,00 - R4366,20	**R3390**	Test Report
aygra Alternate Power olutions 43 722 7061 aygra.daygra@gmail.com	Eastern Cape					

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
endevous Engineering uilding Contractors cc T/A P Plumbing 33 968 8375 evor@plat-tau.co.za	North West	SHE Solar Heat system 200 Litre Flat Plate Indirect Thermosiphon	From R15 276,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2519**	Test Report
		Ksh201 Giordano Indirect 175 Litre Flat Plate Thermo Siphon	From R18 924,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2388**	**SABS Mark Approval***
		Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	From R26 562,00 Depending on roof type.	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R4452**	**SABS Mark Approval***
olar Beam egional office: 31 563 9585 olarbeam@netactive.co.za ww.solarbeam.co.za	KwaZulu-Natal	SBG Direct Thermosiphon 200 Litre Direct Flat Plate	R9 630,00	R2760,00 – R4610,00	**R2500**	**SABS Mark Approval***
		SBG Direct Thermosiphon 300 Litre Direct Flat plate	R15 100,00	R3590.00 – R5440.00	**R3943**	**SABS Mark Approval***

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
		SBG Indirect Thermosiphon 200 Litre Indirect Flat plate	R10 500,00	R3130,00 – R5205,00	**R2082**	**SABS Mark Approval***
		SBG Indirect Thermosiphon 300 Litre Indirect Flat plate	R15 975,00	R3980,00 – R5980,00	**R3100**	**SABS Mark Approval***
olardome SA egional office: 21) 886 6321 ennen@solardome.co.za	Western Cape	Solardome SA 200 Litre Flat Plate Direct Thermo Siphon	R17 200,00	R2500,00 – R5500,00	**R3422**	Test Report
		Solardome SA 300 Litre Flat Plate Direct Thermo Siphon	R21 845,00	R3500,00 – R6500,00	**R4925**	Test Report
		Solardome SA 200 Litre Flat Plate Indirect Thermo Siphon	R18 200,00	R2500,00 – R5500,00	**R2778**	Test Report

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
		Solardome SA 300 Litre Flat Plate Indirect Thermo Siphon	R23 000,00	R2500,00 – R5500,00	**R4098**	Test Report
olahart egional contact number: 361 solahart 861 7652 4278) ales@solahart.co.za ww.solahart.co.za *egional Distributors*	National	Solahart 302KF 300 Litre Flat plate Indirect Thermo Siphon	R28 850,00	R4950,00 - R6840,00 `(incl timer switch and CoC)`	**R4917**	**SABS Mark Approval***
olamatic System CC 11 833 5350 bsouth@solahart.co.za	Johannesburg					
unergy Solar Energy olutions 360 786 349 860 sunegy) bcentral@solahart.co.za	Johannesburg Eastrand					
amble Electrical CC 1 425 2549 astrand@solahart.co.za	Benoni					

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Note: All prices are estimates, final prices are to be determined between the supplier and customer.

articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
en Harrison Reliable lumbers 11 421 4448 astrand2@solahart.co.za	Eastrand					
XC Solar Geysers CC 33 561 7070 ugersdorp@solahart.co.za	Westrand					
olarhart Pretoria Tshwane 12 348 3336 hwane@solahart.co.za	Pretoria					
olahart Durban 31 762 2088 urban@solahart.co.za	Durban					
onruc Products 36 631 4999 dysmith@solahart.co.za	Northern Natal					
dego Africa t/a Solahart MB 32 651 5887 etermaritzburg@solahart.co.za	Pietermaritzburg					
itbank Plumbing CC 72 452 8636 tbank@solahart.co.za	Mpumalanga					
ower Plus Energy Solutions 13 750 2676 iteriver@solahart.co.za	Mpumalanga					

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** Eskom will not be held responsible for either the setting of supplier prices or price changes.

Note: All prices are estimates, final prices are to be determined between the supplier and customer.

articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
olaheat Services CC 21 713 3734 apetown@solahart.co.za	Western Cape					
rrols Electrogas CC 44 691 1088 osselbay@solahart.co.za	Mossel Bay					
olar Harvest ational Office: 11) 763 1944 (T) 11) 760 2667 (F) astern and estern Cape 44) 534 8217 vrle@solarharvest.co.za waZulu-Natal 33) 342 1541 ntact@solarharvest.co.za ww.solarharvest.co.za	KwaZulu-Natal Eastern Cape Western Cape	SH_001 150 Litre Flat Plate Direct Pumped	R10 250,00 – R11 500,00	R1500,00 - R3500,00	**R2078**	Test Report
olar Heat Exchangers egional office: 36 11 solar 86 11 76527)	Gauteng	SHE Solar Heat system 200 Litre Flat Plate Indirect Thermosiphon	From R15 276,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2519**	Test Report

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Note: All prices are estimates, final prices are to be determined between the supplier and customer.

articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
fo@solarheat.co.za ww.solarheat.co.za		Ksh201 Giordano Indirect 175 Litre Flat Plate Thermo Siphon	From R18 924,00 Depending on roof type	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R2388**	**SABS Mark Approval***
		Ksh302 Giordano Indirect 250 Litre Flat Plate Thermo Siphon	From R26 562,00 Depending on roof type.	From R4997,00 (Incl. CoC, labour and timer) Depending of type of installation	**R4452**	**SABS Mark Approval***
olarzone ational office: 21 845 4440 fo@solarzone.co.za ww.solarzone.co.za	National	Schueco SWH 150 150 Litre Flat Plate Indirect Thermo Siphon	R13 563,00	R3000,00 - R4000,00	**R1903**	Test Report
		Schueco SWH 300 250 Litre Flat Plate Indirect Thermo Siphon	R21 891,00	R4000,00 - R5000,00	**R4261**	Test Report
	Coastal	Solar Zone AC System 200 Litre Flat Plate Direct Pumped	R20 000.00	R2300.00 - R6800.00	**R2360**	Test Report

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articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
asol Solar ational contact number: 36 111 3078 han@tasolsolar.co.za ww.tasolsolar.co.za	Eastern Cape KwaZulu-Natal Western Cape Southern Cape	Tasol TAS16 Retrofit 150 Litre Evacuated tube Direct Pumped	R8 421,84	R2000,00 – R3000,00	**R1989**	Test Report
	Eastern Cape KwaZulu-Natal Western Cape Southern Cape	Tasol HPS104 150 Litre Evacuated tube Direct Pumped	R10 744,50	R1000,00 - R2000,00	**R1912**	**SABS Mark Approval***
	Eastern Cape KwaZulu-Natal Western Cape Southern Cape	Tasol TAS20 Split 200 Litre Evacuated tube Direct Pumped	R12 765,11	R2500,00 – R3500,00	**R2043**	**SABS Mark Approval***
	Gauteng Eastern Cape KwaZulu-Natal Western Cape Southern Cape Mpumalanga	Tasol TAS F/P 200 Litre Flat plate Indirect Thermosiphon	R11 417,00	R2000,00 – R3000,00	**R2084**	Test Report

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* Please note that the SABS Mark Approval is a better form of quality assurance as system components are re-tested each year.

** Eskom will not be held responsible for either the setting of supplier prices or price changes.

Note: All prices are estimates, final prices are to be determined between the supplier and customer.

articipating Supplier	Active areas	Registered System	Indicative retail price (incl vat)	Expected range of installation charge	Qualifying rebate	SABS
	Gauteng Eastern Cape KwaZulu-Natal Western Cape Southern Cape Mpumalanga	Tasol TAS20 200 Litre Evacuated tube Indirect Thermo Siphon	R11 934,64	R2000,00 - R3000,00	**R1869**	**SABS Mark Approval***
nplugged Renewable nergy egional contact numbers: el / Fax: 043 726 2213 el (Alt): 043 721 0687 ax2email: 08654SOLAR fo@off-the-grid.co.za ww.off-the-grid.co.za	Eastern Cape	Dura-Line 200 Vaal 200 Litre Flat plate Indirect Thermo Siphon	R11 700,00	R3500,00 – R5600,00 Standard close coupled / split installation. Excludes all electrical work	**R2166**	Test Report
		Dura-Line 300 Vaal 300 Litre Flat Plate Indirect Thermo Siphon	R20 900,00	R3500,00 – R5600,00 Standard close coupled / split installation. Excludes all electrical work	**R2858**	Test Report
		Solardome SA 200 Litre Flat Plate Direct Thermo Siphon	R18 800,00	R3500,00 – R5600,00 Standard close coupled / split installation. Excludes all electrical work	**R3422**	Test Report
		Solardome SA 300 Litre Flat Plate Direct Thermo Siphon	R23 500,00	R3500,00 – R5600,00 Standard close coupled / split installation. Excludes all electrical work	**R4925**	Test Report

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