CITY ENERGY SUPPORT UNIT
a south african sustainable energy and climate protection initiative

Solar Water Heater Installation Guide:
for low-income communities

SEED URBAN

Why?

- Save Money
- Avoid air pollution Reduce fire risk
- 'Free' hot water for poor households
- Reduced CO2 emissions
- Reduced electrical demand
- Sustainable, clean energy service

Why Solar Water Heaters?

Most low-income houses do not have electric hot water geysers; they use kettles, paraffin cookers and coal burners to heat water. Using paraffin stoves and coal burners to heat water is dangerous in terms of the risk of starting fires and because of health problems related to reducing indoor air quality. Using a kettle to heat water is far safer and healthier than using coal or paraffin but South Africa's electricity is predominantly derived from coal fired power stations. The use of electricity to heat water contributes to South Africa's greenhouse gas emissions and to global warming.

Using these technologies to heat water can place a high financial burden on poorer households both in terms of energy costs but also in terms of the costs associated with the adverse health effects of burning coal and paraffin.

Solar Water Heaters (SWH's) provide an excellent alternative for heating water. They draw on the sun to heat water in a clean, safe and sustainable manner. As the source of energy being used is the sun, the household is also protected from the inevitable increase and fluctuations in the price of electricity and other fossil fuel sources. Use of kettles to heat water is also a major contributor to peak demand and therefore SWH's are an important solution to the national electricity generation crisis as well as local electricity distribution constraints.

Related to this is another important consideration in terms of reticulation infrastructure and distribution of electricity to developments. Most low-income developments were planned not to have electric geysers and therefore the electricity supply to these areas is not designed to cope with the excessive loads created by electric geysers. As these communities inevitably develop, the distribution system will most likely fail under the new load and any repairs/upgrades will be extremely costly. By installing solar water heaters, the communities can still develop and improve their quality of life without straining the distribution network.

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What?

- collector captures solar energy as heat
- heat transferred to water either directly, or via a transfer fluid
- Hot water is stored in a hot water cylinder (geyser)
- Systems are available for high pressure and low pressure scenarios

Technical Guide: What is a Solar Water Heater?

A solar water heater uses energy from the sun to heat water. A solar water heater works on two basic principles. Firstly, dark objects absorb more heat than light ones and secondly, when water gets hot it rises due to density differences between hot and cold water (thermo siphon effect).

A solar water heater comprises three main parts: the collector, the storage tank and an energy transfer fluid.

The collector

The collector is the part of the SWH that captures the incoming solar energy as heat, which is then transferred to the water either directly or indirectly via a heat transfer fluid. The two main collector types are Flat Plate and Evacuated Tube collectors.

Flat-plate collectors: The main components of a flat plate collector are a transparent front cover, collector housing, and an absorber. This technology has been used for over 50 years by manufacturers and has a well established track record of reliability and performance.

Evacuated-tube collectors: This comprises a closed glass tube, inside which is a metal absorber sheet with a heat pipe in the middle, containing the heat transfer fluid. Evacuated tubes are a newer technology manufactured mostly in China. Generally evacuated tubes have exceptional performance but have not yet had time to establish a track record of reliability.

Photo: Solar Heat Exchangers

Flat-plate collectors

Photo: New Energy

Evacuated tube collectors

High Pressure vs. Low Pressure

Solar water heaters can be designed to function as a high water pressure systems or low water pressure systems. High pressure systems are generally more expensive than low pressure systems. This is because the materials used for high pressure systems must be of high quality and strength in order to withstand the pressures created by the system.

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Low pressure systems need to be durable, but do not need to withstand any pressure other than that generated by the weight of water they contain, keeping material costs down. Low pressure systems also do not require any additional valves to regulate the internal pressure of the system, further reducing costs. Low pressure systems are 'gravity fed' - therefore the higher the SWH is off of the ground, the stronger the water pressure will be at the water point. Mixing water, for example in a shower, is difficult with low pressure systems, as the cold water supplied by the municipality is at a substantially higher pressure than that supplied by the SWH, there are however means to overcome this issue. In South Africa, high pressure systems are usually targeted for the mid-high income sector, while low pressure systems are targeted for the low income sector.

Heat Transfer

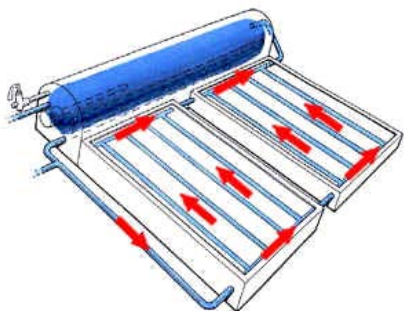
As mentioned above, heat transfer can either be done directly or indirectly. In a direct system, the collector heats the water directly and the water then circulates between the collector and the storage tank, the water in the system is therefore the heat transfer fluid. A direct system can only be used in areas which are frost and lime free.

In an indirect system, the collector heats a heat transfer fluid, that flows around a jacket which surrounds the storage tank. The water in the storage tank is then heated indirectly. An indirect system can be used in all conditions.
The fluid/water in both systems can either be circulated actively by using a pump, or passively by relying on natural convection.

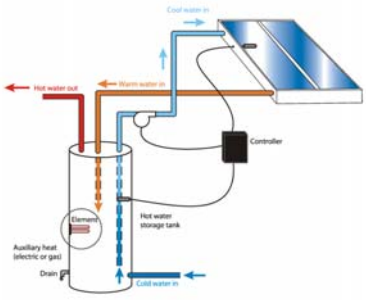
Installation Methods

Close coupled system: This is the most energy efficient and most commonly used installation. It consists of a roof-mounted solar collector, combined with a horizontally-mounted storage tank which is located immediately above the collector.

Split coupled systems: These refer to systems where the water storage tank is situated elsewhere – usually within the roof. Where the tank can be installed above the collectors a passive systems can be used (using thermo siphon to circulate water), where not, a pump (active system) would need to be installed to circulate water through the collectors.



Close couple system



Split coupled system

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Considerations for Low Income Developments?

Generally low income developers need to go for lowest cost and most reliable systems. To date, the systems used in low income developments consist of low pressure direct systems with evacuated tube collectors. When choosing a SWH for a development, one should ideally look for the following:

- An SABS approved system, to ensure reliability.
- A system registered with the Eskom subsidy scheme, to help bring costs down.
- Local systems to promote local jobs and ensure continued/reliable support.
- Local installers, preferably from the community in which the SWH's are being installed.
- Installer should be trained to recognized standards to create employment.
- Availability of spares/service support, which will depend on the service provider.
- A guarantee on the system being provided.

The Case

- protect poor households against future electricity price increases
- less peak demand – fewer power stations needed and lower electricity costs for municipalities
- reduce pressure on distribution grid
- local job creation through system installation

The Case for Mass Implementation?

As mentioned earlier, SWH's are an efficient, safe and sustainable means of heating water and can be used to provide an energy service to low-income households, which will greatly increase the quality of life of those within the household. By installing SWH's instead of electric geysers to provide the same service, the future demand of low-income settlements will be reduced as they will not have a need to install electric geysers as they develop.

From a city and national perspective this reduction will have the following benefits:

- The reduction in residential power use will improve the energy security of a city as it needs to draw down less power from the grid supply.
- The reduction in demand (during peak times in particular) from the residential sector means that fewer power stations need to be planned for in the future. Eskom has recognized that solar water heaters will play a major role in its demand side management (DSM) programme. This also holds a positive impact on City electricity departments who often pay Eskom more for electricity over these periods.

Jobs will be created in the solar water heater industry – both in manufacturing and system installation. Employment creation is a huge national and city priority.

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Financially Feasibility

- Eskom subsidy and carbon offset monies available
- Attractive financing and innovative business model needed
- Financially feasible

Financial Feasibility of Low Income Residential SWHs

In the past, it has been difficult to make a financial case for SWHs in low income households. This is because these houses typically do not have electric geysers installed. Recent approaches to low pressure SWH system implementation in low income households, notably at Kuyasa in Khayelitsha, are beginning to make a financial case for SWHs in this sector. Low unit prices are key to this financial case. This is becoming a reality through:

- Bulk purchase discounts: Installed costs of ±R5000 are possible for low pressure systems.
- The Eskom subsidy being made available to low pressure systems: This is a relatively new development, and further price reductions of R1000-R2000 can be expected.
- Future carbon funding imminent: The argument of 'suppressed demand' (measure of potential future energy use of household) is one which has been made to and accepted by the CDM board, and agrees fundamentally with the concept of sustainable cleaner development. The large scale methodology of claiming carbon credits for low income SWH installations is in the final phase of being completed, which will then open the door for the registration of mass low income SWH projects with the CDM.

All of these factors need to be taken into account when making a financial model for low income households.

Through a creative financing model which uses CDM funding, the Eskom incentive and development bank loans, a sustainable system of SWH delivery can be established in low income households.

The main premises of the financial model for low income SWH rollout are based on research conducted by the Kuyasa low income housing project. This project has secured carbon funding to assist in the installation of SWHs, insulated ceilings and efficient lights in 2000 low income households in Kuyasa, Khayelitsha. The following premises are used:

- people in the community are prepared to pay R20-R30 per month for hot water (following a survey conducted in the Kuyasa community)
- carbon certificates generated by the project can fetch €10/T on the carbon market
- through the CDM methodology used, the SWHs generate 1.4T of carbon credits per year.

Photo: Kuyasa CDM project

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Based on the above, a strong financial model based on low monthly repayments (R30 or less) can be developed, and make a compelling case for low income solar water heaters. Broadly the model will work in the following way:

1. The SWH implementing agent (company/local municipality) registers their project with the CDM using the large scale SWH methodology
2. The implementing agent secures a development bank loan to cover supply, installation and maintenance costs of the SWH
3. The implementing agent ensures that the SWH used is SABS approved and qualifies for the Eskom incentive
4. The community is approached to determine who would like to sign up with the programme. This would require that they agree to pay around R30 per month for their solar water heater (including maintenance)
5. The electricity distributer in the area recoups the R30 through the prepaid metering system – a critical element in the scheme. This can either be through a deduction from the first electricity payment of the month, or a reduced number of FBE kWh's available (though this may be trickier institutionally, given that profit is gained through determining a suitable repayment period.

Cities can choose to be the implementing agent, or assist a private implementing agent by collecting via the prepaid meter system on their behalf. It is strongly suggested that SWHs are not simply put into communities with no way of recouping money. The payment for the community ensures a certain level of pride and ownership in the technology and encourages the community to be more involved, which is vital to the future sustainability of the project. It also allows for an extra cash flow, which can be used for maintenance schemes or continual roll-out of SWHs to other communities.

Indicative quantitative financial analysis	
Cost of 110l SWH	R 5,000
Eskom Incentive	R 1,500
Annual payment *Development bank @ 8% pa, 10 yrs	R 521.60
Tonnes of CO2/unit/year	1.4
CDM Income pa (€10/T)	R 154.00
End user payment/year	R 367.60
End user payment/month	R 30.63

Key Criteria required to get this model working
1. Buy in from distributor (City/Eskom) that collection for SWHs occurs through prepaid meter system
2. Access to attractive financing
3. CDM financing available
4. Eskom incentive available

Community Engagement

It is widely agreed that increased community participation in government decision making and service delivery choices produces important benefits. Dissent is rare: it is difficult to envision anything but positive outcomes from citizens joining the process, collaborating with others and reaching consensus to bring about positive change. Collective ownership and responsibility for the project will help ensure the security and safety of the solar water heating equipment. Community involvement is also pivotal in the continued monitoring and evaluation of the project.

The community involvement process should be well thought through and planned before the implementation of the project. It should be noted that the community process does not necessarily have to wait for the appointment of the service provider; the two processes can be run in parallel. This guide aims to support municipalities by outlining some key considerations to think about and discuss when designing a community consultation process and providing an outline of possible steps in a community participation process.

Beneficiary Selection

It is important, especially where donor funding is involved and where no monies would be recouped from beneficiaries, that a clear selection criteria for households is adopted. This is vital in the spirit of the social equity principle. Needless to emphasize, community unrest can be expected where members of the community do not understand what criteria were used to identify the beneficiaries. Hence, the involvement and active participation of community members in the design of an equitable selection criterion is critical. The community, for instance, may decide that households which moved in first into the area should be the first to benefit. Or they may choose to have a register set up and interested members of the community submitting their names on a first come first served basis. The point here is transparency.

Whatever method is used to select the community and then to select the households within the community, should not be taken lightly and the criteria used must be ones, which can be defended if queries arise from within the community as well as from neighbouring communities. Once identified, it should be stressed that attendance at subsequent project meetings is compulsory and that they must commit to this in writing. Special arrangements should be made for people with disabilities and the elderly so that they can also remain informed.

If members of the community are to be trained and employed, the criteria for this selection is also very important and an equitable system needs to be spelled out clearly to the community.

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Step Number One: Capacity building and awareness creation – for broader community

Key points to be covered:

- *Energy Use in a Household*
- *Brief description of the SWH technology*
- *Electric vs. Solar Water Heater*
- *Social, Environmental and Economic benefits of SWHs*

1. Introductory Meeting

It is highly recommended that a number of community workshops be held to create awareness about the project and to leverage support and buy-in from the community. It is important that the first meeting is officially addressed by the local leadership (e.g. Councillor). The main aim of this first general meeting should be used to introduce the community to the solar water heater technology and the benefits to the households must be described. It is also a good opportunity to introduce the community to the process, which will be used to roll-out the technology including some insight into possible repayment, allocation of SWHs, maintenance etc. This meeting should also help clarify some of the misunderstandings, rumours and common questions surrounding the technology and answer some common questions such as:

- How much does each SWH cost?
- Are we expected to pay anything?
- How much hot water will I be getting?

If already appointed, the service providers can be introduced to the community at this point and if community members are going to be trained to help install and maintain the systems, this process can also be discussed. This is also important to ensure the safety of the service providers in the community later in the project.

2. Community Workshop

A second workshop targeting the selected beneficiaries should then be used to again introduce the topics mentioned above but should also cover economic, social and environmental aspects and benefits of the project. The service provider also needs to be involved to provide technical input and answer questions about the technology and to demonstrate an actual SWH unit. It is also extremely useful to have an input from a resident of another community that has had SWHs installed and can be a very powerful tool in sharing best practice from someone with which the community can relate.

The main purpose of the second workshop is to have a more detailed discussion with beneficiaries. Cited below, is a possible outline of the workshop agenda:

Part One – Welcome and Introduction
After all protocols have been observed, it is of paramount importance that local (elected) leadership (e.g. Councillor) be present and afforded and opportunity to address the beneficiaries. Community Development Workers (CDWs) involved in the projects also need to be introduced to the people. The SWH programme then needs to be outlined and explained, focusing on objectives, strategy, current project status as well as maintenance and sustainability plans going forward.

Part Two – Household Energy Use
This session aims to draw the attention of the beneficiaries to the fact that the use of the SWH technology to provide hot water is not foreign to their knowledge.

For a useful table on types of energy and appliances used in households, see

APPENDIX 1

For instance, they dry their clothes by putting them on the line. The facilitator may discuss the different types of energy and appliances used in the home to provide energy services and demonstrate that some energy sources are better for certain functions than other. For example, one can demonstrate that using electricity for lighting is far more efficient than using paraffin lamps and is also less dangerous and less polluting. This session should then lead into heating water and the energy involved and show the benefits of SWHs over other technologies. The key point here: use of free energy from the sun!

Part Three – Service Provider Input
In this session, the contractors appointed to install SWHs discuss the technology with beneficiaries. The discussion may range from installation, maintenance, breakages and how to make the most of the SWH technology. If the terms of reference of the contractor requires that they provide recruit and provide training to local labour to install and maintain the systems, this is also a perfect opportunity to introduce them to the beneficiaries.

Part Four – First Hand Experience
This brings a testimony from an end user and a member of a community, which has already received solar water heaters. This representative would share their experience of how their system works and what the benefits have been to them and the community. This has proven to be extremely valuable in community workshops by having someone with which the community can relate relaying real benefits and issues of SWH's and providing firsthand experience.

Some of the frequently asked questions

The following are a sample of questions asked by community members involved in a SWH rollout programme. It would be a good idea to go through these questions (internally and with your service provider) before a community workshop to make sure there are reasonable answers available.

Question: Is the water from the SWH fit for human consumption?

Answer: Water from South African Bureau of Standards (SABS) tested SWH systems are safe for human consumption.

Question: Are we expected to pay anything for this service?

Answer: This will depend on each municipality's roll-out plan. For example, in Zanemvula the municipality provides full maintenance of the systems only for the first 12 months of the project.

Make sure that both the service provider and all those involved in running the workshops are well prepared for answering questions.

Question: How much does each SWH costs?

Answer: Municipality should have this information from the project plan.

Question: Who do we report faults to?

Answer: Municipality should have this information from the project plan.

Question: Does a SWH provide warm water on a cloudy day?

Answer: Even on a cloudy day, the SWH does provide warm water.

Question: Should beneficiaries be concerned with water leaking from the SWH

Answer: they should not; it's a normal process for the SWH to manage water expansion from the cylinder. This should be explained.

And other questions you need to be able to respond to:

- Electric geysers, unlike SWHs do not have water leaks, is it because SWHs can't switch themselves off when the tank is full?
- Kids mess around a lot in this place, where do I go for a glass tube replacement, and how much will it cost me?
- If glass tube breaks and I don't have money ready to buy a replacement, can't each household be supplied with a spare one to keep in case?
- Installation of SWHs involves shifting some tiles, if I need to do some maintenance work on my roof, how do I do it without tampering with SWH tubes?
- Some people (especially the elderly) can't make it to workshops held outside their location...can't the contractors do a crash course with them before and after the installation of the units, in their houses?
- My hot water is only accessible from the kitchen...how do I access water from the shower?
- The units being installed come in different sizes (e.g. ELNINO 85L + TASOL 11L), what criteria is being used in terms of who is getting which? This relate to cases where different type and sizes of SWHs are supplied in one project.
- Who is responsible for the maintenance of the units...do these units come with a factory guarantee?
- Who can I contact if my SWH is not working properly?

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A guide to Monitoring and Evaluation (M&E)?

M&E

- Assess impact of project against desired objectives
- Gather data for policy development
- Gather data for carbon finance management

If you don't care how well you are doing or what impact you are having – why do it at all? The M&E process is a management tool to see how the project is doing against objectives - is it having the desired impact, what unforeseen impacts are arising, is it working efficiently? It is also important to learn how to do it better.

As the mass rollout of SWH's in low-income areas is still in its infancy, it is very important to gather data upon which future decisions and planning can be made. It is important to know exactly how the project has performed from both a social as well as a technical perspective, especially in terms of community buy-in as well as for future carbon financing.

The M&E can be divided into two sections. Firstly, there is technical M&E where the actual performance of the SWH is measured in terms of how much solar energy is captured, how much hot water is used and if there is an electrical backup on the system, how much electricity is needed. The long-term performance and maintenance of the systems is also monitored.

Secondly, social M&E needs to take place to accurately assess the perceptions and concerns of the communities involved; this is a vital aspect of any project of this nature and is often overlooked by implementers. It is important to have an M&E strategy built into your project plan from the start.

Technical:

- Measure actual performance of SWH
- How much solar energy is captured
- How much hot water used
- How well is system maintained over time

Technical M&E

Zanemvula is a low-income development in Nelson Mandela Bay Metropolitan Municipality, where a large SWH implementation project is being rolled out on 1263 households. Various M&E aspects have been included in this project and the section below outlines some of the aspects of what is being done, what is being planned and what the thinking behind some of these decisions has been. Some monitoring has taken place prior to the installation of the SWH's in Zanemvula and there are plans for continual M&E into the future, which is important to secure carbon funding, but these plans have not yet been formalised into an M&E strategy for the project.

The efficiency of the SWH systems is monitored by calculating how much solar energy is being harvested and converted into heat. On a system chosen to be monitored, the temperature of the cold water is measured coming into the SWH tank. The hot water coming out of the tank is then measured, as well as its flow rate, to know the amount of hot water coming out. This allows the amount of incoming solar radiation being captured to be quantified, which can then be directly compared to standard electricity usage. In Zanemvula, monitoring is going to performed on three groups of twelve houses to give a total of 36 houses being monitored.

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A weather station is also installed in the area where these 36 houses are being monitored. This would read ambient temperature, rainfall, wind as well as incoming solar radiation. This can then be used to calibrate the efficiency readings according to weather data to make future monitoring and evaluation, as well as energy efficiency estimates, cheaper and easier. The idea is that once a specific system has been monitored and calibrated to the weather data then only the weather data is needed to estimate how much energy is being saved by having a SWH installed.

In Zanemvula, there are also two substations in the study area, which are being monitored. Just beyond the transformer a three phase meter is placed, which will measure the current energy use as well as the demand of the settlement as a whole over time, both before and after the SWH's have been installed. The meter also measures ADMD (After Diversity Maximum Demand), which will allow the city to calculate the ADMD for a low-income household with a SWH, which can then be used for the future planning of electricity supply to such development.

Each house also has a pre-paid electricity meter, which only measures energy use, and not demand. By having pre paid electricity meters in each house it allows a month by month electricity usage patterns to be studied. Electricity usage for each house can then be compared before SWH installation and afterwards as well as to similar communities in the area without SWH's.

The aim is to carry out the technical M&E over two years to take into account seasonal variation in results. Some SWH projects in South Africa have been monitored for short periods of time but this is going to be one of the first projects to be able to compare the performance of SWH's over an entire year. This will give thorough data on a variety of conditions, which will be very useful in the planning of future projects as well as in the estimation of carbon savings, especially with regard to the rigours of M&E of CDM projects.

Social:

- Gather base line energy and water use information
- Understand the impact of the intervention
- Assess social acceptance of the technology
- Improve service delivery over time

Social M&E

Both pre- and post-implementation surveys need to be done. The main objective of conducting the pre-implementation survey is to gather baseline information to identify what the profile of energy and water use is before the installation of the SWH's. This can then be used to evaluate the impact of SWH's on energy use within the households. The survey does not only focus on energy and water use but also asks questions around social acceptance, health and quality of life impacts of the SWH's.

Follow up surveys (possibly twice a year – in summer and winter - over a couple of years following installation) need to be planned throughout the lifetime of the project to monitor both the immediate as well as the long term impacts of the installation of SWH's in the community.

An example of a baseline as well as a follow-up questionnaire area available on the City Energy Support Unit website (http://www.cityenergy.org.za). These questionnaires are based on the ones used in Zanemvula, Nelson Mandela Bay, which in turn was based on an earlier questionnaire from Kuyasa, Cape Town. The benefit of all projects of this nature using similar sets of questions as far as possible, is that the results of the surveys can be compared to build up a body of knowledge and identify whether impacts in different parts of the country are similar or not. Of course, this should not stop your municipality from adapting this survey to include locally important questions or issues.

For a direct link to the questionnaires, go to;

http://www.cityenergy.org.za/resources/solar-water-heaters

Appendix 1:

TYPES OF ENEGY AND APPLIANCES USED IN THE HOUSEHOLDS

Type of Energy	Energy service	Appliances commonly used	Participants comments
Paraffin	Cooking, space heating, water heating, lighting	Primus stove, flame stove, paraffin heater, lamps	Paraffin is unsafe and very dirty
Gas	Cooking, space heating, water heating, lighting	Stoves	Gas is difficult to carry around, the tanks are heavy
Electricity	Cooking, space heating, water heating, lighting	Electric two plate, big stove, kettle, electric heater, micro wave, lights, iron	While some people preferred electricity, they stated they cannot afford it
Wood	Cooking, space heating, water heating, lighting	Fire, Imbawula for space heating	Cheap but not much appliances
Solar	Cooking, space heating, water heating, lighting	Solar water heater, solar stoves, can make electricity	It is free,
Wind	Provides electricity for the above services		They were not aware of the wind power