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**Do solar water heaters improve access to hot water and reduce electricity costs? The complexities of implementing energy poverty interventions in South African Townships: a case study of Nyanga Township**

**By**

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**A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering**



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## **Declaration**

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part, submitted it at any university for a degree.

University of Cape Town

*S. Maboda*

Signature

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## **Abstract**

Solar energy is abundantly available in South Africa, but it is a highly under-utilised resource. One way of efficiently using the resource is solar water heating (swh), a natural process whereby hot water for domestic and/or industrial use is heated by the sun. In 2009, a national swh strategy was drafted by the Department of Energy, which specifies a target to install 1 million heaters in households by 2015. Provincial and local governments have also developed their own swh strategies and the roll out of swhs has started in some municipalities (i.e. the Nelson Mandela Bay Municipality and the City of Cape Town).

The Western Cape Department of Environmental Affairs and Development Planning (DEADP), as part of its 1000 swh project, installed swhs in a low-income area in Nyanga Township. This dissertation assesses the contribution of the project's installed swhs on people's lives in Nyanga - Zwelitsha and reflects on the complexities of implementing energy poverty interventions in Townships more generally.

The results of this study suggest that, while there are significant benefits accruing from the swh project, there are many inhibiting factors to the effective implementation of the project. Community participation, for instance, in decision-making processes was non-existent in this pilot project. The beneficiaries were not aware of the criteria used to select them. They did not know the implementing agent or who to contact should there be anything wrong with the swh. However, households were generally happy with the swh and had a general, rather than technical understanding of how it functions. Households understood that the water is heated by the sun hence water is cold in winter. In winter they turned to the electricity grid to heat the water.

In addition, households used hot water from the swh geyser primarily for washing clothes and bathing. This was a significant benefit for households as the readily available hot water encouraged children and old people to bath more often, bettering their health and saving time that would have been spent on boiling water using the kettle. The swh is not used for cooking, however, mainly because households are uncertain about the safety of the water as the system is mounted outside the house and there is a perception that it contains chemicals. It was reported that sometimes water comes in a dirty (milky) colour.

Households indicated that the amount they spend on electricity is the same as before the installation of swhs. The reason being that electricity is used for cooking and lighting. Furthermore, households indicated that they used mainly paraffin in winter for space heating. In consequence a high proportion of household budgets are spent on paraffin in winter. However, I found that their perception that the swhs has not reduced their energy expenditure is because poor households do not measure energy consumption in a precise, technical manner. The research demonstrates that households are saving on costs as they boil less water using electric kettles, but these reductions are not easily quantifiable in this context.

While affecting families' electricity use, the project has also in a more limited way built some temporary and a few longer term possibilities for household livelihoods. According to the project implementers, for instance, 240 people were trained and temporarily employed in the installation stage of the 1000 swh project. Access to solar hot water has also enabled some women to run their own salon businesses, drawing on the solar-heated water for hair washing, which for some has improved their ability to run these businesses.

These findings demonstrate that solar water heaters improves access to hot water for poor households and it reduces (although unclear) electricity costs for households. Implementation, however, remains an enormous challenge.

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## Abbreviations and Acronyms

<b>CDM</b>	Clean Development Mechanism
<b>CFL</b>	Compact Fluorescent Light bulb
<b>CoCT</b>	City of Cape Town
<b>DoE</b>	Department of Energy
<b>DEA</b>	Department of Environmental Affairs
<b>DME</b>	Department of Minerals & Energy
<b>DEADP</b>	Department of Environmental Affairs & Development Planning
<b>FBAE</b>	Free Basic Alternative Energy
<b>FBE</b>	Free Basic Electricity
<b>GHG</b>	Greenhouse Gases
<b>INEP</b>	Integrated National Electrification Programme
<b>NEP</b>	National Electrification Programme
<b>LPG</b>	Liquid Petroleum Gas
<b>NMBM</b>	Nelson Mandela Bay Municipality
<b>RE</b>	Renewable Energy
<b>SACAN</b>	South African Cities Network
<b>SANERI</b>	South African National Energy Research Institute
<b>SWH</b>	Solar Water Heater
<b>UNDP</b>	United Nations Development Programme

## **1. Introduction**

Energy is arguable one of the major challenges the world faces today, touching all aspects of our lives. Energy forms an integral input to the primary development challenge of providing sufficient food, shelter, clothing, hot water, sanitation, medical care, education and access to information (Reddy, 2008). The energy dimension of poverty known as energy poverty prevents individuals from the benefits that access to modern energy brings. Energy poverty is a lack of choice in accessing adequate, reliable, good quality, safe and environmental benign energy services to sustain economic and human development (UNDP, 2000). Since energy is essential for human development, the challenge lies to the over 1.4 billion population worldwide who lack access to modern energy (UNDP, 2010).

Similarly, energy poverty prevails in South Africa in spite of the spectacular progress made since 1994 in service delivery. According to StatsSA (2009), 18% of South Africa's population lack access to modern energy and 70% of rural households' still rely on wood fuel and paraffin, and this is in spite of the fact that some have electricity. Furthermore, Cowan and Mohlakoana (2005) argue that energy poverty is manifest in poor households using multiple sources of energy to meet basic energy needs. Provision of adequate and affordable energy is integral to poverty alleviation, improving human welfare and increasing living standards (UNDP, 2000).

Renewable energy technologies such as solar water heaters have the potential to alleviate energy poverty. Solar radiation is relatively predictable throughout South Africa, but is highly under-utilized. According to Austin & Morris (2005) swhs are the least expensive means of heating water for domestic use on life-cycle cost basis. According to Prasad & Visagie (2006) providing hot water using swh technologies

has the potential of saving money for households in the long term, and mitigating green house gas emissions associated with the use of fossil fuel. Furthermore, Austin & Morris (2005) state that a national swh rollout programme to the residential sector could potentially reduce the overall national energy demand by 4.5% of GWh/annum.

In 2009, the South African government drafted the National Solar Water Framework to accelerate the rollout of swhs in the country. The framework specifies a target to install 1 million solar water heaters in households by 2015 (DoE, 2009). The aim of the mass rollout is to address the country's electricity challenge such as the shortage of generation supply capacity which has led to unprecedented levels of loading shedding nationally in 2007/2008, mitigate green house gas emissions, create employment and alleviate poverty (Afrane-Okese, 2009).

Solar water heaters are assumed to be a beneficial technological intervention for low-income families, but there are very few studies conducted on the social benefits of swhs (Wlokas, 2010). Mallet (2007) also states that debate on renewable energy technology transfer and adoption often overlooks the social aspect.

This paper supports the debate on social benefits of renewable energy technology with a particular focus on swhs. The dissertation seeks to answer the following questions: Do swhs improve access to hot water and reduce electricity costs for households? What are the social issues/complexities involved in implementing energy poverty interventions in low-income areas? To answer these questions Nyanga Township in the Western Cape Province was selected as a case study.

The paper begins by analyzing and discussing the literature on poverty and energy poverty and the contribution (benefits) of solar water heating on poverty

alleviation. The paper further analyses national policies that are geared towards energy poverty alleviation and the promotion of solar water heating in low-income areas. The paper further provides background of the study area, and analyses research findings using a household survey. Finally, the conclusions and recommendations based on the findings of this research are presented in the last section.

### **1.1 Motivation for doing the research**

This study is motivated by an interest in sustainable urban development, with a particular focus on sustainable energy. For the past two years the researcher has been working on a project that seeks to improve energy service delivery to poor households in South Africa.

In addition, the researcher worked on a partnership project with the Western Cape Department of Environmental Affairs and Development Planning. The project involved the development of a sustainable energy white paper – with the aim to promote renewable energy and energy efficiency in the province. The policy is aimed at energy poverty alleviation. As an initial step to implement the policy; the province has installed swhs in low-income areas, Nyanga Township being one of the many areas chosen as pilot areas.

The researcher chose Nyanga Township because he worked with the provincial government in developing the sustainable energy policy, and the other reason is that no social impact study of swhs has been conducted in Nyanga Township.

## **2. Poverty, Energy Poverty and Solar Water Heating**

In this section, the researcher analyses and discusses literature on poverty in South Africa. This is to ascertain the extent of poverty in South Africa and how it affects people living in low-income areas (including Nyanga Township). Following that, is the review of energy dimension of poverty known as energy poverty. The purpose is to get a sense of the extent of energy poverty in South Africa and how it affects those that already live in poverty – particularly the low-income housing sector.

Since the focus of the study is on low-income areas, understanding household energy use patterns and preferences is essential. The discussion on this is contained in this section – this is important for the analyses of the case study as it provides a snap short of what people use energy for and how much they spend on energy.

Having reviewed the literature on poverty, energy poverty and household energy use, the question remains – what is the government doing about the issues? The section further provides an overview of policies geared towards energy poverty alleviation. For the purposes of this research, the emphasis is on energy poverty policies and how these policies are important instruments in combating energy poverty.

Finally, the section concludes by a review of literature on swhs in low-income areas and its potential to reduce energy poverty – by increased access to hot water and the housed electricity budget implications. Complexities and possible solutions in implementing projects such as swhs in low-income areas are also discussed.

## 2.1 Poverty in South Africa

Poverty is multidimensional and it is not an easy concept to define. It can mean different things to different people. Experts have adopted approaches to defining poverty and these will be highlighted below. These approaches include the monetary approach, the capability approach, the social exclusion approach and the participatory approach.

The monetary approach is the most publicized approach to define and measure poverty. The international poverty line of less than 1\$ per day is one typical example of the monetary approach. This measure is used to attain a minimal standard of living. For example if one lives below 1\$ per day is classified as poor or living under poverty. According to SACN in Parnell et al (2003: 15) 'Poverty is more than a lack of income. Poverty exists when an individual's or a household's, access to income, jobs, infrastructure or services is inadequate to ensure full access to opportunities in society'. The monetary approach focuses on income and neglects other aspects of poverty.

The capability approach on the other hand acknowledges the importance of income as it increases the capabilities of individuals and permits functioning in a society (Alkire, 2005). However, the capability approach emphasizes that people need to be capable to lead a long life, to function with chronic mobility, be capable of reading, writing and performing numerical tasks and be able to move from one place to another (UNDP, 2010). In this approach, if a person falls below a minimum acceptable capability level they are classified as poor. The capability approach is broad as it builds on the income approach and takes into account social aspects of poverty.

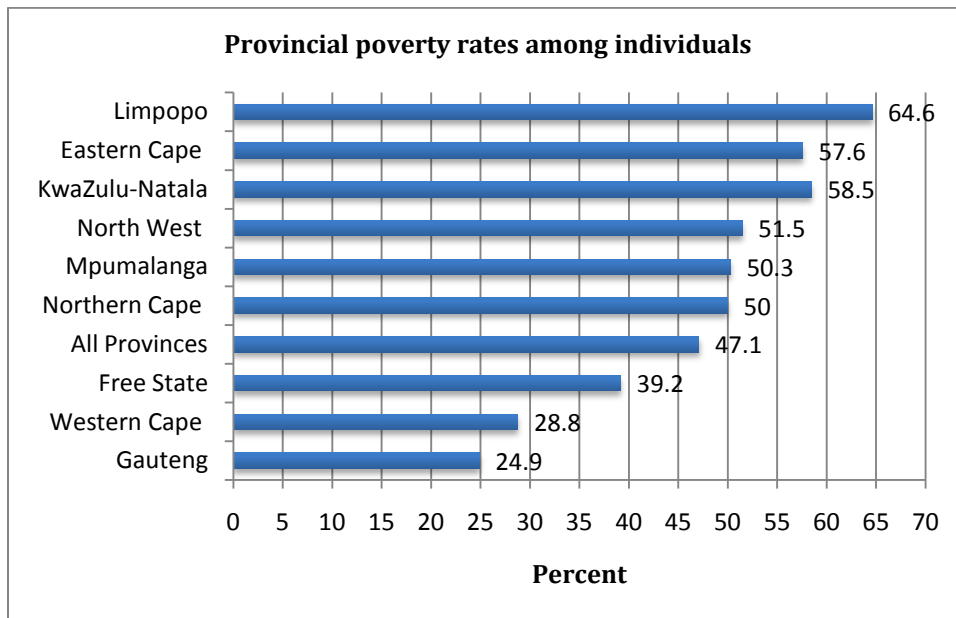
Furthermore, exclusion occurs when individuals in the community do not participate fully in matters affecting their lives in the society in which they live. This could involve the exclusion of women, the aged, the disabled, racial or ethnic groups, geographic location, occupation and health (UNDP, 2010).

In contrast to the exclusion approach, the participatory approach takes into account views of poor people. It gives poor people a platform to define themselves what it means to be poor and what poverty relief measures would be appropriate for them, reflecting an attempt to adopt a bottom up approach (UNDP, 2010).

The concept of poverty is broad – one cannot reduce it into income but various aspects of poverty need to be taken into account. The focus on one measure, such as income could have implications for the policy of the country and the impact thereof on the poor. However, the poverty measure generally used in South Africa is the income measure (StatsSA, 2008). Researchers have contested the validity of the income poverty measure indicating that there are ‘obvious and not so obvious flaws’ in the data (Seekings, 2007). In spite of the different views about the poverty measure, there is a broad general consensus from the academics that poverty levels have not greatly reduced since 1994 (Seekings, 2007, Luyt, 2008) and, moreover, economic and social inequalities have increased. Furthermore, Lyt (2008) acknowledges that there are good pro-poor policies, but the implementation thereof is poor. Seekings (2007) suggests that there needs to be a mind shift with politicians, to emphasize pro-poor economic growth, not just economic growth.

According to the National Income Dynamics Study (2008), almost half (47%) of South Africans live in poverty – and 56% of the black population live in poverty compared to 2% of whites. Similarly Jacobs and Andrew (2009), argue that the rural population– and particularly the black Africans, experience the highest level of

poverty, estimated at 70.9% compared to the 47% national poverty rate. StatsSA (2008) report found that the three provinces with the highest rural population also showed the highest levels of poverty – and these provinces are Limpopo, Eastern Cape and KwaZulu Natal (see graph below).



Graph 1: Poverty rates in South Africa

Source: Statistics South Africa (2008)

The Western Cape Province in which Nyanga Township is located has the lowest levels (second after Gauteng) of poverty in the country (StatsSA, 2008). Yet, almost 29% (just over a million) households in the province live below the poverty line (Punt et al, 2009).

The lack of access to basic services is at the same time the result and cause of poverty (UNDP, 2008). The constitution of the Republic of South Africa strongly states that individuals have the right of access to basic services, which are energy, water, sanitation, electricity. However, this right is not realized by all, especially by the poor and those living in rural areas and the informal settlements within cities.

## 2.2 Energy Poverty

The general condition of poverty, combined particularly with a lack of access to services and infrastructure also results in energy poverty. Energy poverty tends to be higher in rural areas and poorer countries. According to Heltberg (2003), for instance, 85% of household in Nepal and 58% in Ghana did not have access to electricity in 2003. In South Africa, 18% of the population lack access to electricity (StatsSA, 2009).

Energy is important to human survival and the provision of adequate and affordable energy is integral to poverty alleviation, improving human welfare and increasing living standards (CURES, 2009). It is shocking that in the 21<sup>st</sup> century more than a billion people worldwide still do not have access to electricity. According to the UNDP (2010), over 1.4 billion people worldwide do not have access to electricity and over 2.5 billion people still rely on the traditional use of biomass for cooking. Over eighty percent of those who lack access to electricity reside in rural areas (UNDP, 2010).

According to the UNDP (2010) the new policy scenarios also predict that 1.2 billion people will still lack access to electricity by 2030 and that the majority of those that lack access will be from Sub-Saharan Africa and other developing nations. The new policy scenarios predict that the number of people using biomass for cooking will rise to 2.8 billion by 2030 (UNDP, 2010).

In addition, StatsSA reported that 70% of rural households in South Africa still rely on wood fuel and paraffin, and this is in spite of the fact that some of them have electricity (StatsSA, 2009). The reason for the latter could be associated with affordability issues. Access to an electricity connection does not necessarily mean

that households can afford to pay for the use of it. Furthermore, official figures released by StatsSA in 2009 show that 2.5 million households were not connected to the electricity grid, and the majority of those not connected are in rural areas – rendering them to depend on low-grade fuels, such as paraffin, biomass and coal (CURES, 2009, StatsSA, 2009).

Certainly, a concerted effort has been organized by the South African government to address these shortcomings. For instance, the national electrification rate had increased from 36% in 1994 to 82% in 2009 (StatsSA, 2009); yet, at the same time, the Eastern Cape and the Limpopo provinces were reported to have had a high rate of wood and paraffin usage (StatsSA, 2009). This is an indication that the rate of electrification in rural areas is slow as the majority of the population without access to electricity is in rural areas. This is supported by Winkler's research findings that low level of electrification in rural areas is largely due to the fact that it is expensive to electrify rural communities because they are remote and settlements are dispersed (Winkler, 2006). Access to modern energy<sup>1</sup> services for both rural and urban areas is critical for many reasons.

Firstly, the poor households spend up to 20% or more of their household budget on energy compared to 2 or 3% spent by the wealthy households (SEA, 2006). The poor spend more on energy because the fuel and appliances they use are expensive and inefficient (CURES, 2009). Access to modern energy services has the potential to expand the ability of the poor to engage in income generation activities (UNDP, 2010).

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<sup>1</sup> Modern energy is access to clean, affordable, and reliable energy (Kirai & Hankins, 2009: 4)

Secondly, access to modern energy frees up people's time – particularly for women who spend time collecting fuel wood. In addition access to energy can mean increased hours for working - particularly if workers had to close business early because there were no lights. This in turn means increased income for the households due to the additional work hours (UNDP, 2008).

Thirdly, access to modern energy also improves educational opportunities for children and adults. For example access to lighting at homes means additional hours of study – not only restricted to study during the day (UNDP, 2008). For adults, access to electricity opens opportunities for them to work during the day and study at night. Access to media (radio & television) is also an educational and entertainment opportunity for all and energy access is key to this (UNDP, 2008).

Fourthly, there are environmental and health opportunities associated with access to modern energy. Access to modern energy for the household means reduced use of fuel wood and paraffin, which means reduced indoor air pollution. According to Lambe et al (2009), cooking often accounts for 90 percent or more of poor households total energy demand. Cooking is typically done on open fires and inefficient paraffin stoves – particularly in rural areas and un-electrified urban households. The use of inefficient fuels and appliances, particularly solid biomass results in increased indoor air pollution which has negative health impacts. According to the World Health Organization (2006), indoor smoke can result in chronic obstructive pulmonary diseases for women. Furthermore, exposure to indoor smoke can lead to asthma, tuberculosis, adverse pregnancy outcomes, lung and heart diseases (WHO, 2006). Indoor air pollution affects the immune system and this becomes a risk to those infected by HIV and Aids. Moreover, indoor smoke is responsible for the deaths among young children and adult women in less developed countries (Lambe et al, 2009). Access to energy improves the health of

women due to less smoke inhalation and the resulting physical exhaustion (UNDP, 2008).<sup>2</sup>

Fifthly and lastly, access to modern energy has implications for the development of the country. According to the UNDP (2010:11); 'energy is essential for the provision of clean water, health care, sanitation, provision of reliable and efficient lighting, heating, mechanical power, transport and telecommunication services'. Energy is the life blood of development, no country in modern times that can substantially reduce poverty without massive investment into modern and/or efficient energy.

Lack of access to modern energy has a negative impact for the development of the country – not only for the individuals. For reasons highlighted above, improving access to modern energy is essential. The international instrument to assist in this regard would be the Millennium Development Goals (MDGs), adopted in 2000 with the aim to eradicate extreme poverty by 2015 (UNDP, 2000). Access to modern energy has a profound bearing on human wellbeing. It thus can accelerate the achievement of the MDGs, particularly those related to income, poverty, health and education (Kirai & Hankins, 2009). Unfortunately the eight MDGs are silent on energy poverty. However, there is a recognition that 'higher quality and larger quantities of energy services than current approaches provided are required to meet the MDG challenge' (UNDP, 2005, p. 9).

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<sup>2</sup> It has been acknowledged by the international community that climate change is happening, and that not responding to it now will have disastrous consequences and for world and for the future generation (Andrea, 2007). More than 90% of South Africa's electricity is generated from fossil fuels (i.e. coal). The use of fossil fuels contributes to climate change. Access to modern energy services results in less use of wood, traditional open fires, paraffin etc, and this in turn has the potential to reduce the energy related carbon dioxide emissions (Kaufman & Milton, 2005). Access to modern energy does not automatically mean reduced emissions, efficient use thereof becomes critical. By efficiency I mean the way energy is generated, transported and used at the household and industry/commerce level.

In South Africa, cities, provincial and national government have included energy poverty targets on the sustainable energy policies and strategies. The Western Cape Provincial Government and the City of Cape Town have progressive strategies and policies that aim to alleviate energy poverty. The provincial energy white paper emphasizes that poverty alleviation be an integral part of all policies in the Western Cape (DEADP, 2010). It is also emphasized in the white paper that targets developed have a cross cutting effect on all aspects of interventions so as to address energy poverty<sup>3</sup>.

### **2.3 Household energy use in South Africa**

Since the focus of this study is on low-income areas, it is important to outline households' energy use patterns and preferences.

The apartheid government focused on supplying electricity to industry and commerce – as the focus of the government at the time was on the development of modern industrial society (mining, chemical and agricultural industries which were the backbone of the South African economy).

In terms of domestic access to electricity; there was (and still is) a huge discrepancy between population groups and areas (Malzbender, 2005). The majority of people without access to electricity are likely black Africans and electrification levels in rural areas fall short of the ones in urban areas (Malzbender, 2005). However, in

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<sup>3</sup> According to Kanal et al (2006), 89% of households in the Western Cape used electricity for cooking. Similarly, the city of Cape Town's priority is to electrify all households including those living in informal settlements - as a result the city has electrified around 90% of informal settlements that fall within the city jurisdiction (Salida, 2010). Furthermore, according to the City of Cape Town (2006) more than 70% of households in Nyanga Township used electricity for lighting.

post 1994 household electrification has become one of the main priorities in government, as will later discuss in the paper.

There are 11 million households in South Africa, 82% of the households are electrified and 18% un-electrified (DoE, 2009). According to StatsSA (2009) the main energy sources used by households in South Africa for cooking is primarily electricity, followed by paraffin and wood. Similarly, with heating, the main energy source used is electricity, paraffin and wood. Electricity, candles and paraffin are energy sources predominantly used by households for lighting (StatsSA, 2009).

Moreover, a study conducted in 2004 on a low-income urban community in South Africa found that 55% of households used mainly electricity for cooking, 38% used paraffin and only 6% used Liquid Petroleum Gas (LPG) (Cowan & Mohlakoana, 2004). The cooking appliances predominantly used for cooking was the electric stove and paraffin stove (Cowan & Mohlakoana, 2003). According to Cowan and Mohlakoana (2003) 40% of the households used paraffin for space heating, whereas only 12% used electricity.

Contrary to South Africa, the most widely used energy source for cooking in Brazil, Central America and India is LPG (Heltberg, 2003). However, Heltberg argues that LPG tends to be a fuel for the non-poor in these countries because of the high price. The low use of the LPG in South Africa by the poor could be attributed to the high costs and the fact that the price of LPG was not regulated. The poor distribution network in South Africa also leads to problems of LPG access.

As clearly indicated above, 18% of households in South Africa still do not have access to modern energy and therefore do not benefit from the additional benefits associated with access to modern energy. Universal access to modern energy is

crucial as it directly and indirectly addresses developmental objectives of the country such as poverty alleviation. A number of policies geared towards energy poverty relief (to accelerate access to modern energy) have been developed in South Africa since 1994.

## **2.4 Energy poverty policies in South Africa**

The pre-democratic energy policy and planning prioritized energy security and less emphasis on equal access to energy. In a nutshell, access to energy was racially skewed. The post apartheid energy policies focused on redressing the racially skewed provision of energy services. The national government committed itself to implementing reasonable legislative and other measures, within its available resources, to progressively realize universal household access to electricity (DME, 1998). To this end, an inclusive Energy White Paper (1998) was developed.

Major objectives of government's Energy White Paper are (DME, 1998)

- Increasing access to affordable energy services;
- Stimulating economic development – encouragement of competition within energy markets;
- Managing energy-related environmental and health effects;
- Securing supply through diversity – increased opportunities for energy trade and diversity in both supply sources and primary energy carriers.
- Increased access to affordable energy services becomes one of the areas that government considered in addressing the racially skewed provision of energy services, thus addressing household energy poverty.

Below is an overview of the policies that emanated out of the energy white paper, and which seeks to address energy poverty.

### ***National and Integrated National Electrification Programme (INEP)***

Historically (pre 1994), 64% of the total population in South had no access to electricity. To address this problem, the national government of South Africa between 1994 and 1999 introduced the National Electrification Programme (NEP) with the aim to provide access to electricity to 2 500 000 households, mainly in disadvantaged rural areas, schools and clinics with no access to electricity (DME, 2001). The electrification target was met as 66% of households were connected to the electricity grid by end of the programme in 1999 (DME, 2001).

In response to the commitment made by government in the Energy White Paper, the Integrated National Electrification Programme (which is essentially phase two of the NEP) was launched in 2000. The programme aimed to address electrification backlog by 2012. The un-electrified household backlog in South Africa in 2006 was 3.4 million households, 28% of the backlog was in the municipal area of supply and 72% in the Eskom area of supply (NEAC Meeting No.2, 2007).

According to Bekker et al (2008) to electrify everybody by 2012 is impossible because it will require a funding of +5 billion rand per annum and an increase in generation capacity. Bekker et al (2008) further state that the Department of Energy's definition of universal access did not take into account growth in the number of households since the target was set in 2004. However, the progress made by the national electrification programme needs to be commended. The electrification rate has increased from 36% in early 1990's to 82% by 2009. Secondly it has contributed to quality of life through increased access to modern energy carriers, improved health care in clinics and adult education in the evenings at schools (Winkler, 2006). Winkler further states that '31% of those earning less than \$1 per day had access to electricity in 2000, compared to 20% in 1995'.

### ***Free Basic Electricity (FBE)***

Despite the spectacular progress made by the national electrification programme, poor households continued to use multiple fuels such as paraffin, fuel-wood and LPG (SANERI, 2008) because of the costs of access. This means that physical access to electricity is not the only issue – but access is also limited by affordability. In addressing affordability issues in electrified households, in 2000, national government announced its intent to provide free basic services to poor households. Energy was identified as among the basic services that would be supported by government's programmes with respect to poor households. In 2003 the FBE policy was launched with the aim to provide free electricity to qualifying households (DME, 2003). Also seeing that poor households use multiple fuels, cabinet approved in 2001 – the removal of value added tax from paraffin (DME, 2003).

In determining the amount of free electricity to be allocated to each household, pilot studies were commissioned. The FBE offers an amount of 50kWh of electricity to qualifying households. The sufficiency of this quantity has been debated however. A study conducted by the University of Cape Town concluded that an allocation of 50kWh of electricity is sufficient to meet basic human needs such as lighting, media access, limited water heating, basic ironing and basic cooking (UCT, 2002). The 50kWh allocation per month was also motivated on the basis that “56% of households in South Africa connected to the national grid (Eskom's licensed areas) consumed on average less than 50kWh of electricity per month” (Eskom in DME, 2003). The 50kWh comes with an associated blocked or stepped tariff for electricity consumption levels exceeding 50 kilowatt hours, therefore resulting in restrictions in terms of access, restricting even the poor that are meant to benefit from the subsidy. The FBE is meant to benefit the poor, however in most situations this is not the case because the allocation in most municipalities is based on consumption. If a household consume more than 150kWh of electricity per month it does not qualify

for FBE (because according to the policy once a household spends more than 150kWh that means they can afford to pay for electricity). However, it must be noted that the criteria used to qualify for FBE differs from one city to another. Also backyarders cannot access FBE because they do not have their own electricity box meter<sup>4</sup> as they normally get their electricity from the main house.

In consequence, some studies have criticised the UCT study saying that the study does not expand on whether people use the small amount because 50kWh is sufficient for households or because they cannot afford to pay for more electricity (Earthlife Africa, 2010: 15). The Earthlife Africa study concluded that 50kWh is not sufficient to create a better life. Similarly in an interview with Professor Anton Eberhard (Graduate School of Business, University of Cape Town), he argued that “the 50 kWh amount is probably not suitable for urban areas with big households and multiple energy demands, not least because the FBE amount does not take into account the typically large sizes of low-income urban households.” (CURES, 2009). These debates necessitate the review of the policy. With the realization that 18% of poor households still do not have access to electricity (thus not benefiting from FBE), and they will remain so beyond 2012, the Free Basic Alternative Energy (FBAE) Policy was introduced in 2007.

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<sup>4</sup> The City of Cape Town has embarked on a project to put separate meters for backyarders

### ***Free Basic Alternative Energy***

In the absence of electricity, the provision of alternative energy sources is essential for the un-electrified households to meet basic energy needs<sup>5</sup>. Bearing in mind that the informal housing sector is growing faster than the formal housing (SANERI, 2008) and that it is very difficult to electrify remote rural areas, electrifying all households in the short or even longer term becomes impossible. The FBAE policy becomes an instrument to cater for the un-electrified households.

The FBAE policy, introduced in May 2007 was developed in order to assist poor households where electricity is not available, with a basic amount of free energy necessary to meet their basic energy needs (DME, 2007). The objectives of the policy are:

- 1) to facilitate the provision of basic energy needs to poor South African households that do not have access to electricity,
- 2) where possible to address a whole suite of socio-economic issues that arise from inadequate provision of services to the households, such as job creation etc;
- 3) to minimize health risk by promoting safe use of these energy carriers,
- 4) to ensure that energy carriers chosen are sustainable, safe and easily accessible to poor households and
- 5) to maximize efficient use of energy carriers for the benefit of all citizens.

(DME, 2007)

Municipalities are tasked with implementing the policy by identifying the indigent<sup>6</sup> households and therefore recipients of the subsidy and issuing them with an

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<sup>5</sup> Alternative energy is also a viable option for all households in light of the electricity challenge and the climate change problem.

<sup>6</sup> The term “indigent’ in recent municipal discourse in South Africa has tended to refer to a policy on how chronically poor households should be dealt with in relation to the generation of income” (Parnell et al, 2003: 15). Income level is used by the municipalities to administratively identify the poor households falling below a certain income level. Municipalities

alternative fuel to the value of R55 per month (DME, 2007). Municipalities can choose the source of energy appropriate to their geographic location and environment, and the socio-economic circumstances of the municipality and indigents. Examples of energy sources are paraffin, LPG<sup>7</sup>, coal and bio ethanol gel. This policy came into effect in May 2007 and the efficacy of the policy has not been assessed as yet. FBAE is funded by national government, through the Equitable Share Grant (a grant disbursed by national government to local government via the Department of Cooperative Governance (formerly known as Department of Provincial and Local Government) which funds the provision of an entire suite of free basic services for the poor. These funds are classified as Free Basic Electricity/Energy within the broader Equitable Share Grant and where no electricity infrastructure exists, the policy directs the funds to be channelled to fund FBAE. The policy also directs that municipalities are to supplement the FBAE grant from their own income in ensuring that the poor households receive FBAE (DME, 2007).

The purpose of this policy was to improve the energy welfare of the poor, however to date the implementation of FBAE has been very limited largely because it is

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have different criteria's of identifying the poor – as they have different income level measurements. Once a household meets the indigent criteria, it then becomes registered as indigent, thus qualifies for the free basic services such as the free basic alternative energy, inter alia. However, administering the indigent register poses a huge challenge for the municipalities.

<sup>7</sup> The LPG is an alternative energy carrier that poor households can tap into, however in South Africa there has been no poverty relief measure applied in LPG as the fuel was perceived as being predominantly an industrial fuel (DME, 2003). In 2010, government announced that the price of the LPG will be regulated. The unregulated price of LPG was the main impediment for the uptake of the resource in South Africa. With this realization a pilot study was conducted in 2009 to assess the viability of LPG as an alternative resource for low-income households. The study revealed that there was a demand for LPG, particularly in rural areas, but the excessive price of the resource was a problem (Peters, 2009). To regulate LPG, government reduced the LPG price at refinery gate by 30% with the hope that should mean lower prices for energy buyers – particularly the low-income households.

extremely difficult to roll out from an administrative point of view and because the subsidy only includes the cost of the fuel and not the infrastructure required to roll out. Therefore municipalities have tended to not focus on this policy as a mechanism to address energy poverty(SEA, 2010) Thus, in general, delivery of energy services within poor areas and integrating sustainable approaches to energy service delivery at the local government level requires new ways of doing things.

Alternative energy sources identified in the policy are not exhaustive; some municipalities are rolling out solar photovoltaic to poor rural areas. Another alternative energy source which cities, provinces and national government have embarked on as an energy poverty, energy efficiency and climate change mitigation intervention is solar water heating.

### ***National Solar Water Heating Strategy***

The National Department of Energy has developed a draft National Solar Water Heater Framework. In the document government sets a target to install 1 million solar water heaters in households by 2015 and 5.6 million installations by 2020 (DoE, 2010).<sup>8</sup> The aim of the mass rollout is to address the country's electricity challenge, mitigate green house gas emissions, create employment and alleviate poverty (Afrane -Okese, 2009). However, the goals are laudable but not easily implemented.

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<sup>8</sup> The policy is ambitious. To achieve this target the country has to install 900 SWH's per working day, currently the country is installing 100 swh per day. At the current pace it is impossible to reach the target by 2015 (DoE, 2009).

## 2.5 Barriers in promoting Renewable Energy (swhs)

While this approach holds potential, there is a debate about its viability. Renewable energy, for instance, is perceived as costing “more than other energy resources, resulting in cost driven decisions and policies that avoid renewable energy” (Beck & Martinot, 2004: 3). The problem with this perception is that, the costing takes into consideration only the low initial capital costs and ignores the total life cycle costs. With this perception in mind renewable energy is then indeed expensive as the initial capital costs are high and the thermal generation is seen as cheap which is why the South African government has invested in coal, nuclear and crude oil for the generation of its electricity. Electricity derived from coal, nuclear and crude oil excludes external costs, hence the low electricity costs (DME, 2003). According to Mallon (2006: 12) “...renewable energy is more expensive than thermal generation if the environmental and social impacts; the ‘externalities’ are not priced”. Banks et al (2008) also argues that there is “unsubstantiated assumption that low energy prices are the key to international competitiveness”. Similarly Holm (2005), Prasad & Visagie (2006) argue that the high upfront capital costs of swhs are still cited as the major barrier to the development of SWH market locally and internationally.

The intermittency of renewable energy is also cited as a barrier in adopting renewable energy. With wind and solar energy there is an argument that what happens if the wind does not blow or the sun does not shine; where do we get the energy or hot water in the case of solar water heating? (Banks et al, 2008). These erroneous assumptions are a result of lack of education and awareness about the technology, unpacking these issues is critical at all spheres of government and at the community level where the technology is implemented especially in the case of solar energy as is the focus of this study. In spite of the technology challenges, governments have embarked on solar water heating projects.

## 2.6 Solar water heating in South Africa

Certainly, swh is a viable option in South Africa. A solar water heater uses the energy from the sun to heat water. “The solar panel gathers the sun’s energy and heats the water in the pipes beneath it. Through the process called convection, the hot water rises and circulates through the solar absorber and into the geyser. When the water cools in the geyser, it flows back to the collector where it is heated again” (DEADP, 2008:1).

Solar water heating has proved to be a beneficial technology for the residential sector, and to this end, there has been a noticeable progress<sup>9</sup> from the South African government in trying to promote and implement the technology. The residential sector in South Africa consumes more than 17% of the country’s electricity (SEA, 2007). The installation of swhs would play a significant role in reducing electricity consumption.

For the household; the installation of a solar water heater has the benefit of reducing water heating for a mid – high income household by some 60%, and this amounts to about 25 – 30% saving on an average monthly electricity bill (SEA, 2007). Access to solar hot water has positive health impacts for the household and the environment. This is because the water is heated mostly by the sun and reduces household indoor air pollutions that would have been caused by the burning of paraffin stove. Solar water heating reduces household’s CO<sub>2</sub> emissions by about 2.6 tons per year – depending on technology and size (SEA, 2007).

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<sup>9</sup> Cities e.g. the City of Cape Town, Nelson Mandela Bay Municipality, Ekurhuleni Municipality, City of Johannesburg and the Western Cape Provincial Government have embarked on the installation of swhs in low-income areas. At the national level, a policy that promotes the mass roll out of swhs in households is being developed.

Similarly, Milton and Kaufman (2005) argue that improved quality of life and a reduction in electricity costs can be expected in a low-income household, where energy costs are often a large component of household expenditure and the swh may replace the use of “dirtier” fuels, such as paraffin, for water heating” - helping to mitigate climate change, and sometimes improves indoor air quality.

With regards to the latter, Milton & Kaufman (2005) further state that solar water heaters reduce the health impacts that would have been caused by the use of wood and other fuels such as paraffin. The health benefits include the reduction in ‘chronic respiratory diseases associated with smoke inhalation, greater availability of hot water for household sanitary needs, hot water provides an additional level of disinfection over cold water’ (Milton & Kaufman, 2005: 15).

Since solar water heater require high capital intensive manufacturing equipment, these systems can be made and are made in many developing countries – thus boosting the economy of the country through skills development and employment creation (Milton & Kaufman, 2005). Prasad & Visagie (2006) also argue that swhs bring about employment creation in manufacturing, installing, retail sales, business administration, system design and maintenance. Austin (2003) calculated that 120 000 new and direct jobs could be created by the swh industry should appropriate targets be set. Moreover, Austin and Morris (2005) indicate that swhs are less expensive means of heating water for domestic use because the energy from the sun is free.

Eskom has focused on subsidizing swhs in the mid-high income groups in South Africa over the past few years. This has partly been driven by the fact that these consumers typically use 50% of their annual electricity consumption to heat water for sanitation purposes. Eskom has focused on rolling out swhs to this market, given

that if all mid-high income households in the country had a swh, the country could (at a minimum) remove a large coal power station off the grid (SEA, 2007)). In this context a solar water heater is treated as an energy efficiency intervention and plays a demand side management role.

In contrast, very little attention has been given to the rollout of Solar Water Heaters in low-income areas. Installing a Solar Water Heater in low-income areas would not really be an energy efficiency intervention but rather an intervention that provides social and health benefits. The draft national solar water framework aims to promote the mass installation of swhs in low-income areas.

There are benefits accruing with the use of swhs in the residential sector – and these range from economic and social to environmental. Solar water heater pilot projects have been implemented in some cities across the country (and abroad). A review of the social studies on swhs and their impacts on households is discussed below.

## **2.7 Impact of solar water heating in low-income households**

The first low-income solar and energy efficiency project was introduced in Kuyasa, Khayelitsha in 2005. The Kuyasa Clean Development Mechanism (CDM) project in Khayelitsha has been proved to be a success. The project involved the retrofitting of about 2300 households with solar water heaters, energy efficient lighting (replacement of incandescent light bulbs with low-watt CFLs) and ceilings. A study conducted by Cousins and Mahote (2003) on the social impact of the interventions found that ceilings reduced the amount of energy required to heat the houses resulting in savings that have been spend on essentials such as food and education,

swhs drastically reduced the amount of energy spent on heating water for cooking, bathing and clothes washing.

Furthermore, Cousins and Mahote (2003) found that the efficient light bulbs outlasted conventional bulbs and provided more hours of light for less money. In this project, the community (beneficiaries) participated extensively through information - sharing and household energy awareness raising workshops (Cousins and Mahote, 2003). However, from the case study it is not clear at what stage was the community involved in the decision making process – what is clear is that the beneficiaries were made aware about the technologies.

A social research study done in ten pilot houses in Khayelitsha – a low-income area near Nyanga Township found that before the installation of the swh households were using mainly paraffin and electricity for heating water (Cousins and Mahote, 2003). After the installation of swh households were using hot water from the swh for washing clothes and dishes, bathing, tea-making - saving household energy and time. But, despite these changes, residents in this pilot programme felt that they are spending the same amount on paraffin and electricity, and some felt they were spending more on electricity because the swh would sometimes need electric back-up (Cousins & Mahote, 2003).

However, a similar study done in a low-income area in India indicated that there are massive savings on electricity when using a swh. Interviewees indicated that “their electricity consumption had dropped from 125 kWh to 65 kWh a month” after the installation of the system (Doyle & Humphreys, 1995:9). Lack of education and awareness raising about the technology appears to be a major barrier, amongst others, in India (Doyle & Humphreys, 1995).

A study done in a Durban low-income township (Klaarwater) on the impact of swhs found that household's expenditure on electricity had dropped by between R50 – R100 per month four months after the installation of the system (Green, 2004). The study also found that most households were generally satisfied with the solar water heater technology and they understood that hot water was dependent on the weather. This can be attributed to the marketing strategy done prior to the installations. In particular, the strategy included demonstrations in the pilot areas and advertisements in local isiZulu newspapers (Green, 2004).

A similar study of a pilot project on the deployment of solar water heaters has been completed in Nelson Mandela Bay Municipality (Port Elizabeth) in Zанемvula in particular. Similarly to the Durban experience, households were generally satisfied with the technology except that the majority of households had maintenance problems such as system leakages (NMBM, 2009). Other findings included time savings and sense of relief both for males and females. Households not selected for the pilot study also wanted swhs. Moreover 24 local people were temporarily employed as a result of the project and the health situation of the surveyed households had improved since the installation of the swh (NMBM, 2009). Similarly to Durban, an awareness raising workshop, which was poorly attended was held for the community.

As seen above, swhs have an important role in terms of energy poverty reduction and environmental sustainability. However, equally important is the acceptance of the technology itself by the beneficiaries. Researchers have done some work on the social acceptance of renewable energy – specifically on solar water heaters. The following section discusses the social acceptance of renewable energy and the importance of that in terms of project implementation at the community level.

## 2.8 Social acceptance of Renewable Energy

According to Mallet (2007), the transfer and adoption of renewable energy technology tends to overlook the importance of social acceptance. Social acceptance is generally an understanding of why the technology is used or not being used – it is an active process as opposed to just passive approval of the installation of the technology (Mallet, 2007). Mallet stresses the importance of involving all the relevant players and stakeholders, especially the end users, in renewable energy technology transfer debates. His study on social acceptance of swhs in Mexico City, found that “there is generally a lack of awareness among potential users about the technology” (Mallet, 2007: 4). Lack of awareness about the technology in Mexico is attributed to the fact that swh companies do not have time to devote to awareness raising amongst end users (Mallet, 2007). Some claim that government is also doing little to promote solar water heaters in Mexico. Informal conversations on Mallet’s study indicated that after purchasing a swh there was a little follow-up or guidance to ensure the user knew how to maintain the product, confirm it was working etc (Mallet, 2007). Similarly in Lebanon, local acceptance has neither been due to published research nor due to government support (Hourri, 2005).

Contrary to Mexico and Lebanon, solar water heaters are widely accepted in all spheres of government and by various stakeholders in South Africa. This is partly due to the fact that the policy making process in South Africa is very participatory. Forms of participation in the solar water heater programme in South Africa include “workshops, summits and presentation of strategies, exhibitions at summits, conferences and workshops, market and community pilot projects” (Prasad, 2007:10). The Kuyasa Pilot project in South Africa is an example of a participatory decision making process. The project involved workshops with the end users of

swhs. Involving the end users in decision making process makes it easier for the technology to be accepted.

In conclusion, there is a general consensus from researchers, academics, policy makers and practitioners that swhs have a potential to reduce energy poverty in low-income areas. The above swh case studies revealed that swhs have a potential to reduce electricity costs for households, save time for both male and females as a result of the readily available hot water. However, there are complexities involved in terms of implementation; hence community participation is essential in the adoption and implementation of the projects. The Nyanga Township swh case study below seeks to contribute to this debate

### **3. Nyanga Township**

The Nyanga Township swh case study seeks to contribute to the debate on swhs highlighted in the literature above and provide practical experience of the benefits of solar hot water for households and the challenges of implementing energy poverty intervention in low-income areas.

Nyanga Township lies approximately 20 km from Cape Town. It is bordered by Lansdowne Road in the South, Klipfontein Road in the North, NY 78 in the west and Mahobe Drive in the east. According to Seleoane (1985) the township was proclaimed in 1946 and consists of state-built and employer built houses.<sup>10</sup>The

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<sup>10</sup> According to StatsSA (2001) the study area has a population of more than hundred and seventy thousand. Almost the entire population consist of black people (99%) and 1% coloured. More than 95% of the population speaks isiXhosa as their first language. The unemployment rate in 2001 was 35%. The average income of households is R25, 437 per year (StatsSA, 2001). Forty five percent of households lived in informal dwellings in 2001 whereas the remaining households lived in formal houses (StatsSA, 2001).

actual area Zwelitsha Drive where the research was conducted is opposite Nyanga taxi rank. Zwelitsha consists mainly of the houses that were built by the state during apartheid era.



**Map 1: Street Map showing Nyanga Township and Zwelitsha**

**Source: City of Cape Town (2011)**

### ***Nyanga Township swh pilot project***

The Western Cape is a leading province on energy and climate change issues. The province was the first to develop a sustainable energy strategy and a provincial sustainable energy white paper which will consequently become an act. The province has a renewable energy target of 15% by 2014 (DEADP, 2007). The net renewable energy contribution to the target of swhs is 0.214TWh by 2010 – this

represents about 1% of electricity demand (DEADP, 2007). To contribute to this target, the Western Cape started installing swhs in low-income areas.

A solar One Thousand project, as the name suggests, providing thousand swhs to various communities as part of a pilot project to stimulate the swh industry in the Western Cape was launched in April 2008 by the then Minister of Minerals and Energy, Buyelwa Sonjica and the then Western Cape Minister of Environment, Planning and Economic Development, Tasneem Essop. Solar water heaters have already been installed in Riversdale, Elsies River, Nyanga, Atlantis, Prince Albert, Oudtshoorn and Mossel Bay. Based on the success of this project the province is committed to further install swhs in other low-income areas. To this end; 200 swhs have been added to the 1000 solar project and this totals the installation of swhs by the province to one thousand two hundred.

In 2007, Atlantic Solar Company won a contract to supply and install swhs in low-income areas in the Western Cape. The company was responsible for the supply and installation of swhs in the above mentioned low-income areas – including Zwelitsha Drive in Nyanga. Why did the province select these areas? The then premier of the Western Cape (Ebrahim Rasool) identified twenty five disaster areas based on crime, drugs and poverty. These areas were prioritized in terms of development as a way to reduce crime and poverty. Furthermore, “the rollout was part of the commitment made by Premier Rasool on his 2008 state of province address, where he said that the provincial government would rollout 1000 solar water geysers as part of its effort to help save 500MW a day” (DEADP, 2008).

The project was implemented jointly with the community who were responsible to assign the systems to the beneficiaries. The ward councilor (ward 37) was responsible for the management of the selection process. The beneficiary selection

criteria focused on elderly, people with medical challenges and single mothers. The project was funded by the Western Cape provincial government and the lead department was the Western Cape Department of Environmental Affairs and Development Planning (DEADP).

In Nyanga, one hundred swhs were installed in 2008 in Zwelitsha, KTC and Old Location. The focus of the research was in Zwelitsha.



*Photo 1: These pictures show Zwelitsha in Nyanga Township where the research was conducted.*

As can be seen, homes in Zwelitsha are council built houses, characterized by one bedroom, no ceiling, no bath or shower unless the owner or landlord has extended his/her house as evident in the house on the far right hand side. The swhs installed in this area are 80 litre systems with 1.5 square metres solar-flat collector panel.



*Photo 2: solar water heater on the roof of council built house in Zwelitsha (80L system)*

Nyanga Township swh project is ideal in answering the research questions posed in page 9.

Firstly, Nyanga Township was chosen because of its historical significance in the Western Cape. Secondly, it is the first historical black township in the Western Cape that received swhs. Thirdly there is no social research study that has been done on the impact of swhs on people's lives – and the project is relatively new.

#### **4. Methodological Approach**

In my methodological approach I was interested in the following main questions: Do swhs improve access to hot water and reduce electricity costs for households? What are the complexities of implementing energy poverty interventions such as swh in a South African Township?

To gather the information, a household survey with a mix of both closed and open-ended questions was used. Twenty households in Zwelitsha were interviewed during weekends. The interviews were conducted on the 6<sup>th</sup> and the 14<sup>th</sup> of March 2010. The interviews took about an hour and a half each. Interviews were conducted almost a year after the installation of swhs.

Solar water heaters have been installed in 100 houses. Twenty interviews out of hundred beneficiaries were conducted. The twenty houses were selected randomly with the help of the councilor and colleagues from the Western Cape Department of Environmental Affairs and Development Planning. The researcher set appointments with the beneficiaries to conduct interviews. The actual interviews were conducted the following week on Saturday as most interviewees indicated that they were most available on that day.

An unemployed, experienced field worker was employed to assist with conducting the interviews. The field worker was trained prior to conducting the interviews; and he did pilot interviews with the researcher to ensure that the subject and the questions were understood before embarking on an actual research. Lastly, the majority of residents in Nyanga speak isiXhosa and the researcher(s) speak isiXhosa; the interviews were therefore conducted in Xhosa. This helped because the interviewees were comfortable in speaking their own language.

This research has complied with research ethics of confidentiality, integrity and honesty, as prescribed by the University. The purpose of the research was clearly outlined to the participants; no one was forced to participate. According to Babbie and Mouton (2001) participants need to be ensured of the confidentiality of the information they are giving. Information that could embarrass the participants is not revealed in this study. In cases where information was useful for the research the identity of the participants was hidden by labeling the participant as anonymous. Overall, the methodology used to gather information addressed the research questions.

The types of questions that were asked included, amongst others:

- Household energy use and expenditure: the purpose of this question was to get a sense of what households use energy for and how much it costs. The question also helped to establish how much households spend on energy for water heating and whether the installation of swhs had reduced the cost.
- Performance and maintenance of the swh: the purpose was to ascertain people's knowledge about the swh, the technical understanding of how it functions as well as their satisfaction or acceptance of the technology.
- Project additional benefits and training: the purpose of this question was to determine the level of community engagement in the project. By community engagement I mean proper consultation with the beneficiaries about the project, training and awareness raising about the technology, and their understanding of the beneficiary selection criteria.

### *Limitations of the study*

It is important to note that the questionnaire was in English and had to be translated<sup>11</sup> into Xhosa when conducting the interviews. The researchers found it extremely difficult to translate some energy vocabulary into Xhosa – but have managed to explain it in the manner that the interviewees would understand it. This is not necessarily a limitation but something that needs to be borne in mind when conducting research in other languages.

Access to the study area was gained without any difficulty. The only problem though is that there were some areas that we were warned not to go to due to crime.

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<sup>11</sup> Note that the questionnaire itself was not translated into Xhosa; the interviewers asked questions to the respondents in Xhosa.

## **5. Solar water heater installed but what are its benefits for Nyanga (Zwelitsha) residents?**

This section attempts to provide answers to the research questions posed above. In doing that, the researcher first provides a broad description of the study area (household characteristics and household income). Following that are the analyses of the household water consumption and expenditure. This is to establish how much households spend on water heating and what difference the installation of swh has made (if any) on energy consumption. In addition to the cost, analyses of what people use solar hot water for and its benefits are explained.

Furthermore, household energy consumption and expenditure is analyzed. The purpose of this analysis is to ascertain what households use energy for? How much they spent on energy before the installation of swh and whether that has changed or remained the same since the installation.

Lastly, in attempting to answer the question on the complexities of implementing energy poverty interventions in low-income areas – community participation in the project is analyzed and discussed.

### **5.1 Household characteristics**

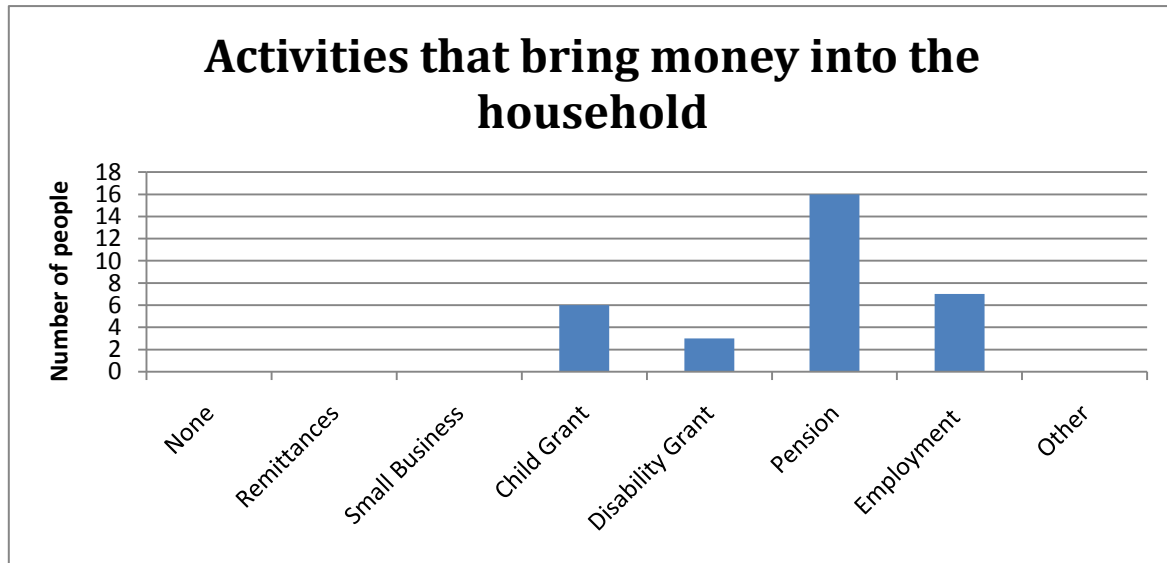
Zwelitsha is a well established township; all households said they had municipal water connection and electricity connection before the installation of swh. All households had swhs and these, according to them, were installed in 2008 by a certain company(Atlantic Solar).

Of those who were interviewed, households had on average five people per house. The houses consist of a bedroom, a kitchen, dining room and a bath room – unless otherwise extended by the owner. The number of children is on average one per household. I interviewed home owners which in some instances became a more complicated situation. For instance, one interviewee said that her mother who had lived with her had recently passed away and her family is fighting for the ownership of the house – it was not clear who owns the house in this particular circumstance.

Almost all households had someone over the age of sixty living with them; and one person per household had special needs. The special needs cited were that people had TB, disabilities, high blood pressure, were old and thus 'house bound'.

## **5. 2 Household income, jobs and external support**

All the interviewed households had a source of income. The household income consisted of a mix of contributions in the form of money from employment, pension or government grants. The majority of the households were dependent on pension, followed by employment, child and disability grant. None received an income from small business or remittances.



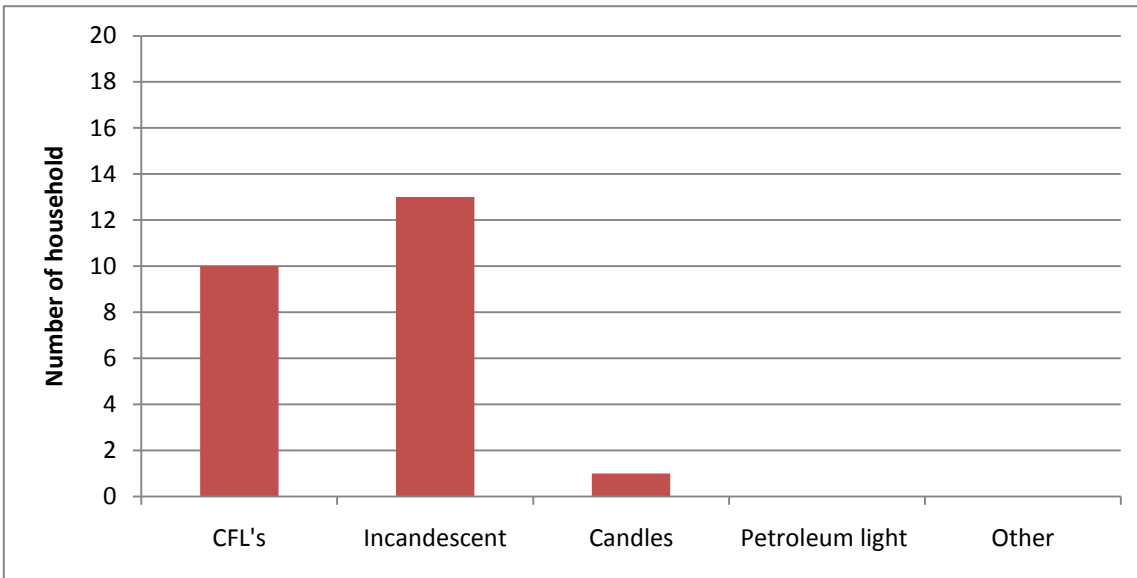
Graph 2: Number of people and the sources of income

As can be seen in graph 2 above respondents receive their income from pension<sup>12</sup>, employment, child grand and disability grant.

### 5. 3. Household energy consumption and expenditure

For lighting; households used incandescent light bulbs, followed by compact fluorescent lights (CFL's). The remaining 5% used a candle for lighting.

<sup>12</sup> Pension in this case refers to old age pension which is a state pension of R1 140.00 per month. Pension was purely used because participants were confusing other government grants with old age grant. They identified themselves better with the usage of the word 'pension' when referring to old age grant – hence government grant has been broken down in graph 2



**Graph 3: what people use for lighting**

Households spend on average hundred and eighty three Rand (R183.00) per month on electricity. The majority of households said this is the same amount they used to pay before the installation of the swh. Only one household indicated that the household expenditure has changed since the installation of the swh. Mrs. Posiya<sup>13</sup>, age 77, said that she saves on electricity (went from R500/month – R300/month – the high expenditure on electricity is because they have a large family, 5 people in the house, excluding backyarders) because she uses mainly the water from geyser for bathing as opposed to boiling a kettle. This was a view held by other participants although they could not produce physical evidence of saving. Also when further asked later on whether they are spending the same amount on electricity – all said yes. I asked for pay slips to verify this but households were able to provide the recent pay slip – they either misplaced or lost older pay slips. Therefore, this did not help in terms of comparison.

<sup>13</sup> Not her real name – all names used in this document are not the real names of the respondents.

The response to these questions was very ambiguous. It was ambiguous in the sense that participants assume that they are and should be saving electricity as they boil water less than they used to. However, the money they spend on electricity remains the same to 95% of the respondents. The uncertainty about electricity consumption could be attributed to the fact that poor households (from personal experience) do not measure electricity consumption – they normally monitor the number on the pre-paid electricity box – to ensure that it does not get to zero. Other than that they do not have an interest or an understanding of their expenditure on electricity. Similarly with water, households do not check their water meter because they do not know how it works – they just pay the amount they are presented with in their water bill from the municipality.

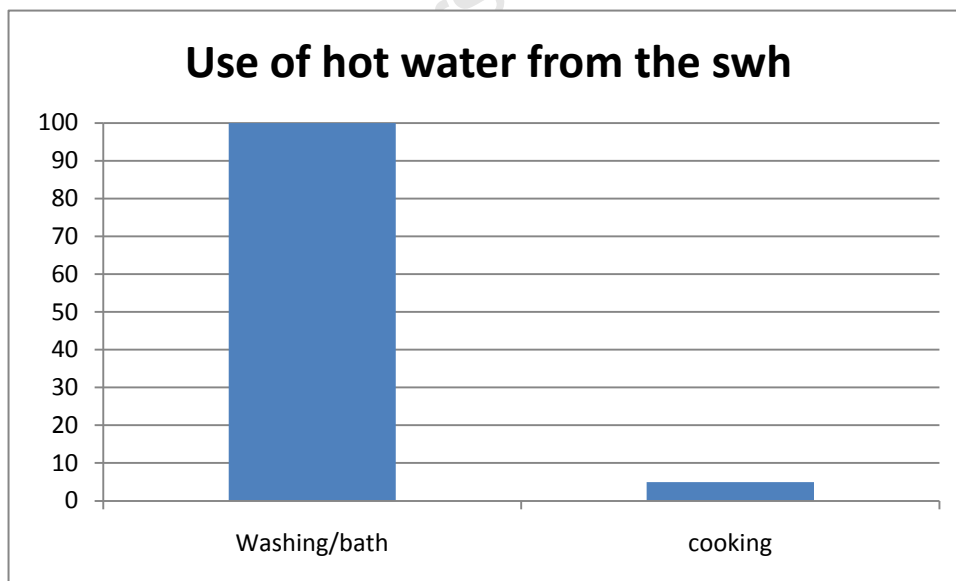
Ideally, one would expect that having a swh means less use of electricity for boiling water; however this seems not to be the case in this instance. The rebound effect of energy efficiency (EE) study found that energy efficiency improvements (i.e. installation of swhs) are lost to subsequent behavior change (Davis, 2010). By subsequent behavior change the author is referring to a situation where a household saves electricity as a result of the installed EE intervention, with evident less energy use the household decides to buy additional appliances such as entertainment units which in turn increase the consumption back to where it was before the installation.

Despite not reducing monthly expenditure, additional appliances add value to the residents as it opens opportunities for extra household activities that require the use of electricity. These issues need to be taken into consideration when implementing projects at the community level. Education and awareness raising becomes critical – knowing the importance of the installed intervention can result in electricity savings for the households.

## 5.4. Household water use and expenditure

*What do people use swh for?*

All respondents use hot water from the swh for washing clothes and bathing. One of the respondent said he also uses the hot water for cooking; he uses the water for rinsing rice, instead of boiling water to rinse rice – but he emphasized that after rinsing he uses tap water because there is uncertainty about safety and cleanliness of water from the swh. This is a view also held by those who do not use swh for cooking. Households argue that water coming from the geyser is sometimes not clean; it comes in a milky colour. Another argument for the uncertainty is that the system is mounted outside and that it can be rusty and have some chemicals within it. Even though households have a swh they still heat water using a kettle or a pot on the stove for washing sometimes. Respondents indicated that they heat water mainly when it's cold and cloudy as water from the swh tends to be cold or lukewarm at such times. For the efficient use of swhs a clear communication strategy about the safety of water from the solar systems is critical.



*Graph 4: Use of hot water from the swh*

With regards to the frequency of water heating, respondents indicated that they mostly heat water 1-4 times per day (to make tea/coffee) with electricity. Also the water from the swh tends to be used in the morning between 05:00 -12:00. This is mainly the times when adults prepare themselves for work and their children for school.

Households spend on average R44 (this is not a fixed amount – it is a metered amount, it changes every month) per month on water. They have indicated that the amount is the same as before the installation of swhs.

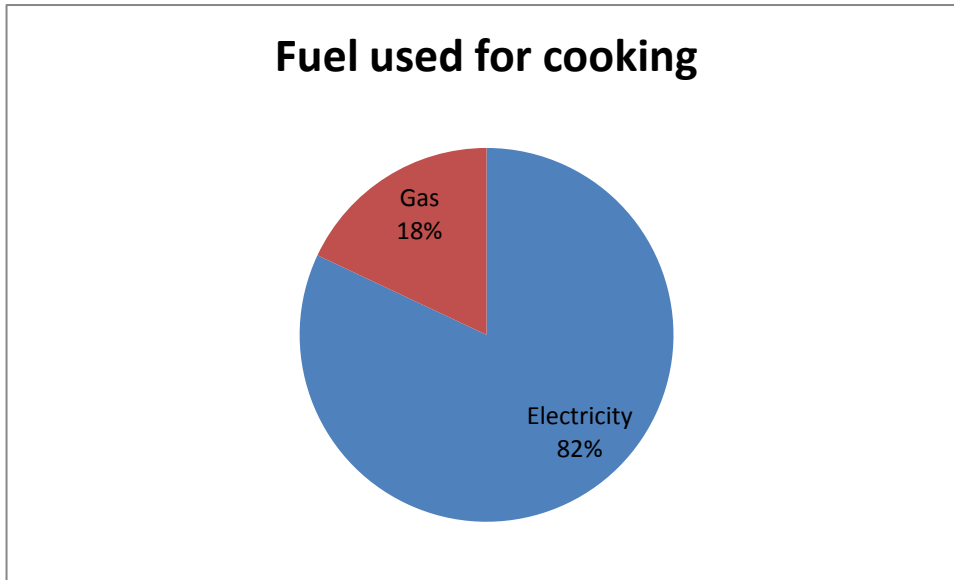
Respondents were asked if they know how to adjust swh when the water is too hot. The response was generally a no. They completely do not know how a swh functions but do understand that water is heated by the sun – that’s all they know and just appreciate the warm water they are receiving.

Prior to the installation of swhs households had no readily available hot water – they were reliant on the water boiled using electric kettle or stove. Interestingly, households adjusted well to the swh and they have a good understanding that water is warm in summer and lukewarm in winter. In summer, households are conscious that water from the solar can be too hot especially for children. Some households indicated that they still use the lukewarm water in winter as it is not as cold as the water from the tap.

## **5.5 Household and cooking**

Concerning the appliances for cooking, 82% of the respondents expressed that they use electric stoves for cooking – and very few (18%) respondents said they are using gas stoves for cooking. Interestingly, none of the participants responded that

they use paraffin for cooking. They indicated that they only resort to paraffin in emergency when electricity is not available. Otherwise, electricity is the main source of energy used for cooking even prior to the installation of swhs households have been using electricity.



*Graph 5: Fuel used by households for cooking*

### **5.6 Space Heating in winter**

Ninety five percent of the respondents heat their homes in winter using paraffin heater. One participant indicated that she does not heat her home. Participants were further asked if they heat their homes in winter how much do they spend on average on fuel for heating (other than electricity) per month. On average households spend R139 on space heating (paraffin) per month. Participants indicated that the amount they spend on space heating is the same as before the installation of swhs.

## 5.7. Community participation in the project

There is a tendency to plan and decide what the community wants, instead of discussing the needs of the community with the community and then implement the project. Sufficient participation in the project from its start would result in increased benefits, both for the implementer and the beneficiaries.

The majority of households were not informed about the project. They argue that the neighbours are asking why only they were selected for the installation of the solar water heater. The community does not know what the selection criteria were. But they suspect that it may have been through the councilor and the ward committee. And they assume that the criteria for the selection were old age, poor health and disability as the swhs are installed in households of people who have these characteristics.

According to the project implementers the decision making process was transparent and the communities were consulted. The implementing organization communicated with the ward councilor. The ward counsellor had the responsibility to inform the community about the project and the criteria used for the selection of beneficiaries. According to the counsellor, the community was consulted about the project. This is contradictory to what the respondents said they experienced.

Some participants when asked who installed the geyser they said that it was a white and a black male. They did not know from which department or company the installers were from and who the lead department is for the project. If anything were to happen to the geyser they would not know who to report to. However one respondent who communicated with the 'white male' referred to by the community

had a good understanding of what to do if anything was to happen to the geyser. He had taken contact details of the company.

The above analysis indicates that there are benefits accruing from the use of swh although there is uncertainty on some of the benefits such as savings on electricity. Community participation on project implementation was non-existent and this supports the argument by Mallet (2007) that adoption and implementation of renewable energy technologies (including swhs) tends to overlook the importance of social aspects of technology transfer.

In addition to the benefits of swhs highlighted above, there are also indirect and direct benefits associated with solar hot water.

### **5. 8. Health impacts**

There are arguments that suggest that increased access to hot water has benefits for health, such as greater availability of hot water for household sanitary needs, reduced indoor air pollution (see Milton & Kaufman, 2005). In this case, participants in the study were asked if they suffered any illnesses in the past year. All interviewed households indicated that at least one member of the household suffer from either TB, high blood pressure and coughing (this is because beneficiaries were selected on the basis that they were pensioners and had poor health). Participants further stated that these illnesses are ongoing because they are linked to the fact that the household members are old. These illnesses have not necessarily changed since the installation of swh but there are indirect positive impacts on the health of the households. The indirect positive health impacts included the fact that elderly and the sick used to boil water using a kettle or pot and wait for water to get hot. According to the participants, the installation of swh has

had a very positive impact on their lives. For example Mrs. Posiya, age 77, said that she is 'completely happy with the swh; citing that recently there was a power cut but water from the geyser remained hot – and the household was using it for bathing and washing dishes'.

Mrs. Nombewu, age 49, also said that *“swh helps with children because they are enjoying bathing now, and she does not have to boil water for them before they go to school, they pour water and bath themselves. This swh saves my time and their time and they (children) bath more often and quickly because of the geyser”*.

However there was one participant that was not happy with the swh. She said *“water from the geyser does not taste good – there must be some acid in it. Granny (her mother) was sick and she couldn't use water from the geyser because it was always lukewarm and not clean, if we use it we still mix it with boiling water. Even if it's too hot we still have to boil water to mix water from the geyser. The swh is useless – granny could have benefitted from it because she was sick and house bound – she eventually passed away. Furthermore, geyser is installed in the kitchen not in the bathroom”*. This homeowner's dissatisfaction was unique; all other households interviewed indicated that they were satisfied with swh but raised some concerns about the housing design.

The design of the houses was cited as a challenge by all households. They argued that the houses do not have a bathroom and that the geyser had to be installed through the kitchen. This inconveniences households somehow – especially the old and sick as they have to fetch hot water from the kitchen to where they bath. Nevertheless, the readily available hot water had positive health impacts on the elderly, the sick and the children, with the exception of one household that was completely unhappy with the swh.

There are unexpected benefits that are not typically highlighted in the literature on swhs and their implementation in low-income areas.

### **5.9 Other benefits of the swh pilot project**

Concerning the benefits of the swh project participants are generally happy with having a swh and have indicated that other people from the community would like to have one. One interviewee highlighted that she feels the installation of swh has changed her life because hot water is readily available – she is “old and lazy” to plug the kettle. The same homeowner also indicated that her 19 year and 21 year old daughters are using hot water from the geyser in their salon to wash hair. The salon is situated at the back of the main house. This meant an additional income for the household. The owner of the house is pensioner and the two daughters are self-employed. The use of hot water from the swh for business purposes is interesting – because she reduces (ideally) expenditure on electricity. The mother was exceptionally happy about this positive contribution of the swh in their lives.

Saving on electricity and time for both men and women was also highlighted as a major benefit. For women access to readily hot water resulted in less time spend in preparing children for school, whereas for men it meant less time in preparing for work and not wait for women to prepare hot water for a bath.

In conclusion, the case study findings reveal that Nyanga households spend a high proportion of their budget (R183 per households on average) on electricity. The savings on electricity costs as a result of the installation of swh is unclear – this can probably be attributed to the “rebound effect” and the fact that households do not keep accurate records of their energy expenditure. From the households responses

and the discussion with the researcher there is a clear sense that as a result of the swh less water is being boiled using the electric kettle.

Similarly, households spend a lot of money on space heating in winter, using paraffin heaters. Provision of ceilings for the low-income households could potentially reduce the households spending on space heating in winter.

With regards to health, there are clear direct and indirect benefits for Nyanga households – and these include, the readily available hot water for the old and sick, encouraged children to bath more often, saved time for both males and females for preparing for themselves to bath and their children for school. The section that follows discusses these research findings in relation to the existing literature on the subject.

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## **6. The impact of solar water heating on people's lives**

This paper assessed whether access to swh improves access to hot water and reduces electricity costs for households. Furthermore, the paper assessed the complexities of implementing energy poverty interventions such as swhs in South African townships. It is clear from the literature and from the case study that swhs improve low-income households access to hot water. However, it is not clear if households save on electricity cost as a result of swhs.

The literature also revealed that there is lack of community participation in renewable technology transfer such as swhs. Community participation is important for the acceptance of the technology and the project itself. Community participation was non-existent in the case study area and this (community participation) is essential for the successful implementation of energy poverty interventions in low-income areas. The discussion below considers the key issues that emerged in the case study area, linking it to the existing literature.

An impact of swh on low-income areas in India and Durban revealed that households saved from fifty to hundred rand on energy expenditure as a result of the installation of the system (Green, 2004, Doyle & Humphrey, 1995). A similar study conducted in a low-income solar water pilot project in Khayelitsha showed that households spent the same amount on energy or even more after the installation of swh (Mahote & Cousins, 2003).

Research findings by Mahote and Cousins (2003) are consistent with the findings of this study. Households in Nyanga – Zwelitsha spend a lot of their expenditure on energy - R183 on average per month; this amount excludes an average of R139 spend on space heating per month in winter. Households felt the amount is the same

as before the installation of the swh. On the other hand; households kept on reporting that they are saving on energy expenditure as they often use water from the geyser as opposed to boiling the water using electric kettle. This is inconsistent with their response outlined earlier that they are spending the same amount on energy. The reason for the inconsistency could be attributed to the fact that households do not keep the record or measure the household energy expenditure. From their perception about the changes on their water heating habits one could conclude that there are and should be savings on energy expenditure as per India and Durban experiences – but that is not as clear in the Nyanga study.

According to Milton & Kaufman (2005), swhs may replace the use of dirtier fuels such as paraffin for water heating– helping to mitigate climate change and improve indoor air quality. In the study area households use mainly electricity for water heating. Similarly with cooking; households in the study area use electricity and would use water from the geyser too but uncertainty about the cleanliness and the safety of the water prevents households from using it. Access to electricity and to readily available hot water prevents households from using paraffin and in the process improving the indoor air quality and minimizing the potential contribution of the dirtier fuels to climate change.

Contrary to the point made above that swh replaces the use of dirtier fuels – households continue to use paraffin for space heating in winter. I found that all of the interviewed households use paraffin for space heating in winter. This was also found in the Khayelitsha low-income study where more than 40% of households used paraffin heaters for space heating (Cowan & Mohlakoana, 2005). The use of paraffin could be regarded as a problem as the fumes of paraffin heater could provoke asthma and fire. In this case, the provision of ceilings would be useful in keeping the house warm in winter.

The criterion used for the selection of beneficiaries was based on poor health, old age and disabilities. Positive indirect health impact included the readily available hot water which saves time and energy for the households. Readily available hot water encouraged children and parents to bath more often. According to Milton & Kaufman (2005), hot water is a fundamental aspect of a healthy and hygienic life. In addition, water-borne diseases can be prevented with proper washing and hot water provides an additional level of disinfection over cold water (Milton & Kaufman, 2005).

According to Mallet (2007), the transfer and adoption of renewable energy technology tend to overlook the importance of social acceptance. Similarly Prasad (2007) argues that the participation of the community in renewable energy technology deployment is important. However, with the Nyanga swh project there has been minimal if any consultation with the recipients of the swh. According to the participants there were no workshops on awareness raising about the technology. Households are not even aware about the project i.e. which department or company is responsible for the swh pilot project. This is consistent to Mallet's argument that the importance of social acceptance of the RE technology tends to be overlooked. In this case implementing the project or spending the budget could have been the main priority but overlooking the need for community participation.

Community participation and education about the technology is very important; it instills the sense of ownership of the technology and therefore a reason for the technology to be well taken care of. For instance, the respondent that was completely dissatisfied with the swh did not fully understand how the swh works and she felt that it was useless for the hot water to come from the kitchen as opposed to the bathroom. Should there have been proper consultation with the community, she might have understood the functions of swh and raised her

concerns about the area where the geyser is or should be installed. Without this information, this household clearly did not appreciate the swh, labeling it as “*useless*”.

Overall, the Nyanga experience mirrors that swhs have a potential to reduce energy poverty due to improved access to hot water and the resulting health benefits associated with the use of hot as opposed to cold water. But also the Nyanga experience suggests that provision of swhs/energy efficiency interventions does not necessarily result in reduced electricity costs due to the rebound effect described earlier. And this points to the imperative of community participation and education on the technology itself and implication thereof on peoples’ lives.

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## 7. Conclusions and Recommendations

From the literature reviewed it is clear that access to modern energy services is critical for health, economic and environmental reasons – essentially it is life blood to the development of the country. Access to modern energy and the efficient use thereof has the potential to reduce GHG emissions. At the household level energy enables households to run businesses, saves time and energy, reduces negative health impact as a result of dirty fuel that could have been used in absence of modern energy.

The literature on energy poverty gave an overview of governments intentions in accelerating energy access to all households in South Africa. As indicated in the discussion – challenges in implementing these policies are enormous and the intended recipients do not benefit. Furthermore, the literature on solar water heating has shown that there is a potential for the technology to contribute to the reduction of CO<sub>2</sub> emissions; poverty alleviation, and improve people's health. However, barriers such as the capital costs of swhs hinder the promotion of swhs and renewable energy in general.

The case study specific literature on the benefits of swhs revealed that literature is silent on the social aspects of the technology – emphasis is on the technical aspects. By technical, I mean installing a swh and ensuring that it is working and not educate the recipient about the interventions. This is evident in Nyanga Township as households indicated that they were not properly consulted about the project and that they did not know who to contact if anything wrong was to happen to the swh. The social aspect is critical for the acceptance and ownership of the technology at the community level.

In spite of the lack of communication, households in Nyanga (Zwelitsha) expressed satisfaction and appreciation of having hot water. The latter has contributed enormously to households health as the criteria used for selection of beneficiaries was based on health and age – the readily available water saves time for the grannies, the sick and the disabled for boiling water to wash themselves and to prepare grand children for school.

Saving on electricity as a result of swh is not clear as households reported that they spend the same amount on electricity as before the installation of swh. Similarly with employment, it is not clear how many people (if any) were employed and trained. Interestingly, households had an understanding of what a solar water heater is and how it functions, in spite of the fact that there was no awareness raising workshop.

Overall, this dissertation has assessed whether solar water heaters improve access to hot water for Zwelitsha households in Nyanga and reduce electricity cost, and also assessed the complexities involved in implementing energy poverty interventions in townships.

It was found that access to solar water heater improve households access to hot water. Residents in the case study area do not have an electric geyser, they used electric kettle to boil water. Access to solar hot water was welcomed by the households and had positive impacts for households. Ms Florence for example said that *'the positive impact of solar hot water in my family is that it helps with bathing...children enjoy bathing because they do not have to boil water using the kettle that takes a long time to boil'*.

Similarly with savings on electricity expenditure Mayephu said that *'the geyser saves him money, he uses less electricity to boil water since the installation of the geyser...he used to spend R500.00 a month on electricity now spend R300.00'*. But, the saving on electricity was not as clear as with Mr. Mayephu's case. All households, with the exceptions of Mr. Mayephu, said that they spend the same amount on electricity as before the installation of solar water heaters. The response to this question was ambiguous because in discussion with them there was a general sense that they should be saving on electricity expenditure, as they do not boil water using electric kettle. The reasons for the ambiguity are twofold: firstly, households do not keep accurate record of their electricity consumption – the most important thing for households is to ensure that electricity unit does not get to zero. Secondly, solar hot water may save electricity cost for households but savings are not evident as hold buy additional entertainment appliances as a result of the reductions in electricity cost. In conclusion, savings on electricity as result of the installation on swh in the case study is unclear.

Despite benefits and uncertainties about the benefits, I have found that community engagement in the project is very important, if not taken seriously it may have negative impacts in project implementation and the acceptance thereof. In the case study, community or beneficiary education and awareness raising about the project was non-existent. Studies as discussed in literature review points the imperative of community engagement in renewable energy projects such as solar water heating. A poor communication between the implementer and the beneficiaries may result in swhs being vandalized by members of the community that did not receive them without any explanation as to why they did not.

The above points to the complexities of implementing projects in communities, however, apart from that solar water heating has a huge potential to reduce energy

poverty. The technology contributes to households' health by providing the hot water which is important for sanitary and hygienic purposes. In addition, solar water heater project have the potential to create jobs for the unemployed and develop skills for the youth within communities.

The research conducted yielded enough information and allowed the researcher to come up with key recommendations to rectify the challenges or the problems stated or the research questions posed in section 1.

**More specifically, this case facilitates the following policy-related recommendations.**

**1. Inclusive decision making process**

In the project of this nature the following should have happened:

- i) **A workshop between Provincial Government, the Ward Councilor, Community Development Worker (CDW) and the company appointed to install swhs.** The purpose of the workshop would be for province to explain the intentions of the pilot project and the background. The ward councilor and CDW would assess the relevancy of the project comparing it to current issues and needs within the community. If the project is relevant to the community, the CDW and the councilor could consider the project but not make a decision until the community has been consulted.
- ii) **A workshop with the community** organized by the CDW and councilor. The purpose of this meeting would be to explain to the community the government intent and to find out if the community is supportive of such a project. The workshop would involve explaining the selection criteria for the beneficiaries. Once the community buy-in is obtained, the next step is the

implementation of the project, but before the actual installation of swhs another workshop with the beneficiaries is crucial.

**2. Education and awareness raising workshop:** this workshop should be organized by the implementing agent (province in this case). The workshop should involve a broad education on energy poverty and energy efficiency. However, the emphasis should be on the swh i.e. what it is and how it works etc. The information could also be communicated in the form of flyers or an easy to read manual showing a swh with descriptions of what it is and what it does. Depending on the community, information should be written and printed out in English and IsiXhosa or whichever is the home language of a particular community. The flyers should include contact details of the implementing organization and the company that will install swhs so that if there is anything wrong with the geyser, the community or the beneficiary knows what to do.

The three workshops will result in greater community participation and results in high levels of acceptance and ownership of the technology by the community.

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