How to implement renewable energy and energy efficiency options

Support for South African local government




SEA Sustainable Energy Africa

reeep renewable energy & energy efficiency partnership

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✷ solar water heaters ✷ energy efficient lighting ✷ energy efficient building ✷ public transport ✷ waste to energy ✷ photovoltaics ✷ power purchase agreements ✷ concentrated solar power ✷ wind power

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This handbook has been developed with a wide range of city stakeholders, however Sustainable Energy Africa is responsible for the views expressed and any errors made in this document.

Contents

Using this manual

This Manual has been designed for use by city officials and planners. It is a practical handbook, which identifies easy to achieve energy interventions that will save money (for cities, businesses and households), promote local economic development and enhance the sustainable profile of a city. This manual is specifically aimed as a support tool to achieve the implementation of key interventions within South African municipalities.

These key interventions have been identified as important and sensible starting points for cities. They are tackled as separate chapters in the manual:

- Solar Water Heaters
- Energy Efficient Lighting
- Energy Efficient Building
- Sustainable Transport Planning
- Waste to energy with a primary focus on Landfill Gas

In each chapter, the manual will:

- Make the case (broadly) for the intervention.
- Explore the potential for mass rollout of the intervention to determine
    - The energy and carbon savings resulting from the intervention
    - The financial impact of the intervention
    - Poverty alleviation through the intervention if applicable
- Identify key barriers to mass rollout of the intervention, and highlight current efforts to resolve these
- Provide practical steps towards implementing city rollout of the intervention.

In addition to this the following interventions will be elaborated on:

- Solar Photovoltaics
- Green Power Purchase
- Concentrated Solar Power
- Wind

These serve more as information and feasibility updates than implementation approaches.

Unless otherwise referenced, all data and graphs in this manual are sourced from Sustainable Energy Africa's publications and city models.

1. Success through sustainability

Our current energy use patterns – predominantly our huge dependency on fossil fuels – cannot continue. A move to a more sustainable path is important for the following reasons:

1.1 Better local air quality and human health

Local air pollutants from burning fossil fuels (power stations, petrol and diesel exhaust fumes) cause respiratory ailments and airborne particulate matter has been associated with cancer. Negative health effects of air pollution have been estimated to cost South Africa R4 billion annually.

1.2 Arrested global warming

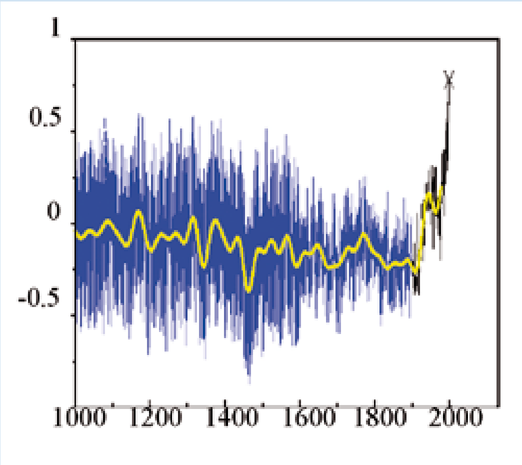
Climate change is an accepted reality. It will place enormous strain on our health sector, agricultural production, plant and animal biodiversity and water resources. Disruptions in agriculture are likely to result in increased urbanisation and pressure on urban resources. Fossil fuel-based energy use is the largest contributor to

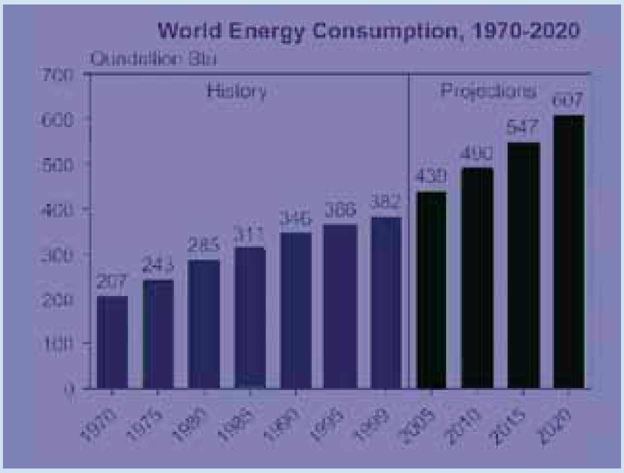
Cedric Nunn

Coal-burning electricity generation and fuel burning for transportation and industry results in poor local air quality in many South African cities.

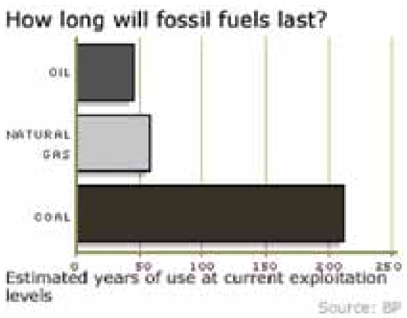
Particularly high levels of local air pollution occur in industrialised areas and in poor households where coal, wood and paraffin are used for cooking and heating.

Cedric Nunn

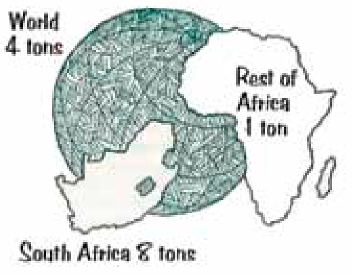




Average planetary temperatures are rising, and global consensus is that this is due to the release of carbon dioxide and other greenhouse gasses, largely linked to energy generation and use. Worldwide energy use predictions still point to a steady increase, indicating that the situation is likely to get worse before it gets better.



Annual per capita CO_2 emissions – South Africa compared to the rest of the world



The figure shows carbon emissions per person per year around the world. Although developed countries are the main global warming gas emitters, South Africa is the 11th highest contributor to global carbon emissions, and we can expect to come under increasing pressure to reduce our carbon emissions, and thus fossil fuel use, over the coming years.

carbon dioxide emissions – the principle global warming gas. South Africa is almost entirely dependent on fossil fuels for electricity generation (i.e. coal) and for transport energy (oil products).

1.3 Energy security

Fossil fuel reserves are finite. In particular, the relatively short horizon for oil reserve depletion means that there is an urgent need to find alternative transport fuels, transport modes and approaches to mobility.

1.4 Equity

Currently, there is a huge divide between the energy use patterns and problems of the wealthier and poorer sections of the population. The poor often are burdened with inadequate, unsafe and inconvenient energy sources while wealthier, particularly urban people consume high levels of energy and are inefficient in their use of energy.

1.5 Financial efficiency

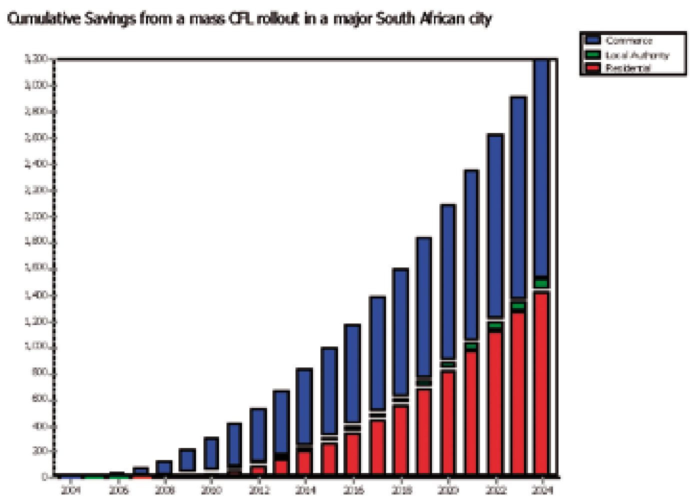
Current inefficient energy use patterns mean that countries, cities and people have to spend more money than necessary for the energy service required (e.g. water heating, lighting etc). Many more efficient and cost-effective appliances and practices are available, including efficient lighting, using solar water heaters and constructing buildings to use less energy for heating, cooling and lighting.

Some 16% of city households are not electrified, including those informal settlements around South African cities. Here they have to rely on less convenient, dirtier and often unsafe energy sources.

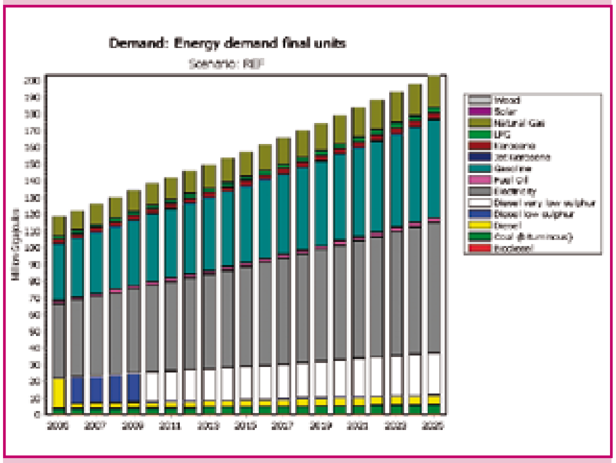
Fires caused by paraffin appliances, for example, are alarmingly common in South Africa, and destroy hundreds of homes at a time.

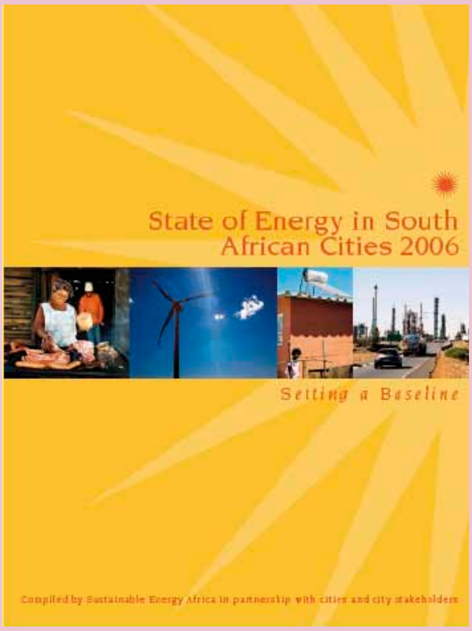
1.6 City development

The energy sector in SA creates employment opportunities for about 250 000 people and contributes about 15% to the total GDP. However, it is highly centralized. Many sustainable energy initiatives could be undertaken locally, thus stimulating local economic development. Examples of this could be the manufacture and installation of solar water heaters, putting ceilings in houses, energy efficient building retrofits and small local power generation plants (wind farms etc).



This graph shows the financial saving that is expected from implementing an efficient lighting programme in one South African city. This example uses CFLs – compact fluorescent lights – in place of the 'traditional' tungsten filament bulb.





To download the State of Energy in SA Cities Report, go to www.sustainable.org.za

2. Cities as energy leaders

Cities are energy intensive nodes in a country. South Africa's seventeen biggest cities use about 50% of the country's energy. Fifteen municipalities recently studied (shown on the map alongside) use about 40% of the country's energy, yet occupy only 3% of the land area. Cities have an important role to play in the shift to a more sustainable energy picture in South Africa. This is all the more pertinent given the high rates of urbanization and population growth in many of our cities.

Modeling projections show us that unsustainable increases (a doubling of energy consumption) in city energy use are expected under the 'Business-as-usual' scenario. The projection alongside is for one of the larger cities in the country. The expense and emissions associated with these increases comprise burdens which will not be tolerable in the future.

City authorities have a much greater influence over energy use patterns within their boundaries than is often realized. This is through:

- Building regulations
- Urban layout
- Transport planning
- Bylaws
- Standards & codes
- Air quality control measures
- Electrification

If the country is to move towards more sustainable energy paths, cities will be essential partners in this process. Achieving the targets set by national government, for example around energy efficiency, will be largely reliant on the actions of cities.

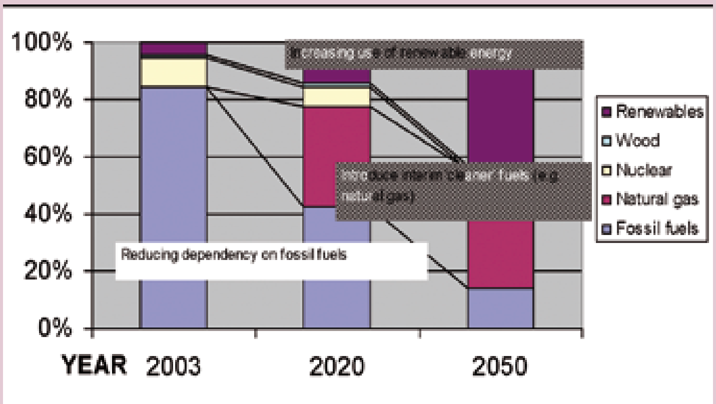
3. City action towards a sustainable energy path

It is the responsibility of leaders in all spheres of government, commerce, industry and civil society to promote action towards more efficient and renewable energy use. The focus here is on what cities can do to promote action.

The path to sustainability

2003

- *Inefficient use of energy*
- *Dependence on coal, petroleum*
- *High CO2emissions*
- *Poor air quality*
- *Fires, paraffin poisoning, respiratory illnesses among households*



2050

- *Efficient use of energy*
- *Reduced dependence on fossil fuels*
- *Low CO2 emissions*
- *Clean air*
- *Safe and affordable energy for all*
- *'Clean & Green'*

Key to moving towards sustainability will be a city's ability to shift its chief energy sources from non-renewable fossil fuels to more efficient fuels and clean renewables. Cities must be open to the notion of transition, as failure to change will have dire future consequences.

3.1 A sustainable energy strategy for your city

Energy is the lifeblood of a city and runs through every area of a city's functioning. Departmentalization within local government often means that cities do not have a complete understanding of energy use, energy issues and energy initiatives within its boundaries. These need to be gathered and understood in order to inform longer term energy planning.

Step 1: Develop a State of Energy Report. This summarises current energy use, energy supply and key energy issues in a city. For information around State of Energy Reports - examples, TOR for the development or an introductory presentation go to www.cityenergy.org.za/resources/state-energy-reports

Step 2: Develop a Sustainable Energy Strategy. This will coordinate energy planning with an overarching city energy vision and set realistic renewable and energy efficiency targets based on current data. For an example of a city energy strategy go to www.cityenergy.org.za/resources/energy-strategies

Step 3: Develop an Action Plan. This maps out how the targets are going to be achieved. This is where this manual, in combination with the City Energy Efficiency Tool (explained below) can be used effectively to assist Cities to move forward towards implementation

3.2 The first steps within the action plan

It makes sense to begin with those sustainable energy interventions which are proven and cost effective within the current environment. SEA has developed an Energy Efficiency Tool to assist Cities to understand the impact each intervention will have on their overall energy consumption levels.

This tool takes a city through available energy efficiency options and allows the city to develop a three year action plan to achieve their energy efficiency targets. The tool with supporting documentation is available for download at www.cityenergy.org.za/resources/energy-efficiency

The tool does not indicate how to achieve these targets though. This manual is aimed as a support to cities once they have decided to pursue a particular intervention. Each of the following chapters will go into some detail around a particular intervention on what the best approach or approaches may be within the current context. The manual is also available online at www.cityenergy.org.za/implementation, and will be updated with relevant new information as it becomes available, making it a 'living' document.

Are you a City on the move?

	YES	NO
Are we steadily moving from dirtier fossil fuels?		
Are we promoting interim cleaner options such as natural gas?		
Are we promoting renewable energy "low hanging fruit" such as solar water heaters?		
Are we pursuing energy efficiency aggressively in all sectors?		
Are we promoting passive solar / efficient design of buildings?		
Are we improving access to safer and healthier energy sources for the poor?		
Are we keeping the cost of energy affordable for the poor?		
Are we balancing these concerns with economic growth?		

4. Solar water heater implementation

4.1 What is a solar water heater?*

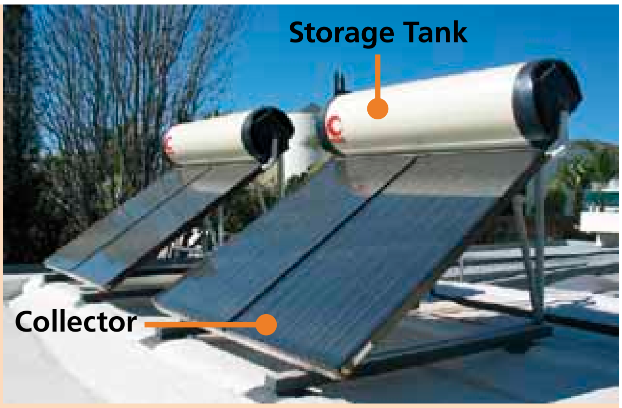
A solar water heater uses energy from the sun to heat water. A solar water heater works on two basic principles. Firstly when water gets hot it rises due to density differences between hot and cold water (thermosiphon effect) and secondly that black objects absorb heat.

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

Solar water heaters are classified as either active or passive and direct or indirect systems. They may make use of either flat plate collectors or evacuated tubes. Below the differences are briefly discussed.

Photo: Solar Heat Exchangers

Photo: Solar Heat Exchangers



Heat Transfer fluid

Active vs passive

Active: Uses a pump to circulate the fluid/water between the collector and the storage tank.

Passive: Uses natural convection (thermosiphon) to circulate the fluid/water between the collector and the storage tank.

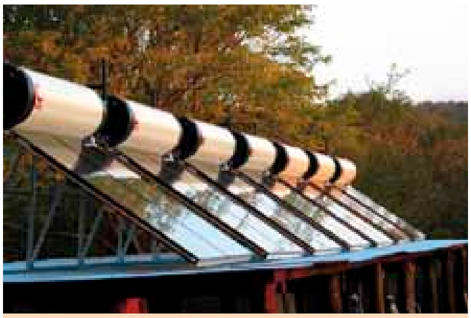
Direct vs indirect (open-circuit)

Direct: The collector heats the water directly and the water then circulates between the collector and the storage tank. A direct system can only be used in areas which are frost and lime free, without treated or borehole water.

Much of this information was drawn from the Solar Heat Specialist Handbook

Indirect: The water is stored in the storage tank, and is heated by a heat transfer fluid. This is heated in the collector and flows around a jacket which surrounds the tank and thereby heats the water. An indirect system can be used in all conditions.

Photo: Solar Heat Exchangers



Flat-plate collectors

Photo: New Energy

Evacuated tube collectors

Photo: Solar Heat Exchangers

Close coupled system

Flat-plate vs evacuated tube

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 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.

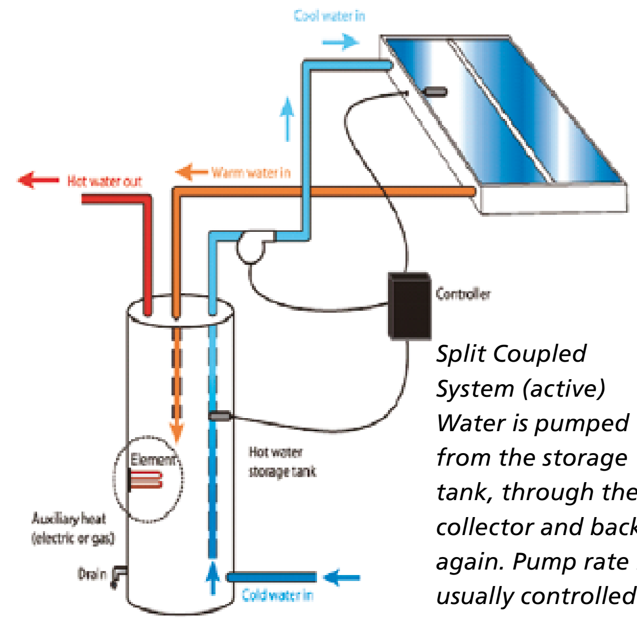
High Pressure vs Low Pressure

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. 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, the stronger the water pressure 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. 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.

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 thermosyphon to circulate water), where not, a pump (active system) would need to be installed to circulate water through the collectors.



Split Coupled System (active) Water is pumped from the storage tank, through the collector and back again. Pump rate is usually controlled electronically.

Split Coupled System (passive)

4.2 The case for mass implementation

Most Solar Water Heaters are fitted with an electrical element for those cold overcast days when the sun can't do its job properly

Residential solar water heaters

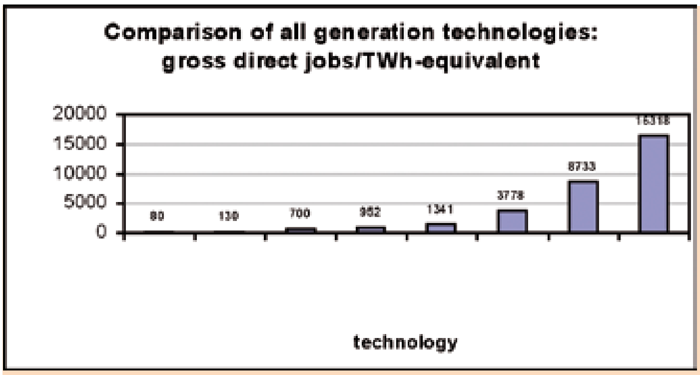
The residential sector in South Africa consumes 17% of the country's electricity. The largest electricity consuming appliance in our houses is usually the electric geyser. It makes up typically 30% of the total electricity used in many households which translates to around 5% of the country's energy consumption. A solar water heater may reduce this energy consumption figure by more than half.

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.
- As water is heated mostly by the sun, a solar water heater will reduce a city's CO_2 emissions by about 2 tons per household per year (Eskom).

For households, a solar water heater (SWH) also has several benefits:

- Water heating costs for a mid-high income household can be typically reduced by 60% with a SWH (CEF 50 study). This amounts to about a 25 to 30% saving on an average monthly electricity bill. With the price of electricity increasing sharply in the next few years, the financial case for SWHs is very strong. Under current conditions a bonded SWH will immediately be more financially beneficial to the end user when compared to a bonded electric geyser.



Source: Employment potential of Renewable Energy in SA (2003)

Job creation potential from solar water heaters is significant

Photo: Sustainable Living Projects

Simple installation and robust technology, along with obvious economic, environmental and social benefits make solar water heaters a viable option for mass rollout

- From an environmental perspective, water will be heated mostly by the sun reducing a household's CO2 emissions by about 2 tons per year (Eskom). A useful comparison is if an average family car drives 7800km, it will produce the same amount of CO2.
- 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.

Financial Feasibility of Mid-High Income Residential SWHs

This section discusses the financial feasibility of a SWH for an end user when compared to an equivalent electric geyser. The reason for this in depth analysis is that **if the financial feasibility of SWHs can be proved, then a large implementation barrier can be removed, leaving cities open to determine which mass implementation approach will be the most suitable for them to pursue** (See 'Potential for rollout' later on in this chapter). Three financial scenarios are presented:

1. Cash payment + operating cost comparison between SWHs and electric geysers – new build or blown geyser replacement scenario
2. Financed (monthly) payment + operating cost comparison between SWHs and electric geysers- new build or blown geyser replacement scenario
3. Financed (monthly) payment + operating cost comparison between SWHs and electric geysers- retrofit a working geyser scenario

The benefits and disadvantages of each approach will be discussed and recommendations made for best approaches or financial models. In each of the scenarios, a high pressure SWH system is used. This system currently qualifies for the Eskom subsidy, provided that it has been tested by SABS. The subsidy can reduce SWH unit costs by up to 20%.

Assumptions Table for SWH Analysis

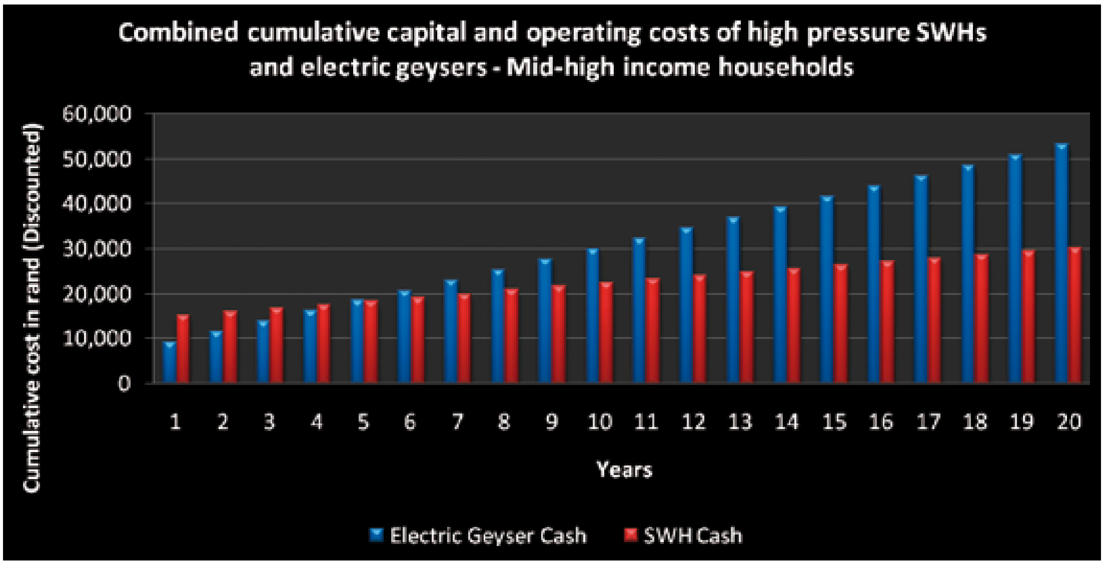
Finance Rate	15%	
Cost of Electricity	65 c/kWh	(current CoCT rates for 400-800kWh users)
Predicted annual increase in Electricity	15%	(conservative estimate as expected to double over next 3 years)
Average Cost of high pressure 150l SWH after Eskom incentive (installed, with timer)	R14500	(Average of all Eskom approved SWH units-2008)
Average Cost of 150l electric geyser (installed)	R6900	(Average of quotes from CT installers)
Daily Hot Water Use (mid-high income)	150 l	(50 l per day per person)

Electricity Savings for SWH (mid - high income)	60%	(with timer - conservative estimate based on independent SESSA SWH Study)
Discount Rate	15%	(bring costings to present day prices)
Geyser Thermostat setting (mid-high income)	60 °C	(conservative – most geysers set for 70 °Cand result in higher electricity use)

(i) Cash Payment Analysis

In this scenario, a SWH and an electric geyser are bought for cash, and operated for 20 years. The combined capital and operating costs of each unit are then compared.

- Results show that if a system is bought for cash, it will become financially more viable than an equivalent electric geyser after 5 years.
- For a full analysis please go to the City Energy Support Unit Website: www.cityenergy.org.za/resources/solar-water-heaters



Conclusions:

1. From this analysis it can be seen that provided the SWH lasts longer than 5 years in the mid-hi income, high pressure SWH scenario, it will be financially viable.
2. If the end user has the capital available, this is a financially feasible approach, given that SWHs are designed to last at least as long as electric geysers (7yrs min).

3. The disadvantage is that the high capital cost of the SWH is a deterrent to end user purchase. This approach will most likely be followed by wealthier end users with spare capital, typically in the mid-high income bracket.
4. New information from Eskom indicating Eskom/SABS approved SWHs at less than 50% of the cost of the norm has been made available. Should these prices become the future norm, then SWH systems would become financially feasible after 1 year.

(ii) Financed Payment Analysis (New Build/Blown Geyser Scenario)

Financing a SWH, by including the cost in a home bond, is immediately more viable than financing an electric geyser. The combined monthly repayments and electricity costs of a SWH are less than those of a financed electric geyser from year 1, indicated in the graphs and tables below. The analysis includes 20 year and 10 year repayment scenarios.

20 Year Repayment term analysis:

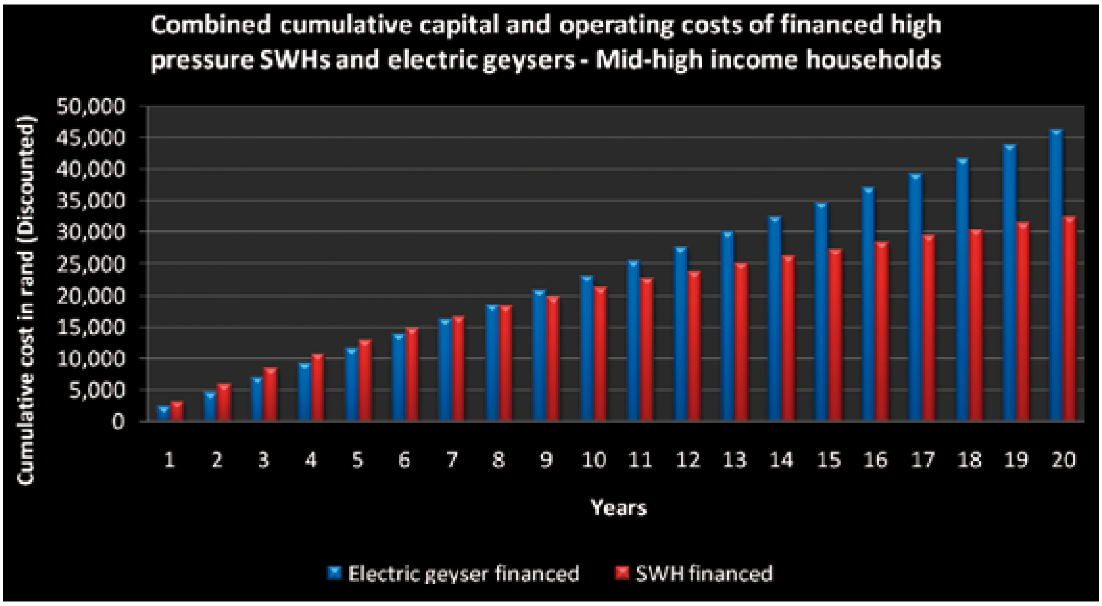


Table quantifying savings for the first 5 years realised from using a SWH instead of an electric geyser as per the graph on previous page:

	Year				
	1	2	3	4	5
SWH					
Financed payments	R 2,317	R 2,014	R 1,752	R 1,523	R 1,324
Electricity	R 786	R 786	R 786	R 786	R 786
Total (Annual)	R 3,103	R 2,801	R 2,538	R 2,309	R 2,111
Total (Cumulative)	R 3,103	R 5,903	R 8,441	R 10,751	R 12,862
YEAR	1	2	3	4	5
Electric Geyser					
Financed payments	R 1,102	R 959	R 834	R 725	R 630
Electricity	R 2,313	R 2,313	R 2,313	R 2,313	R 2,313
Total (Annual)	R 3,415	R 3,271	R 3,146	R 3,037	R 2,943
Total (Cumulative)	R 3,415	R 6,686	R 9,832	R 12,870	R 15,812
Annual Savings from choosing a SWH instead of a geyser	R 312	R 783	R 1,391	R 2,119	R 2,951

10 year repayment term analysis:

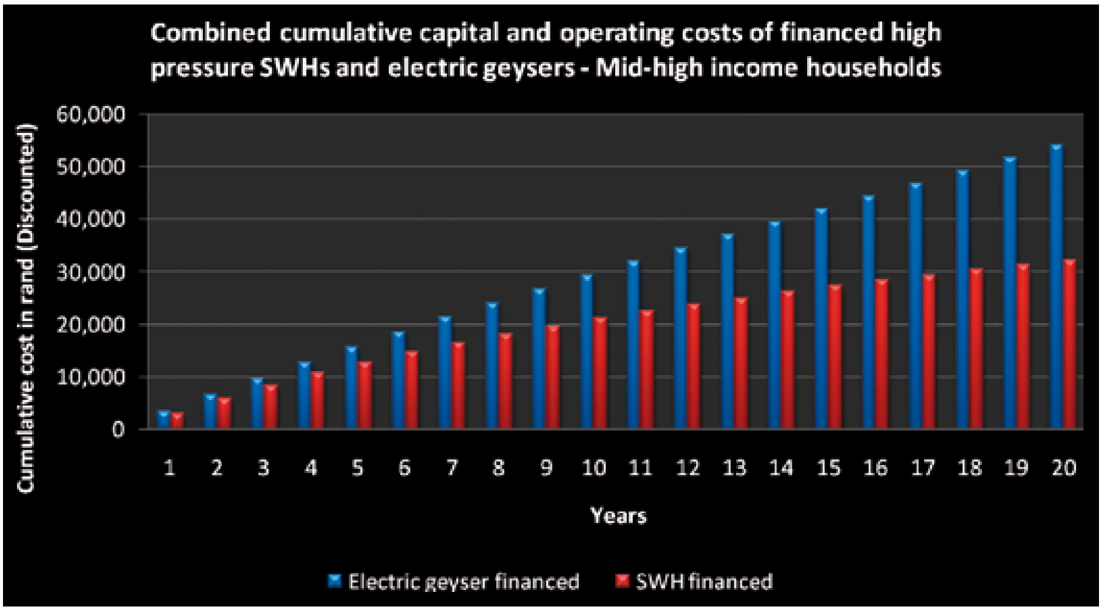


Table quantifying savings for the first 5 years realised from using a SWH instead of an electric geyser as per the graph on previous page:

YEAR					
	1	2	3	4	5
SWH					
Financed payments	R 2,889	R 2,512	R 2,185	R 1,900	R 1,652
Electricity	R 786	R 786	R 786	R 786	R 786
Total (Annual)	R 3,675	R 3,299	R 2,971	R 2,686	R 2,438
Total (Cumulative)	R 3,675	R 6,974	R 9,945	R 12,631	R 15,069
YEAR	1	2	3	4	5
Electric Geyser					
Financed payments	R 1,375	R 1,196	R 1,040	R 904	R 786
Electricity	R 2,313	R 2,313	R 2,313	R 2,313	R 2,313
Total (Annual)	R 3,687	R 3,508	R 3,352	R 3,217	R 3,099
Total (Cumulative)	R 3,687	R 7,195	R 10,548	R 13,764	R 16,863
Annual Savings from choosing a SWH instead of a geyser	R 12	R 221	R 603	R 1,133	R 1,794

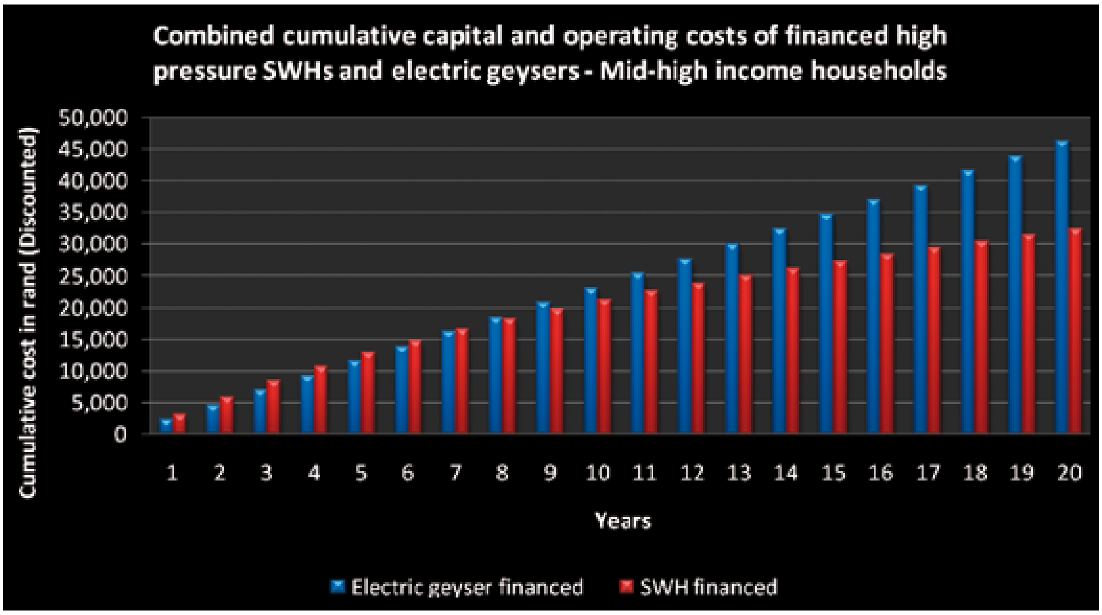
There is a strong case to be made for SWH installation in all houses above RDP level, including GAP housing which typically would use a small 150l electric geyser. A financed SWH's payment and electricity costs are immediately less than that of an electric geyser.

Conclusions

1. Financing of a SWH makes excellent financial sense, particularly in a new build scenario where the SWH cost can be included in the bond and repaid over 20 years. This makes a very strong case for legislation to be passed to require SWHs in all new buildings which require hot water for sanitation purposes.
2. This analysis works with the least economically feasible SWHs (150l systems). Therefore as system size increases, the economic feasibility increases.
3. Financing in this manner also makes sense from a blown geyser perspective, with immediate benefits even for a shorter 10 year repayment term.
4. Should the unit costs be reduced further, a strong case can be made for 5 year payback terms and mass implementation businesses.
5. Recent indications are that new SABS/Eskom accredited units have reduced in cost substantially from the norm (in some cases by more than 50%). Should this become the future norm, the business case for even a 2 year payback becomes very attractive, and the viability of a mass rollout exceptionally high.

(iii) Financed Payment Analysis (Retrofit)

Retrofitting involves the replacing of an already-functioning electric geyser with a SWH. The cost of installing and running a SWH is compared with only the operating costs of a geyser, as there is no geyser capital cost involved. In mid-high income households retrofitting is not as financially feasible as a new build/blown geyser scenario, but still possible. If financed over 20 years, the payments and electricity costs of a SWH only overtake the operating cost of an electric geyser after 8 years though.



Conclusions

1. Based on the data generated, it is clear that a strong financial case for retrofitting high pressure SWHs in the short term cannot be made, as the end user will have to pay extra for a minimum of eight years, depending on financing arrangements. A strong 10 year case can be made though. In this case, further reduction of unit price, or longer payback periods would make the unit more attractive.

2. However, the likelihood of an existing high pressure electric geyser not needing to be replaced over a 10 year period is very low. It is reasonable to consider that at some point additional financed costs will be incurred for the electric geyser. Naturally, the point at which this occurs will affect the point at which a SWH becomes more financially feasible.

3. Even in the most unlikely (worst case) scenario of no electric geyser being replaced, this model is feasible should the SWH system installed be of sufficient quality to last at least 8 years. SWH suppliers should ensure the system is capable of this for end user to reap the full benefit of the system.

4. It should be noted though that a recent addition to the Eskom/SABS approved SWH list will retail at less than half the price of similar systems in the market. As the availability, upscalability and actual quality of this system has not yet established, it would not be prudent to base the above calculations on such a system yet. However, this does provide an indication of what prices can be reduced to in the short term. If this system price were to become the norm then a very strong case for retrofitting and financing for the unit over 2-5 years can be made.

Financial Feasibility of Low Income Residential SWHs

In the past, it has been difficult to argue for the installation of SWHs in low income households. This is because these houses typically do not have electric geysers installed. Recent approaches to SWH 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
- The Eskom subsidy being made available to low pressure systems
- 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. At this point it is anticipated that the methodology will be accepted in mid 2009.

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 1.8T of carbon credits per year.

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 R20 per month for their solar water heater (including maintenance)
5. The electricity distributer in the area recoups the R20 through the prepaid metering system – a critical element in the scheme.
6. Profit is gained through determining a suitable repayment period.

The table below provides an indicative quantitative financial analysis

Cost of 100l SWH (installed including Eskom incentive)	R 3,500
Annual payment (Development bank @ 8% pa, 10 yrs)	R 521.60
Tonnes of CO2/unit/year	1.8
CDM Income pa (€10/T)	R 234.00
End user payment/year	R 287.60
End user payment/month	R 23.97

As can be seen the end user payment of R24 is achievable provided all the pieces of the financial model are put in place.

Commercial and industrial use of SWHs

Solar water heaters can be used effectively in several commercial applications (eg hotels), as well as in hospitals, clinics and old age homes. Although the hot water demands here may be higher than residential, the increased roof area of these buildings allows for more collectors to be installed. Efficiency figures comparable to those of the residential sector can be achieved (see modelling above). As the relative cost of these systems is cheaper/litre than for residential systems, the financial case for these units is even stronger than the residential cases illustrated above.

Solar water heaters are not suited to replace boilers and other high temperature water apparatus in industry. However they can be used for preheating purposes, so that at least a percentage of the heating operation draws on solar, rather than carbon-based, energy.

4.3 Potential for rollout

How much energy, carbon and peak demand power would be saved if 15 of SA's major cities had solar water heaters installed today?

	10% penetration of SWHs (thousands of systems)	Peak demand reduction (MW)	Energy saving (GWh/yr)	Carbon reduction potential (thousand tons CO_2/yr)	50% penetration of SWHs (thousands of systems)	Peak demand reduction (MW)	Energy saving (GWh/yr)	Carbon reduction potential (thousand tons CO_2/yr)	100% penetration of SWHs (thousands of systems)	Peak demand reduction (MW)	Energy saving (GWh/yr)	Carbon reduction potential (thousand tons CO_2/yr)
Buffalo City	19	12	42	50	96	60	210	248	191	119	420	497
Cape Town	76	48	167	198	380	238	836	988	760	475	1,672	1,976
Johannesburg	105	66	231	273	525	328	1,155	1,365	1,050	656	2,310	2,730
Tshwane	56	35	124	146	282	176	619	732	563	352	1,239	1,464
Ekurhuleni	75	47	164	194	373	233	820	969	745	466	1,639	1,937
eThekwini	79	49	173	205	394	246	866	1,023	787	492	1,731	2,046
King Sebata	9	6	20	23	45	28	98	116	89	56	196	231
Mangaung	19	12	41	48	93	58	204	241	185	116	407	481
Msunduzi	13	8	29	34	65	41	143	169	130	81	286	338
Nelson Mandela	26	16	57	68	131	82	287	339	261	163	574	679
Potchefstroom	3	2	7	8	16	10	35	42	32	20	70	83
SaldanhaBay	2	1	4	5	9	6	20	23	18	11	40	47
Sedibeng	23	14	50	59	114	71	250	295	227	142	499	590
SolPlaatje	5	3	10	12	24	15	52	61	47	29	103	122
uMhlatuze	7	4	15	17	34	21	74	87	67	42	147	174
ALL CITIES	**515**	**322**	**1,133**	**1,340**	**2,576**	**1,610**	**5,667**	**6,698**	**5,152**	**3,220**	**11,334**	**13,395**

Assumptions (from Eskom DSM estimates):

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

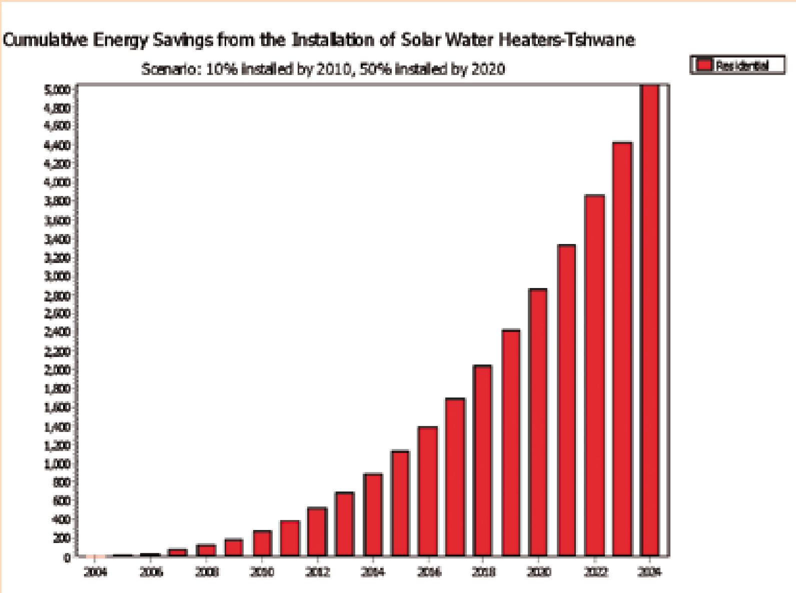
As can be seen from the table above, there is huge potential for a mass rollout of solar water heaters in cities around South Africa. The following modelling exercise quantifies the benefit of a large scale SWH rollout in a large South African City, in this case Tshwane:

In their Energy Strategy of 2006, the City of Tshwane set targets for household penetration of solar water heaters of:

- 10% by 2010
- 50% by 2020.

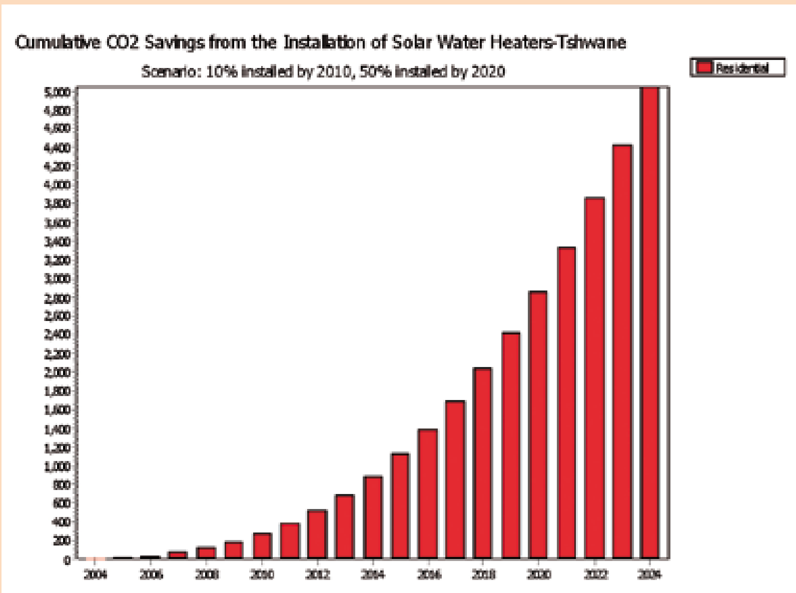
These targets are similar to those adopted by other cities in South Africa.

Energy savings



Achieving SWH targets in Tshwane will result in a cumulative saving of 5 million MWh of electricity by 2024.

Carbon savings



If the city achieves its targets, nearly 5 billion kilograms of CO_2 will have been saved by 2024.

4.4 Barriers to implementation and efforts to resolve these

South Africa has one of the highest insolation (hours of sunshine) rates in the world, and solar water heaters are making financial sense in many scenarios. Despite this less than 1% of households across the country have solar water heaters – a great contrast to a country such as Israel, which has installed SWH in 60% of houses.

Various barriers have hindered the full-scale implementation of solar water heaters. These include:

Unit Costs: Recent electricity price increases are making SWHs more financially viable, yet their capital cost still needs to come down if mass implementation is to take place. The argument for installation of a SWH instead of an electric geyser in a new building or a scenario where the old electric geyser is 'blown' is clear (See section 4.2 earlier in chapter), but retrofitting by replacing an existing working electric geyser with a SWH does not hold such clear financial gains. Retrofitting would be made more viable by a decrease in SWH capital costs.

Effort to resolve:

The SWH market is still very small in South Africa. With the inevitable growth in the industry, unit costs are expected to reduce substantially. Very recent information indicates competitive SWH units coming in at less than 50% of current normal SWH costs. Should these figures become the norm, the SWH cost barrier will be **effectively eliminated**.

Financing: As shown in 4.2 earlier, financed SWHs are financially viable, and becoming even more so as unit costs continue to reduce. Very few attractive financial sources are available to businesses looking to upscale their operation to a mass implementation approach, providing financed units to the end user.

Effort to resolve:

Work is currently underway to establish a national financing source which makes attractive RE financing available to business and end users, in an effort to make their business plans more viable.

Standards: Eskom currently provides subsidies for SWHs if they are SABS approved. However, the SABS approval system is not currently linked to international standards systems. This leads to unnecessary re-approval of internationally approved products. Insufficient testing facilities at the SABS also cannot currently cope with the waiting list for SWH systems, creating an industry bottleneck.

Effort to resolve:

In an effort to resolve this, Eskom and SABS are working towards accepting a list of recognised international SWH testing facilities. An effort is also being made to speed up the approval process and remove the bottleneck.

Trained plumbers and installers: There is a lack of trained plumbers and installers who are qualified to install solar water heaters in South Africa; particularly if there is going to be a radical growth in the market over the next few years. The Central Energy Fund (CEF) has launched training programs through various training providers and a registered qualification through the South African qualification authority exists.

Effort to resolve:

Industry experts indicate that training a plumber to install a SWH effectively will take 2 days maximum. This is not really seen as a barrier by most in the industry, and is more a perceived problem by those not directly involved.

Awareness: There is a lack of general public awareness of the benefits of solar water heaters.

Effort to resolve:

Various SWH products are now enjoying advertising space on national television, and Eskom are also raising awareness through the mass media.

Long term support from government: In order for SWH businesses to scale up, they need legislative support for SWHs from government to decrease their risks. Based on the current modelling, the financial case for a new build scenario is clear. An energy efficient water heater bylaw at City level could do this locally, or National legislation through the National building codes would also be an effective mechanism. Additional support through the establishment of city based SWH mass implementation mechanisms will also assist in the large scale uptake of SWHs

Effort to resolve:

Cape Town is currently working towards an energy efficient water heater bylaw, and indications are strong that it will be enacted. The SABS have developed a voluntary building energy efficiency standard (SANS 204), which includes SWHs in a range of energy efficiency building measures. The goal is to integrate this standard into the National Building Codes. However, this process could take another 3 years. The City of Joburg is currently establishing a mechanism which will install SWHs as infrastructure. Nelson Mandela Bay and Ekurhuleni are both looking into supporting the establishment of mass implementation businesses.

No carbon financing or effective TREC system: Carbon financing would incentivize SWH projects, but thus far is proving difficult to put into place. There are no useable SWH Cleaner Development Mechanism methodologies currently available for SWH mass rollout, though they are being developed. As of yet there is no voluntary Tradable Renewable Energy Certificate (TREC) market focusing on SWHs. DME would need to be the verification body to improve credibility of TREC trading once it is implemented.

Effort to resolve:

TRECs are available but focussed mainly on RE generation. There is currently no clear process for SWHs. The methodology for low income SWH rollout will be approved by the CDM board in mid 2009, which will allow smaller low income SWH projects to receive carbon financing without exorbitant registration costs.

Insurance industry not offering SWHs as an alternative to electric geysers in their replacement policy:

Over 200 000 geyser are replaced in the country annually by insurance companies. Currently very few companies offer SWHs as an alternative.

Effort to resolve:

Eskom is currently negotiating with the insurance industry to include SWHs as an option for geyser replacements.

4.5 How Cities can go about implementation

Solar water heaters are a truly sustainable solution to water heating. The benefits for the country and individual users are clear. They are a particularly important way to reduce middle to high income electricity consumption and to provide low income households with a better quality of life. Some initial mechanisms and incentives to facilitate mass implementation and 'kick start' the market are outlined below.

Considering a bylaw?

Draft Bylaw and legal opinion justifying a city's mandate to pass the legislation available on City Energy Support website:

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

Solar water heater/Efficient Water Heater bylaw

Legally, it has been accepted that Cities have the constitutional mandate to legislate for SWHs, or more generally for energy efficient water heaters (so as not to exclude other viable technologies such as heat pumps). A city bylaw can enforce the installation of solar water heaters in

i.) all new buildings built in the city

ii.) all additions to existing buildings in the city where extra water heating for sanitation purposes will be required.

Given that the financial case is clearly beneficial to the end user for all households that require a hot water system (above RDP level), this is a potentially very effective mechanism to drive implementation and stimulate the solar water heater industry. In order to allow for initial supply capacity deficits, a tiered introduction process can be adopted to ensure the industry keeps up with the new growth in demand. For example for the first year of the bylaw, only new houses or additions exceeding R1,000,000 in value need to install SWH, then the following year all new houses and additions exceeding R750,000 need to install SWH, and so on. Ultimately, any new house above RDP level should have a SWH, given the immediate financial benefits to the end user.

A bylaw does hold particular challenges for a city:

i.) Building inspectors will need additional training so that they can approve installations and enforce the law correctly.

ii.) The tiered method of introduction should be carefully considered in order to make the bylaw practicable.

City of Cape Town the first SA city to embark on Energy Efficient Water Heater Bylaw process

Cape Town is currently in the process of implementing an energy efficient water heater bylaw. The drafting of the bylaw was initiated under the City's Energy and Climate Change Strategy. The bylaw is shortly to undergo a public participation process.

To find out more about the Cape Town by-law go to www.cityenergy.org.za/resources/solar-water-heaters and click on the 'Solar Water Heaters and Cape Town Bylaw' tab.

Business/City Driven Mass SWH rollout approach

SWH Mass Implementation Entities

Based on the financial analysis made earlier in this chapter, it is clear that a strong business case can be made for mid-high income SWHs when they are financed over periods of 5-20 years, the strongest case being 10-20 years under current economic conditions. With the onset of new SABS approved systems on the market which are considerably cheaper, the business case for financing units over 3 years becomes very strong. There is a real opportunity available to entities – and this could be businesses or cities, who are prepared to provide SWHs to end users at attractive monthly repayments. For a detailed SWH business analyses go to www.cityenergy.org.za/swh/business cases.

On the low income side the case is beginning to be made for a sustainable business model which allows end users to have a low pressure SWH installed at very low monthly repayments (around R20-R25, see 4.2 previously).

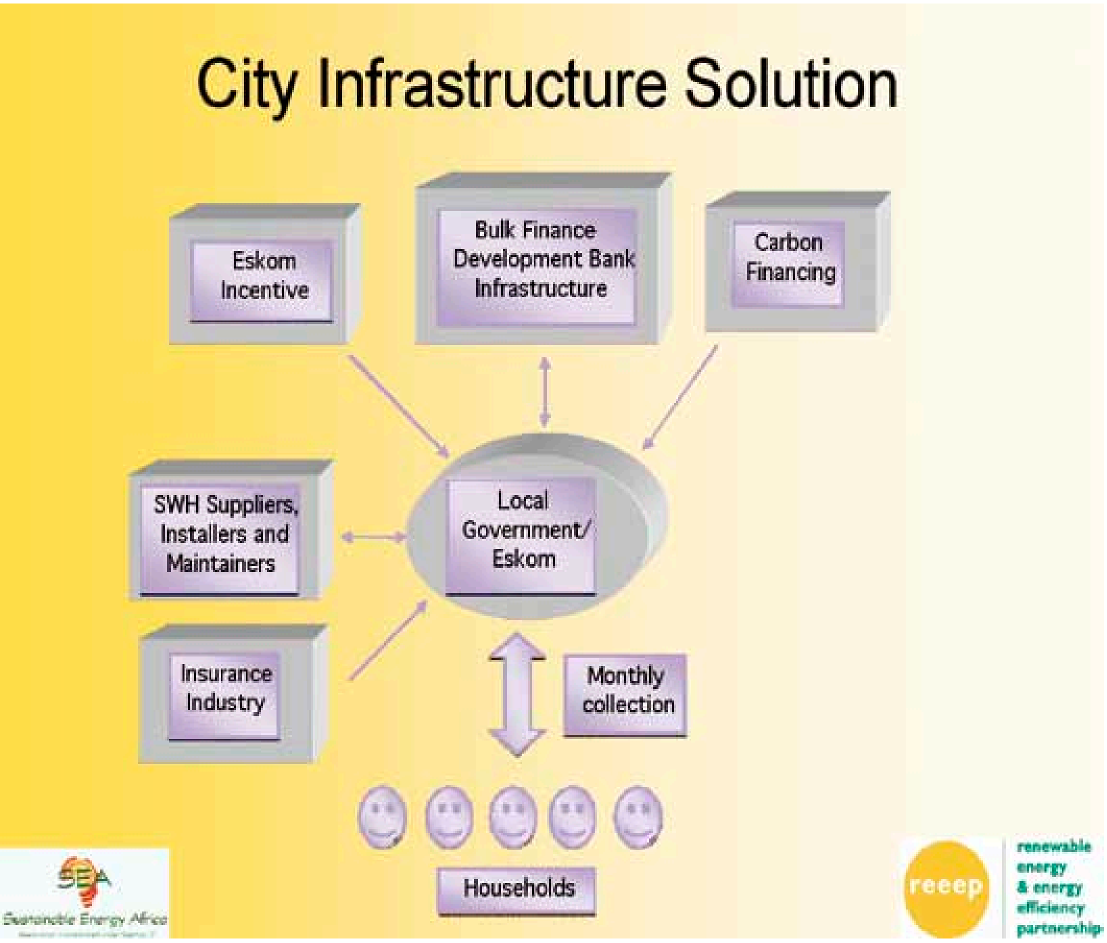
To roll out in both the low income and mid-high income markets, the business model will be very similar: Attractive monthly repayments offered to the end user based on the implementing business securing–

- Attractive financing
- Bulk purchase unit cost reduction
- Carbon financing
- Effective collection mechanisms

A City must determine the level at which it wishes to get involved in these businesses. In an environment with no City assistance, it is unlikely that large scale businesses will start up in the short term. This is due to businesses being reluctant to take the risk in upscaling to a large degree without many guarantees from government. Increased levels of city involvement will result in linked reductions in the risk that business has to take, making the environment more attractive. The following scenarios show the various levels at which a City can get involved:

1. City SWH as infrastructure approach (least risky to business) - the city installs the units as infrastructure, and collects the end user's monthly repayment through the rates bills.

   This is the least risky approach for business. This approach is currently being implemented by the City of Joburg. The City contracts a SWH service provider to perform the function of marketing and installation of SWHs in set areas. The City organises attractive financing, unit cost reduction through bulk purchasing power, the Eskom incentive and carbon financing to minimise unit costs. They also interact with the insurance industry to ensure that SWHs are available as an option to replace blown geysers. The City then installs them on willing households through their appointed service provider. A preliminary study around this model can be found in www.cityenergy.org.za/resources/solar-water-heaters cases.



The benefits of this approach are:

- Risk is shared between City and contracted SWH service providers

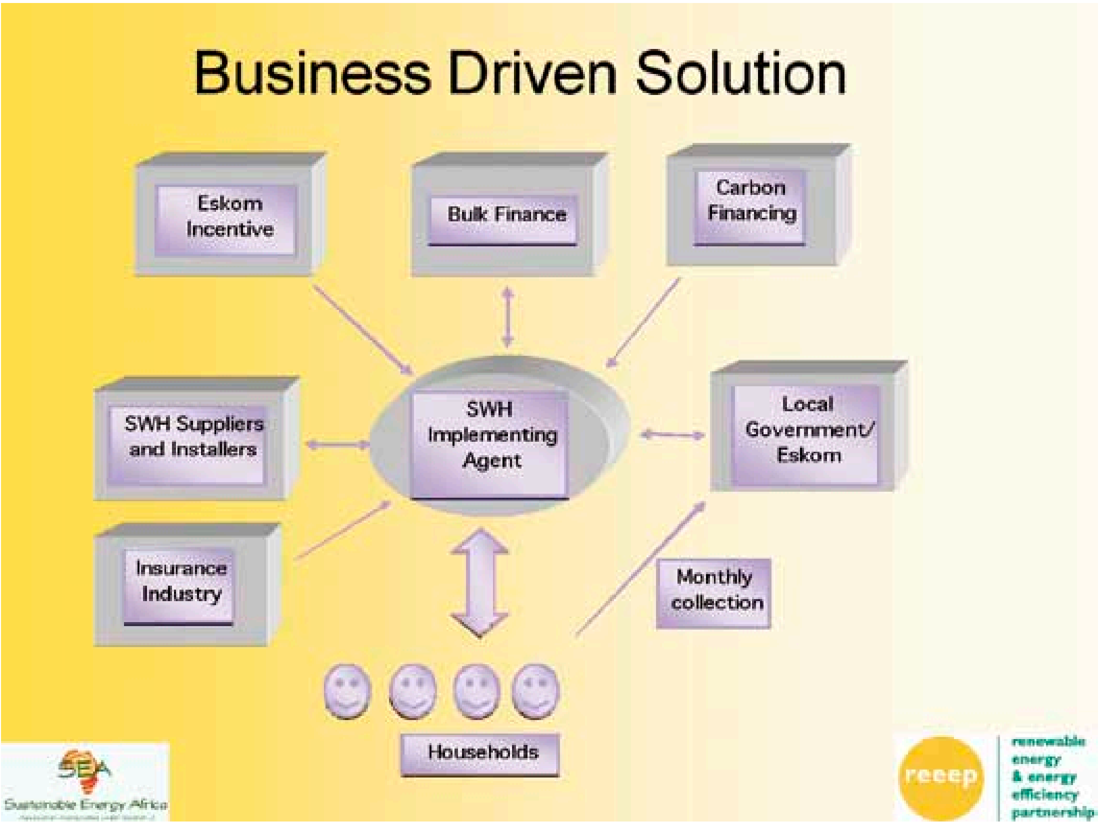
- Quality system (10yr warrantee) installed
- Maintenance built in to ensure system functions effectively
- Simple fee collection using existing channels
- City stands to supplement electricity income with SWH repayment income

The challenges in this approach are:

- Appointing a service provider will involve lengthy MFMA processes which must be taken in to account
- SWHs are not core government business
- Additional internal capacity is required to manage process
- Long term commitment to SWH installation (10 yrs minimum)

2. Business based Implementing Agent with strong City support (risky to business, but with benefits for City).

   A study around this model can be found in www.cityenergy.org.za/resources/solar-water-heaters Nelson Mandela Bay Municipality and Ekurhuleni are currently exploring this route for mid-high income implementation. On the low income side the Kuyasa project is looking to do the same.



Various levels of City involvement can be used for this approach. On the least active level the City will play no role and leave business to perform the work alone. On the most active level, the City appoints an approved implementing agent which pulls together attractive financing, bulk purchasing power, the Eskom incentive and carbon financing to minimise unit costs. They interact with the insurance industry to ensure that SWHs are available as an option to replace blown geysers. The City

- collects monthly repayments on their behalf through the rates bills
    - note that in terms of City law, the City must recover all of the end user's outstanding monthly rates, water, electricity and refuse payments before the portion allocated to the SWH implementing agent can be paid
- provides marketing and awareness raising wherever possible

The benefits of this approach are:

- Business can operate in a field in which it excels, and if the business model makes sense, can upscale fairly quickly
- Government takes no risks – provides support where it can

The challenges in this approach are:

- Business carries all of the risk (but makes the profit)
- City stands to lose 30% electricity income per household with a SWH
- Government cannot influence the process greatly
- Slow growth in this area likely as risks currently are keeping most businesses from expanding

Using the Cleaner Development Mechanism (CDM)

Up until November 2005, only individual projects could register as CDM projects. For small carbon saving projects, the net carbon revenue (after taking off transaction costs) is very small, due to the costs of designing the project, taking it through the CDM process and the sales transaction costs for a small carbon credit volume. In response to this problem a new type of CDM, Programmatic CDM, has been established enabling the pooling and crediting of all emission reductions occurring under a programme of similar projects. This significantly increases the volume of credits generated, hence tapping into economies of scale. Work in this area is still nearing completion and the methodology will soon be available to cities and other entities wishing to utilise it. Moves are well under way to establish a national facility in the Department of Housing – the Sustainable Housing Facility or SHF – which will register all programmatic CDM low income housing projects and collect CDM funding to subsidise sustainable interventions in these households. Current estimates are around its establishment by 2010.

For more details on a programmatic approach to CDM visit

www.southsouthnorth.org

Utility subsidies

Eskom has committed itself to promoting the use of solar water heaters as an element of its demand side management (DSM) programme. Eskom provides a significant subsidy (up to 20%) to the consumer for the installation of an SABS approved SWH system. This increases the financial viability of SWHs considerably. The incentive is currently available to both high and low pressure systems, thereby effectively covering all formal households from RDP level to high income.

Tradeable Renewable Energy Certificates (TRECs)

TRECs (Tradable Renewable Energy Certificate System) have been traded since 2002 in South Africa. It is currently working well in Europe, parts of America and Australia. When completely operational in South Africa, the TREC system may provide a useful mechanism to subsidise the capital cost of installing a solar water heater. The sale of TRECs generated over the lifetime of a solar water heater can cover roughly 15% of the SWH's capital cost.

Looking for more info on TRECs in SA?

Go to www.dme.gov.za

Once the system is up and running, a TREC can potentially be issued to anyone who displaces 1MWh of conventionally generated 'dirty' grid electricity (e.g. through installing solar water heaters) or anyone who generates 1MW-hr of 'clean' electricity (e.g. a wind farm). This certificate can then be sold on the open market to individuals or businesses who want to 'green' their electricity consumption.

"Incentivising" SWH installation: the Australian REC system

The government of Australia supports renewable energy by offering rebates to households who install solar water heaters. In addition to the rebate, households are also eligible for up to $900 through renewable energy certificate (REC) sales. A REC is the equivalent of 1 MWh of energy.

The number of REC's a consumer receives is calculated as displaced energy over 10 years, based on the daily sunlight hours and system efficiency.

Through adopting this simple demand pull system the return on investment for the end user has dramatically increased, and demand has grown, assisting government towards reaching their mandatory renewable energy target. For more information please visit:

http://www.bcse.org.au/default.asp?id=289

http://www.orer.gov.au/publications/mret-overview.html

http://www.orer.gov.au/recs/index.html

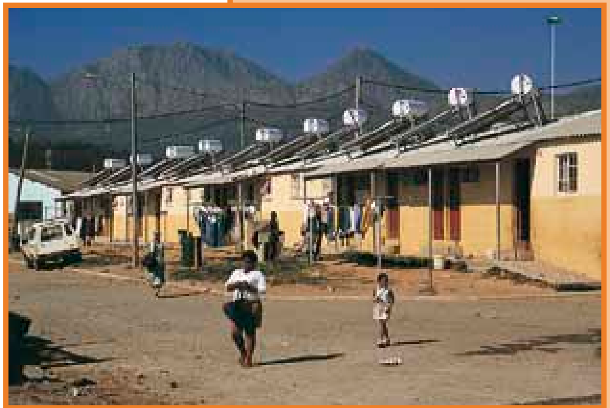
What about Solar Water Heaters in informal housing?

It is often feasible to provide electricity to informal settlements, but there are no widely available solar water heating solutions for these houses at present. Informal houses have little or no plumbing, which means that conventional solar water heating systems are not applicable. However simple, cost effective ideas such as coiled rubber tubing on the roof or even black buckets could work.

4.6 Case studies

Case study: SWH implementation in low-income households – the Lwandle solar water heater project

The Lwandle hostel, lies tucked away in Lwandle township in Somerset West, within the Western Cape. The hostel, owned by the Helderberg Municipality originally served as a single men's accommodation for the Gants food and canning factory. Through an extensive community participation process motivated by the closure of the Gants factory in the late 1980s, the community announced their primary needs as being jobs, privacy, toilets and hot water.



The community development project which ensued worked towards meeting the needs of the community and came to be known as the Lwandle Hostel to Homes Rental Project. The hostel was converted into family units with some provision for singles, giving rise to 967 units owned by the local authority and available for rental from R114-R172.

In terms of satisfying the community need for hot water, 305 SWHs were installed (without electricity back-up) to provide hot water. Provision of SWHs was made possible through the local authority securing a low interest loan from the Development Bank of Southern Africa. Residents paid a fixed rate for hot water as a way of servicing the loan. The SWHs are mounted on stands on the existing rooftops in order to receive the best orientation (north) for the heating of the panels.

Initially the community expressed a high level of satisfaction with the hot water service. A survey conducted in 2003 found residents continuing to use the SWHs, but complained of heaters not heating water sufficiently over the cold rainy winter months of the Cape. Systematic maintenance did not seem to be taking place either.

The SWH systems are now owned by the City of Cape Town, and residents/tenants continue to pay a fixed monthly rental fee (the monthly rental fee increased from R17.50 to R23 by 2003) included in their monthly rent to cover the repayments on the capital cost of the SWHs. As regards the current situation, little is known, except for anecdotal evidence of some systems being broken or in need of maintenance. Momentum around this project has ceased and the City of Cape Town should be encouraged to assess the current status and develop a plan to take project forward to a more sustainable situation.

Case study: SWH implementation in low-income households – the Kuyasa Project

An example of mass rollout of SWHs in low-income households is the Kuyasa Project. It involves the retrofitting of over 2000 existing RDP households in Kuyasa, Khayelitsha, with SWHs, insulated ceilings and the supply of 2 CFLs per household. The City of Cape Town, as the project owner, worked in partnership with SouthSouthNorth and the beneficiary community to produce the project design, which was registered as the world's first Gold Standard (has social upliftment value) Clean Development Mechanism (CDM) project in August 2005. AGAMA Energy was appointed as the implementer.

Benefits include an estimated emission reduction of 2.85 tons of CO_2 per household per year and an energy services cost reduction of over R600 per household per year. Employment opportunities have been created through SWH installation, ceiling installation and CFL retrolfits. Human capacity was built around project design aspects, including energy efficiency and renewable energy. This project is in line with the City's SWH target of 10% installation by 2010 and its renewable energy generation target of 10% by 2020. The project has huge potential for replication across all low-income housing in South Africa and will assist municipalities in achieving their renewable energy targets.

Funding is obtained from the Provincial Housing Department research grant, ICLEI (International Association of Local Governments) and through the Poverty Alleviation Grant from the Department of Environmental Affairs and Tourism. A further income stream will be gained from the sale of Certified Emission Reductions (CERs) at €8 per ton. The Net Present Value of the CERs will cover 30-40% of the project's capital cost. Currently households are paying R30 per month for their hot water service, as on ongoing contribution.

Despite the interest shown by many other municipalities for project replication, carbon financing is an issue. The registration of a new CDM project will take several years, but the pending "programmatic" application to the CDM Board will enable the sale of CERs from SWH installation projects without having to register new projects. The projects would need financing from local public sources, as a CDM project does not allow for the use of ODA (Official Development Assistance). A DSM (Demand Side Management) Eskom subsidy for SWH, currently under negotiation, will decrease a project's capital cost.

Case study: Facilitating solar water heating in cities through commercial installation in new, private developments and fee for service models

An increasing number of companies are emerging in the area of solar water heating with a range of innovative approaches and products. These 'products' provide opportunities for cities to adopt solar water heating within their own buildings (residential and public institutional facilities) without incurring upfront capital costs. Cities may also be able to promote widespread use of such mechanisms through providing administrative support in the form of monthly tariff collection through city rates tariff systems. Cities might also prompt new, private housing development to include solar water heating through encouraging this in development approval application processes.

Photo: Trevor van der Vyver

Photo: Trevor van der Vyver

Solar water heater installation in new housing development

A new housing estate development in Randburg, Johannesburg included solar water heaters in the housing development. It considered this to be an important basis for responsible development in addition to providing energy savings for prospective homeowners. Additional bond repayment cost is negligible and the energy saving exceeded the cost of the SWH. The housing development, consisting of 52 two bedroom units, targets new, small, mid-income families. Units were fitted with 190 litre evacuated tube systems (without electricity backup). The SWH's are used as pre-heaters for conventional 230volt 150 litre geysers.

- *Typical electricity savings for the estate is 93 600 kWh per year.*
- *Typical carbon dioxide emissions avoided are 103 tons per year.*
- *Typical water savings from avoided electricity generation is 117 936 litres.*

Case study: Commercial scale SWH installation at a retirement centre through a fee-for-service arrangement

Power cuts resulting in increased dissatisfaction among tenants led a private retirement centre in Pretoria to convert its water heating system from a conventional electric system to a solar heating system with an electric back-up, in 2005. The retirement centre is home to 100 residents. The solar water heating system has been fitted by an energy services company. The retirement centre leases the system and only pays for the energy consumed during the month. 90 solar panels with a collector surface area of 120m2 were installed with a maximum demand control unit built into the circulation unit. The storage capacity of the system is 9000 litres. The system uses a forced pump circulation, and has a differential thermostat control together with antifreeze protection. The savings accrued are:

- *Energy savings (90 panels) = 197.1MWh per year*
- *Financial Savings: R56,000 - R60,000 per year*
- *Environmental Saving: 18tons of coal, 90 tons annual CO_2 emissions avoided*

Photo: Suntank

Photo: Suntank

Photo: Solar Beam

Solar water heating on retirement centre

Large scale solar water heating on mid-high income Durban apartment block

4.7 Support organisations

Key role-players to support implementation of Solar Water Heater projects

Agama Energy (Pty Ltd)

Energy services model

Agama Energy offers a 'fee-for-service' scheme targeted at households with SWHs. This scheme has potential for application in large city SWH projects.

Glynn Morris

Tel: 021 701 3364

Fax: 021 701 3365

Cell: 083 780 9460

Email: glynn@agama.co.za

Website: www.agama.co.za

Department of Minerals and Energy – Renewable Energy Finance and Subsidy Office (REFSO)

Financial assistance

REFSO manages renewable energy subsidies and offers advice to project developers and other stakeholders on renewable energy finance and subsidies. This includes information on the size of awards, eligibility, procedural requirements, and opportunities for accessing finance from other sources.

REFSO Office

Tel: 012 317 8711

Fax: 012 317 8793

Email: daniel.modise@dme.gov.za

Website: www.dme.gov.za

Development Bank of Southern Africa (DBSA)

Debt financing and a limited technical assistance grant facility

DBSA is able to support cities through offering a carbon finance facility in association with the World Bank.

DBSA will consider debt financing of commercially viable clean energy projects.

DBSA also has a technical assistance facility that may support cities to finalise a component of their detailed clean energy feasibility study.

Website: www.dbsa.org

CEF Sustainability

Financial and technical assistance

CEF Sustainability is a division of CEF, and as part of its focus invests in renewable energy and alternate energy fields. They support energy development through commercial, developmental and social projects. Thus EDC is potentially able to assist cities as a promoter, facilitator and developer of commercially viable SWH projects through investment.

CEF Head Office

Tel: 011 280 0300

Fax: 011 880 9803

Website: www.cefgroup.org.za

Energy Service Company (ESCO)

Technical assistance

A number of private ESCOs are registered in South Africa that are able to assist cities with saving energy and improving energy efficiency thereby reducing costs, managing risk and enhancing a competitive edge.

ESCOs offer this through a package, which includes a comprehensive energy audit service, a financing mechanism, equipment procurement, installation and commissioning, operation monitoring and performance guarantees.

Please access **www.eskomdsm.co.za** for a list of Eskom accredited ESCOs.

Note: this does not constitute a complete list of ESCOs registered in South Africa.

Kuyasa CDM

Low Income SWH implementation

Currently at the forefront of energy efficient solutions for low income houses in the country. Responsible for the implementation of SWHs, insulated ceilings and ee lighting in 2000 households in Kuyasa.

Tel: 021 465 7522

Eskom

Financial assistance

Eskom Demand Side Management (DSM) provides financial support to energy efficiency projects and is firmly committed to SWH project development and investment.

DSM Help Desk

Tel: 011 800 4744

Website: www.eskom.co.za

National Energy Efficiency Agency (NEEA), a division of CEF (Pty) Ltd

Technical and financial assistance, as well as 'aggregated bulk procurement' opportunities from accredited suppliers.

NEEA is a division of CEF (Pty) Ltd and will initially oversee various components of the national (Eskom) Demand Side Management (DSM) and energy efficient projects in the country. These would typically include the retrofitting of public facilities (at a National, Provincial and Local government) level, general awareness creation and the formulation and recommendation of policy and regulatory tools required to meet the targets set in government's National Energy Efficiency Strategy for South Africa. NEEA will also look at a broader energy mix than electricity alone, including the application of energy efficiency in liquid fuels for the transport sector, renewable energy and gas projects.

CEF Head Office

Tel: 011 280 0300

Fax: 011 880 9803

Website: www.cefgroup.org.za

Solar Energy Society of Southern Africa (SESSA)

Information provision

SESSA promotes the use of renewable energy with informal education, demonstration and dissemination to end-users and other decision makers of all levels. SESSA has also been involved in the accreditation of SWH installers, by assisting in the creation of appropriate standards for products, systems or methods and training.

SESSA

Trevor vd Vyfer

Tel: 011 789 1384

Fax: 011 789 1385

Website: www.sessa.org.za

Solar Water Heater (SWH) Manufacturers and Suppliers

Manufacturers, suppliers, and installers of SWHs. Some companies also provide maintenance of SWHs.

Able to assist cities with the supply, installation and maintenance of SWH technology.

A comprehensive list of South African SWH industry role-players (manufacturers and suppliers) including the type and description of support offered to cities by these companies, can be accessed at the following website **www.cityenergy.org.za**

South African Bureau of Standards (SABS)

Technical assistance

South African National Standards (SANS) specify the characteristics of domestic solar water heaters. The SABS has developed standards for domestic solar water heaters, which would guide/ inform city procurement of SWHs for SWH projects.

SABS Head Office

Tel: 012 428 7911

Fax: 012 344 1568

Website: www.sabs.co.za

SouthSouthNorth (SSN)

CDM facilitation

SSN is in the process of pioneering a programmatic CDM approach (allowing for project activities – several renewable energy and energy efficiency projects - under a programme of activities to be registered as a single CDM project activity) to attract carbon investment for projects such as SWH projects (expected to be operational end 2007). This approach/methodology will enable project developers to register additional projects as CDM much faster and at minimal cost.

Programmatic CDM is seen as an attempt to lower transaction costs, particularly for renewable energy and energy efficiency projects

Steve Thorne

Tel: 021 425 1465

Fax: 021 425 1463

Email: steve@southsouthnorth.org

Website: www.southsouthnorth.org/

The PACE (Promoting Access to Carbon Equity) Centre

CDM facilitation

The PACE centre provides free support for cities in facilitating the development of a portfolio of smaller CDM projects (renewable energy and efficiency projects) to obtain carbon revenue to support financial viability of project implementation. It does this by matching CDM project implementers with local CDM developers and international carbon investors.

Anton Cartwright

South African PACE Centre Co-ordinator

Tel: 084 780 3450

Fax: 088 031 201 8958

Email: anton@carbon.org.za

Website: www.carbon.org.za

Much of this information was drawn from the Solar Heat Specialist Handbook

5. Energy efficient lighting implementation

5.1 Overview

A Compact Fluorescent Light (CFL) uses five times less energy than an equivalent incandescent bulb

It has been estimated that electricity for lighting consumes almost 20% of the output of the world's power stations. The use of energy efficient lighting is one of the best and most cost effective ways of reducing our national energy consumption. Efficient lighting programmes can be implemented in several areas within cities:

- Replacing traditional incandescent bulbs with compact fluorescent light bulbs (CFLs).
- Replacing old fluorescent tubes with efficient fluorescent tubes in local government and commercial buildings.
- Replacing magnetic ballasts with electronic ballasts in fluorescent tube systems.
- Installing lighting control systems (people and lux level sensors)
- Using light emitting diode (LED) technology wherever possible. This is getting steadily cheaper and more accessible. LED's have several energy and cost saving applications, such as traffic lights and downlighters.
- Making streetlights more efficient through the use of high pressure sodium lights instead of the old mercury vapour light. Sodium lights operate on just over half the power of the mercury vapour light, and last up to 6000 hours longer.

5.2 The case

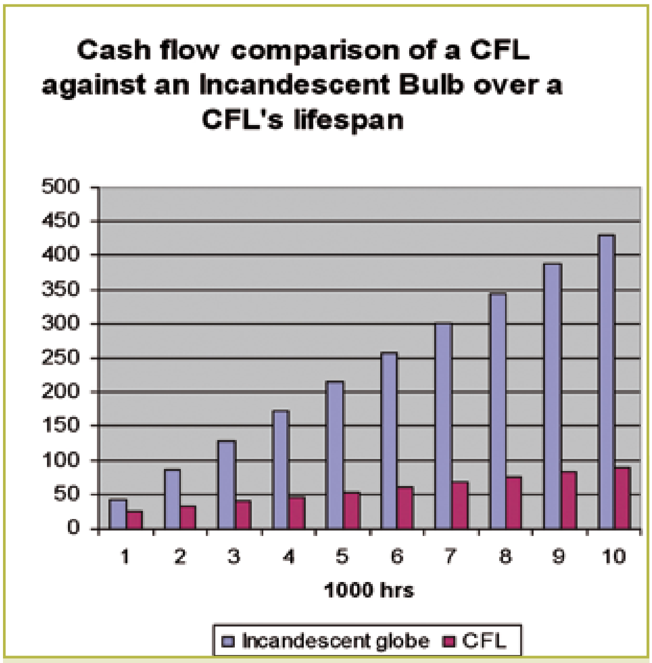
The residential and commercial sectors in South Africa together consume 21% of the country's electricity. Lighting makes up approximately 12% of the total electricity used in this area. By replacing existing incandescent light bulbs and fluorescent tubes with compact fluorescent light bulbs (CFLs) and efficient fluorescent tubes, this figure can be reduced by up to 75%. Further reductions can be expected from the installation of electronic ballasts and lighting control systems. LED installation where relevant and feasible should also be considered.

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

- The reduction in energy consumption and in particular peak demand from the use of efficient lighting will improve the energy security of a city through reducing the dependence that the city has on the national grid.
- Reduction in demand from the residential, local government and commercial sector means that fewer power stations need to be planned for in the future. Eskom has recognized that efficient lighting will play a major role in its demand side management (DSM) process.

From a home owner's, a business owner's or local government's perspective, installing efficient lighting technologies also has several benefits:

- A Compact Fluorescent Light (CFL) is expected to last 10 times longer than an incandescent bulb. Over the life cycle of a CFL, its capital cost (approximately R25) is less than that of the capital cost of 10 incandescent bulbs (approximately R40). The longer lifecycle of a CFL also means lower maintenance costs to a business or a local government building.
- A CFL is 80% more efficient than an incandescent bulb. This means that the same amount of light can be generated using 1/5 of the power. Over the lifetime of one 18W CFL (the equivalent of a 100W incandescent) which is approximately 10 000 hours, a saving of 800kWhrs of electricity will be achieved amounting to R480 of electricity saved per CFL (using today's rates).
- From an environmental perspective, approximately 800kg of CO2 will be saved over the lifetime of one CFL compared to the equivalent incandescent, assuming that the electricity source is a coal based power station.



This graph compares the cost of purchasing and using a CFL with the cost of purchasing and using an incandescent bulb over the same time frame. In this case an 18W CFL (costing R18 with a lifespan of 10 000 hrs) is compared with a 100W incandescent bulb (costing R3 with a lifespan of 1000 hrs).

Lighting Behavioural changes

- If room is well lit use natural light and not electric light
- Turn off lights in unused rooms
- Use task lighting over ambient lighting wherever possible

- Improved quality of life through a reduction in electricity costs for a low income household where the proportion of energy costs to income is very high.
- A 36W efficient fluorescent tube provides the same amount of light as a standard 40W fluorescent tube. Installing electric ballasts will also improve efficiency. Using both will improve efficiency by as much as 25%
- Installing sensors in the building which only switch on lights in the presence of a person and insufficient lux levels have reduced the lighting electricity component of buildings by up to 80%
- Studies have shown that through behavioural changes, up to 10% reduction in lighting energy consumption can be achieved in a building.

Real business experience from implementing such interventions in buildings has shown the technologies paying for themselves in anything up to 2.5 years. These real examples make a very strong case for energy efficient lighting implementation wherever businesses, households or government buildings are trying to cut back on costs.

LEDs (light emitting diodes) of the future?

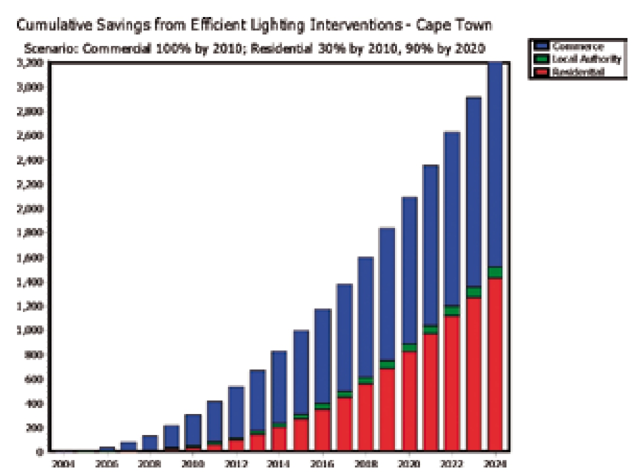
LED downlighters are much more efficient than the conventional halogen downlighters. They typically use 2 Watts, compared with the 35 Watts of a halogen. They also last much longer – over 50 000 hours. LED prices are still relatively high, but decreasing fast as this technology becomes more mainstreamed. Besides downlighters, LEDs can be used in traffic lights and streetlights too.

5.3 Potential for rollout

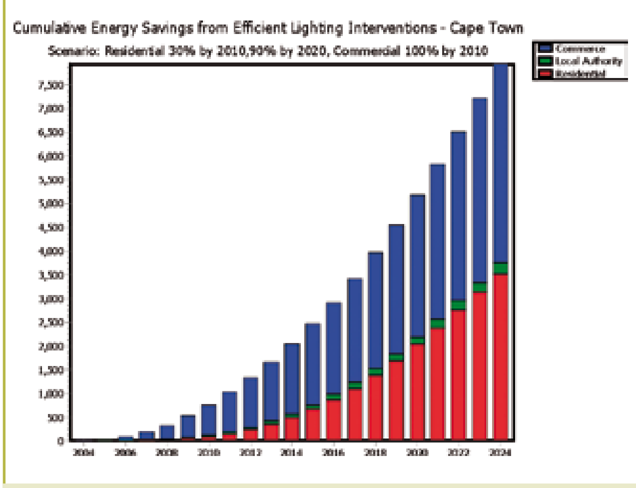
There is great potential for a mass rollout of efficient lighting in cities throughout South Africa. The technologies are tried and tested, and are available on a large scale if required. To demonstrate the impact of a mass rollout of CFLs and efficient fluorescent tubes within a city, we will consider the case of Cape Town

Cape Town has the following penetration targets set for energy efficient lighting in its energy strategy:

- Commercial and Local Authority 100% by 2010,
- Residential 30% by 2010 and 90% by 2020



Energy savings
Achieving city targets will mean 8 million MWh of electricity saved by 2024.



Carbon savings
On the carbon saving side, if the city achieves its targets, over 7.5 million tonnes of CO2 will have been saved by 2024.

Financial analysis

Considering rollout from a project cost perspective using the same scenario, R882 million will be saved from both reduced capital costs and energy saved, based on today's electricity and light bulb costs.

Poverty alleviation

Each CFL used in a low income house will save more than R300 over its lifetime. This is a substantial saving for an impoverished household.

5.4 Barriers to implementation and efforts to resolve these

Building owners will not pay for efficient lighting interventions when their leaseholders gain financial benefits: Most commercial buildings are occupied by businesses which pay rent to the building owners. The businesses are responsible for their own electricity bill. It therefore makes no sense for the building owner to implement efficient lighting systems as they do not reap a financial benefit from the intervention.

Effort to Resolve

Businesses planning to occupy the rented office space for a period of two years or longer should investigate making the financial investment, even though it is not their building. Businesses which have implemented efficient lighting interventions typically show a return on investment within 2.5 years – a very attractive business proposition.

Lack of information and awareness: There is the perception that CFLs are expensive, and this is particularly a problem for low income electrified households. Although the lifecycle savings of a CFL are well documented, the initial cost seems to be the deterrent.

Effort to Resolve

Awareness around the benefits of CFLs has increased thanks to Eskom's various mass rollout programmes and energy efficiency advertising campaigns. The CDM methodology for large scale efficient lighting projects for low income houses will be approved shortly and this will subsidise the installation of CFLs in these areas.

MFMA makes cities reticent to enter into contract agreements with ESCOs: The Municipal Finance Management Act makes it difficult for Cities to enter into contracts with service providers that last longer than three years. Most shared savings agreements will last longer than this.

Effort to Resolve

The MFMA allows for a revision of a contract, provided the correct process is followed. Treasury will also consider an exemption clause should a compelling case be made for the contract. There is also a strong case for government building management to rather finance the retrofit and recover the money spent within three years.

City electricity departments want to 'sell' not 'save': Many cities depend heavily on their income from their electricity departments, and are more interested in selling electricity than saving it.

Effort to Resolve

Municipalities as large power users have been directed by national government to reduce their energy use by 10% over the next 3 years. This national directive has placed pressure on cities to find effective ways to reduce energy use, and will heavy hand electricity departments to develop strategies to save electricity.

Inertia in procurement process (use existing suppliers and technologies): Governments and large corporations are often tied to procurement policies which dictate that a particular supplier or technology must be used. In the case of lighting, these suppliers often don't supply energy efficient options. Staff involved with procurement are often not aware of the energy efficient options available. Some buildings are tied to maintenance contracts with similar problems.

The City of Tshwane has green procurement guidelines. Download these at www.cityenergy.org.za/resources/green-procurement

Cheap technologies have given good quality CFLs a bad name.

CFLs cannot be used in dimmer applications.

CFLs contain mercury vapour, which makes safe disposal difficult: The safe disposal of CFLs is an important environmental issue which cities, within an efficient lighting programme, need to give serious consideration. Any efficient lighting programme MUST be accompanied by a safe disposal programme.

Responsible CFL disposal

In 2006, over 5 million CFLs were distributed within the Western Cape as part of Eskom's DSM programme. Many stakeholders, however, raised concern about the safe disposal of these lamps at the end of their life, because of the mercury found in the lamp. CFLs are hazardous waste and will need to be disposed of safely.

A task team, made up of Eskom, government, lighting manufacturers, waste disposal experts and NGOs has been established to look at safe ways of disposing CFLs. A recycling plant for CFLs is being planned and the safe disposal of CFLs will be implemented. To view the CFL disposal strategy document go to **www.cityenergy.org.za/resources/useful-documents**

5.5 How to go about implementation

The business case for energy efficient lighting is so strong that all buildings should be implementing appropriate efficient lighting technology wherever possible. Paybacks of a few months for a CFL replacement to 2.5 years for a commercial retrofit are typical.

Typically an energy services company or ESCO should perform this work. In most cases the ESCO will arrange the financing of the project and implement it, while the end user and the ESCO share the energy savings resulting from the work. Alternatively the ESCO will merely implement the required interventions at the end user's cost. ESCOs can operate in both large commercial or government buildings, as well as in residential areas. ESCOs typically offer a suite of energy efficiency interventions, but efficient lighting is often the most attractive starting point from a payback perspective.

City buildings and council housing retrofits and ongoing procurement processes

Cities need to develop policy and strategies around energy efficiency in council buildings and premises and in council-owned housing. This will provide overarching direction to the city's intent to move towards energy efficiency in lighting. Implementation of the strategy then requires:

a) Locating responsibility for retrofit with a specific line department.

b) Identification of building stock and a programme of retrofit.

c) Identification of financing for building retrofit. This may come from internal sources through usual budgets for maintenance of building infrastructure costs (and making the case to city finance departments that future savings more than justifies the upfront additional capital costs). Additional capital costs can also be met through funding sources such as ESCOs and Eskom DSM

d) Longer term implementation requires that City procurement policies be adjusted to ensure that efficient lighting is routinely procured and installed. This may also require a capacity building process amongst staff involved in lighting procurement. Such capacity building would need to ensure that building maintenance staff is aware of the safe disposal requirements for CFLs.

City Streetlight Programmes

Replacement of old mercury vapour streetlights with high pressure sodium (HPS) streetlights is becoming the norm within cities, due to the huge energy and financial savings achievable.

Voltage reduction devices to dim the lights are a viable approach to further daily energy reductions. For an update on streetlight technologies, go to www.cityenergy.org.za/resources/lighting

Awareness programmes

As the business case for energy efficient lighting is so strong, the City can assist in raising awareness generally and in focused areas of the city.

Awareness needs to be built amongst staff involved in the procurement and maintenance of lighting in government and large corporations, highlighting the sustainable benefits of using efficient lighting. There also needs to be continued education of the population at large of the benefits of using CFLs, as well as the need for careful disposal.

Cities can promote efficient lighting through environmental education campaigns, household environmental campaigns and building partnerships with business to address energy efficiency.

ESCO programme with Working for Energy and EPWP

There is a strong case for ESCOs to operate in both residential and commercial areas. Not only will an increase in ESCOs in the country result in a reduction in national energy use, but it will also be a major employment creator. The government driven Working for Energy and Expanded Public Works (EPWP) Programmes have recognised this, and are looking to partner with Cities in driving ESCO development within the municipalities, with an initial focus on residential areas. Funding can be accessed for training of ESCO teams, as well as ongoing technical and business support. Cities can provide awareness to specific urban areas through notices in the rates bills, city newspapers and local bulletins to support the ESCO energy efficiency rollout programme.

Utility

Eskom, as part of its demand side management (DSM) programme, has indicated that it will subsidise suitable CFL projects by 50%. The money will only be made available subject to a project feasibility study done by one of ESKOM's approved energy services companies (ESCOs) and its subsequent approval from Eskom DSM. These projects can also have CDM benefits if they are large enough.

Eskom DSM provides a source of funding for cities striving to achieve efficient lighting targets.

Regulation

Given the advantages of efficient lighting over traditional tungsten filament bulbs, the Australian government has proposed placing a ban on the sale of tungsten bulbs. However, such action appears to be legally and procedurally complicated and at this stage other routes, such as voluntary programmes, internal procurement and building management decisions, seem to be more appropriate.

CFL lighting disposal

Local authorities are responsible for waste disposal services and need to ensure that safe CFL lighting disposal programmes are part of their waste disposal campaigns.

5.6 Case studies

Case study: LED Traffic lights

Some new traffic lights are being made out of arrays of light emitting diodes (LEDs). These are tiny, purely electronic lights that are extremely energy efficient and have a very long life. Each LED is about the size of a pencil eraser, so hundreds of them are used together in an array. The LEDs are replacing the old-style incandescent halogen bulbs rated at between 50 and 150 watts. LED units have three big advantages:

- *LEDs are brighter. The LED arrays fill the entire "hole" and have equal brightness across the entire surface, making them brighter overall.*
- *LED bulbs last for years, while halogen bulbs last for months. Replacing bulbs costs money (trucks and labour costs) and it also ties up traffic. Increasing the replacement interval can save a city a lot of money.*
- *LED bulbs save a lot of energy.*
- *The energy savings of LED lights can be huge.*

Assume that a traffic light uses 100-watt bulbs today. The light is on 24 hours a day, so it uses 2.4 kilowatt-hours per day. If you assume power costs 40 cents per kilowatt-hour, it means that one traffic signal costs about R1 a day to operate, or about R365 per year. There are perhaps eight signals per intersection, so that's almost R2920 per year in power per intersection. A big city has thousands of intersections, so it can cost millions of Rands to power all the traffic lights. LED bulbs might consume 15 or 20 watts instead of 100, so the power consumption drops by a factor of five or six. A city can easily save millions a year by replacing all of the bulbs with LED units. These low-energy bulbs also open the possibility of using solar panels instead of running an electrical line, which saves money in remote areas.

Case study: Ekurhuleni Metropolitan Municipality – efficient

lighting in municipal buildings

The Ekurhuleni Metropolitan Municipality (EMM) presiding over 2.5 million residents, has been institutionalising a sustainable energy approach through conservation practices in its municipal buildings since 2005. The Germiston Civic Centre and EGSC buildings, serving as EMM's political head office and administration head office respectively, were identified for an energy efficiency retrofit in 2005.

EGSC Building

Among the energy efficiency measures implemented in both buildings, was the replacement of conventional incandescent lights with compact fluorescent light bulbs (CFLs), the replacement of cool-beam down lighters with light-emitting diodes (LED) lights and the replacement of ninety-six, 8-foot double fluorescent light fittings with open channel-5 foot double fluorescent lights with electronic ballasts and installation of lighting timers.

Germiston Civic Centre

In total 2003 CFLs, 90 LED lights and 2 lighting timers were used for the lighting component of the project. The CFLs were found to be highly efficient with a high return on savings after the initial capital outlay. The CFLs, designed to screw into standard sockets, made for an easy replacement of incandescent light bulbs. Substantial savings were amassed from the efficient lighting installations:

- *Pre retrofit energy use: 387 718 kWh/year*
- *Post retrofit energy use: 109 894 kWh/year*
- *Energy savings: 277 823 kWh/year*
- *Percentage of energy savings from the use of CFLs and LEDs: 75%*
- *Percentage of energy savings from the use of fluorescent lights with electronic ballasts: 13 %*

8 foot double fluorescent lights

The emissions reduction for greenhouse gases represented in CO2 equivalent and other pollutants such as NOx and SOx were:

- *CO_2e reduction: 260 tonnes/year*
- *SO_x reduction: 2205 Kg/year*
- *NO_x reduction: 1 035 Kg/year*

Lights timer set to switch on at 05h30 and switch off at 19h00

This small scale retrofit project with regard to the lighting component alone resulted in 387 718 kWh of energy saved in one year, this represents an economic saving in the order of R369 126.00 with a payback period of less than year. This significant saving is enhanced by the additional benefits in GHG emission reduction: 260 tons of CO2e, 2.2 tons of SOx and 1.1 tons of NOx. Since the installation of the new lights, staff reported no equipment problems and had no complaints about the quality of lighting. Everybody seemed satisfied by the project.

Lessons learned

It was found that in a retrofitting project involving the replacement of old equipment with new and more efficient technology was a swift way to save both energy and money. The project did not require a long time to implement. However projects involving municipally-owned buildings and municipal operations, may take more time due to council procedures and policies that need to be followed. Further challenges arise in interdepartmental collaboration within government, spanning the planning stage to the actual project implementation. It was also found that it was important to select appropriately skilled people and companies to perform the work. Since energy efficiency technology and equipment is relatively new in the South African market, difficulty arises in finding experienced tradesman to provide the necessary services. This is envisaged to improve as the demand from more local governments and institutions for energy efficient equipment increases.

Key replication aspects

The formulation of the policy on Energy Efficiency in Council Buildings and on Council Premises, the State of Energy Report, the draft Energy Efficiency and Climate Change Strategy of Ekurhuleni and the subsequent retrofit project are part of an easily-replicable strategy that can be applied to other South African cities interested in reducing energy costs and reducing the environmentally harmful impacts of their municipal operations.

The equipment purchased and implemented in the municipal buildings of Ekurhuleni was proven to be cost effective and are readily available in South Africa.

It is noted that the achievement of successful and efficient project implementation lies in the allocation of enough time by cities for the project during the planning phase as well as the assemblage of a motivated interdepartmental task team.

Case study: International experience

Energy efficient lighting, particularly CFLs, is a readily available technology which can be easily installed by consumers throughout the world. At one time, the price difference between CFLs and tungsten filament bulbs was prohibitive but economies of scale from mass production have reduced the differential. Additionally, some governments have provided subsidies to assist the market in energy efficient lighting to develop. As a result, the widespread availability of energy efficient lighting and expanding knowledge of its benefits has led policy-makers, such as those in Australia, to propose a ban on the sale of tungsten filament bulbs.

Whilst the growing switch to energy efficient lighting is a welcome development, the initial high cost of CFLs is clearly a problem for poorer consumers. However, practical solutions exist to overcome this barrier. Many electricity utilities have found it advantageous to provide energy efficient lighting at a reduced price or free to their consumers. The benefits of subsidised energy efficient lighting to electricity utilities were first appreciated in the 1980's in the United States of America where such demand-side management (DSM) measures enabled these companies to avoid expensive investment in new power stations. This approach has been translated, for example, into a recent DSM scheme in Karnataha State in India. Faced with an increasing peak capacity deficiency caused mainly by evening lighting demand, the local utility is enabling domestic consumers to obtain 1 million energy efficient lights and allowing them to pay the costs by installments through their electricity bills.

5.7 Support organisations

Key role-players to support Implementation of Efficient Lighting projects

National Energy Efficiency Agency (NEEA), a division of CEF (Pty) Ltd

Technical and financial assistance, as well as 'aggregated bulk procurement' opportunities from accredited suppliers.

NEEA is a division of CEF (Pty) Ltd and will initially oversee various components of the national (Eskom) Demand Side Management (DSM) and energy efficient projects in the country. These would typically include the retrofitting of public facilities (at a National, Provincial and Local government) level, general awareness creation and the formulation and recommendation of policy and regulatory tools required to meet the targets set in government's National Energy Efficiency Strategy for South Africa. NEEA will also look at a broader energy mix than electricity alone, including the application of energy efficiency in liquid fuels for the transport sector, renewable energy and gas projects.

CEF Head Office

Tel: 011 280 0300

Fax: 011 880 9803

Website: www.cefgroup.org.za

Eskom

Financial assistance

Eskom Demand Side Management (DSM) provides financial support to energy efficiency projects and is firmly committed to SWH project development and investment. Eskom has a list of approves Energy Services Companies (ESCOs) to perform retrofits.

DSM Help Desk

Tel: 011 800 4744

Website: www.eskom.co.za

Lighting Companies

Suppliers of energy efficient lighting technology.

Technical support and advice also offered.

Able to assist cities with the supply of energy efficient lighting technology such as compact fluorescent light bulbs, LEDs (light emitting diodes) and fluorescent lights with electronic ballasts.

Able to also provide technical support and advice to cities with respect to energy efficient lighting technology.

Some of the big lighting companies have donated substantial quantities of lights to municipalities and can be potentially approached in this regard.

A list of lighting companies from which energy efficient light lighting technology can be procured can be accessed at the following website: www.cityenergy.org.za

PEER Africa

Residential ESCO experience

PEER Africa has experience in piloting the training and operating of ESCOs for residential implementation. Their current work involves working with the Working for Energy Programme and EPWP and Cities to establish large amounts of residential ESCOs in Cities.

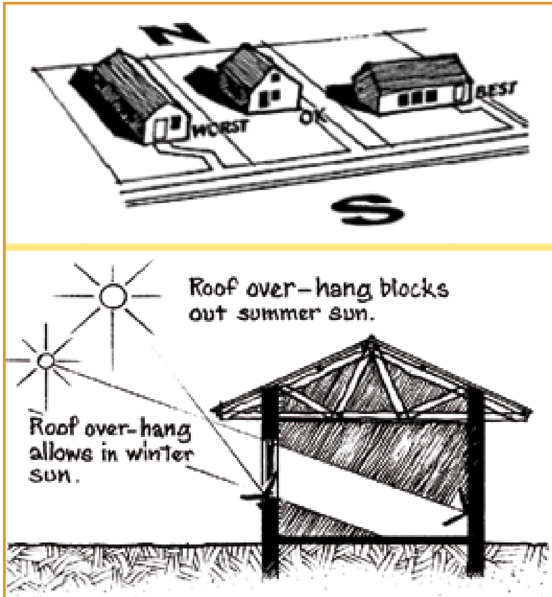
Clinton Foundation: Climate Change Initiative

Programme to facilitate ESCO development in Joburg

An effort to facilitate the establishment of ESCOs in Joburg to retrofit government buildings using international expertise and reduced material costs. Can provide support to other cities but will only focus on delivery in Joburg.

JLess@clintonfoundation.org

6. Energy efficient building implementation



A roof over-hang on the north side of the house should let in winter sun and shade rooms from summer sun.

6.1 Overview

Efficient building encompasses several areas, from efficient design and orientation methods right through to the technology used inside a building to make space heating or cooling more efficient.

Passive Solar Design

Passive solar design is used to reduce energy consumption and to ensure comfortable accommodation. Climate plays a major role in passive solar building design. The sun's movements, the prevailing wind direction, and changing temperatures and humidity are local climate conditions that vary from place to place and must be considered. Some examples of passive solar design are:

Insulation: Good insulation in the roof and walls help to keep the inside temperature warm in winter or cool in summer.

Orientation: North orientation ensures that as many well-used spaces face north as possible.

Shading: Suitable roof overhangs let in the lower winter sun but shade rooms from the higher hot summer sun.

Windows: Sensible fenestration (windows) let in light and catches winter sun, while not allowing too much window area so that warm or cool air cannot be retained inside when needed.

Ventilation: Suitable ventilation provides fresh air and cool breezes, so rooms can be ventilated as needed using airbricks, forced ventilation or by opening windows.

Lighting: Natural lighting through windows and light wells reduces the need for artificial lighting.

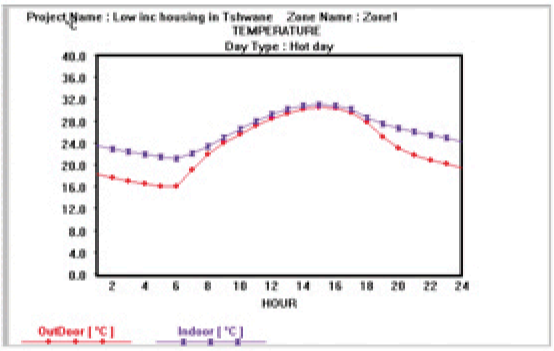
Building Materials: Materials such as concrete floors and brick or clay walls absorb heat from direct sunlight and releases it again at night.

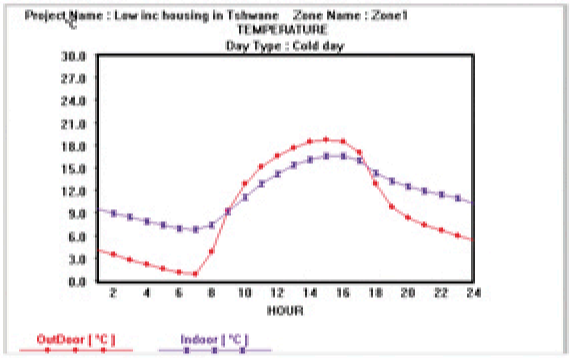
Landscaping: Planting evergreen trees or shrubs to block strong winds in the winter, and deciduous trees to provide shade and reduce sunlight reflection in the summer, but let sun through during winter, helps to reduce the need for artificial heating and cooling.

Technological Efficiency Interventions

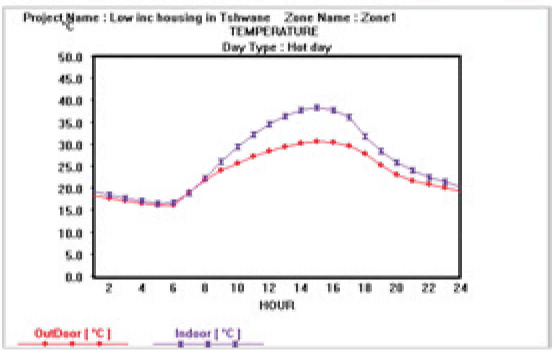
Most modern buildings have not been built keeping passive solar design in mind and rely on technology to regulate internal temperatures. Sensible technological interventions can still increase

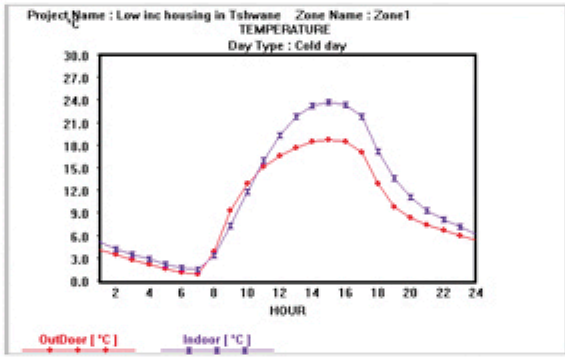
Passive solar design of houses results in their being more comfortable and healthy, and reduces the energy costs of heating and cooling.





The graphs show indoor and outdoor temperatures for a low income house in Gauteng. – without passive design features (below) and considering key passive solar interventions such as proper orientation, window shading, roof insulation and wall materials (above). The temperature extremes experienced by the former are excessive, and are greatly reduced in the house where such intelligent design is considered.





energy efficiency in these buildings, as well as in passive solar designed buildings. Some examples of technological interventions are:

- Installation of efficient heating, ventilating and air conditioning (HVAC) systems if required and ensure they are efficiently used.
- Installation of solar water heaters. They are financially viable and result in substantial savings on electricity bills (See SWH chapter (Chapter 4) in this manual for detailed analysis).
- If needed, energy efficient lighting retrofits are financially viable, and can pay for themselves in anything from a few months to 2.5 years. (See Efficient lighting chapter (Chapter 5) for detailed analysis).

The Green Building, Cape Town

Energy consumption

'Normal' commercial building: ~300+ kWh/m2/yr

Existing efficient examples:

Multinational corporate head office (Cape Town) ~115 kWh/m2/yr

Small commercial office block (Cape Town) ~30 to 50 kWh/m2/yr

An evaluation of 33 Green Buildings in California sums up the situation in many countries, including South Africa…

"It seems obvious: the reason only a tiny percentage of new American buildings and retrofits aren't green isn't cost. It's lack of ingenuity or knowledge of new construction techniques – architects and builders wed to the 'same-old,' lenders leery of anything unconventional."

Weather sealing

A significant amount of energy is lost from homes and buildings when the envelope of the structure is compromised. Air leakage can result in 40% of the energy lost from an existing building[1], and ensuring the envelope is continuous and consistent is fundamental to minimizing this loss. Doors and windows are the most significant areas of concern and can usually be addressed at little cost and without the help of a contractor.

This problem can exist in newer and older homes. It is fairly simple to detect drafts by running a hand along door jams and window jams. Drafts can be minimized by fitting door and window openings with self-stick foam, bronze weather-stripping, or plastic insulator kits[2]. This will also result in cleaner air and comfortable humidity levels.

In more extreme situations, installing storm windows and doors may be necessary to contribute significantly to energy savings. They create a barrier of dead space between the interior and exterior of a building, preventing air from infiltrating.

Weather sealing is one of the cheapest things a homeowner can do to save energy and make their home more comfortable. It is important to make homeowners aware of how easily and cheaply this can be done.

1. Zimmerman, Gary. (2008) Building Operating Management – Energy Efficiency: The Envelope Please. Retrieved on June 9, 2008 from http://www.facilitiesnet.com/bom/article.asp?id=8385.

2. (2008) Home Energy Savings – Windows and Doors. DIY Networks. Retrieved on June 9, 2008 from http://www.diynetwork.com/diy/he_weather_sealing/article/0,2037,DIY_13897_2274798,00.html.

6.2 The case

6.2.1 Economic benefits of passive solar interventions

Overview

There is currently no local resource which makes the business case for passive solar interventions. Understanding the economic benefits of these interventions will assist both political and built environment decision makers to make informed choices. The information contained in this chapter, along with the linked detailed tables fills this gap, and will be of use in the following ways:

- Inform town planning building conditions for new developments
- Influence bylaws and EE additions to the National Building Regulations
- Assist Cities in making the case for passive solar within their Green Building Guidelines
- Inform technical professionals (architects/engineers/developers) on the economic benefits of passive solar interventions

Scope of study

- Three different building types
- Low income residential
- Mid-high income residential
- Commercial office block

were modelled in three high population climatic zones:

- Cape Town – Temperate Coastal
- Durban – Sub – Tropical
- Pretoria – Cold Interior

The energy saving benefits – both from heating reduction in winter and cooling reduction in summer – of each intervention in each building in each climate zone was calculated. Based on these figures and the cost of the intervention, the financial case for each intervention was then made.

It is important to note that only the energy saved from heating reduction in winter was considered for households which in all likelihood did not have an air conditioner to bring the internal temperature down in summer. This includes all low income households, most mid-hi income households and some commercial buildings.

Types of intervention and Feasibility

The interventions were initially divided into two financial subcategories: cost free interventions and capital cost interventions. Cost-free interventions are passive solar techniques that, if implemented during the construction phase, require no additional capital outlay beyond the normally assumed costs of construction. The second category of capital-cost interventions requires additional financial investment for implementation.

What is IRR?

For each intervention there is an associated energy savings. An Internal Rate of Return (IRR) is calculated using this energy savings and the intervention's capital cost. **The viability of investing in each intervention is based on its IRR.** An intervention is a good investment if its IRR is greater than the rate of return that could be earned by alternate investments. **Government projects should have an IRR of 5% or higher to be considered a good investment, whereas private projects typically require an IRR of 30% or higher.** Certain interventions have no associated capital costs when constructing a new building, resulting in an infinite IRR. In these cases, the actual annual energy savings must be considered to find the best alternative.

This division directly affects the financial feasibility of an intervention. Feasibility refers to the capacity of an intervention to provide enough energy savings over time to cover the capital costs of installation and the interest incurred for financing. A twenty (20) year time period was used for this exercise. As cost-free interventions do not require additional investment, they are considered feasible for all projects. In this regard, these interventions are passive solutions that offer savings over the lifetime of a building. For this reason, all of the cost-free interventions are recommended for use in all project locations.

Establishing feasibility for the capital-cost interventions is slightly more complicated. The exercise used the current cost of electricity, 60c per kilo-watt-hour (kWh), as the base price for data computations. The energy savings were then compiled on an annual basis for a twenty (20) year period at conservative electricity inflation rate of 10% per year.

The resulting outputs were used to compose an internal rate of return (IRR) for each intervention. The IRR is a data computation commonly used by investors and developers to measure whether or not a given project is financially feasible in terms of the expected return on investment.

As publicly funded projects are subject to lower interest rates on borrowed capital, such projects do not require as high an IRR for the given intervention to be financially feasible. A 5% IRR has been used as the feasibility requirement for publicly funded projects, while interventions to attain or surpass an IRR of 30% to be declared feasible for privately funded projects. The effect of this becomes apparent upon review of the results where quite a few interventions are shown to be feasible across many of the locations, but only for publicly funded projects.

The Interventions

The following section briefly visits the interventions that were modelled, according to the building type. The cost-free interventions are found at the top of each chart. To quantify energy savings per intervention, use was made of building energy analysis software called Builder's Toolkit.

A few quick definitions worth noting:

1. **Aluminium foil roofing** refers to the use of sisalation, an aluminium based insulation that is installed in close proximity to the roof. This intervention does not refer to use of aluminium as a substitute for traditional roofing materials.

Builder's Toolkit

Builder's Toolkit is award winning South African software developed by the University of Pretoria, that calculates the energy benefits of orientation, ceilings, insulation, shading, wall material, wall and roof colour, window size, window type, and ventilation on internal building temperatures for specific climatic conditions. It does this by calculating the energy that is required to keep the building's internal temperature at an acceptable level throughout the year. This information can be used to conduct a life cycle cost analysis for each passive solar intervention.

2. **Aluminium foil roofing + insulation** refers to the use of both sisalation and traditional insulation between a roof and a ceiling.
3. **20% Window Area and 50% Window area** are interventions that challenge the traditional commercial standard of 30% window area on the northern façade of a building. The 20% Window Area reduces the amount of window space on the northern façade by 10%, while the 50% Window Area increases the standard by 20%.

Interventions for Low Income Housing Developments

No-cost Interventions	Clay Walls
	North Orientation
	Concrete Block Walls
Capital Cost Interventions	Aluminium Foil Roofing
	Insulated Ceiling
	Ceiling
	2 Skin Walls with air gap
	Tile Roof
	Window Shading
	Exterior Colour

Interventions for Mid to High Income Housing Developments

No-cost Interventions	North Orientation
	Clay Walls
Capital Cost Interventions	Insulated Ceiling
	Aluminium Foil Roofing + Insulation
	Aluminium Foil Roofing
	Tile Roof
	Window Shading
	Exterior Colour
	Double Glazing
	2 Skin Walls with air gap

Interventions for Commercial Office-Space Developments

No-cost Interventions	North Orientation
Capital Cost Interventions	2 Skin Walls with air gap
	Window Shading
	20% Window Area
	50% Window Area
	Double Glazing
	Exterior Colour

Clay as a building material

There are clay buildings around the world that are hundreds of years old and are still intact. Thick clay walls are excellent insulators – far better than bricks – that will keep a house cool in the summer and warm in the winter, while keeping air humidity at a comfortable level. There are a number of construction techniques that use clay as a base for walls. Clay bricks, rammed earth, cob, and lightweight clay construction are just a few.

While the benefits of using clay wherever possible are clear, there are regulatory, financial and social barriers to it:

- A clay building is classified as an alternative building in SA. The National Home Builders Registration Council must approve a house before banks will finance it, and the council currently has no guidelines for alternative clay buildings. No housing grants or subsidies are available for the same reasons.
- At a low income level, the perception is that clay is inferior, and that only brick and mortar constitute a 'proper house'

A code of practice for clay based structures was developed for Namibia in 2007. This has enabled people to build safe and solid clay houses while serving as a base for construction approval by authorities. For a copy of this contact Sustainable Energy Africa.

Results

Graphically, the modeling results have been separated into two types of charts. The first are those that focus on the IRR returned by an intervention given the building type, ventilation system, and project location. The second are those that focus on the public and private feasibility of the interventions given the building type, ventilation system, and project location. The charts that focus on feasibility can be used to determine the appropriate interventions for use in specific buildings depending on the type of ventilation system and the project location. The charts that focus on the actual IRR can be used to determine which of the appropriate interventions, given the project location and ventilation system, will result in the largest return on investment. These charts can be particularly helpful in projects where the budget will only allow for a single intervention to be employed.

Beyond labeling interventions as capital-cost or no-cost, there has been an additional distinction made for "No-Value Interventions". This category refers to interventions that, when modeled for the specific building type, ventilation system, and location, resulted in an IRR below 5%. The reference does not imply that an intervention has no effect on energy savings, but rather that, over the modeled time period, the effect is too little to declare the intervention economically viable on borrowed capital, regardless of the source of funding.

The appropriate interventions for use in specific building types are presented according to building type and ventilation system. In general, this section will focus on the financial feasibility of an intervention, rather than the specific IRR returned. For a full list of IRRs, please go to

www.cityenergy.org.za/resources/built-environment-and-housing

Please note that as no-cost interventions result in an infinite IRR, and are thus feasible for all projects regardless of location or source of funding, they are not discussed any further in this section.

Intervention Results for the Low Income Housing Developments

<table>
<tr><th colspan="5">Low Income - cross city comparison- Government Financial Feasibility</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">Intervention</th><th colspan="3">City</th></tr>
<tr><th>Cape Town</th><th>Durban</th><th>Pretoria</th></tr>
<tr><td rowspan="3">No-cost Interventions</td><td>Clay Walls</td><td rowspan="3">Yes</td><td rowspan="3">Yes</td><td rowspan="3">Yes</td></tr>
<tr><td>North Orientation</td></tr>
<tr><td>Concrete Block Walls</td></tr>
<tr><td rowspan="3">Immediately Beneficial Capital Cost Interventions</td><td>Aluminium Foil Roofing</td><td rowspan="3">Yes</td><td rowspan="3">Yes</td><td rowspan="3">Yes</td></tr>
<tr><td>Insulated Ceiling</td></tr>
<tr><td>Ceiling</td></tr>
<tr><td rowspan="4">No-value Interventions</td><td>2 Skin Walls with air gap</td><td rowspan="2">Yes</td><td rowspan="2">No</td><td rowspan="2">Yes</td></tr>
<tr><td>Tile Roof</td></tr>
<tr><td>Window Shading</td><td rowspan="2">No</td><td rowspan="2">No</td><td rowspan="2">No</td></tr>
<tr><td>Exterior Colour</td></tr>
</table>

It should be noted that for low income households, the energy savings will be realised by the end user while the investment is made by the government. In this sense, the table above indicates which interventions the government should consider to be most beneficial to the end user, for the money that they put in.

The modeling for low-income housing developments revealed the use of sisalation to be feasible for all projects regardless of the source of funding, while the use of ceilings, and the use of insulated ceilings are publicly feasible for all projects regardless of location. Of these three interventions, the use of sisalation seems to be the most efficient intervention as it returned the highest IRR across all project locations. The use of two skin walls with an air gap was also found to be a publicly feasible option for use in Cape Town and Pretoria.

Low Income – cross city comparison– Private Financial Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No-cost Interventions	Clay Walls	Yes	Yes	Yes
	North Orientation			
	Concrete Block Walls			
Immediately Beneficial Capital Cost Interventions	Aluminium Foil Roofing	Yes	Yes	Yes
	Ceiling	Yes	No	Yes
	Insulated Ceiling	Yes	No	Yes
No-value Interventions	2 Skin Walls with air gap	No	No	No
	Tile Roof			
	Window Shading			
	Exterior Colour			

The table above indicates which interventions will be beneficial to end users should they wish to implement the interventions at their own expense.

With regards to privately funded low-income housing developments, the use of sisalation is the only intervention that proved to be financially feasible for all project locations. However, the use of use of ceilings, with or without insulation, was shown to be financially feasible for privately funded projects in Cape Town and Pretoria.

None of the other interventions modeled for the low-income distinction resulted in financially feasible rates regardless of the project location or source of funding. These interventions are not recommended for use in low-income housing developments that require borrowed capital.

Intervention Results for Mid to High Income Houses with Air Conditioning (A/C)

With regards to mid to high-income houses using air conditioners, only the use of insulated ceilings proved to be feasible for all projects regardless of the source of funding or location of development. It can also be noted that, regardless of location, the use of exterior colouring and double glazing did not prove to be of any value for these houses.

Government Investment

Mid to High Income With A/C – cross city comparison-Government Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
	Clay Walls	Yes	Yes	Yes
Capital Cost Interventions	Insulated Ceiling	Yes	Yes	Yes
	Aluminium Foil Roofing + Insulation	Yes	Yes	Yes
	Aluminium Foil Roofing	Yes	Yes	Yes
	Tile Roof	Yes	Yes	Yes
	Window Shading	Yes	No	Yes
	2 Skin Walls with air gap	No	Yes	Yes
No Value Interventions	Exterior Colour	No	No	No
	Double Glazing	No	No	No

In addition to the use of insulated ceilings, the use of sisalation with or without an insulated ceiling, and the use of tile roofing proved to be financially feasible for all projects of this distinction, regardless of location. The use of window shading did prove to be financially feasible for publicly funded projects, but only in Cape Town and Pretoria. The use of two skin walls with an air gap was also publicly feasible, but only for Durban and Pretoria.

Private (End user) investment

Mid to High Income With A/C – cross city comparison-Private Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
	Clay Walls	Yes	Yes	Yes
Capital Cost Interventions	Insulated Ceiling	Yes	Yes	Yes
	Aluminium Foil Roofing + Insulation	Yes	No	Yes
	Aluminium Foil Roofing	Yes	No	No
	Tile Roof	No	No	yes
No Value Interventions	Window Shading	No	No	No
	2 Skin Walls with air gap	No	No	No
	Exterior Colour	No	No	No
	Double Glazing	No	No	No

The use of sisalation alone, or in combination with an insulated ceiling, in addition to the use of insulated ceilings alone, did prove to be financially feasible for privately funded mid to high-income housing developments in certain locations. While the use of sisalation alone was found to be privately feasible in Cape Town, the use of sisalation in combination with an insulated ceiling was found to be privately feasible in both Cape Town and Pretoria. Beyond the use of insulated ceilings, no other capital-cost interventions proved to be financially feasible in the city of Durban for this distinction.

Intervention Results for Naturally Ventilated Mid to High Income Houses

With regards to naturally ventilated mid to high-income houses, none of the capital-cost interventions were financially feasible for all locations and all funding sources. Likewise, the use of window shading and exterior colouring did not prove to be of any value regardless of project location or funding source.

Government Investment

Mid to High Income Without A/C – cross city comparison-Government Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
	Clay Walls	Yes	Yes	Yes
Capital Cost Interventions	Insulated Ceiling	Yes	Yes	Yes
	Aluminium Foil Roofing + Insulation	Yes	Yes	Yes
	Aluminium Foil Roofing	Yes	Yes	Yes
	Tile Roof	Yes	Yes	Yes
	Double Glazing	No	No	Yes
	2 Skin Walls with air gap	No	Yes	Yes
No Value Interventions	Window Shading	No	No	No
	Exterior Colour	No	No	No

For publicly funded mid to high-income housing developments with natural ventilation the use of insulated ceilings, sisalation, a combination of the two, and the use of tile roofing proved to be feasible for all project locations. In addition to this, the use of double-glazing was found to be publicly feasible for Pretoria, while the use of two skin walls was publicly feasible in Durban and Pretoria.

Private (End user) Investment

Mid to High Income Without A/C – cross city comparison-Private Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
	Clay Walls	Yes	Yes	Yes
Capital Cost Interventions	Insulated Ceiling	Yes	No	Yes
	Aluminium Foil Roofing + Insulation	Yes	No	Yes

No Value Interventions	Aluminium Foil Roofing	No	No	No
	Tile Roof	No	No	No
	Double Glazing	No	No	No
	2 Skin Walls with air gap	No	No	No
	Window Shading	No	No	No
	Exterior Colour	No	No	No

None of the capital-cost interventions proved to be privately feasible across all locations. The use of insulated ceilings, either alone or in combination with sisalation, proved to be feasible for private projects of this distinction in Cape Town and Pretoria. None of the modeled capital-cost interventions were found to be privately feasible for the city of Durban.

Intervention Results for Commercial Office with Air Conditioning Systems

For commercial spaces with air conditioning (A/C) systems there were no modeled interventions that proved to be financially feasible for all funding sources and locations. Similarly, three interventions proved to be of no value regardless of project funding source or location: 50% window area, double glazing, and exterior colouring.

Government Investment

Commercial/Office With A/C- cross city comparison-Government Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
Capital Cost Interventions	2 Skin Walls with air gap	Yes	Yes	Yes
	Window Shading	Yes	Yes	Yes
	20% Window Area	No	No	Yes
No-value Interventions	50% Window Area	No	No	No
	Double Glazing	No	No	No
	Exterior Colour	No	No	No

The model did find the use of two skin walls and the use of window shading to be publicly feasible options for all locations. It was also found that the use of 20% window area is publicly feasible in Pretoria.

Private (End user) Investment

Commercial/Office With A/C - cross city comparison-Private Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
Capital Cost Interventions	2 Skin Walls with air gap	Yes	No	Yes
No-value Interventions	Window Shading	No	No	No
	20% Window Area	No	No	No
	50% Window Area	No	No	No
	Double Glazing	No	No	No
	Exterior Colour	No	No	No

With regards to privately funded commercial developments with A/C systems, the use of two skin walls was found to be financially feasible in Cape Town and Pretoria, but not for Durban. None of the other capital-cost interventions proved to privately feasible for all of the locations.

Intervention Results for Naturally Ventilated Commercial Office-Space

None of the modeled interventions for naturally ventilated commercial offices-spaces proved to be financially feasible for all locations and funding sources. Likewise, four of the interventions were found to be of no value for any location regardless of the source of funding. These interventions included: 50% window area, the use of window shading, the use of double glazed windows, and the use of exterior colouring.

Government Investment

Comm/Office Without A/C – cross city comparison-Government Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
Capital Cost Interventions	2 Skin Walls with air gap	Yes	No	Yes
	20% Window Area	No	Yes	Yes
No-value Interventions	50% Window Area	No	No	No
	Window Shading	No	No	No
	Double Glazing	No	No	No
	Exterior Colour	No	No	No

None of the modeled interventions proved to be financially feasible across all locations for publicly funded commercial office spaces with natural ventilation. However, the use of two skin walls is publicly feasible in Cape Town and Pretoria, and the use of 20% window area is publicly feasible in Durban and Pretoria.

Private (End user) Investment

Comm/Office Without A/C- cross city comparison-Private Feasibility				
	Intervention	City		
		Cape Town	Durban	Pretoria
No Cost Intervention	North Orientation	Yes	Yes	Yes
Capital Cost Interventions	2 Skin Walls with air gap	No	No	Yes
No-value Interventions	50% Window Area	No	No	No
	20% Window Area	No	No	No
	Window Shading	No	No	No
	Double Glazing	No	No	No
	Exterior Colour	No	No	No

The only intervention found to be financially feasible for privately funded projects in this distinction was the use of two skin walls with an air gap, which was only of value for the city of Durban. All other interventions were found to be of no value for privately funded commercial projects with natural ventilation.

6.2.2 Benefit of Technological Interventions

Solar Water Heating and Efficient Lighting – See separate chapters

Efficient use of heating, ventilation and air conditioning systems

Eskom reports that HVAC systems contribute an estimated 5 400 MW to electricity demand in peak periods. This is approximately 15% of South Africa's current peak demand consumption.

1. HVAC technology has improved greatly over the last few years, and efficiencies of these systems are far better. For example some new air conditioning systems are 30% more efficient than their older counterparts.
2. Simple behaviour changes outlined below can make HVAC systems at least 10% more efficient.

- Using 'fresh' air to cool a building down at the start of the day. The outside air, even in summer, is fresh and cool early in the morning and by switching the air conditioning system's fans on, the cool, natural air is drawn into the building. Not only does it lower the inside temperature, but it also flushes out the stale air from the previous day. In this way, the building is cool and fresh when the employees and customers arrive, and the energy intensive chillers need only start operating towards mid-morning.
- Slight adjustments to the temperature setting of the air conditioning system can result in substantial savings. It is advisable that the difference between the inside and outside temperatures should not exceed 10 degrees Celsius. Compared to current practices, this means that air conditioners can be set a degree or two higher in summer and a degree or two lower in winter. Not only would the air conditioning not have to work quite so hard to maintain the desired temperature, but health wise it is also wiser to not subject the body to severe temperature contrasts. If the outside temperature is 35 degrees, for example, and the inside temperature is maintained at 25 degrees instead of 20 degrees, a 33% saving in energy consumption will be realized.
- Towards the end of the working day, the building's air conditioning system could "wander". This means allowing the temperature to gradually increase, given that employees are due to leave soon and will then encounter the temperature outside. It is not energy efficient to maintain a cool interior long after the people who needed it, have gone.

6.3 Potential for Rollout

Passive Solar

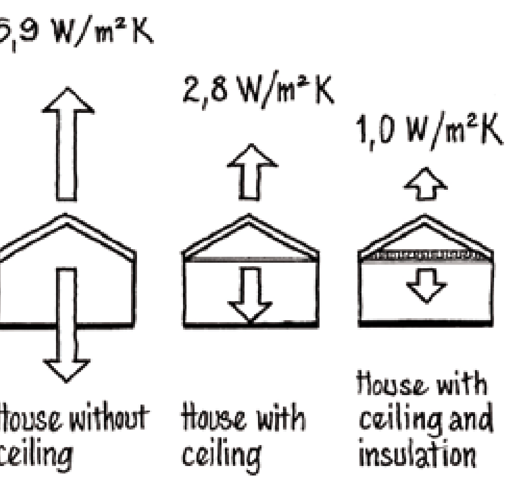
Based on the detailed analysis provided around passive solar interventions, a strong financial case can be made for several interventions across all building types. As such these interventions can and should be rolled out around the country using mechanisms which will be discussed in the following section of this manual. The following table indicates the potential benefits of these passive solar interventions should they be applied to a large municipality such as Cape Town, and if they were applied to all the housing stock in the country.

	Annual Energy Savings from Low Income Housing interventions (GWh)			
	Orientation	Ceiling	Additional insulation	Sisalation
Cape Town	29	296	231	310
South Africa	421	2,641	2,028	5,819
	Annual Energy Savings from Mid-High Income Housing interventions (GWh)			
	Orientation	Additional insulation	Sisalation	
Cape Town	62	289	625	
South Africa	5,907	27,497	59,378	

Fitting ceilings in low Income houses

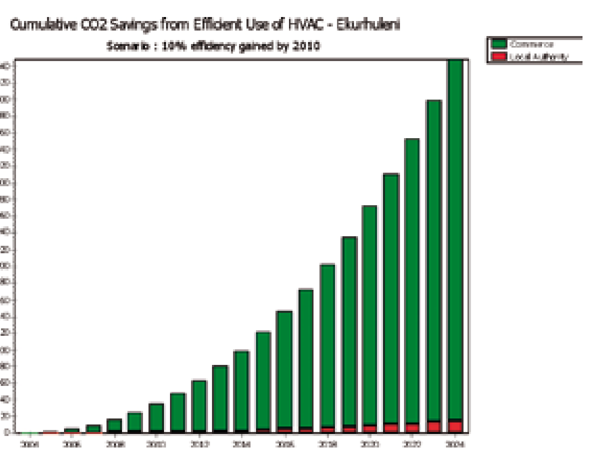
One of the best ways to make a house more energy efficient is to reduce the flow of heat into and out of the house. This is achieved through insulation. Insulation keeps a house cooler on a hot day and warmer on a cold day. As most heat in a house is lost through the roof, the most effective way to insulate a house is to fit a ceiling. In areas with cold winters, a ceiling can reduce space heating costs by up to 50%.

In South Africa, most of the low cost houses built by government don't have ceilings fitted. This means that large amounts of additional energy are required to heat these houses in winter. For



Heat resistance gained by ceiling and insulation material.

For a more detailed analysis of the efficiency gains possible through efficient HVAC in your particular city, make use of the energy efficiency tool which you can download from www.cityenergy.org.za/resources/energy-efficiency



a household that has little money, the cost of this extra heating can be exorbitant. Installing a ceiling will therefore have several benefits:

- Financially feasible based on analysis in previous section. Less money spent on heating in impoverished households.
- Improved indoor air quality (where paraffin stoves and fires are used for heating), health and comfort.
- Less energy used means less non renewable resources being used and less CO2 being produced.
- In poor households that cannot afford heating, ceilings will have a positive affect on the health of the household. This is good for the city economy as well as fewer working days will be lost through illness.

HVAC

Efficient use of HVAC

Ekurhuleni set the following target in their Energy Strategy:

- 10% efficiency gained by 2010

Energy savings

If Ekurhuleni achieves its targets by 2024, 450 thousand MWh of electricity will have been saved. In power station capacity terms, in 2024, it will negate the need for a 7MW facility (including transmission line losses and a reserve capacity of 30%).

Carbon savings

On the carbon saving side, if the city achieves its targets, over 440 thousand tonnes of CO2 will have been saved by 2024.

6.5 How to go about implementation

Ceiling installation in low cost housing delivery

Current subsidised housing in South African cities does not include ceilings in the top structure, with the exception of those cities falling within the Southern Cape Condensation area, which receive a top-up subsidy for ceiling and plastering of houses in a bid to combat the damp-aggravated TB epidemic in the region.

Installation of ceilings in homes is identified at an important intervention within the Department of Housing's Draft Framework on Environmentally Efficient Housing. The mechanisms through which to ensure this intervention occurs remain unclear. Cities need to consider inclusion of ceilings within their minimum requirements for low cost housing development and lobby national government for an extension of the "top up" subsidy to all areas in South Africa to cover additional costs. Local government would then administer this subsidy.

Additionally, the programmatic CDM methodology for energy efficient low income households will soon be approved, which will subsidise amongst other interventions the installation of ceilings in low income households. The proposed Sustainable housing Facility (SHF) which will be housed in the Department of Housing, will collect this income and directly subsidise low income households.

Subsidies / Initiatives for energy efficient implementations

A government or utility subsidy would encourage the development of more passive solar buildings. This would help to facilitate more sustainable energy consumption. Building owners are more likely to incorporate passive solar aspects into older buildings when given financial incentive.

The South African Department of Housing is currently developing a support programme in collaboration with Global Environment Facility (GEF) to encourage financial incentives for energy efficient houses.

Business and industry are large consumers of energy. In 2007, Cape Town's Central Business District (CBD) launched an Energy Efficiency Initiative aiming to improve energy security by facilitating and managing energy efficiency in the city. This initiative is being managed by the Cape Town Partnership. The main functions of the initiative are to analyze project viability, finance and manage audit procedures and project implementation, and provide information, support and advice throughout the process.

Create awareness around savings and benefits from passive solar design and technological energy efficiency options

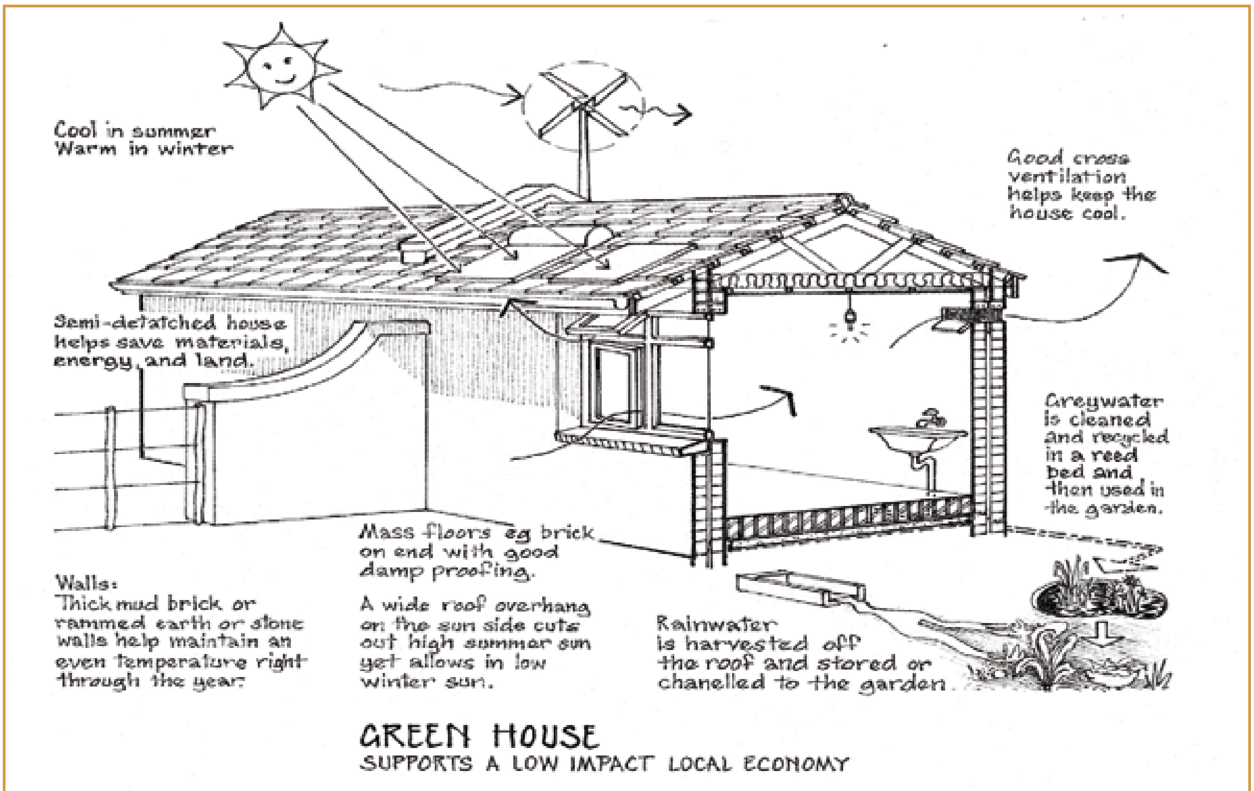
Educating building owners and eventual building owners on the benefits of passive solar design will make them aware of the potential energy savings. Building awareness programs can be launched within cities to promote passive solar design and to facilitate relationships among designers, suppliers, contractors, and buyers.

Educate building users and administrators as to the benefits of efficient use of HVAC. Also make them aware of potential savings from using more energy efficient technology. Cities can do this amongst their own staff and building administrators. They can also, through partnerships with business, encourage such awareness within the business sector. For long term impact it is important that procurement policies be adjusted to ensure efficient HVAC systems are installed in buildings, and efficient HVAC practices are built into the operational practices of buildings and responsibilities of building managers.

Develop a set of green / energy efficient building guidelines or codes – SABS Green Building Standards

Cities are mandated to enforce building regulations established by national government. As all new building plans must pass through the City for approval, this provides an important opportunity to intervene to either encourage (guidelines) or prescribe (regulation) energy efficient building interventions. Some cities have explored developing local energy efficiency building regulations, but have since abandoned this process given that building regulations are established nationally in order to promote uniformity within a vast sector, where a plethora of local standards creates conflict.

National government is in the process of exploring how to incorporate energy efficiency into the National Building Standards. Legal opinion is being sought on whether this could involve a relatively quick change to the regulations flowing from the Act, or a revision of the National Building Standards Act itself (4 years). If latter, alternative approaches may be considered by DME



in order to meet their commitments regarding energy efficiency targets.

In the absence of local regulatory powers, cities can consider developing local guidelines or standards. For uniformity and acceptability these should ideally be based on existing standards or norms. The South African Bureau of Standards has developed energy efficiency standards (SANS 204) for residential and commercial buildings that were published in October 2008. Upon researching the energy efficiency standards of several countries, the following structure for energy efficiency standards for buildings in South Africa was decided upon:

- SANS 204-1: Energy Efficiency Performance Parameters for Buildings
- SANS 204-2: Energy Efficiency in Naturally Ventilated Buildings
- SANS 204-3: Energy Efficiency in Artificially Controlled Buildings

SANS 204-1 could ultimately become part of the National Building Regulations, and SANS 204-2 & 3 will become part of the Building Code of South Africa. This will encourage the implementation of passive solar design in the residential and commercial sector. Currently the standards are voluntary, but will be made mandatory by the Department of Minerals and Energy as soon as is practical. The timeframe in which all this could take place is set between 1 to 4 years. Local government does not have the power to enforce these standards, but could actively promote and encourage their adoption through awareness and capacity building programmes within the building and architectural industry. The national utility may cooperate within such an initiative as part of their Demand Side Management programme.

A set of South African Energy and Demand Efficiency Standards (SAEDES) guidelines for new and existing commercial buildings have been developed (and form the basis for the SABS standards) and may provide an interim guideline. The City of Tlokwe has shown interesting local initiative whereby they have made the SAEDES standards guidelines mandatory for all new municipal buildings. The City works to introduce the SAEDES standards as a condition for development when commercial building applications must go through an environmental impact assessment process.

Green Building Rating System: Setting Standards using Green Star SA

In order to objectively assess how "green" a building is; standards and benchmarks must set. This can be done using a points system like that of LEED in the US, BREEAM in the UK, or Green Star from Australia.

Green Star SA is a green building rating system that has being developed by the Green Building Council of South Africa based on the Australian Green Building Council's Green Star system. It has been customized for South African use, and is currently only applicable to commercial buildings. For more information go to **www.gbcsa.org.za.**

Australian Green Building Rating System: Green Star

Green Star is a rating system that evaluates the environmental design and achievements of buildings. It is a voluntary program that is in place all across Australia. With the need to establish a common national system, Australia has set a standard of measurement for green buildings that assesses the environmental impact resulting from a projects site selection, design, construction, and maintenance.

Green Star was developed in order to promote integrated, whole-building design, to recognise environmental leadership, to identify the life-cycle impacts of a building, and to raise awareness about the benefits of building green. A credit system results in a corresponding Green Star Certified Rating that is based on the following nine categories: Management, Indoor Environment, Quality, Energy, Transport, Water, Materials, Land Use & Ecology, Emissions, and Innovation.

Each category is divided into credits that represent initiatives that improve or have the potential to improve environmental performance. Associated with each initiative are points that demonstrate the objectives of Green Star have been met by the project. A percentage score is calculated using these credits, and Green Star environmental weighting factors are applied to give one of the following Green Star Certified Ratings:

- 4 Star Green Star Certified Rating (score 45-59) signifies 'Best Practice'
- 5 Star Green Star Certified Rating (score 60-74) signifies 'Australian Excellence'
- 6 Star Green Star Certified Rating (score 75-100) signifies 'World Leadership'

Limiting building energy footprints

Given that local authorities may not be well placed – legally and technically - to tackle the complex task of establishing local building regulations, the possibility of local authorities approaching the problem 'from the other side' could be considered. This would involve local authorities limiting the quantity of energy consumption in buildings through setting maximum energy/m2 caps within building applications. This approach requires exploration in terms of whether cities may legally apply such quantity limitations, as well as what computer tool and capacity would be needed to apply such a system within the building applications process.

6.6 Case studies

Case study: Improving energy efficiency of the Tygerberg administration building in the City of Cape Town

The Tygerberg Administration building in Parow, Cape Town was chosen as a lead building energy efficiency project after an energy audit was performed and huge saving opportunities were identified. The project, initiated in 2003, aimed to reduce energy use, expenditure and greenhouse gas (GHG) emissions through introducing technological interventions and the promotion of behavioural change amongst building users (city staff).

Based on an initial energy audit, a 20% savings target was established for the project. Regular project meetings were held with relevant staff members to plan for the interventions, provide feedback on successes and problem areas of the project and decide on what follow-up actions were required.

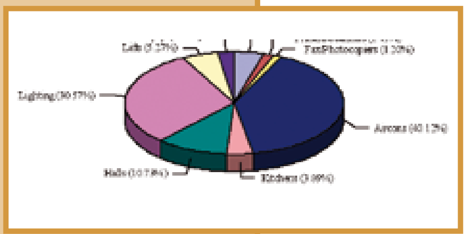
The Tygerberg building housed 200 staff and comprised 150 offices, 6 kitchens, 4 meeting rooms and one council chamber. The building contained a range of electricity appliances, ranging from air conditioners and computers to printers and fridges.

The technological interventions included the replacement of 500 incandescent light bulbs with compact fluorescent light bulbs (CFLs), installation of a solar water heater, installation of geyser timers on hot water cylinders, the replacement of some of the tea urns with insulated urns (hydroboils), installation of more efficient fluorescent tubes/ballasts and adjusting air conditioning thermostat settings and use times.

The behavioural change component of the programme involved regular contact with staff members via email updates, a display board set up at the entrance of the building displaying savings from the project; information pamphlets and newsletters keeping staff constantly updated on project achievements and requesting staff to take action to reduce their electricity bill.

The average monthly electricity consumption was 57 507 kWh prior to project implementation. Air-conditioning systems and lighting were the largest consumers of electricity. The

Tygerberg Administration building



Electricity use profile of the Tygerberg Administration building

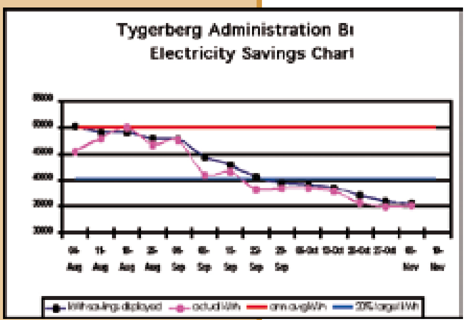


Table 1: Total savings

	Saving/ mth	Saving/yr
kWh/ month	12 000	144 000
Tons CO2	13.2	158.4
Rands	3 240	38 880

project achieved a saving of 12000 kWh per month amounting to annual saving of 144 000 kWh of electricity – a 22% saving. This translates to saving of R 39 000 per year and 158.4 tons of carbon emissions avoided per year. The benefits were substantial. Approximately 14% of the savings was achieved in the technical phase (when the technological interventions were implemented) and a further 8% achieved in the 'staff participation' behaviour change phase.

The total reduction in carbon dioxide emissions was 13.2 tons of carbon per month. The payback period for the project was estimated at 2 years.

Lessons learned

The project reflected huge savings potential from the interventions used, shown by the project targets being easily met and a short payback period. This implied that the application of such interventions in other City of Cape Town buildings would likely be technically and financially feasible, save substantial amounts of money and reduce greenhouse gas emissions.

It was difficult to determine a clear distinction between change attributed to technical interventions and staff awareness (behavioural change). This was due to change in staff behaviour already occurring on hearing about the project being performed in the building, well before the behavioural changes were requested.

Substantial support from external consultants was provided during project implementation. At the time of the project it was noted that internal city capacity was not adequate to undertake such initiatives in other City of Cape Town buildings.

Case Study: BP Head Office, Cape Town

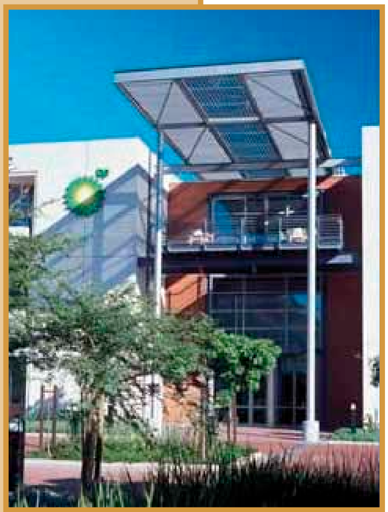
BP prides itself on being committed to sustainability. To compliment minimizing the environmental impacts of their activities, BP is providing an eco-friendly, energy conserving environment for their employees at the BP South Africa head office in Cape Town. Using consistent and high environmental standards, the BP building was designed to incorporate passive solar initiatives, renewable energy, and energy efficiency starting with the construction process and following through to the functioning of the building.

With a Mediterranean climate, Cape Town is hot and very dry during the summer months, and wet and cool during the winter months. The strong winds and severe weather that result from the merging of two oceans also have to be considered when designing a building with an environmental focus. With these conditions in mind, BP aimed for "ground breaking environmental performances".

Environmental targets

The annual energy consumption of the BP head office was projected to be 115 kWh/m2, which is considerably less than the 250-400 kWh/m2 that standard buildings use. BP aims for 10% of this energy consumption to come from renewable resources, and water consumption was to be 20% better than an equivalent conventional building. Imported building materials were kept to a minimum, locally sourcing them wherever possible, with a large amount being recycled materials. Construction waste was also sorted and recycled. In cold weather, when the outside temperature is ±7˚C, BP aimed to keep the indoor temperature no lower than 21˚C. In hot weather, when the outside temperature is ±32˚C, the aim was to keep the indoor temperature no higher than 24˚C.

Interventions



The major passive solar interventions that had the most effect on the performance of the BP building are shading the building and insulating the envelope. Roof insulation, the façade of the cavity walls, and deeply recessed, double glazed windows also added to the building's energy efficiency. Decreased demand resulted in 80% of the building's energy savings with no extra cost.

Openings in the roof, called roof lanterns, have a number of functions. They allow natural light in for plants and trees while lessening the need for artificial light and reducing solar gains. They also provide passive exhaust of warm, stale air and naturally ensure smoke extraction in the event of a fire. Dimmable fluorescent lights are automatically regulated to compensate for fluctuations in sunlight.

Energy from the sun is harnessed to lessen the need for electricity from the grid. Hot water is produced with thermal solar panels and photovoltaic panels cover almost 1/3 of the building's roof, providing 10% of its overall energy requirements. Solar collectors are also used to shade the envelope and canopies/ walkways.

Water consumption targets were met and exceeded by recovering rainwater from the roof and hard surfaces. Condensed water from AC units and water from showers and hand wash basins is also recovered and stored in a grey water tank. The building uses only 25% of the potable municipal water that a conventional building would use.

Awards

Within weeks of opening its doors, the BP Building won the South African Property Owners Association (SAPOA) 2005 Award for innovative office developments.

Case Study: Green Building, Cape Town

Being a promoter of sustainable energy approaches and practices, the founders of Sustainable Energy Africa wanted to show that a green office building could be built with limited financial resources. They aimed to do this through passive solar design and by reusing resources, recycling waste, reducing energy consumption, using clean energy sources, locally sourcing materials, and reducing water consumption.

Interventions

A number of passive solar design features were used to achieve the energy efficiency of the Green Building, including building orientation, shading and windows, and thermal mass. As a direct result, the energy required for heating and cooling has been dramatically reduced. Daylighting was maximized using clerestory, window area optimization, and avoiding deep office spaces. This has made the need for artificial lighting during the day almost obsolete. Hot water is generated with a solar water heater on the roof, where solar panels also generate electricity that is fed back into the City's power grid via a grid-synchronising inverter.

During the construction of the Green Building, recycled content was maximized by using recycled windows, doors, and timber flooring. Reconstituted bricks containing 92% recycled material were also used throughout the building. The materials and contractors were locally sourced, requiring minimum transport to the site.

Where water is concerned, the intention is to reduce water usage, and to collect and re-use water wherever possible. Water consumption has been reduced by using multi-flush toilet cisterns and low-flow taps and shower heads. Recycled grey water and harvested rainwater take care of the water requirements of the water-wise and functional garden. External paving in the parking lot of the Green Building allows water seepage into the aquifer.

The result of the Green Building's interventions is a building that surpasses most energy efficiency targets. An office building is considered efficient if it uses less than 100 kWh/m2/year. The Green Building uses only 30 kWh/m2/year, whereas conventional offices use 250-400 kWh/m2/year. The cost of building green was 30% lower than the cost to build a conventional building, and the value of the building increased by 32% after two years.

Awards

The Green Building received the 2004 Sustainable Building Best Practice Award for noteworthy sustainable buildings in Africa, with a score of 3.9 out of 5 concerning social, economic, and environmental factors. It also received the 2004 Cape Times Caltex Environmental Award for outstanding achievement in environmental conservation.

6.7 Support organisations

Key roleplayers to support Energy Efficient Building Implementation

CSIR

Technical support

CSIR can offer support in the areas of research and technology (including testing), training and capacity building. Cities can engage with them as necessary.

CSIR is involved with a Green Building for Africa Programme working on green labelling of buildings. Cities should keep abreast with developments of this programme.

Technical Enquiries

Tel: 012 841 2000

Email: callcentre@csir.co.za

Website: www.csir.co.za

Department of Housing (DoH)

Capacity building and policy development

DoH are busy finalizing a Framework for Environmental Efficiency in Housing in South Africa. They are also working towards the establishment of a Sustainable Housing Facility to access CDM funding for making low income housing more energy efficient

Pretoria Switchboard Tel: 012 421 1311

Cape Town Switchboard Tel: 021 466 7600

Website: www.housing.gov.za

Department of Minerals and Energy (DME)

Capacity building, policy development

DME is engaged in Building Energy Manager training support for government. This could potentially extend to cities.

Head Office

Switchboard Tel: 012 317 8000

Fax: 012 322 3416

Centurion

Reception Tel: 012 679 9565 / 9563

Website: www.dme.gov.za

Development Bank of Southern Africa (DBSA)

Debt Financing and a limited Technical Assistance grant facility

DBSA is able to support cities through offering a carbon finance facility in association with the World Bank.

DBSA will consider debt financing of commercially viable clean energy projects

DBSA also has a technical assistance facility that may support cities to finalise a component of their detailed clean energy feasibility study.

Website: www.dbsa.org

Eskom

Financial assistance

Eskom Demand Side Management (DSM) provides financial support to energy efficiency projects.

DSM Help Desk

Tel: 011 800 4744

Website: www.eskom.co.za

Green Building Council of South Africa

Promotion of Green Building practices in SA.

GBCSA encourages and facilitates green building in the South African property and construction industry through:

- Green building promotion
- The provision of Green Building resources
- The development of a green building rating system
- Offering training and education around green building

Tel: 021 659 5990/1

Fax: 021 689 3737

Website: www.gbcsa.org.za

7. Public transport

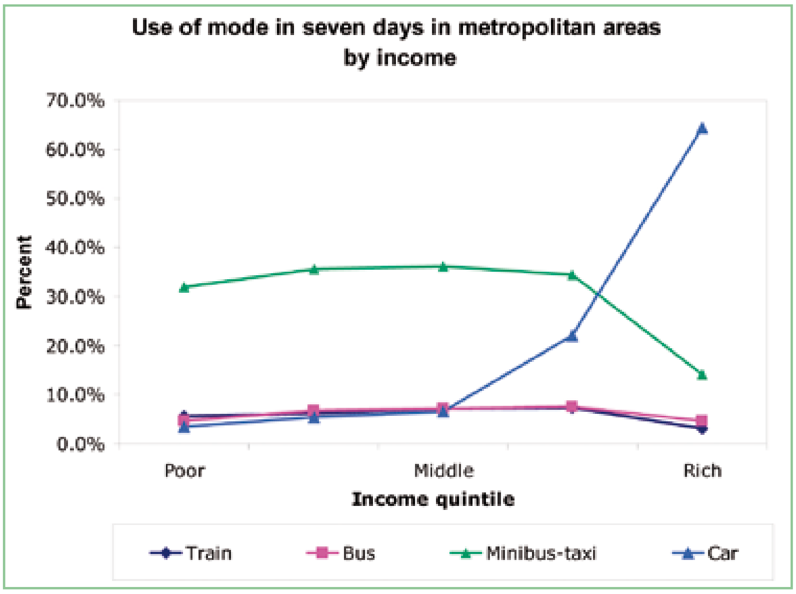
7.1 Overview

While public transport is a huge field and can't possibly be covered in a few pages, the benefits for cities of a move towards improved public transport are so significant that the sector must be addressed, if fairly broadly. In this section we provide an overview of the key issues and hopefully strengthen the case for prioritizing public transport in South African cities.

The focus of this section is on how to achieve a transport modal shift in South Africa. Modal shift should be viewed from two perspectives:

- a shift from private to public or non motorized transport of daily commuters.
- optimizing the use of public transport.

A large percentage of commuters use private vehicles. In the large metropolitan cities, the modal split is generally 50% private to 50% public transport going into the CBD. Generally the private commuters are single occupancy vehicles which lead to increased congestion and inefficient fuel consumption with associated high levels of carbon emissions. The transport sector is responsible for 25% of carbon emissions in South African cities.



Available public transport services differ across cities. In most cities there are bus and minibus taxi systems, with rail found in the main metropolitan cities, but not in the smaller cities. City bus and train systems provide the most efficient forms of transport in terms of energy per commuter kilometre; however, even though these are by and large the same price or cheaper than minibus taxis, they are underutilized. This is due to:

- Inconvenience. Bus and train systems do not service many informal settlements and are often not well linked in to an efficient network of transport systems.
- Unreliable reputation.
- Perception that they are slower than taxis.
- Safety concerns, particularly on trains.

There is a need for large scale infrastructure to improve the current public transport system in order for it to improve its current share of commuters.

For more information on cities and transport go to www.cityenergy.org.za/resources/transport

7.2 The case

Economic

An increased use of public transport will result in commuter savings on fuel and maintenance costs. In addition, lower traffic volumes will result in reduced road maintenance costs for cities and provinces. Our heavy dependence on oil imports (some 70% of all liquid fuels) with long supply lines renders South Africa vulnerable to fluctuations in international oil prices and supply disruptions. In an era when oil supplies appear to be 'peaking' this is likely to mean a substantial upward trend in the price of oil, with enormous consequences for our city economies.

Mode of Transport	Person / hour / lane	Total cost per person km (US cents (2001))	Total emissions per passenger km (gram)
Walking	1 800	Negligible	None
Bicycling	1 500	0.12	None
Motorcar	440 800	8.6	18 965
Bus: Mixed Traffic	10 000	1.4	102
Bus Rapid Transit	54 000	2.4	Coal : 4.97 Gas : 0.23 Fuel Oil : 0.17

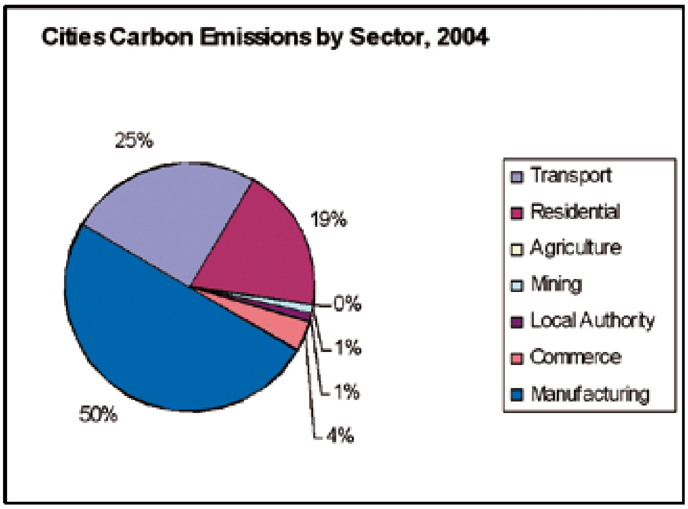
This set of photos demonstrates how the use of public transport or private motorbikes over the use of private cars can reduce congestion in a city. Each option will transport the same amount of passengers!

Environmental

The transport sector is a significant source of greenhouse gas emissions in South African cities (25%) and a major source of local air pollution. It is also responsible for 50% of energy consumption in South African cities.

A modal shift will mean less traffic on our roads, and a substantial reduction in fuel being used. This in turn leads to significantly less CO_2 emissions and local air pollution within cities.

Public transport reduces the amount of green space that must be paved over for new roads and parking lots. It also makes cities cleaner, quieter, safer and more convenient for getting around



Social benefits / Poverty alleviation

South Africa is currently experiencing high levels of unemployment, while many of those who are employed are receiving very low wages. Accessible, cheap and safe public transport for access to employment, education, health and other essential services and opportunities, is important for the development of poor communities.

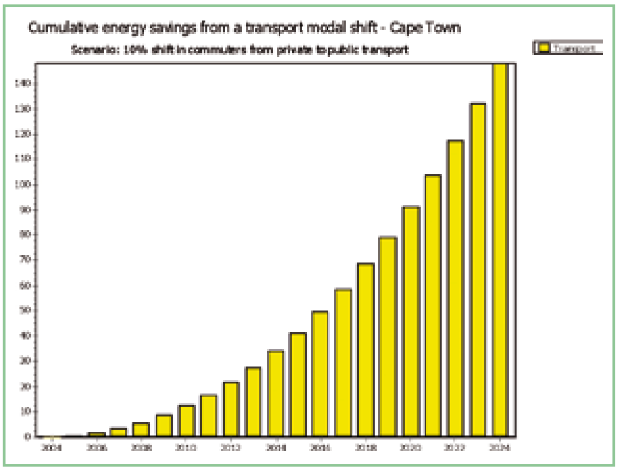
A modal shift will decrease air pollution in a city substantially, which will have large scale public health benefits. The people most affected by local air pollution from transport fuels are those walking along busy roads to work and school. As indicated in the graph above, this is predominantly poorer people without resources to cope with ill health and the economic consequences thereof.

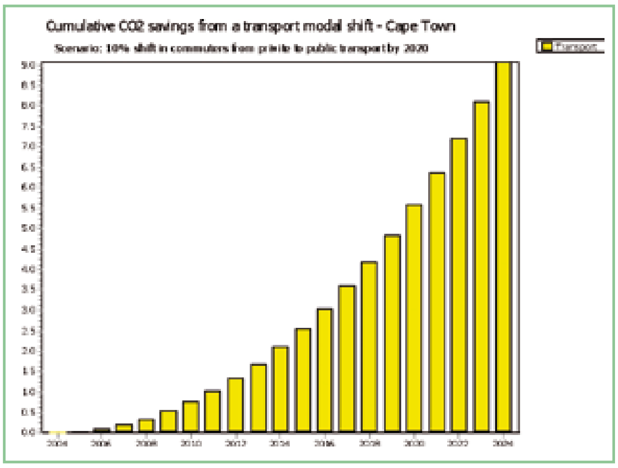
Quieter roads mean a decrease in daily travelling time and a subsequent increase in an individual's free time.

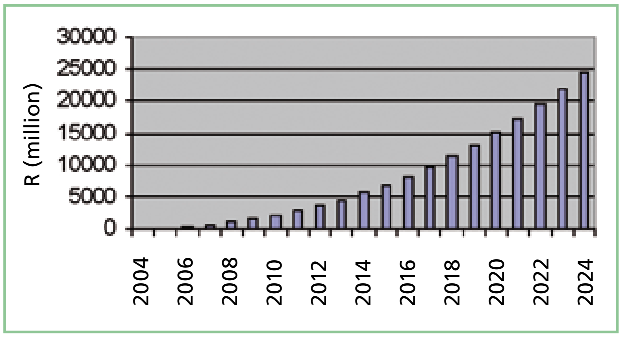
7.3 Potential for rollout

There is great potential for a transport modal shift in cities around South Africa. To demonstrate the impact of this, we will consider the case of Cape Town.

The impact of a transport modal shift in a city: the case of Cape Town







Cape Town has set the following target for achieving a transport modal shift:

- 10% shift in commuters from private to public transport by 2020.

Energy savings

If the city achieves its targets by 2024, 148 million gigajoules of energy will have been saved. This is the energy equivalent of 4.7 billion litres of petrol saved.

Carbon savings

If Cape Town achieves its targets, 9 billion tones of CO_2 will have been saved by 2020

Financial analysis

If Cape Town meets its targets, nearly R25 billion of fuel will have been saved based on today's fuel prices. Note that this graph does not take into account the huge infrastructure costs required to achieve a modal shift.

Barriers to implementation

- A shift towards increased use of public transport in South Africa will require a major upgrade and improvement in terms of the equipment, quality of service and reliability of service. This is an extremely expensive undertaking. It is also a long term undertaking. Achieving a modal shift over 20 years is thus challenging, given short-term political horizons.
- Management of public transport services is highly fragmented, which leads to competition, rather than cooperation, between the different modes.
- A current lack of public transport network integration makes for cumbersome and lengthy commutes. Unless this is addressed the commuter will prefer to make use of their private vehicle, because of convenience, even if the cost is higher.

- There is a perception amongst commuters that public transport is unsafe. Security issues need to be addressed.
- Transport strategies and approaches, originally developed in the late 1950s, remain today and don't generally look at managing demand but continue to focus on the problem of traffic congestion and the construction of new roads and highways to alleviate the problem. Integrated land use and transport planning is not yet taking place, although some municipalities have acknowledged the need for such an approach.
- Due to apartheid planning, the previously disadvantaged sectors of society have been placed on land that is situated far from formalized public transport nodes.

There are a number of projects that are currently taking place around the country, many of which are linked to the 2010 Soccer World Cup. These include the Gautrain and Rea Vaya in Johannesburg, a Bus Rapid Transit system in the Nelson Mandela Metropolitan Municipality, and an integrated rapid transport system in Cape Town. Most public transport upgrades or new developments require large capital investment as well as large scale marketing and educational awareness programmes that will inform commuters about changes.

7.4 How to go about implementation

It is necessary to develop the public transport system from what already exists. This involves a combination of regulation, integration, investment and step-by-step improvement. As passenger usage increases, income expands and re-investment in new systems and technologies becomes a realistic option.

Addressing institutional fragmentation: development of a Transport authority

The current trend in South African cities is to develop a Transport Authority, made up of transport officials from different spheres of government, the relevant transport agencies and the transport operators. The Transport Authority should help overcome institutional fragmentation and allow for integrated planning and decision-making amongst all role players.

Ethekwini was the first municipality in South Africa to have a Transport Authority. Tshwane Metropolitan Municipality and the City of Cape Town are now exploring this approach.

Improvement of the public transport system

It is important to upgrade the public transport system in order to increase the use of public transport by commuters who are currently using private vehicles. The upgrade is generally in terms of the subsidized public transport services (rail and bus), but the taxi recapitalisation process is playing a role in upgrading the minibus taxi system.

There are two possible options:

1. The upgrade of the current system with new equipment, improving the service by changing the frequency of trips, based on the commuter's needs, and a marketing programme to encourage public transport use.
2. The development and implementation of new public transport infrastructure/system, such as a Bus Rapid Transit (BRT) system, which will require some infrastructural changes including dedicated public transport lanes, stations and public transport nodes, for the feeder systems.

An important aspect that will need to be looked at is improved safety for the commuters, which is currently one of the reasons why people are not using public transport.

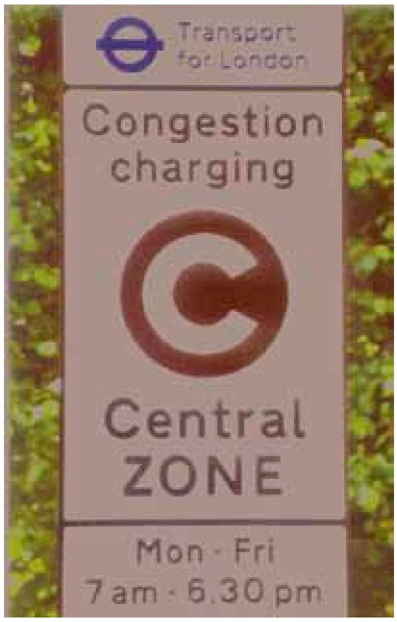
In addition, associated infrastructure around the public transport nodes, such as secure parking lots at stations for people who will "Park-and-Ride", require attention. This includes ensuring covering that will protect commuters from inclement weather when waiting for the service at bus stops, stations or minibus transfer nodes.

Promotion of travel demand management strategies to minimize single occupancy vehicles

The upgrade of a public transport system to a more reliable, convenient and safe system can encourage people to change to public transport. Other strategies need to be put in place to encourage movement away from automobile dependence.

These strategies include:

- Implementation of high occupancy vehicle lanes, which mean that cars with three or more occupant can have access to a dedicated lane. This lane usually moves more quickly during the peak periods, with free flowing traffic rather than the bumper-to-bumper traffic that is common in the peak periods.
- Employer programmes which aim to encourage the use of alternative transport, such as public or non-motorised transport or car-pooling, to get to work. This could include preferential parking for those carpooling, subsidies for public transport tickets, guaranteed ride home and moving away from subsidized parking for single occupancy vehicles.
- Park-and-Ride schemes allow people to park their cars at public transport interchanges and continue the journey on public transport. An important aspect here is the need for security at the site, in order to ensure the safety of the commuters as well as making sure that the cars are secure.
- The cost of traveling by private vehicle should also be looked at, including the need for accurate parking charges in the CBD. An international trend, which has been successful in London, is the implementation of a congestion charge for access into certain areas of the CBD. The money taken from the charge covers the operational costs of the service as well as upgrading aspects of the public transport system.



The travel demand management strategies can only work if there are suitable alternatives put in place for the commuter.

Integration of Sustainable Transport Philosophies and Approaches into City Transport Planning Departments

The placement of Sustainable Transport Professionals within cities is a useful starting point to achieve this. Having dedicated City staff whose function is to push a sustainable transport agenda will raise the profile of sustainable transport in the city, and ensure the integration of sustainable transport planning approaches, many of which are listed above, on a citywide basis. Getting sustainable transport to run as a 'golden thread' through the City's Integrated Transport Plan (ITP) would also be a key task of the STP. See 'Urban Tran:SIT Programme' Case study for more information around such a process.

7.5 Case studies

City of Johannesburg – Bus Rapid Transit (BRT)

The City of Johannesurg is building a Bus Rapid Transit (BRT) system. The system is expected to cost about R2 billion and will be the first unsubsidized public bus system in South Africa.

The first phase of the BRT system is expected to be operational by April 2009. The system will use 18m articulated vehicles running from 5:00am till midnight and will be operated by private contractors to the city. The BRT system will also make use of feeder systems and will link with existing rail stations. The city's goal is eventually to have the bus route accessible to 85% of the city's population.

The BRT will be part of "Rea Vaya Joburg" the city's plan to address growing traffic congestion. Rea Vaya ("we are going") will feature 325km of special public transport lanes and intersections and 40 transport interchange nodes where commuters can switch from one mode of transport to another.

TransMilenio – Bogotà, Columbia

Bogotà is one of the most densely populated cities in the world. In the 1990's, many of the main road ways were heavily congested and the traffic speed during rush hour was only 10km/hour. The use of private cars was a major cause of congestion. Although ± 71% of motorized person trips were made by bus, 95% of road space was used by private cars, which transported only 19% of the population.

By the end of the decade, a new mass transit system, named TransMilenio was designed and partially implemented to solve these large inefficiencies of mass transit in Bogotà.

TransMilenio is a flexible bus system that uses exclusive bus-ways to feed people into and out of the central business district (CBD). The stations are located in the middle of the road to facilitate the transfer between buses in both directions. The bus stops are 57 stations, located every 700 meters and are equipped with pay booths, registering machines, surveillance cameras and infrastructure such as bridges, pedestrian crossings and traffic lights designed to ease the entrance of passengers into the system.

At the end of the corridors, three principal access stations were built as the meeting point for feeder buses and buses from traditional systems that work in the neighbouring municipalities.

A survey conducted 2 years after TransMilenio was introduced revealed:

- 32% decrease in travel time for users
- 80% decrease in traffic accidents
- 30% decrease in the number of fatalities caused by traffic accidents

- 30% decrease in noise pollution
- 37% increase in time spent by mothers and fathers with their children
- There have been a number of criticisms based on the way the system works
- Buses and stations are often packed to or beyond safe operating capacity, even during non-rush hour periods.
- The use of diesel buses instead of clean burning natural gas or electric-powered light rail is best defined as an economic decision made to benefit the private contractor and not the best interest of the city.
- Because TransMilenio is based on diesel rather than electric energy, its costs increase with increasing oil prices and this causes the fares to be increased to meet this cost.
- Many users complain about pick-pocketing inside the bus, a problem which is made worse by overcrowding.

In addition to exclusive bus-ways, the City of Bogotà has 230km of bike lanes, with plans to increase this to 350km, as well as expanding side walks and adding a 17km pedestrian zone. Among the travel demand management (TDM) measures instituted are forbidding private cars to operate in Bogotà CBD during the morning and evening peak. Parking fees were increased by 100% and fuel taxes were increased by 20%. Bollards were built to prevent people from parking illegally on the sidewalk. A key promotion measure is "car free day" held once a year on a week day and car-free Sundays on particular roads.

The Urban Tran:SIT Programme – City of Cape Town

The Urban Tran:SIT Programme was a three-year partnership between the City of Cape Town Transport Department and Sustainable Energy Africa (SEA) that ran from 2006 - 2009. SEA, a not-for-profit NGO, catalysed the programme by securing funding from the British High Commission.

The purpose of the programme was to build capacity in the City of Cape Town around sustainable transport and to integrate sustainable transport approaches into planning, policy and implementation of projects. In order to achieve this, a "working from the inside" approach was adopted through the placement of a dedicated Sustainable Transport Professional (STP). The STP's function was to focus exclusively on sustainable transport in the City. The idea was that through this approach a far more effective change could be achieved than through traditional consulting methods. Not only was her work within the Transport Department, but her involvement with other City departments raised the profile of sustainable transport broadly within the City of Cape Town.

Integrating sustainable transport into planning and policy was a key focus area of the programme. Through meetings, focused workshops, technical and advisory support the work of the STP, the Tran:SIT programme was instrumental in ensuring that sustainable transport planning approaches were accepted and then entrenched in the City's transport planning policy document, the Integrated Transport Plan (ITP). Central to this document will be a set of sustainable transport performance indicators, which the Tran:SIT programme helped to develop.

The Urban Tran:SIT programme supported the implementation of a number of projects that showcased aspects of sustainable transport and two demonstration projects were embarked on during the programme as part of the STP's portfolio of sustainable transport programmes. A Park 'n Ride project, which is linked with 2010 planning, will encourage car users to use the train for their work commutes, by upgrading parking facilities at key train stations. A Large Employers Programme is focussed on encouraging big business in the CBD to promote sustainable transport approaches to their employees for travelling to work.

The Urban Tran:SIT Programme was the first of its kind in South Africa and a number of lessons from this experience have been learnt over the last three years. The key lessons from the programme are highlighted here as part of the knowledge exchange with other Cities and stakeholders.

For a sustainable transport programme to be successful at a municipal level, a change in the way the City operates is required. To this end there must be both the **political will** to instigate and inspire the change, as well as an **enthusiastic buy-in from senior City officials**. A political champion, such as an Executive Councillor or Mayor is ideal to promote this message, while a leader at official level who champions sustainable transport will be the 'on the ground' source of inspiration for other City staff.

Capacity building, including training up and supporting the STP, workshops, information dissemination and technical support, is fundamental to getting a City to think differently about transport planning and implementation. Working with the City from the inside through the STP has proved to be an effective method of achieving this, as there is a 'face of sustainable transport' within the City.

Once capacity is built, the **integration of sustainable transport into policy** is the next step. Essentially, this means that the Integrated Transport Plan needs to have a sustainable transport thread running through the document. Programmes and projects focussing on transport through a sustainability lens can then be embarked on, safe in the knowledge that the work fits within the framework of the ITP and more broadly the Integrated Development Plan for the City.

There is a danger in an under capacitated City Transport Department that the STP can be seen as 'another pair of hands' and will be brought into work that is not clearly linked to the focus of the programme. This did occur from time to time, largely due to pressures being placed by the 2010 World Cup deadlines. **Future STP appointments must have clear job descriptions and work on specific sustainable transport projects** from the outset.

The programme would have been **more effective if STPs were place concurrently in several cities** around the country. Not only would the STP's have a dynamic support network, but better inter-city communication channels around sustainable transport would have been created.

The City of Cape Town **procedures and processes are bureaucratic in nature** and resulted in delays in aspects of the project. This will need to be budgeted into future programmes, as this generally cannot be ignored when working in a local authority environment. The capacity constraints within the Department have also impacts on the implementation of the projects.

The 2010 World Cup and implementation of related projects are currently the priority for the City and much of the capacity within the staff has been given to that. This has to some extent limited the interaction with some key officials in the department as well as limited interactions at capacity building and awareness raising workshops. A core group of officials have, however, been actively involved in the programme and their input has been very valuable to the process.

The programme has facilitated better relationships with other city departments, as the STP has been involved in several inter departmental workshops, meetings and forums, awareness has been raised around the City's new focus on sustainable transport, and fostered a new level of inter-departmental communication.

At the end of the programme, it can be said that most of its objectives have been met, and in some cases exceeded. The STP post – initially planned as a 3-year contract post – was recognised by the City as a strategically critical position, and was converted to a permanent post. Sustainable transport was integrated into the heart of City transport planning and policy through the Integrated Transport Plan and sustainable transport indicators to measure progress towards achieving sustainable transport in the City of Cape Town were developed. Implementation projects were undertaken to promote sustainable transport approaches, including non-motorised transport projects in the Inner City, implementing upgraded public transport facilities and the promotion of more energy and fuel efficient vehicles.

For more information on cities and transport go to www.cityenergy.org.za/resources/transport

8. Waste to Energy

8.1 Overview

When electricity or heat is generated from a waste source it is utilizing waste-to-energy (WtE) technology, thus reducing the amount of waste that would otherwise go into landfill, or reducing the amount of methane being released into the atmosphere from landfill and sewerage sites. It is necessary to consider the possibilities that WtE technologies present, not only from their energy generation potential, but also from their potential to reduce greenhouse gases.

A number of WtE technologies exist worldwide, with the most prevalent being landfill gas, wastewater gas, incineration and gasification. These will be examined in more detail below.

It is important to remember that the most sustainable way to deal with waste is to eliminate it entirely. Reducing the amount of waste generated, reusing discarded items, and recycling and composting are fundamental principles in achieving zero waste. Municipalities should strive to achieve this goal.

Landfill Gas

When organic waste decomposes without the presence of oxygen, anaerobic fermentation slowly produces landfill gas. Landfill gas contains 40-60% methane, with the remainder being mostly carbon dioxide. Methane is 23 times more potent than carbon dioxide when it comes to its properties as a greenhouse gas, making it a key climate change gas to address. Burning methane produces energy, carbon dioxide and water. This is a very useful outcome as besides being an energy source, the hugely potent methane is replaced by the considerably less potent CO_2. For this reason landfill gas projects are potentially very lucrative CDM projects.

A landfill gas electricity generator at La Mercy landfill site, eThekwini

Landfill gas energy facilities capture the methane and combust it for energy. It can be used to produce electricity, or used directly for cooking and for space and water heating. When concentrated and compressed, it can also be used as a vehicle fuel source.

Wastewater Gas

The theory behind anaerobic digestion of wastewater is very similar to that of landfill gas in that waste is decomposed without the presence of oxygen to produce a gaseous mixture of methane and carbon dioxide. The volume and mass of wastewater sludges are reduced by anaerobic digestion, as is the emission of volatile organic compounds and odours into the atmosphere. Similar to landfill gas facilities, anaerobic digestion of wastewater produces a biogas of 60% methane and 40% carbon dioxide that can be used for energy production. This biogas can be used to generate heat and electricity or it can be used as a vehicle fuel.

Incineration

Incineration involves the combustion of organic materials into incinerator bottom ash, flue gases, particulates, and heat, which can be used to generate electricity. It is both a landfill reduction method, reducing the volume of waste by 95-96%, and a WtE technology.

The heat produced upon incineration can be used to generate steam which can then be used to drive a turbine in order to produce electricity. 500 kWh of electricity can be generated per ton of municipal waste.

Gasification / Pyrolysis

Just about any organic material, such as biomass, wood and plastic waste, can be converted into a gas mixture of carbon monoxide and hydrogen by gasification and pyrolysis.

Unlike incineration, gasification does not produce energy from waste through direct combustion. Waste, steam, and oxygen are fed into a gasifier where heat and pressure break apart the chemical bonds of the waste to form synthesis gas (syngas). It allows the breakdown of hydrocarbons into the gaseous mixture by carefully controlling the amount of oxygen available.

Syngas may be used directly in internal combustion engines or to make products that substitute for natural gas, chemicals, fertilisers, transportation fuels and hydrogen. Pollutants are removed from syngas before it is combusted, so that it does not produce the high levels of emissions associated with other combustion technologies.

Like gasification, pyrolysis also turns waste into energy by heating under controlled conditions, but involves thermal degradation in the complete absence of air. Pyrolysis produces char, pyrolysis oil, and syngas, all of which can be used as fuels.

8.2 The Case

All of the WtE technologies generate energy from products that would otherwise not be used. South Africa disposes almost all of its waste into landfills. There is a constant need for waste disposal, resulting in an equally constant energy generation potential.

By providing an alternative to fossil fuelled power stations, WtE plants reduce the emissions these plants would otherwise produce, and reduce the levels of methane being generated at the waste site. In addition to reduced emissions, these technologies reduce other adverse impacts related to coal-fired electricity production, such as coal mining and transportation. WtE technologies can help meet renewable energy targets within cities and can help to diversify energy profiles.

Currently in South Africa, and specifically from a City perspective, primary focus has been on landfill gas generation sites. For the rest of this chapter, landfill gas will receive more attention than the other technologies, as it is deemed to be the most feasible in the current climate.

Landfill gas

Using landfill gas to generate energy and reduce greenhouse gas emissions has been financially viable in South Africa to date, provided suitable carbon funding is sourced. This has been proved at eThekwini where several landfill sites currently capture methane and burn it for electricity. The cost to generate electricity from landfill gas depends primarily on the size of the generating unit, which can range from a 500 kW unit to a 4 MW unit. Data generated from a 2004 DME report on landfill gas potential gives a range of production costs from 17 to 30c/kWh (See tables below). Given inflationary increases of 8%, this figure is more likely to be around 25 to 44c/kWh for 2009.

Landfill Gas cost per kWh (DME, 2004)

Category Name		Annual Production Output (GWh)	Static Financial Cost (R/ kWh)
1	Micro	191	0.30
2	Small	160	0.19
3	Medium	215	0.18
4	Large	32	0.17
	TOTAL	598	

The following tables outline the capital costs as well as the operation and maintenance costs of the various plant sizes, ranging from 500kW to 4MW.

Landfill gas capital cost (DME, 2004)

Category Name	Category 1 Micro	Category 2 Small	Category 3 Medium	Category 4 Large
Building	110,255	–	–	–
Civil	982,925	1,632,735	2,286,280	2,858,099
Mechanical Machinery	3,691,574	6,137,612	8,525,751	10,784,794
Electrical Machinery	1,328,894	2,219,003	3,112,681	3,949,145
Other	1,089,652	1,392,110	1,683,526	1,951,202
Total Capital Cost	7,203,300	11,381,460	15,608,238	19,543,240

Landfill gas operating and maintenance cost (DME, 2004)

Category Name	Category 1 Micro	Category 2 Small	Category 3 Medium	Category 4 Large
Consumable Inputs	412,300	1,276,577	1,914,866	2,553,155
Staff				
-Skilled	37,500	37,500	37,500	37,500
-Semi-skilled	12,500	12,500	25,000	12,500
-Unskilled	12,000	24,000	36,000	48,000
Annual Maintenance	216,099	341,444	468,247	586,297
Total Operational Costs	278,099	415,444	566,747	684,297

Eskom currently sells electricity to municipalities at approximately 18c/kWh. Based on the landfill gas electricity production cast figure of 25-44c/kWh, it is clear that to make the project feasible, additional funding sources need to be present. This is where traditionally carbon funding has played a role.

However, in 2009 an alternative financing source has been made available to potential landfill gas projects. NERSA's renewable feed in tariff (REFIT) stipulates that electricity generated by landfill gas projects will be bought at 90c/kWh. Therefore, with the REFIT, no carbon funding needs be sourced to make the project viable, which means a far less onerous and complicated process to implement a landfill gas project. It is anticipated that this tariff structure will accelerate the building of landfill gas generation sites around the country.

The technology to generate electricity from landfill gas is mature, and expertise to implement the technology in South Africa exists. With the highly attractive REFIT being provided, there is a very strong case for all viable landfill sites to be set up as a landfill gas electricity generation site.

Wastewater Gas

Anaerobic digestion is a waste treatment process that powers itself. CO_2 emissions can be reduced by 16% when it is used to treat sewage waste rather than using conventional sewage treatment techniques. In addition to producing energy, anaerobic digestion can also produce quality soil conditioner to fertilize land. The conditioner is a result of the solid and liquid residue called digestate that is produced throughout the process. If the digestate is clean enough, it can also be used for land reclamation and landfill restoration.

Current costings for wastewater gas facilities place them higher than landfill gas projects. Also given that no REFIT is available for them, it is unlikely that cities will focus on this area in the short term.

Incineration

Incineration reduces mass and volume of landfill, lightening the load of landfill management in cities. There has been concern around the health ramifications of incineration, but significant advances in emission control have occurred and strict regulations have been initiated internationally concerning dioxin and furan emissions (both of which are highly toxic substances). By diverting municipal solid waste, incineration avoids the release of methane into the atmosphere. In addition to methane, for every ton of municipal solid waste that gets incinerated, approximately one ton of CO_2 is prevented from being released into the atmosphere. It is estimated that 2000 tonnes of waste have an electricity potential of 1050 MWh.

Gasification / Pyrolysis

Gasification and pyrolysis are extremely efficient ways of using biomass to produce energy, both being more efficient than incineration. They are flexible technologies where existing gas-fuelled devices (ovens, furnaces, boilers, etc.) can be retrofitted with gasifiers and syngas can directly replace fossil fuels. Gasification is able to generate energy in engines and gas turbines, which is cheaper and more efficient than the steam process used in incineration.

Municipal solid waste can be reduced by as much as 75% through this process, reducing to the same degree the amount of potential emissions the waste would have created in a landfill. The process of sorting and preparing the solid waste (autoclaving) for pyrolysis is well established and the technological expertise is available in South Africa.

8.3 Potential for rollout

Landfill Gas

The Economic and Financial Calculations and Modeling for the Renewable Energy Strategy Formulation document (DME, 2004) from the DME identified 57 feasible landfill to energy sites ranging from micro (650 kW Capacity) up to Large (4000 kW Capacity) in South Africa that are estimated to produce 43 million m^3 of methane gas per year and are planned to ultimately deliver 830GWh of electricity per year. For the full DME report go to www.cityenergy.org.za/resources/renewable-energy

If all the proposed landfill to energy sites are implemented, the following savings will occur:

Additional renewable energy added to the grid/year	830GWh
CO_2 reduction from offset coal fired electricity/year	830 000T
CO_2e reduction from burning methane	1 928 550T
Total CO_2e reduction/year	2 758 550T

Given that the renewable energy feed in tariff (REFIT) will be made available to landfill gas projects, making them more than financially viable, there should be a large scale rollout of these projects in the short term.

Such projects are employment creators, currently a key national issue.

Wastewater Gas

The total potential for wastewater gas in South Africa is not clear – estimates vary from 36 MWh (1.13 PJ) per annum for electricity generation and 96 MWh (3.0 PJ) for heating purposes (DME, DANCED, 2001) to 800GWh per annum (Holm et al, 2008).

Currently there is limited focus on sewage gas methane production in the country. This is partly because landfill methane is considered a more feasible option in terms of institutional and technical capacity, and financial viability (including CDM carbon revenue generation). Municipalities therefore tend to focus on this option. It is however recognized as one of the options that will be exploited in the medium-term to promote the renewable energy profile of cities.

Gasification / Pyrolysis

More than 140 gasification plants are in operation around the world, and the worldwide capacity is projected to grow 70% by 2015. Although high capital costs are associated with gasification power plants, there is the potential for operating costs to be significantly lower than those of conventional processes or coal-fired plants. Gasification plants are more efficient, require less pollution control equipment and are able to generate a variety of energy products.

South Africa does have expertise in this process, and construction of these plants using local skills is possible.

8.4 Barriers to implementation and efforts to resolve these

Onerous project planning process: To date the establishment of a landfill gas project has required the onerous process of registering the project for carbon financing, lengthy EIAs and local government approval processes. This coupled with Municipal Finance Management Act constraints has led most cities to hold back on landfill gas project development.

Effort to resolve

The renewable energy feed in tariff (REFIT) will now make landfill gas projects financially feasible which will negate the need for carbon financing, and make city approval processes for projects less problematic. If cities can see a clear and simple financial case for the intervention, it should pave the way for increased implementation.

Economy: Most WtE facilities have high capital costs and require technical expertise for maintenance, requiring long contract periods to recover initial investment costs. It is likely that other forms of WtE technologies will only become implemented on a mass scale if they are also included in the REFIT.

Efforts to resolve

WtE plants can access carbon funding to make them more financially feasible. Landfill gas now qualifies for a REFIT, making it financially viable even without carbon funding.

Toxicity: Despite advances in emission control and government regulations, public perception is that anything requiring combustion still produces significant emissions. Where incineration is concerned there is a debate over whether it is possible to convert thousands of tons of trash into nothing and achieve zero emissions, but this is unresolved. Incineration produces particles containing toxic metals, dioxins, and furans that are so small that they can evade pollution control devices. Incineration also produces a highly toxic fly ash that must be safely disposed of; leading to transportation and residential health concerns. Gasification and pyrolysis on the other hand are cleaner processes and do not pose toxicity threats.

Effort to resolve

This does not pose an immediate threat as incineration is not currently a priority for Cities.

Sustainability: The real sustainable solution is zero waste. Waste has a lighter impact on climate change and has more economic value when it is reused, recycled or composted than when it is converted to energy. When materials are recycled, three to five times more energy is conserved than is generated by incineration. Intensive recycling and composting programs are needed, but these may be hindered where WtE streams are implemented.

Effort to resolve

With the focus on already established landfill sites, this is not an immediate concern, but could become so in the future as more WtE sites are established.

8.5 How to go about implementation

Landfill Gas Projects

As landfills are City owned, a landfill gas project should be predominantly a City Council driven process. Landfill sites have a substantial potential for income generation through a carbon offset project (methane flaring and green electricity generation), in addition to the savings from electricity generation. It is therefore an attractive prospect for City Councils to consider if the business case is made. In order for the City to participate in the process though, certain guarantees have to be in place, to ensure that public money will not be put at risk. A willing buyer for the carbon credits has to be sourced, and the project has to be approved by the Designated National Authority (DNA) as a valid carbon offset project. Negotiations in this area are critical as a first phase of the project, and should be done at a high level – preferably mayoral - to ensure city buy in.

For first hand experience in this process, the eThekwini landfill gas projects are the most useful information source – see the case study in the next section.

However, with the onset of the Renewable Energy Feed in Tariff (REFIT), it is unlikely that carbon will be required to make landfill gas projects feasible in the future (see Making the Case earlier in this chapter). The process to qualify a project for the REFIT is not available yet, but this should be the priority in any landfill gas project planning process.

Once secured, the city will have to go through the necessary internal assessment and approval processes to determine who will plan, construct and operate the landfill gas site. These City processes are well established and should not present too many obstacles, given that

- the project will not place a financial burden on the taxpayer, and is in fact financially viable
- with the REFIT in place there are very low financial risks associated with the project
- employment will be created in the City
- CO_2e emission levels will be reduced in the City, supporting local and national targets
- the energy security of the city will be enhanced
- a source of renewable energy will be added to the grid, supporting local and national targets

Other WtE Technologies

It is unlikely that Cities will pursue other WtE technologies in the short term, given the viability of landfill gas projects and support for these from the REFIT. However, should the REFIT be made available to these technologies, it is anticipated that they too will enjoy mass implementation in the country. These WtE technologies will most likely be exploited in the medium term by cities in order to promote their renewable energy profiles.

8.6 Case studies

Case Study: Landfill Gas to Electricity Project – eThekwini

In March 2007, Africa's first landfill gas to electricity project was launched; aiming to enhance landfill gas collection and use it to generate electricity for export to the municipal grid in Durban.

Landfill gas is collected at the Bisasar Road, Mariannhill and La Mercy landfill sites in Durban. The Mariannhill landfill site had received 850 000 tonnes of waste by 2004 and will continue accepting waste until 2024. The La Mercy landfill site is an old landfill that will soon be closed; having received over 1 million tonnes of waste to date. Combined, the Mariannhill and La Mercy landfill sites have the potential to generate up to 2 MW of electricity. The Bisasar Road landfill site is the busiest landfill in Africa accepting 3500 to 5500 tonnes of municipal sewage waste daily and will continue to accept waste for another ten years. It has the potential to generate up to 10MW of electricity through collection, combustion and landfill gas. The final wells will be installed in approximately 2016.

With the annual estimation of emission reductions beginning in 2006, it is estimated that a total of 480 000 tonnes of CO_2 will be reduced at the three locations by 2013. There are also significant positive effects on local air and groundwater quality and safety. Emissions related to fossil fuel electricity generation are reduced by displacing electricity from these sources, as are those related to the transport and mining of fossil fuels. The amount of landfill gas in the atmosphere is reduced, thus reducing the risk of dangerous methane concentrations. This is particularly significant for the Mariannhill landfill site, as it is located close to residential areas. There has also been the economic benefit of additional employment, providing skilled jobs for the operation and maintenance of equipment at the landfill and at the power generation units.

Overview of project

eThekwini landfill gas project makes use of methane extracted from city landfill sites for the generation of electricity. The project is registered with the Cleaner Development Mechanism (CDM) and generates income from the sale of carbon credits through:

i) The process of flaring – burning methane to produce CO_2 (methane is approximately 23 times more potent a greenhouse gas than CO_2)

ii) Offset of coal generated electricity through the use of methane powered generators for electricity (reduction in electricity use from coal fired power stations)

Without the CDM funding, the project would not have been viable. In fact, the generation of electricity is secondary when compared to the CDM credit income from the flaring process.

Three landfill sites were targeted – Marianhill (1MW generator - installed), La Mercy (750kW generator – installed) and Bisasar (two 4MW generators installed, first commissioned in early 2008).

The project is expected to have reduced greenhouse gas emissions by 7.8 million tonnes by 2021. Once fully operational, the project will also have the capacity to generate a total of 10MW of electricity.

Drivers for the project

Prototype Carbon Fund (PCF)/World Bank: Offer to buy CDM carbon credits from eThekwini Municipality through a landfill gas project

eThekwini Cleansing and Solid Waste Department: Cleansing and Solid waste Department drove the project through the many administrative hurdles (CDM registration to verification, EIA positive Record of Decision). By all accounts, the project would not have succeeded without their championing the project.

eThekwini Electricity Dept: Driving the process for the installation and commissioning of electricity generators on landfill sites and linking the generators to the electricity grid.

City Involvement in the Process

This is predominantly a City Council driven project. Landfill sites are City Council owned and the potential for income generation through a carbon offset project (methane flaring and green electricity generation) is substantial, not to mention the additional savings from generating their own electricity. It is therefore an attractive prospect for City Councils to consider if the business case is made. In order for the City to participate in the process though, certain guarantees had to be in place, to ensure that public money would not be put at risk. A willing buyer for the credits had to be sourced, and the project had to be approved by the Designated National Authority (DNA) as a valid carbon offset project.

All this required an internal driver, and the Champion of this process, Lindsay Strachan from the Cleansing and Solid Waste Department, coordinated this. High level buy in was sought from the outset. The mayor (Mr Mlaba) was involved directly in negotiations with the World Bank around the sale of carbon credits generated by the project. Once the MOU agreement was signed, and conditional approval for the project from the DNA was given, the project was presented to Council and it was approved.

Reasons why project took so long to reach implementation

This project took four and a quarter years to get from first contact to start of construction. Several barriers had to be overcome to reach this point.

1. *Negotiations leading up to MOU between eThekwini and World Bank – 9 months*
2. *Emissions reductions purchase agreement (ERPA) with World Bank – 1 year*
3. *EIA process – 1 year*
4. *Tendering to contract award process – 1 year*

The table below provides a full breakdown of the project's progress with associated timelines

First contact with PCF/World Bank - November 2001
Letter to the Mayor of from PCF/World Bank – May 2002
Ken Newcombe (PCF) – Mayor Mlaba meeting at WSSD 2002 – August 2002
Letter from DNA of Conditional Approval for CDM project – November 2002
MOU between eThekwini and PCF – February 2003
Report to full Council and EXCO on Project – June 2003
Council Approval – July 2003
Commence EIA's – July 2003
Adhoc Approval for funds – October 2003
ERPA Signing (Conditional to EIA's) – June 2004
ROD's for Mariannhill and La Mercy ("Component One") – July 2004
Appeal against "Component One" by a Mr Childs – August 2004
Appeal response to Minister of DAEA for "Component One" – September 2004
ROD Bisasar ("Component Two") – October 2004
Started construction …. "Component One" - January 2006
Final Revised ROD for "Component Two" (Bisasar) - August 2006
CDM Registration of Component 1 (Mariannhill & La Mercy) - November 2006
Commissioning of Mariannhill & La Mercy Flares & Gens - Nov~Dec 2006
Initial Verification of Component 1 – January 2007
"Component Two" (Bisasar) Start Construction – March 2007
Delivery of 1st CER's ("Component One") – May 2007

Replicability

Landfill gas projects are replicable for cities around the country. They are made economically feasible either through CDM funding (like this project) or through the Renewable Energy Feed in Tariff.

Important lessons learnt

1. Internal communication and buy in at the highest level was key to getting the project implemented. A strong financial, environmental and social case was made for the project.

2. A project champion with good management and communication skills ensured that the correct processes were put in place and the necessary agreements and approvals obtained. This driver within the City is crucial for the success of such intensive city centred projects

Case Study: World's largest WtE plant in SA

The world's largest WtE conversion plant, a R28 million facility, was opened in July 2008 in the Gauteng province of South Africa by Prestige Thermal.

Prestige Thermal has been at the forefront of WtE technologies for more than six years and this has led to the development of a specialized autoclaving technology that converts solid waste into clean gas through pyrolysis. An autoclave is a pressurized chamber that aids in the chemical decomposition of organic materials by heating in the absence of oxygen. Autoclaving municipal solid waste conditions the material and aids in its downstream separation. This new technology allows the conversion of many different types of materials and was specially designed for "black bag" general waste.

The biogas that results from the pyrolysis can be used in electricity generating turbines to produce 3 MWh of electrical energy from 3 tonnes of municipal solid waste. It also supplements the steam needed for the autoclaving process.

Case Study: Athlone Sewage Plant

A feasibility study was recently completed which looked into refurbishing and upgrading the sewage gas to energy facility at the Athlone sewage plant in Cape Town.

Based on gas produced from waste water works worldwide, and the average flow at Athlone, it is expected that 10,000 m3/d of biogas with a methane (CH_4) content of 65% will be produced (once the digesters are refurbished). One cubic metre of biogas at 65% CH_4 should generate about 2 kWhe (assuming 30% efficiency) and one cubic metre per day can cook daily meals for 4 people. Therefore the gas produced by the digesters at Athlone could replace the kerosene boilers that heat the digesters and still cook daily meals for about 20,000 people or fuel an electricity generator of 830 kWe to supply about 6.9 GWhe/a (including downtime).

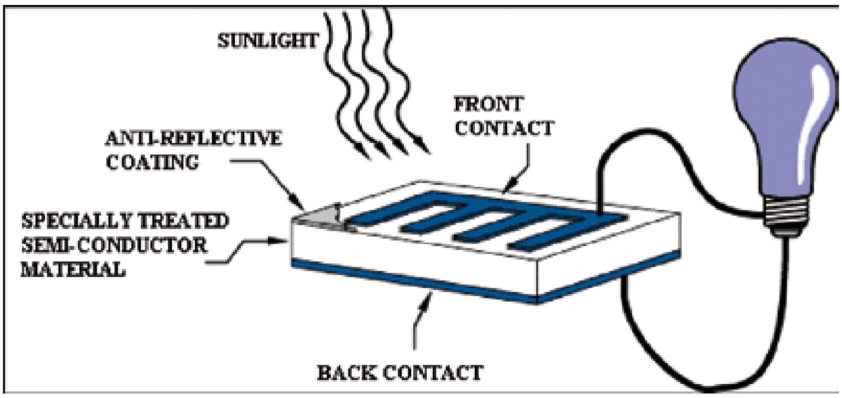
Description	**Heating and Cooking Gas**	**Electrical Generation**
Refurbished biogas generation at AWWTW	10,000m3/d	10,000m3/d
Capacity	1500 households	830kW Generator
CAPEX	R5 million (pressurisation, distribution, CDM but ex EIA costs or refurb)	R14 million (scrubbing and generator, CDM but ex EIA costs or refurb)
OPEX (mainly digester)	R100,000 pa	R200,000 pa
CDM Revenue	R3.8 million pa	R4.5 million pa
Simple payback (ex energy sales or loan costs)	1.4 years	3.3 years

9. Photovoltaic (PV) Implementation

9.1 Overview

Photovoltaics (PVs) involve the direct conversion of light into electricity. A photoelectric material can absorb photons of light and release electrons. It is the capture of these free electrons that results in an electric current that can be used as electricity.

A basic PV cell has a very thin semiconductor material that forms an electric field; positive on one side and negative on the other. When light energy comes into contact with the cell, electrons are released from atoms in the semiconductor material. Electrical conductors attached to the positive and negative sides of the semiconductor material form an electrical circuit and capture the released electrons. This forms an electric current (electricity) which can be used to power a load.



PV modules are a number of PV cells that are electrically connected to each other and mounted, while an array is formed when multiple modules are wired together. In general, a larger area will produce more electricity. They are designed to supply electricity at a specific voltage; however, the current produced is directly dependent on the amount of light that reaches the module. The most common PV cells are made from crystalline silicon. This material has been used for more than 50 years and the manufacturing processes are very well known.

In South Africa, PV panels are mainly used to provide electricity for telecommunications and lighting in remote areas where grid electricity is not available. With the correct economic incentives however, solar PV could become a reliable source of distributed, grid connected power.

It has been estimated that there are roughly 200 000 off-grid PV installations in the country but only around 10 grid-connected PV installations. Most of the installations (as noted above) are for telecommunications and lighting in remote areas. The installed capacity is estimated at around 12MWp and it is expanding. With the current costs of PV however, expansion on a large scale will not happen without a national incentive program.

9.2 The Case

When considering the installation of PV, cases in both electrified and unelectrified areas need to be considered. This is because generation costs in remote areas are different to those in electrified areas, and these need to be considered when making decisions around PV installation.

The financial case for an electrified area

South Africa's population is over 47 million with roughly 50% living in urban areas. The population growth rate is 1.9%, with stabilization expected by 2100 at 80 million. South Africa faces an electricity shortage due to population growth and the resulting increasing electricity demand. The installation of PV systems in households that are already electrified will have the following advantages:

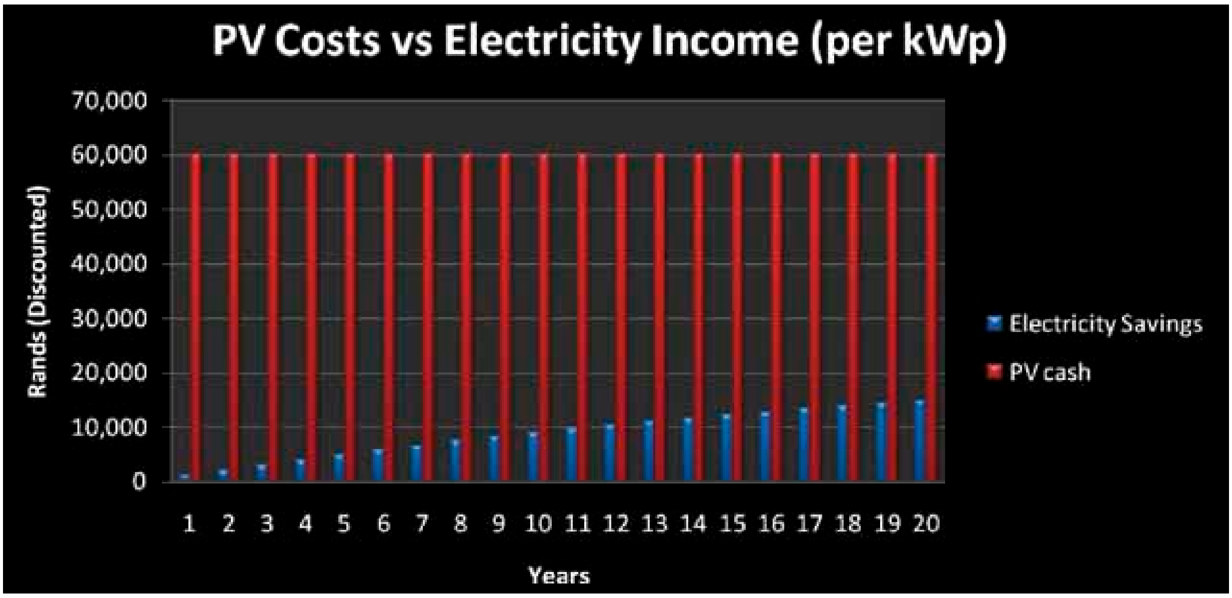
- Reduce impending pressure on local utility: Eskom cannot sustain current electricity demands for South Africa.
- Less money spent on electricity: Systems can be sized to provide all electricity needs, but the installation of a small system will also provide some electricity savings to a household.
- Less non-renewable resources being used and less CO_2 being produced: Solar energy is a free source of energy that will not run out and produces no pollution during operation,
- If an electricity surplus is generated through PV systems, this can be fed back into the grid. The equivalent amount of electricity can be used later from the grid at no cost, further lowering electricity costs.

Although all of the above is true, the financial case for PV is currently not very strong, due to the high capital cost of the technology. To provide an indication of how the current financial scenario looks, this manual will consider two financial cases:

1. PV units are installed on building roofs and supplement the power supplied to the building. No battery backup is provided, and the excess energy generated is fed into the distribution network
2. A PV farm is established to feed in to the national grid

Case 1: The financial case for an individual building

The graph below shows PV performance on an individual building in terms of electricity saved over 20 years (blue) against the capital cost of the unit (red).



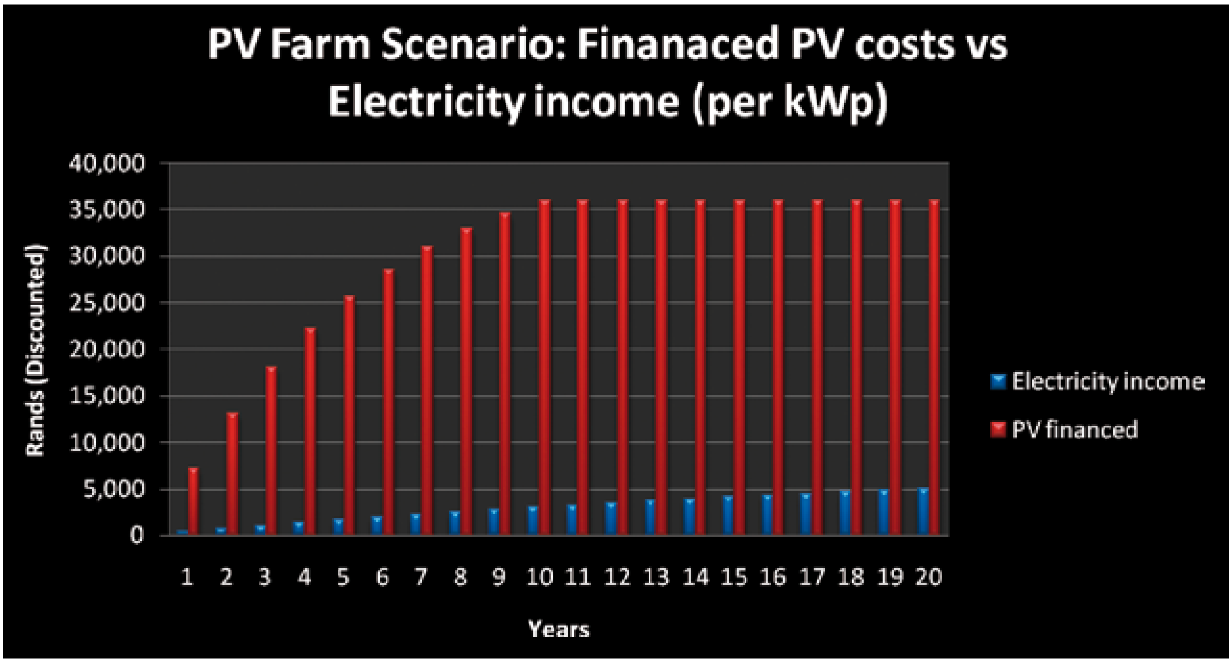
Assumptions: 1kWp system installed costs R60 000 (including inverter, no battery backup); electricity cost 60c/kWh, increasing at 15% pa; discount rate 20%; generation of 5kWh per kWp per day

Based on this, it is clear that the installation of PV would only qualify as a sound environmental choice and not a financial one. Arguments around the saved costs that businesses would gain through productivity during power cuts are starting to be made though. It is difficult to quantify these due to unknown factors such as the duration of the power cut and the value of the productive hours gained.

To make financial sense – in other words for a household to financially justify installing PV panels – a minimum electricity rate of R5.50 per kWh needs to be charged by the electricity utility. This is 8-9 times higher than the current rate.

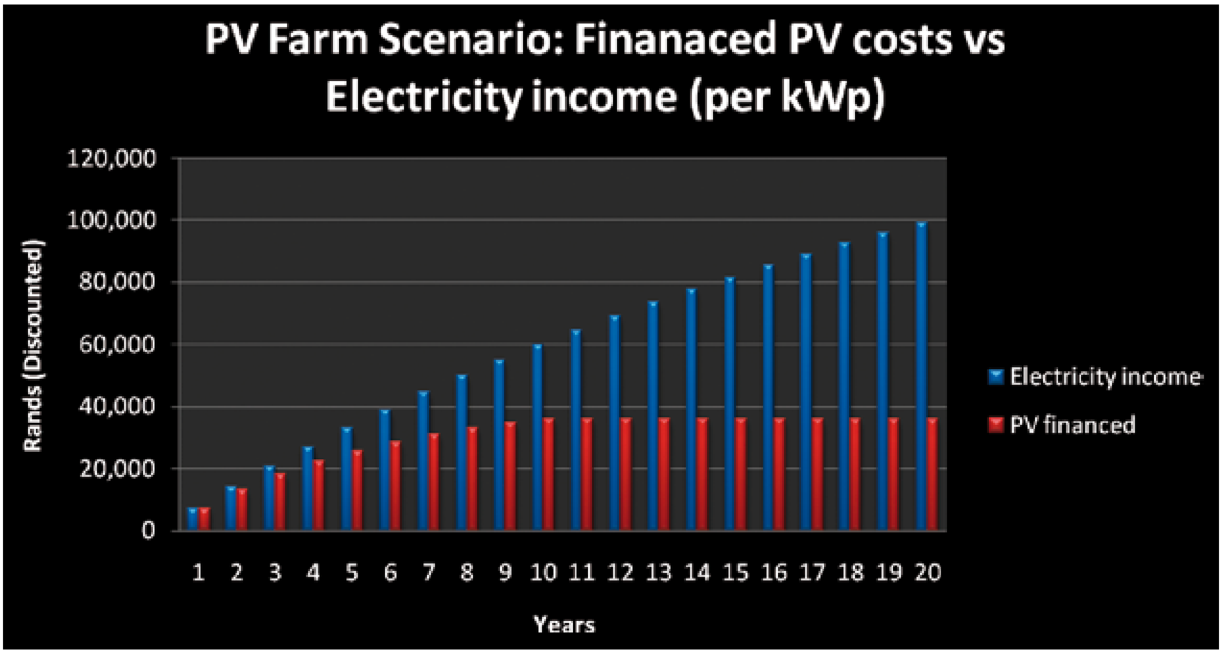
Case 2: The financial case for a large scale PV farm

The case for large scale PV farms to feed into the national grid is still a difficult one to make. Even with bulk purchase and installation reductions of 20% when compared to smaller residential systems. The following graph shows this, with a purchase price for the electricity of 20c/kWh (municipal purchase price for electricity from Eskom) and with attractive financing of 8% over 10 years.



Assumptions: PV farm installed costs R48 000/kWp; electricity purchase price 20c/kWh, increasing at 15% pa; discount rate 20%; financing at 8% over 10 years; generation of 5kWh per kWp per day

If the purchase price per kWh were brought up to R3.90 per kWh while keeping the above conditions the same, the PV farm would be financially viable from year 1. The graph below indicates this:



Therefore, based on the above assumptions, a feed in tariff of around R3.90 per kWh would be required to make large scale pv farms viable. It should be noted that these figures are not the result of a detailed pv farm analysis, and should be taken as indicative.

The case for a non-electrified area

The case for unelectrified areas needs to take into account the cost of obtaining and distributing liquid fuels (diesel for generators, LPG for gas solutions), or of extending the electricity grid to encompass these areas. Also the maintenance of the equipment (usually generators) needs to be taken into account.

Often these areas are very remote and the expense of extending the grid does not justify the small income such an installation will generate. Therefore off-grid solutions need to be found.

Generators generally require high level maintenance, and have the additional problem of requiring a steady supply of diesel to operate. Skilled technicians are not readily available in these areas, and fuel supply is not consistent. Generators are noisy and contribute to air pollution.

PV installations are generally very reliable and low maintenance, and are not dependent on a fuel supply chain. This makes the technology very attractive in remote, unelectrified areas. Electricity generation is clean and noise free.

PV is specifically useful for remote schools and clinics which depend upon a reliable electricity supply to function properly. They are also suitable for home lighting and media appliance use in remote areas. The case for schools is outlined below.

Over 16000 schools in rural South Africa have no electricity. Students educated under these conditions are increasingly segregated, and drop-out and fail rates are high. For these rural communities, getting connected to the electrical grid is not going to happen in the near future. A quality education is difficult to obtain without electricity for reading and for modern technologies such as computers. The most promising way to end the cycle of poverty is to provide these disadvantaged children with quality education that will lead to literacy, numeracy, and information technology skills. PV installation in rural schools and communities has the following advantages:

- Increase enrolment and pass rates: Having such things as overhead projectors, television sets and VCRs, photocopiers, and computers enhances the culture of learning. Students feel that the skills they are being taught are going to get them jobs.
- Attract quality teachers: Quality teachers prefer schools with electricity and supplies. The culture of teaching is also enhanced with modern technologies, and quality teachers can be attracted to provide quality education.
- Provide local jobs for maintenance: New jobs can be created locally by training members of the community in the installation and maintenance of PV systems.
- Provides electricity to rural homes: Electricity would facilitate learning by allowing reading and schoolwork to be done after dark.

PV home systems for domestic use in rural areas are usually only large enough for lighting and media services, with the additional electricity still required for cooking and refrigeration requiring larger PV systems. Even small PV systems require large subsidies to make them affordable to rural communities and economically reasonable to the supply companies. However when faced with expensive (extending the grid) and unreliable (diesel generation) alternatives, the subsidisation of PV in these areas is an increasingly viable option.

Thin film technology

Silicon is readily available, being the second most abundant element in the Earth's crust, but it must be refined to an extremely high purity to manufacture crystalline silicon cells, making it quite expensive. Thin film technologies are being developed to make it possible to create a PV material by sequentially depositing thin layers of different materials into a very thin structure. They require very little semiconductor material and are easy to manufacture, potentially resulting in a significantly lower cost of PV systems. There are still issues regarding life-span and functioning in hot environments, and they currently cost just as much as, or more than, crystalline silicon cells. However, as the technology progresses, thin film panels could make PV systems much more financially viable for everyone.

9.3 Potential for Rollout

Although the financial case for PV not feasible enough to expect a mass rollout in the short term, it is expected that in the long term as electricity prices increase and the cost of PV production decreases the technology will become viable. As such it is useful to know the potential for PV generation in the country.

A rough calculation of rooftop generation potential in SA:

Houses in SA with solid rooftops capable of holding PV panels (assume 50% of all households in SA)	5 000 000
North facing rooftop area per house	$5m^2$
Total area available in SA:	$25\,000\,000m^2$
Generation potential of PV per m2 per yr (500Wh/m2/day)	182kWh
Rooftop Generation Potential in SA per year	4652GWh

Given that Eskom sold 224 366 GWh of electricity in total in 2008, PV on roofs could account for 2% of the country's power requirements in the long term.

In order to make a more significant impact with PV in the future, PV farms would have to be developed. To match South Africa's current electricity demand with PV, a total of $1232km^2$ of PV panels would be required, which would take up 1% of South Africa's land area. Obviously not all electricity in South Africa will be generated using PV in the future. What this does indicate though is the significant impact that PV could potentially have if installed on a mass basis.

9.4 Barriers to implementation

High equipment cost, low electricity prices: The low electricity prices in South Africa and the high cost of PV systems, the payback period is longer than most households and organizations are willing to consider.

Effort to resolve:

Thin film technology is promising a large scale reduction in the cost of PV. However this technology is not proven and may not perform for the same periods as current technologies. Costs can also be brought down through bulk purchase where feasible. PV does not form part of the current renewable energy feed in tariff (REFIT), but some cities may consider a micro feed in tariff – purchasing residential PV generated electricity at attractive rates – in the medium term.

Poor linkages between supply and demand: Outside organisations are needed to work with PV suppliers, potential consumers, non-governmental organizations, development banks and governments, in order to facilitate the implementation and completion of a PV project.

Lack of long term support from government: No effective government support for the technology is currently in place.

Efforts to resolve:

The Renewable Energy Finance and Subsidy Office (REFSO), established by the Department of Minerals and Energy, currently manages renewable energy subsidies. However, the minimum project size eligible for subsidy is 1 MW-too large for small scale residential installations. The subsidy is also not sufficient to incentivise large scale PV farm development. A micro feed-in-tariff for electricity generated using PV within residential areas would most likely be the most effective intervention to incentivise the installation of the technology on rooftops. Including PV in the renewable feed in tariff structure would be the key to the building of PV farms in the country.

9.5 How to go about implementation

Micro Feed-in tariffs

A micro feed-in tariff for PV electricity generation on City rooftops could be a solution in the future for Cities to diversify their energy supply. Incentivising homeowners with attractive electricity purchase rates will encourage households to install PV systems on their roofs and feed this electricity into the grid. This type of scheme can be piloted to iron out potential problems for implementation in the future. However it is not currently a feasible mass roll out intervention due to high capital costs.

Solar Electric Light Fund

SELF designs and implements sustainable energy solutions in rural communities in the developing world. They work with communities that are fully committed to supporting a project, and with a local organization that would ensure implementation and completion of the project. They also broker the purchase and delivery of PV systems by working with local suppliers, non-governmental agencies, multilateral development banks, and governments.

To find out more about SELF and its projects, go to www.self.org

Feed-in tariffs

Getting PV included in the renewable feed in tariff (REFIT) will make the technology viable to PV farm developers. Until such a mechanism is in place it is unlikely that large scale implementation of PV to feed into the national grid will occur. Countries that have feed-in tariffs (over 40 around the world) have seen the largest growth in renewable energy generation.

Support for Implementation organizations

Municipalities can identify rural communities in need of electricity. They can then facilitate the establishment of PV implementing organisations (ESCO type model) who will:

- provide an attractive payment solution to the end user
- establish an installation and maintenance programme

An implementing organisation would buy and install the PV system(s) and retain ownership. The electricity generated from the system would then be sold to the consumer by:

1. Metering electricity used and charging a fixed rate
2. Signing a lease or hire/purchase agreement over a fixed period of time for the PV equipment
3. Charging a fixed monthly tariff

The electricity user would bear no capital costs and would not have to worry about maintenance to the system, which is an important factor to homeowners.

Municipalities can assist this process by:

- sourcing funding to subsidise the systems
- being a Community liason and assisting in awareness raising

9.6 Case Studies

Case Study: Introduction of solar electricity to Myeka High School, Kwazulu Natal

In 1996, SELF began a PV project that would provide 2.4 kilowatts of power to Myeka High School in Maphephethe, Previously, through lack of electricity, only 30% of the school's students were graduating, with little hope of going beyond their village because they lacked necessary skills. Dell Computer and Infosat Telecommunications donated computers and a satellite uplink. Within the first year of implementation the school had an overhead projector, two televisions sets, a VCR, a photocopier, a copy printer, and 20 computers. Teachers, students and the community were enthusiastic as teaching became interactive. Less time spent hand-copying notes off chalkboards freed up more time for discussions and reading.

Upon implementation of the PV system at Myeka High School, enrolment increased by 40%, pass rates jumped from 55% to 69%, and the drop-out rate declined considerably. SELF plans two more PV projects at two additional schools in KwaZulu-Natal but are awaiting funding. The local organisations they will be working with in each case are The Learning Channel Campus and the Program for Technical Careers (PROTEC).

Case Study: Plug and Play, South Africa

Shell International Renewables Limited and Eskom embarked on a commercial solar rural electrification venture, bringing light to 50 000 rural homes in South Africa. The Power House system is composed of a solar panel, a charge controlled battery, a security system, and a metering unit. These are prewired and fitted with plugs so that users can literally "plug and play". The Power House has protection against tampering and theft, preventing major components from working unless connected to their respective control systems.

The system is activated by a magnetic card that is paid for in advance, giving 30 days power supply. This monthly payment of R64 also includes maintenance, repair, and replacement of the equipment. After the initial installation fee of R240, most customers find it is not more expensive than buying candles and paraffin. It has proven easy to use, provides greater energy efficiency, and is more sustainable.

Case Study: Bangladesh – PV solutions for rural, low income households

Grameen Shakti (GS), a rural based renewable energy company in Bandladesh, has installed more than 100 000 solar home systems (SHSs) in rural areas with no access to conventional electricity. They have developed financial models in order to reduce costs and help to make the SHSs financially viable for low income households. SHSs are popular because there is no fuel cost, very low repair and maintenance costs, and they are easy to install in any location.

GS offers several different options for financing a SHS. Their micro-utility model was developed in order to reach low income households where individuals cannot afford a SHS. If a rural business owner purchases and installs the system, he could share the energy produced with some of his neighbours. Instalment payments would be made to GS by this entrepreneur, who would then charge the users of his system a "rent" that could equate to more than 50% of the instalment payment. The SHS would also provide the business owner with extended business hours. GS also offers financing at varying low rates based on the down payment that a homeowner can afford. A buyback system is in place that would buy a SHS back in the case that a community becomes electrified.

The mission of GS is to "empower the rural people with access to Green Energy and income," believing that it is energy poverty that restricts social and economic development. Community members, mainly youth and women, are provided with training to maintain the SHSs, in turn providing extra income opportunities. Demonstrations, door to door visits, and meetings with village leaders have promoted SHSs in remote communities. GS also gives workshops for policy makers at the national level.

10. Renewable Power Purchase Agreements

10.1 Overview

Power Purchase Agreements (PPAs) can be used to make renewable energy more accessible to residential and commercial consumers. A PPA is a legal contract between a generator and a purchaser of electricity. These agreements are important in the financing of electricity generating infrastructure, particularly concerning renewable energies. The owner of the infrastructure is able to use the PPA to get financing, given clearly defined electricity outputs and the revenues associated with them. It is often private developers that seek to develop renewable energy projects, where the electricity generated would be sold to electricity distributors, namely Eskom or Municipalities. These distributors would, in turn, sell this green electricity to willing buyers.

10.2 The case

Fossil fuel based electricity production is one of the largest industrial sources of carbon dioxide, a primary greenhouse gas linked to climate change. It is also a major source of pollutants including nitrous oxide, sulphur dioxide, mercury and particulate matter. The majority of South Africa's electricity is provided by coal-fired power stations, the highest energy-producing polluters in the world.

Coal is a non-renewable resource, which, at present production rates, will last only for 50 more years. In combination with South Africa's strong economic growth, rapid industrialization, and mass electrification this illustrates the need for a shift to renewable energy. The City of Cape Town has a self-imposed target of 10% of its electricity purchases to be from renewable sources by 2020.

The purchase and installation of renewable energy systems is not always an option for the average electricity consumer. PPAs provide citizens with a convenient way to support locally generated renewable power. They encourage residential buyers to demonstrate their commitment to reducing their carbon footprint and investing in a sustainable future by voluntarily purchasing green electricity. Companies are also encouraged to enhance their image by reducing their environmental impact through purchasing green electricity for their facilities. Once it is obvious that there is a demand for green electricity from voluntary purchasers, policy makers will be forced to acknowledge that further investment in renewable energy generation is financially viable and socially responsible.

10.3 Potential for rollout

It has been calculated that there is potential to generate 160 GW of renewable power in South Africa. This is four times the current demand levels in the country. The key to unlocking these sources is the development of effective financial mechanisms to stimulate the growth of the renewable energy market. South Africa is about to embark on the renewable energy feed in tariff (REFIT) route to achieve this.

The feed-in tariff will ensure that renewable power producers are paid a rate for their energy that makes their business feasible. NERSA, the national energy regulator has developed a feed in tariff structure, which provides the national framework for the purchase of renewable power. Currently, only Eskom is permitted to purchase this power, although it makes sense to allow municipalities to purchase power generated inside their area of jurisdiction. The additional cost for the purchase of this power can either be built in to the overall end user tariff, or be paid for as a per kilowatt-hour levy to willing end users.

Evidence from other countries that have followed this route shows a marked increase in renewable energy generation after a feed in tariff is implemented.

10.4 Barriers to implementation and efforts to overcome these

The following issues have been barriers to the implementation of PPAs:

Lack of national renewable energy feed in tariff (REFIT): There are high risks involved in initiating green electricity development, making it currently unattractive to private investors. A renewable energy feed in tariff provides the risk reduction required for the renewable energy industry to grow.

Effort to overcome

A feed in tariff framework has been announced by the National Energy Regulator NERSA in South Africa. The rates are applicable to the following technologies: Wind, Concentrated Solar Power, Hydro and Landfill Gas. The proposed tariff rates are attractive to project developers, and will undoubtedly stimulate the renewable energy market in South Africa. There are some concerns around this still, the primary ones being:

- Only Eskom can purchase this power, not municipalities
- A tender process needs to be followed by developers to qualify for their renewable energy generated to be purchased. This creates risks in the market again

Lengthy processes: Technical and legal complexities existing around institutional and contractual arrangements with NERSA, Eskom, etc. cause implementation to be a lengthy process. Drawn out Feasibility Assessments and Environmental Impact Assessments also hinder progress.

10.5 How to go about implementation

Develop a Feed in Tariff which includes Municipal rights to buying renewable electricity:

It is critical that municipalities are included in the feed in tariff framework as players who have the right to buy renewable energy if it is in their best interests. This includes the legal mechanism to allow them to carry the additional cost over into all the electricity sold by the municipality, or to allow them to sell green electricity to end users at a premium rate. Nationally acceptable power purchase agreements can then be drafted for use by any player – in this case Eskom or municipalities to purchase renewable power from an independent source.

Develop a Micro Feed in Tariff for individual power generators

Cities can consider purchasing green power from micro generators within the municipality's jurisdiction. An example of this could be a photovoltaic array on the roof of a house which is connected to the grid and feeds into it. The city could measure the energy supplied and pay the end user at a rate higher than the municipal selling rate. This will incentivise homeowners to become micro generators within the city. Financing for such systems could come through a levy on the electricity bill. Once again, the legal framework around power purchase must be supportive to allow this to happen.

10.6 Case Studies

Case Study: Darling Wind Farm, Western Cape

The Darling Wind Farm, South Africa's first commercial wind farm, currently consists of four 1.3 MW wind turbines that provide electricity to the City of Cape Town. In 2006 the mayor of the City of Cape Town signed a PPA with the CEO of Darling Wind Farm. The city became involved in the project by providing financial assurance and carrying the risk as a guaranteed buyer of the electricity that was going to be produced. For the next 20 years the 5.2 MW wind farm will supply green electricity to the City of Cape Town, taking the city one step closer to having 10% of its electricity purchases being from renewable sources by 2020.

Over 20 years, the Darling Wind Farm is expected to save 142 500 tons of coal and 370 million litres of water. A significant reduction in pollutants will also result, namely:

- *258 100 tons of carbon dioxide*
- *2200 tons of sulphur dioxide*
- *1100 tons of nitric oxide*
- *58 tons of particulates*
- *42 200 tons of ash*

The City of Cape Town is responsible for selling the electricity obtained through the PPA. Willing buyers will pay a premium for this green electricity, which is set at 25c/kWh above current electricity rates. The Darling wind farm was officially powered up in May 2008.

The wind farm is located 10 km north of the town of Darling in the Western Cape of South Africa, an area that gets strong and consistent winds. The R75-million project was developed by a group of private investors including the Darling Independent Power Producer, the Central Energy Fund, the Development Bank of South Africa, and the Government of Denmark. There are plans to add 6 more 1.3 MW turbines to the farm, bringing the capacity up to 13 MW, providing there are no significant impacts found from the existing turbines.

Case Study: Energy from Bagasse, Tshwane

By 2020 the City of Tshwane aims to have 10% of their electricity supply met by local renewable sources. Tongaat Hulett Sugar Limited and Tsb Sugar generate electricity through the burning of sugar cane fibrous matter called bagasse. Amatola Green Power is an electricity trading company that buys the surplus electricity, giving them a green electricity capacity of 3-5 MW. In 2007 the City of Tshwane signed a 3 year PPA with Amatola Green Power for the purchase of approximately 2 MW of green electricity, which it then sells to customers serviced by the city.

Amatola obtained approval to buy and sell green electricity in a voluntary market from the National Energy Regulator of South Africa and the Department of Minerals and Energy. The green electricity is fed into the National Electricity Grid by Amatola, who then has access to the network in order to sell it to customers. In an attempt to demonstrate its environmental commitments, Mercedes-Benz South Africa Limited became the City of Tshwane's largest customer and the first commercial buyer of their green electricity.

11. Concentrated Solar Power (CSP)

11.1 Overview

Concentrated Solar Power plants generate electricity by collecting incoming solar radiation and concentrating it into a small area to generate very high temperatures. The heat is then used to drive conventional (usually steam) generators in much the same way as current power plants do. A CSP plant can be divided into two basic sections 1) the Collector, which collects the incoming solar radiation and converts it to heat and 2) the Generator, which converts the collected heat into electricity. Most CSP technologies use very similar generators but there are currently three main collector technologies available.

1. Solar Trough:

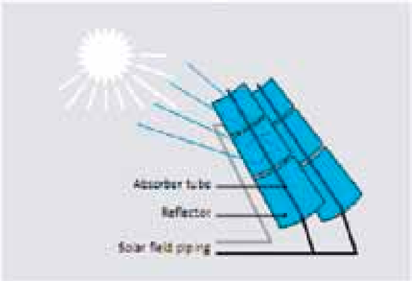
A solar trough consists of a linear parabolic collector, which tracks the sun on a single axis to focus the light onto an absorber tube, which runs along the focal length of the troughs. The collector holds a carrier fluid, which transfers the heat to the storage medium or generator. Currently, examples of solar tough systems can be found in California, Nevada and Spain

2. Power Tower:

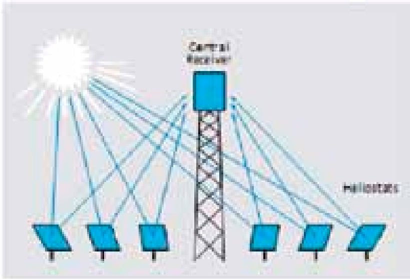
The power tower uses an array of mirrors, which track the sun on multiple axes to focus sunlight onto a central receiver, which is placed on the apex of a tower. Like the solar trough, the collector holds a carrier fluid, which transfers the heat to a storage medium or directly to the generator. Examples of this technology can be found in California and Spain. Eskom has indicated plans to build a 100MW power tower CSP plant in the Northern Cape, although no further progress in this area is evident.

3. Parabolic dish:

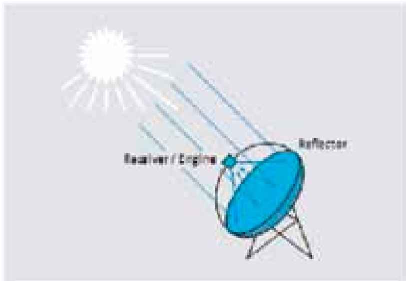
This system consist of stand-alone parabolic dishes, which focus sunlight onto a focal point, which can either hold a collector, which holds a carrier fluid, or a Stirling engine, which would generate electricity directly. Parabolic dish systems are known for their very high efficiencies in converting solar power to electricity. An example of this technology can be found in Canberra, Australia.



Solar Trough



Power Tower



Parabolic Dish

One of the main benefits of CSP is the relative ease of energy storage. As the concentrated solar energy is used to generate heat, this heat can be stored (often as molten salts) in insulated containers and then used to generate electricity on demand, even when there is no sunshine. This means that CSP can be used for both base-load power generation as well as peak load power generation. Energy storage is not as easy from most other renewable sources.

11.2 The Case

Currently there is very little development of CSP in South Africa. Internationally, where there is a stimulating financial market with strong feed-in tariffs and political support, CSP is growing. This is mainly happening in Spain and in the USA. The recently released renewable energy feed in tariff (REFIT) in South Africa includes CSP and offers attractive energy purchase rates to project developers. With this in place, it is expected that a strong case can be made for CSP growth in South Africa.

Financial viability:

CSP technologies are relatively new and therefore immature and the financial viability is still not clear. The quote below gives an idea of the costs of CSP.

"In the recent Integrated Resource Plan developed by Eskom and the NER, a levelised power cost in the range R0.33 to R0.96/kWh is indicated, depending on the assumptions used for discount rate, load factor and other costs. In our opinion, these cost figures are over-stated and do not adequately take account of the potential for cost reductions as the technology develops." (The potential contribution of renewable energy in South Africa, Banks and Schafler, 2005.)

Spain expects to have 500+MW of CSP in operation within the next two years. With typical capital costs of €4-6 M per MW and capacity factors of 25-35%. The tariff for CSP in Spain markets exceeds 3.0 Rand per kWh.

The renewable energy feed in tariff (REFIT) for CSP offered by NERSA currently stands at R2.10 per kWh.

REFIT Tariffs - 2009 (R/kWh)		
Technology	Unit	REFIT
Wind	R/kWh	R 1.25
Small hydro	R/kWh	R 0.94
Landfill gas	R/kWh	R 0.90
Concentrated solar	R/kWh	R 2.10

While this tariff seems reasonable, given that installation and operating costs in Spain will most likely be higher than those in a developing country, it is unclear whether this tariff is sufficient to stimulate developers at this stage.

Installation Capacity

Currently there is no capacity in the country to build CSP plants and due to the fact that there have been very few 'repeat' projects internationally, it is difficult to know what is needed. The technology is however not very complex and South Africa would have the skills and resources to build a CSP plant if combined with some expert international experience.

12. Wind

12.1 Overview


Mark Lewis

Darling Wind farm, South Africa's first commercial wind farm

Wind energy is generated when the kinetic energy of the wind is harnessed by large wind turbines and converted into mechanical energy. To generate electricity, this mechanical energy is used to rotate generators situated in the hub of each turbine. Wind turbines can range in size from small home or boat based 50W units to the large 6MW commercial units which have an overall height of nearly 200m.

Wind turbines for commercial power generation are generally arranged in an array, collectively called a wind farm. Wind farms are typically located in areas where a consistently high level of wind is present. The performance of wind turbines increases exponentially with the linear increase in wind speed. Therefore consistent strong winds are critical to the financial viability of a wind farm. Wind speeds are stronger at higher elevation levels, and on top of smooth hills, which is why most wind turbines are mounted on high masts and on top of hills where possible.

Electricity generated from all the turbines in the wind farm is combined and modified to feed into the power transmission network in the area.

12.2 The Case

It has been estimated that South Africa has the potential to generate 50 GW of power through land based wind turbines (Banks and Schaffler,2006), more than the current generation capacity of Eskom (approximately 40GW)

Wind turbines are currently one of the most financially feasible renewable energy technologies available. Proof of this is their inclusion in the national renewable energy feed in tariff (REFIT). The REFIT electricity purchase price for wind energy of R1.25/kWh is considered highly attractive by project developers, and many wind companies are now gearing up to install wind farms in South Africa.

Small scale residential wind generation is currently not as financially feasible as large wind farms. This coupled with additional factors such as erratic wind supply in built areas, environmental and zoning infringements and 'blade noise' makes it difficult to justify for residential use. Various designs for urban wind turbines are being developed to make them more efficient and financially viable. However, these products are mostly in research and development stage, and cannot be considered serious solutions as of yet.

13. Some useful resources

Sustainable energy for cities website

Many cities are looking to large scale rollout of renewable energy and energy efficiency measures. This is often pioneering work, and cities need support to enable them to achieve their goals in this regard. Thus this portal provides South African cities with fast and easy access to constantly updated and highly useful information and resources to help cities in this regard.

Please follow the link: www.cityenergy.org.za to access information and resources.

SEED (Sustainable Energy for Environment and Development) Programme

The pioneering and award winning Urban SEED Programme promotes sustainable development through the integration of energy and environment issues in urban development around South Africa. SEED proactively ensures that action occurs to make cities more sustainable through better energy planning and implementation. SEED, with its vast institutional knowledge, works closely with partner organisations including national government bodies, metro local authorities and development NGOs.

Please follow link www.sustainable.org.za to find out more.

REEEP (Renewable Energy & Energy Efficiency Partnership)

REEEP is an active global partnership that structures policy initiatives for clean energy markets on the ground and assists with financing of sustainable energy projects. Great potential exists for cities to be supported in the implementation of sustainable energy projects through assistance of REEEP.

Please follow this link to find out more - www.reeep-sa.org

Reegle

Reegle is an international information portal for renewable energy and energy efficiency. As a joint initiative of REEEP and REN21, this website facilitates fast access to constantly updated information on renewable energies and energy efficiency with respect to potential investment conditions and financing models, useful for politicians, project developers, companies, municipalities, banks, credit institutes. Information provided at this website includes; jurisdiction & laws, policies & measures, finance & investment opportunities, reports & analyses and latest news.

Please follow the link www.reegle.info/ for more information.