British High Commission Pretoria

GREEN BUILDING COUNCIL OF SOUTH AFRICA
WORLD GREEN BUILDING COUNCIL

IMPROVING LIVES BY GREENING LOW-COST HOUSING

Case study report of the Cato Manor Green Street retrofit

Led by the Green Building Council of South Africa, with funding from the British High Commission - April 2012.

Main Funder of Phase 1:

British High Commission Pretoria

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GREEN BUILDING COUNCIL OF SOUTH AFRICA

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REPUBLIC OF SOUTH AFRICA

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Executive summary

South Africa's first 'Green Street' upgrade in a low-income area was completed ahead of the COP17 international climate change talks in late 2011. Thirty low-cost houses in a small cul-de-sac road in the historic township of Cato Manor in Durban received a green upgrade, called a retrofit. This project was led by the Green Building Council of South Africa (GBCSA), in association with the World Green Building Council, and was primarily funded by the British High Commission.

The aims of the project were to demonstrate the range of socio-economic, health and environmental benefits which are possible through sustainable design and resource-efficiency interventions in low-income houses; and to show that people's quality of life can be improved, while keeping the country's development on a low carbon and more 'Earth-friendly' path.

National context

The South African government has built almost 3 million low-cost homes since 1994 and a further 3 million are targeted by 2025. Until fairly recently, green considerations have not been a priority, so people living in these houses continue to spend significant amounts of their income on energy, while suffering disproportionate health burdens. Many can't afford the electricity-driven services of appliances and utilities which would make their lives better (beyond the free basic allocation).

A set of greening interventions for 30 low-cost houses

In the Cato Manor Green Street, each household received an energy efficient retrofit in the form of solar water heaters (SWHs), insulated ceilings, efficient lighting, and heat insulation cookers. Rainwater harvesting tanks were also added, and food gardens were established for the production of healthy, home-grown food. The polluted stream in the area was cleaned up and indigenous trees and smaller plants and fruit trees were planted. This project was the first of its kind in KwaZulu Natal, and one of the first in the country, with such a broad set of interventions in one place.

Improved quality of life for residents

Homes are now more comfortable and safer. Residents have greater convenience, and they are realizing significant energy, water and time savings. Fresh, nutritious food grows at their doorstep and the local area has been upgraded. Some project outcomes highlights are:

- **Hot water on tap for the first time**. Many residents could not afford the energy to heat water regularly before. Now they get this heating service free from the sun, without having to rely on traditional electrical geysers which are expensive and contribute to environmental damage and climate change. So residents have leapfrogged to a cleaner technology.
- **Energy saving and greater affordability of utility services.** Households have saved up to 25% of their electricity costs. For many this saving has meant that they can now purchase electricity to power appliances more than was previously affordable (which is called 'supressed demand'), or use the savings for other necessities. They now get more electricity services for less.
- **Carbon emissions avoided, and revenue generated for community.** 105 tonnes of carbon have been avoided, and the sale of carbon credits will generate funds to be ploughed back into this community.
- **Greater human comfort and aesthetics inside homes, and improved health and safety**. Peak temperatures on summer days have dropped by 4-6°C with insulated ceilings, and a further 2°C drop is possible by adding insulation roof paint. Overall internal discomfort levels have dropped, and further ventilation and insulation improvements are planned for this sub-tropical climate context in Phase 2. Less need for fuels like paraffin, coal and wood mean reduced health problems and fire safety risks for these homes. Unsafe electrical wiring was replaced, and (efficient) security lights were installed above the front door of each house.

- **Training and work opportunities created.** A range of practical, on-the-job training sessions and community education workshops were conducted, and 615 days of local employment were created.
- **Water and food security boosted**. The additional rainwater supply harvested boosts water security, especially in times of erratic rainfall or droughts, and will keep water costs down in periods of municipal water shortages. Rainwater is mainly used for laundry and for watering food gardens, which produce fresh, nutritious food at the community's doorstep. The tanks hold about 30 000 litres over an average year of current-level rainfall, which is more than three months' worth of free basic water allocation. Water use is efficient, and grey water is also being used for food gardens. Sixty percent of homes say that they are saving on food costs already.

Scaling up the benefits for low income communities and the country

If retrofits just like this were done for 3 million existing low-cost houses, then the savings from electricity and water are estimated to be worth about R 3 billion per year (at current tariffs). This is money that would go back into the pockets of poor people and be retained in the local economy. The electricity saving would be over 3400 gigawatt hours (GWH) per annum, which is equivalent to about a third of what a city the size of Durban or Cape Town uses. An estimated 3,45 million tonnes of CO_2would be avoided per year from the electricity saving, to reduce the country's carbon footprint. For the purposes of generating revenue on carbon markets, almost 10 million (9,720,000) tones worth of carbon credits are possible. In terms of employment, it is estimated that about 36.5 million days of work could be created, equivalent to employing over 165,000 people for a year of work (or more people working for shorter periods, which would be the case for retrofits done with involvement from local residents who are trained).

Awareness and advocacy value generated

As a COP17 legacy, the Cato Manor Green Street is now established as a permanent demonstration and living learning site. Residents are trained to be tour guides, and signboards have been erected to illustrate the significant makeover that has taken place in this community. There have been more than 10 different tours there already, for local and international conference delegates, media groups, local stakeholders, politicians and officials. The successful launch event on 5th December, during COP17, included an address by the South African Minister of Public Works. Extensive media coverage has also served to raise awareness more broadly.

Lessons learned, and recommendations for future policy and large-scale programmes

Government is looking for ways to promote a green economy that will have far reaching benefits for the country and its people. Rich learning from this project has been recorded and used to make important policy recommendations for the construction of new homes, the retrofitting of existing houses, and the scaling up of key interventions.

Conclusion

The Cato Manor Green Street retrofit is a living showcase and celebration of how greening interventions in low cost housing can improve quality of life for residents and provide multiple benefits for the country. It points towards a more sustainable approach for housing delivery and human development. What was once an ordinary, nameless, township cul-de-sac is now a stand-out example of green principles in action. It is no surprise that residents have proudly named their street 'Isimosezulu (which means 'climate') COP17 Place'.

A summary version of this report is available on the GBCSA website: www.gbcsa.org.za

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A Cato Manor Green Street resident opens a tap to get hot water in her home for the first time, courtesy of her new solar system. The related plumbing and safe electrical wiring are also evident behind her.

Photo credit: Willem De Lange, on behalf of the GBCSA, took most of the photographs in this document.

1. Background and overview

National context

Since 1994, the South African government has built almost 3 million housing units for the low income sector. Cost-cutting has been necessary to maximize delivery, but unfortunately this has meant that these homes have generally been designed and constructed with no water heating system, and little regard for energy and water efficiency, adequate insulation or other 'green' design considerations.

As a result, occupants are frequently exposed to large daily temperature fluctuations and, in some areas, experience excessive levels of condensation. Keeping homes warm in the winter and cool in the hot summer months requires high levels of additional energy – a resource which is costly and therefore largely unaffordable for most members of these communities (beyond free basic allocations). Furthermore, these extreme living conditions have been linked to respiratory illnesses, which are exacerbated by the burning of fuels like paraffin, coal and wood for heat and cooking.

The use of these kinds of fuel sources is linked not only to health-damaging indoor air pollution from smoke, but also to the start of fires which burn both people and property. The negative impact on health and safety is felt by these families as well as public-funded emergency and medical services that attend to them.

The country now faces the enormous challenge of addressing the reality that the vast majority of 'Reconstruction and Development Programme' (RDP) or more recent 'Breaking New Ground' (BNG) houses do not provide adequate internal comfort or maximise efficient use of resources.

A few pioneering pilot projects like those in Joe Slovo, Kleinmond, Kuyasa and Witsands in the Western Cape, Cosmo City in Gauteng, and Zanemvula in the Eastern Cape have demonstrated the economic and societal benefits of more sustainable design in low-income housing. Not only do green interventions translate into energy, water and financial savings, but also reduce associated illness, safety risks, greenhouse gas emissions and environmental impact. It is important to note that that skills training and work creation have been crucial components in the successful delivery of these projects.

Government has recognised the pressing need for more sustainable housing programmes. For the first time, South African National Building Regulations now require that environmental sustainability measures be included in all new and refurbishment housing plans and designs, starting with energy efficiency[1]. The legislation, which was promulgated in November 2011, is now to be reflected in the National Housing Code for low-cost housing construction. It is expected to call for insulated ceilings and walls as a minimum requirement for all new low income housing. Other considerations may include orientation, bigger windows, overhangs and non-electric water heating. It is not yet clear, however, whether these regulations will be enforced in RDP/ BNG housing, or if they will be used to address the issue of retrofitting existing low-cost houses to become more resource-efficient.

Specific project background

In November 2011, South Africa hosted the 17th Conference of Parties (COP 17) international climate change negotiations in Durban. The Green Building Council of South Africa (GBCSA), in association with World Green Building Council (WGBC), identified this event as an important opportunity to showcase progress and further potential in the field of sustainable development, particularly in lower income residential buildings where more obvious socio-economic benefits are possible.

[1] SANS10400 Part XA, 2011

The GBCSA decided to create a legacy site for ongoing learning and advocacy, and led a green upgrade, or retrofit, that would be completed in time for COP17. This kind of pilot project was a first for the non-profit organisation, which until then had largely been focused on commercial buildings and a recent rating tool for multi-unit residential housing.

The British High Commission in South Africa generously provided the main funding to retrofit all 30 houses in the street, and this allowed for the creation of South Africa's first 'Green Street retrofit' in a low-income area. It was endorsed by the Department of Environmental Affairs, and done in collaboration eThekwini Municipality, with further financial support and contributions from over 10 other organisations.

The retrofit project, which took three months, addressed issues relating to energy and water provision and efficiency, recycling, waste management, an upgrade of the local stream, and food gardens. Given the limited time and resources that were available, it is important to note that this initiative was not designed as a high-level research project, nor was it intended to propose the design solution for low-income housing. Instead it is a practical demonstration of the need to green low-income housing, and the potential impact that similar interventions could have on a national scale.

The primary funding from the British High Commission was R 900,000, or R 30,000 for each of the 30 homes. However, it should be noted that this is not reflective of what the costs for much larger-scale projects of a similar nature would be. Retrofit costs could reduce by up to half of this, depending on the scale and the nature of interventions involved (e.g. rainwater harvesting might not be feasible in some areas).

A resident stands in front of her home which has undergone a 'green upgrade'.
The solar water heaters for two homes are seen on the roof behind her.

2. Objectives of the case study report

This case study report sets out to describe the project's interventions and to record the outcomes in a way that captures the impact for residents, important learning gained through the implementation process, some research findings, future policy recommendations, and the spirit of this successful demonstration project.

It includes:

- A description of what was done.
- Impact for the residents who live in these homes.
- The awareness raising and advocacy value of the demonstration site.
- Research findings, drawing conclusions from implementation experience, residents' feedback and the qualitative and quantitative data gathered before, during and after the project.
- Cost-benefit analysis to determine the feasibility of a national rollout of key interventions for residents and/ or the national fiscus.
- Implementation challenges and lessons learned.
- Recommendations for future policy, programmes and legislation.

The impacts, outcomes and benefits are described in the sections below.

Note: This is a longer version of the case study which is intended for policy-makers, development agencies, donors, project managers and academic readers who are interested in the nature of this project and its outcomes. More detail about the research analysis is covered in the Appendices.

A shorter summary is also available on the GBCSA website (www.gbcsa.org.za).

A resident tends her new vegetable garden. A rainwater harvesting tank and solar water heaters can be seen on the roof of two house units behind her.

3. Description of interventions

A suite of green interventions were implemented at Cato Manor. These are described in the section below, and their impact is described later in the report.

Energy efficiency

All 30 homes received the following energy efficiency upgrades:

- **Solar Water Heaters and related plumbing.** Solar water heaters (SWHs) and pipe reticulation systems were installed to deliver hot water directly into the house. They were SABS-approved, 100-litre, low pressure, evacuated tube-type systems with no electrical backup connection. The evacuated tubes were imported, but all other components (more than 85%) were produced in South Africa. This product was selected for its superior performance qualities. It delivers balanced cold/hot pressure and 'safe' tempered water at 50 to 60 degrees Celsius. It also comes with a life-time guarantee against corrosion, which is very important in coastal areas.

- **Insulated ceilings.** 30mm thick Isoboard (insulated ceiling board) with a thermal resistance value (called 'R' value) of 1 was installed to improve thermal performance in the home. Although the new national standard promulgated after this retrofit requires an R value of 2.7 for new buildings, these retrofitted ceilings still made a marked difference to the internal comfort levels of the houses. The ceiling board, which was sponsored by the product supplier, and other materials (such as steel frames) were produced in South Africa.

- **Safe electrical wiring.** Electrical reticulation to plug and light points was provided according to SABS standards. Very dangerous wiring that prevailed in many of the houses was replaced. An external, qualified electrician conducted electrical inspections and produced the required compliance certificates.

- **Efficient lighting.** In line with the national residential lighting energy efficiency standard, Compact Fluorescent (CFL) bulbs were installed in all the homes. These replaced existing high-energy consuming incandescent bulbs, on average four light bulbs per home. To improve safety, an extra light was installed above the front entrance of each house. The bulbs were donated by the national utility, Eskom. Current Light Emitting Diode (LED-technology) was tested and found to be unsuitable for this application because it could not generate sufficient internal light for reading.

- **Heat retention/insulation cookers**. A Wonderbag™, a locally produced heat retention cooker, was donated to every home by Natural Balance, along with training on how to use them. The Wonderbag™ is a highly efficient insulation cooker that saves energy and makes the kitchen much safer. If it is used on average three times a week, a heat retention cooker can save 0.5 tonnes of carbon per year, per house.

Rain water capture and water efficiency

- **Rain-water harvesting systems.** Twenty-six houses received 2500 litre rain tanks, and one house received a 1000 litre tank due to space constraints. The remaining three houses did not have systems installed due to a lack of space, no interest in using rainwater, or disagreements about positioning a tank in a neighbouring property. Rain harvesting systems provide emergency water supplies in periods of drought or service interruptions. The water can also be used to irrigate food gardens, or for doing laundry. Installing the systems was challenging, because it was not possible to fit a conventional gutter system. The houses were designed with no external timber rafters, purlins or trusses to which gutter brackets could be attached, so an adaptation was designed using flexible agricultural pipe, stainless steel straps and buckles. The base was constructed using recycled tyres and locally available sand. Soil sections were planted with indigenous plants or vegetables.

- **Water (and energy) efficient showerheads**. The low pressure solar heating system and existing showerheads delivered water at a low flow rate (less than ten litres per minute) so it was not necessary to install new showerheads to improve efficiency.

Food gardens and plant landscaping

- **Food gardens.** Food gardens of varying size were established for those interested in growing their own food, with training and active involvement from the residents. These included:

- Seventeen food gardens created in soil beds, directly on the ground, using the 'double dig' method of bed preparation.

- Ninety container mini-gardens made out of 20-litre recycled containers. These featured built-in rainwater reservoirs to counteract poor local soil conditions. The containers, which were distributed to 29 homes, were placed on pallets supported by stacked tyres, and raised to a comfortable working height.

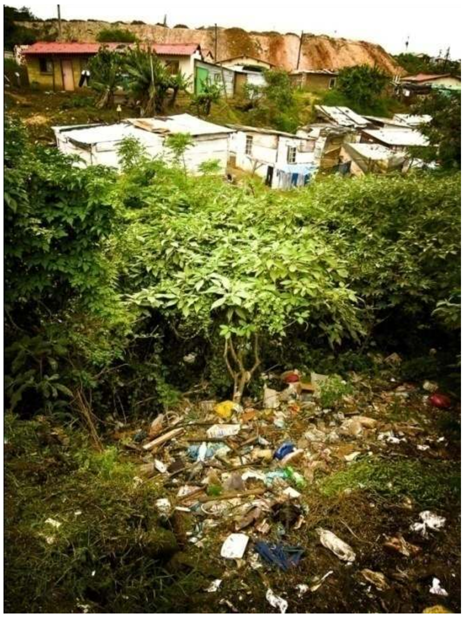
- Fifty small container gardens were created in recycled tyres.

- One demonstration vertical garden was built using recycled bottles.

- One retaining wall was built with old tyres holding a mixture of bank-stabilizing grasses and vegetables.

- **Tree and plant landscaping.** Fifteen indigenous trees, 80 fruit trees and over 950 smaller indigenous plants were planted. These were made possible by sponsorships and 'in kind' interventions from the Botanical Society of South Africa (indigenous trees and plants), Greenpop (volunteer planting) and eThekwini Municipality. The community were directly involved in the planning and implementation of the planting process.

- Permaculture and other food gardening training was provided for the community.



Other installation elements

- **Efficient street lights.** Thirteen Light Emitting Diode (LED) fittings replaced the more traditional, and comparatively inefficient street light bulbs.

- **Insulation roof paint.** Cosmo-Dec sponsored insulation roof paint for two demonstration homes, to assess the effectiveness and feasibility of this material in low cost housing applications. This product is used in the hope of reducing internal heat and maintaining a more balanced temperature. It had been previously tested successfully by the eThekwini Municipality on the roof of one of their office buildings.

- **Recycled accessories.** Furniture and fittings made from recycled materials were provided for a few demonstration homes by Clean Air Factory.

- **Clean up and rehabilitation of the nearby stream.** Alien invasive plants and litter (see above photo) were removed and fruit trees and indigenous plants were planted to prevent soil erosion, and reduce pollution.

- **Stormwater upgrade.** The project highlighted problems with the storm water management infrastructure in this area, which the eThekwini Municipality has since started upgrading.

Community Consultation

Extensive stakeholder consultation was undertaken with the community and its political structures to ensure 'buy in' at the inception stage and co-operation throughout the implementation phase. This process was time-consuming but essential, and must be factored into future projects of this nature. Key consultations were held with the Ward Councillor for overall project issues, the Local Economic Development Committee for labour and economic opportunity issues, and the Area Committee for operational issues. Community meetings were conducted through the Ward Councillor. A local Community Liaison Officer was appointed for the duration of the major intervention period.

Consultation and collaboration with the eThekwini Municipality

Having the municipality on board proved invaluable. Several eThekwini Municipality departments were consulted and provided technical support, training and stakeholder relations for this project. The collaboration included the following:

- Councillor Mngadi from Ward 29, provided project facilitation through the local political structures and committees, and extensive liaison during the project;
- The Electricity Department installed the LED streetlights and provided pre-payment meter data to establish the historical baseline for electricity consumption;
- The Energy Unit provided a key facilitation role and valuable advice;
- City Architects installed four temperature and humidity recorders for the evaluation research, and are pursuing further infrastructure related plans for the area;
- The Solid Waste Department helped conduct the litter clean-up campaign;
- The Agriculture Management Unit and Biodiversity Unit helped with the clearing of invasive plants, and played an integral role in establishing food gardens;
- The Communications Department took video footage of the project;
- The Public Participation Department established a relationship with the community through the Ward Councillor and various political structures and committees.

Community and household characteristics

The Cato Manor houses that were targeted by this project were built in 2006 by the eThekwini Municipality. They are $30m^2$ in dimension, though some have had formal or informal extensions built onto them. All 30 houses are privately owned. Most are owner-occupied, and a few are rented out. Currently 167 people live here (including 34 tenants), which is an average of 5.6 persons per household.

All the houses were built with flush toilets and showers. Eighty percent, however, do not have a sink or basin, so most residents use buckets or basins for collecting water and washing. The homes are connected to the municipal water and electricity supplies. Prepaid electricity meters are used, while water is billed on a post-usage basis. Free basic water and electricity allocations are in place.

Results from the pre-implementation survey showed that almost half of these homes (44%) had been informally extended for rental purposes, or to accommodate other family members. Nineteen percent of households had a formal extension to the house. Post-project survey results point to a 10% increase in new formal extensions in the three month period after the project, while one household undertook informal extensions.

Employment and income

While these households cannot be numbered among the poorest of the poor in South Africa, 77% of the money earners are not formally employed. Combined household income ranges from R550 to R7,000 per month, with an average of R3,031 per household. The vast majority of expenditure reportedly goes on food and transport, a small portion on electricity, and very little on water.

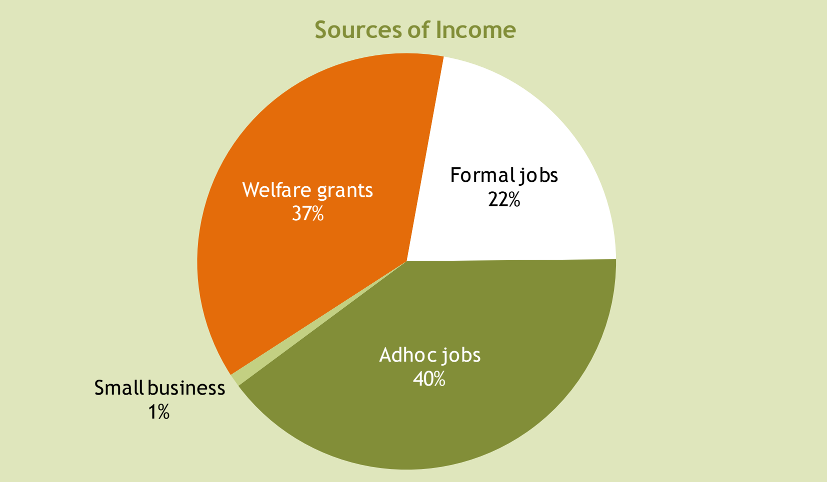


Figure 1:

Sources of income

Energy use

All the Green Street homes use electricity as their main form of energy. Paraffin is also a significant energy source used by almost half of the households (43%), while wood, coal and gas are used to a lesser extent. The tendency to use multiple types of fuel suggests that many households cannot afford electricity for the entire month. After their free basic electricity subsidy and their meagre electricity budget has run out, they rely on small quantities of paraffin, wood, coal or gas that 'fit the pocket', but are also unhealthy and a constant fire risk.

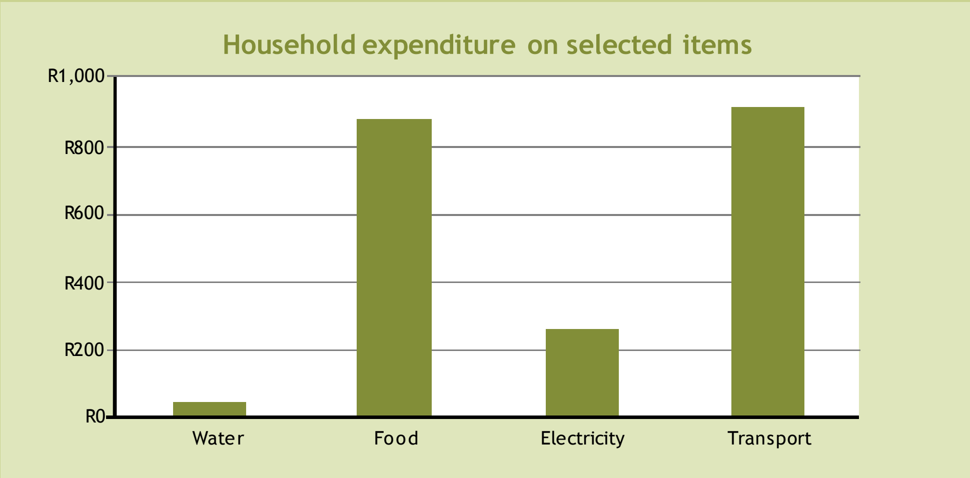


Figure 2:

Average reported household expenditure on selected items

Electricity is primarily used for lighting (100%), cooking (77%) and to power appliances such as a TV, radio and microwave. Paraffin is mainly used for cooking. A few households reported that they used wood to braai and make Zulu beer. The most common electrical appliances in each house were a two plate stove (97%), kettle (90%) and refrigerator (80%). Microwaves, ovens and fans were owned by 30-40% of households.

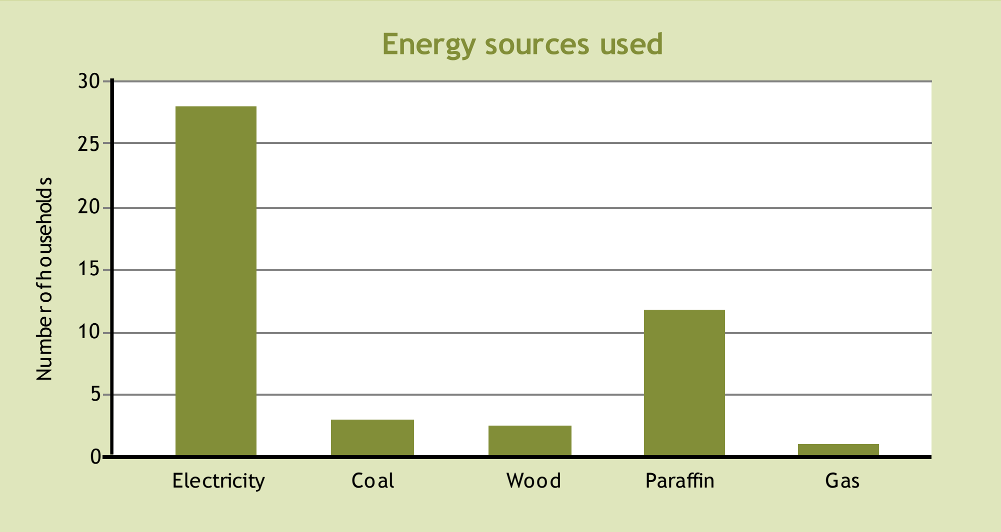


Figure 3:

Forms of energy used by households

Before solar water heaters, water was typically boiled in a kettle for washing. Or those who could not afford electricity - or other fuels - would just use cold water.

4. Research and analysis conducted

Quantitative data for the Cato Manor project was collected in the form of electricity and water usage patterns, temperature and humidity readings. Qualitative data was drawn from pre- and post-implementation household surveys. The pre-installation survey took place in early November 2011, and the post-implementation survey was conducted in early March 2012, three months after completion. The findings of other similar projects were considered, particularly those done at Cosmo City, Kuyasa and Zanemvula.

Analysis focused on the main project interventions and their impact, notably: electricity use, water use, internal temperature and humidity levels, cost-benefit and income, and quality of life. It must be noted that the data gathered was in ‘samples’ over a few months rather than extensive (annual, hourly), as the project was not intended as an in depth research project, but rather as a demonstration project that would spark interest and highlight the need for green interventions in the low-income housing sector.

Wherever possible, conclusions have been drawn and recommendations made. The research findings and results are integrated into the various sections of this document.

More detail, including a list of recommended future research, is addressed in the Appendices.

A CFL efficient light bulb is fitted, while the ceiling boards are still in the process of being installed on the fitted metal framework. In the bathroom another worker is washing his hands using the solar-heated hot water. Safe wiring and plumbing can also be seen.

5. Energy saving and services

Popularity of solar water heaters and heat insulation cookers

The post-project survey found that while all the interventions made a positive impact, the solar water heaters are by far the most popular feature of the upgraded homes. Appreciation for SWHs was widespread, with more than 60% of the interviewed households saying it is the best feature of the project. The water from the SWH is primarily used for bathing (97%), washing dishes (90%), cooking (60%) and laundry (30%). Apart from cost saving, residents value the time saving benefit of having hot water on tap instead of waiting for a kettle to boil. Households feel that the SWHs provide sufficient hot water most of the time. However, more than 90% of the households still use a stove or kettle to heat water occasionally, which may indicate a persistence of water heating habits, or simply the need to top up the heat on cloudy days.

Some of the houses experienced initial problems with their SWHs, which similar projects like Kuyasa have previously shown to be 'teething problems' expected in this kind of installation work. These issues have been addressed through the education of residents, providing a free six month maintenance period implemented by trained locals, and product warrantee backup, if necessary.

> **"Life is great. I now get hot water to wash even when there is no electricity."**
>
> *Resident*

The Wonderbag™ heat insulation cookers have been a huge success. A large-scale uptake of this intervention is evident in that 78% of households report using it at least once a week. Almost half of the homes use it twice a week, and 5% use it every day. The main kinds of meals prepared using Wonderbags™ include rice, samp and beans. Since receiving a Wonderbag™, 60% of households reported that they are using the stove and other fuels less. One household reported that they went on to purchase a second Wonderbag™ to use for their cooking as well.

Some energy saving and increase in electricity utility services

Energy savings have occurred (by as much as 25% in one household) but the overall average saving cannot be seen in consumption data due to 'the rebound effect', short term measurement, and other data and context complexities[2]. Information drawn from the pre-paid electricity system data (which was not a full reflection for all 30 houses) indicates that there was a dip in electricity consumption in November 2011 when the energy efficiency interventions were installed and residents' awareness levels were high. However, over the next couple of months, consumption continued to increase.

When the three months before the intervention are compared with the three months afterwards, half of the residents showed savings. Fifty percent of the households perceived that they were paying less for electricity than previously, which is supported by the electricity meter data. However the overall average indicates a slight increase over time.

> **"There is a change, we pay less for electricity."**
>
> *Resident*

[2] It's important to note that the relatively short monitoring period was insufficient to determine the long term impact of the interventions. There are also many factors which can influence electricity use in these houses and the usefulness of the available data. There was erratic quality of municipal electricity supply services during this period for some homes. Seasonal factors, such as Durban's extremely hot summer months, may have forced an increase in energy use from fridges (which must work harder in summer), and electric fans used for cooling. Household occupancy levels fluctuate, and the electricity from the house connection is often also used by 'outhouses' (informal housing added to the side of the house) or sometimes sold to other informal dwellings nearby. Some even report electricity theft. Another consideration is that quite a few homes have informal, small/micro businesses running from the premises.

All previous energy efficiency research and experience in similar projects indicates that savings must have been realized from the interventions, particularly efficient lighting, solar water heaters and Wonderbags™. For example, in Zanemvula electricity use for water heating definitely dropped, and in Cosmo City 100% of residents reported electricity savings from the SWH and ceilings installed, calculated as an average saving of R 1,154.94 per house per year.

The minimal change in the majority of electricity usage patterns in Cato Manor is probably due to what is called the 'rebound effect' or 'suppressed demand'. These terms explains a common phenomenon in South Africa and other developing countries when a household uses less electricity than it needs or desires because it simply cannot afford to use more. When financial savings are realised, the 'spare' money is often used to purchase more electricity for other household needs.

It is highly likely that this is what has happened in the Cato Manor Green Street. For many, the savings have been spent on the purchase of more electricity services for utilities which have improved their quality of life. However, some households have shown a marked decrease in electricity use since the interventions and are now reaping the financial rewards of their self-discipline.

Profile of a resident who achieved significant electricity savings: Lerato*

Lerato's household realised the biggest savings of all in the Cato Manor Green Street. She managed to cut down their electricity consumption by 25% – an average of 150 kWh less per month, which is 50% higher than the expected savings of 100kWh. Lerato was exemplary in the way that she and her family embraced the interventions and took the required behaviour changes to heart, striving to lower household consumption levels and realise significant monetary savings.

**Not her real name*

The positive impact of LED street lights has also been demonstrated in the Green Street. By implementing this principle, municipalities in particular can reduce rate-payers' contributions to public lighting expenses in the long term. 57W LED streetlights replaced 90W streetlights, which represents a saving of 37 % over traditional lighting systems. The new LED lights installed have higher lux levels than the original lights, and a lifespan of 10,000 hours. This effectively reduces electricity usage over the year by 145kWh per fitting. Projected over their lifespan of about 25 years, the LED streetlights will save 3,300 kWh each.

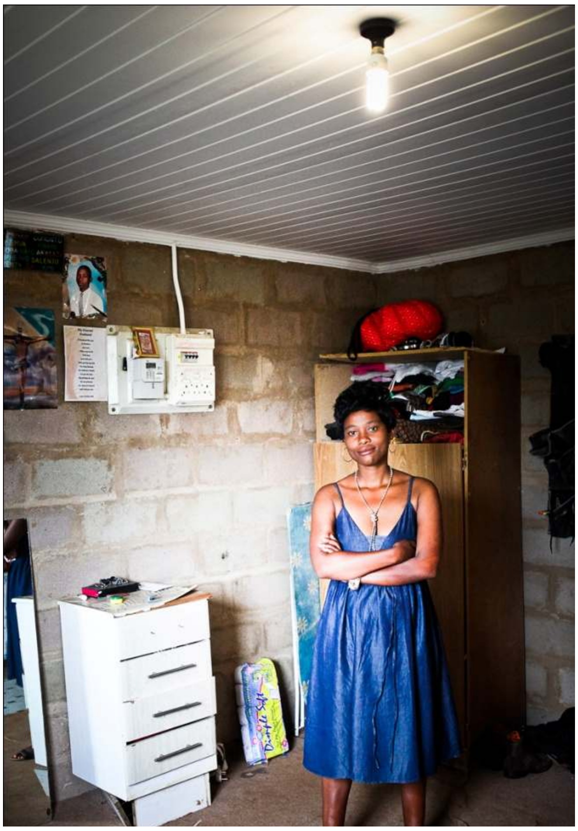
More detail about the research and analysis of energy savings is available in Appendix 1.

Profile of a resident who runs a business from home: Themba*

Despite the energy efficiency interventions, some houses show an increase in electricity use. In Themba's case, a popular local restaurant is run from this house. After the November 2011 retrofit, he installed a potato chip making machine to make chips for his customers and as take-aways for local residents, and his business was booming. Like some others in the area, he is also on-selling electricity to other informal houses around him. It's no surprise then that his monthly electricity consumption from his household connection increased by an average of 200kWh, or 40% in the following few months.

**Not his real name*

6. Human comfort, health and safety



Ceilings have insulated homes and improved their aesthetics

Residents have appreciated ceilings for both their insulating effects and their aesthetic benefits. The post-project survey and informal interviews recorded that residents believed that the addition of ceilings had made their homes more attractive, and that the insulation effect had made a significant difference during the hot summer period.

Peak temperatures have dropped and internal comfort levels have risen

Internal comfort levels in these houses have improved due to the installation of insulated ceilings. Interior temperatures are four to six degrees lower at the hottest time of the day, and human comfort levels have risen overall. Seventy percent of households reported in the post-project survey that comfort levels had improved and said that they were happy with the results.

Measurement and assessment tool used

Data loggers, provided by eThekwini Municipality's Architecture Department, were installed to measure temperature and humidity levels, which form the basis for this finding. A tool called the Human Discomfort Index (HDI) was used to assess the results[3]. The South African Weather Service uses this tool to issue warnings for dangerous temperature and humidity levels in the country. Data collected over short periods reflected extreme summer heat conditions.

Note: For further analysis of the impact on internal temperature and relative humidity, please see Appendix 2.

> "There is less heat in our houses. I feel like I have my own air conditioner now."
>
> *Resident*

Human discomfort levels dropped

Houses with insulated ceilings were found to be more comfortable that houses without, according to the Human Discomfort Index. They had lower internal temperatures, although the relative humidity was higher. (A reduction in temperature typically results in increased humidity.)

> "I am grateful for the beautiful ceiling."
>
> *Resident*

[3] It should be noted that the research analysis would have benefitted from longer monitoring periods, preferably a year, as well as using a more widely accepted method for comfort index, namely the Predicted Mean Vote. Even so, some useful information can be derived from the captured data.

Ventilation and higher insulation would further improve comfort levels

While the insulated ceiling provides a significant benefit at the hottest time of the day, the retrofitted homes were not able to dissipate the heat as easily in the evening. Most of these houses have very poor ventilation. They were not built with air bricks, and many have enclosed their windows by building an extension onto the side of the house. In many cases, windows and doors are kept closed for security reasons, as they do not have burglar bars or other security barriers.

Better ventilation and ceilings with higher insulation levels would improve comfort levels further, particularly in Durban's extreme summer heat and humidity which builds up in the house during the day. To help achieve this, retrofitted air bricks and further insulation (to achieve higher 'R values' and keep radiant heat out) are set to be installed in Phase 2.

Insulation paint on the roof further improved comfort

The impact of adding a heat-insulating paint on the roof was tested on a couple of houses. This product, called 'Sno-Cote', improved comfort levels by further decreasing the temperature (in a North-South oriented house) by an average of 2°C. Overall, the effect of the decreased temperature in the house with Sno-Cote was great enough to counteract the increased humidity, and the HDI was lower than a house with a ceiling, but no Sno-Cote, at the hottest point of the day. This indicates that applying an insulation roof paint like Sno-Cote can further increase comfort inside the home.

Better health and safety

The reduced need for fuel sources like paraffin, coal and wood means that there is a lower health and safety risk in these homes. There is evidence from the household surveys to suggest that both respiratory ailments and waterborne diseases have reduced by up to 20%. Longer term studies would be able to assess this impact with more certainty. However, the positive perception of improved health and well-being cannot be underestimated. In Kuyasa over 80% of residents reported a decrease in the frequency of illnesses as a result of the similar energy efficiency installations.

Safe electrical wiring and plugs (including 'earthing') were installed in this project, replacing very dangerous existing wiring in some homes. This reduces the future safety risk of electrical fires, shocks and other damage from faulty reticulation.

For the first time in a project of this nature, lights (with efficient CFL bulbs) were installed above the front door. This has made a significant improvement in security and is widely appreciated by residents.

> "My son suffers from asthma. I am going to give away my paraffin heater now, because I'm sure I won't need it anymore."
> *Resident*

7. Training and employment

Work creation and skills training were an important focus of the project.

Employment generated

Residents of the Green Street and its surrounding areas were employed to fulfill a number of different roles, from installations to clean up and marshalling. An estimated 615 person days' worth of employment was created during the project[4], broken down as follows:

- 155 person days for the energy efficiency aspects of the project, including installation of solar water heaters and associated plumbing, ceilings and electrical work. A team of 11 people worked for three weeks.
- 60 person days for installing the rainwater harvesting systems.
- 240 person days on the litter clean-up campaign in the river. This role was primarily fulfilled by women in the community.
- 75 person days for stakeholder engagement.
- 85 person days for planting trees and plants and creating food gardens. People from various organizations, some paid and others working on a voluntary basis, undertook the gardening aspect of the project.

A family gets involved with establishing their food garden and planting fruit trees.

[4] This is based on an 8-hour day.

Technical skills training

The most significant technical skills training and work opportunity of the project targeted four local residents, who were taught to assist with the implementation of the energy efficiency technologies. This included installing the solar water heaters and ceilings, with the related electrical and plumbing work. They had 'on-the-job' training from an energy efficiency team who were involved in the previous Kuyasa retrofit project in Cape Town.

The team which installed energy efficiency measures

It is encouraging to see that some of the Kuyasa team have gone on to set up and run their own businesses. This confirms the importance of skills training and practical experience in the creation of job opportunities. With this in mind, Property Point, an enterprise development initiative of Growthpoint Property Company, has committed to providing further training and business development support for the four local residents who worked on this project.

Community training

A range of community training workshops were conducted to educate residents on the efficient use of resources, as well as the use and maintenance of the new technologies and installations provided. The training improved knowledge and provided practical skills. Participants reported afterwards that the sessions were well presented and informative. The following topics and practical training were covered in more than five different training sessions, which took place over a few months:

> "I learned new things about climate change. I also learned to look after my water by fixing leaks."
> ***Resident***

- Introduction to climate change and resource-efficiency.
- Introduction to all the technologies and interventions, and how to use and maintain them for best results.
- How to be more resource-efficient at home to save money and help save the Earth.
- Use and benefits of heat insulation cookers. Practical training for Wonderbag™ recipients.
- How to plant trees and food gardens. Practical demonstrations, including the 'double ditch' method of preparing beds for planting vegetables.
- Permaculture training. For three months following the implementation, Food and Trees for Africa provided on-going support for the community as they learnt to maintain their food gardens. The training sessions continuously demonstrated the importance of adopting simple food growing techniques that make efficient use of natural resources.

8. Water security, provision and wise usage

Rainwater storage enhances water security and food security

The rainwater harvesting systems enhance water security and provision for these households. The 2500 litre rainwater tanks installed in most homes are able to hold a total of 29 000 litres of water over an average year of current-level rainfall (and with regular use). This equates to more than three months' worth of free basic water allocation from the Municipality. A full tank of rainwater is the equivalent of almost R30 of municipal water, in terms of financial savings.

This additional rainwater supply will help boost water security and free provision especially in times of erratic rainfall or droughts, and will keep water costs down in periods of municipal water shortages.

Residents report using the rainwater tanks primarily for laundry and watering their food gardens, and to a lesser extent for dishwashing and other uses like car washing, flushing their tenant's toilet and bathing.

In this 'peak oil' era when the cost of fuel is ever-rising, the transport cost of food is likely to become prohibitive for low-income communities, and local food production will become increasingly necessary. Water is essential to grow food, so this means that the conditions for better local food security have also been boosted.

Although the extent to which these tanks are being used is not being measured, it is safe to say that whatever rainwater is captured and consumed constitutes a saving of municipal water, and provision of free water to residents.

Solar water heaters have not increased average water use

Average water use data provided by the eThekwini Municipality indicates an upward trend over the past two years in Cato Manor. From October 2011 onwards, average consumption exceeded the 9kl free basic water allocation per household. This means that several residents would have just started paying for municipal water bills at the same time as the retrofit occurred.

The upward trend in water use was slightly accelerated in the first two months when solar water heaters (SWH) were installed, but decreased in the following two months. Water usage was expected to increase when SWHs started providing free hot water, and residents were warned in training sessions about the need to use water efficiently to avoid increased water costs. As anticipated, there was a slight increase in consumption over November and December 2011 (5% and 9% respectively), but a drop of 6% occurred in January 2012, and a further 6% in February 2012. This downward trend (over the last two months of readings) indicates that residents adjusted their water usage habits to stay within the free 9kl per month allocation. It is likely that rainwater tank usage would have increased to compensate for this.

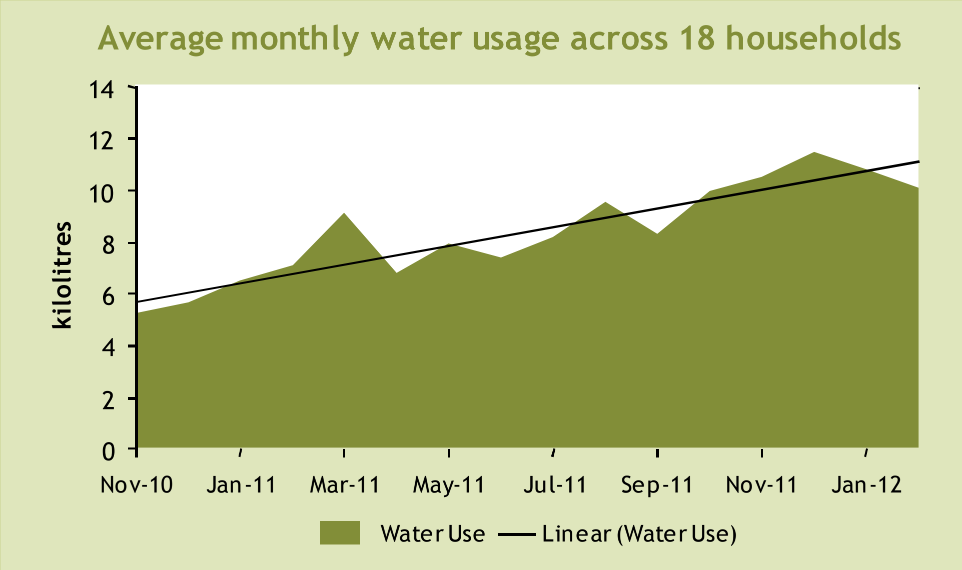


Figure 4:

Average monthly water use for 18 Cato Manor houses with complete water billing data from November 2010 to January 2012

Efficient flow and use of water

The low pressure solar heating system and existing showerheads delivered water at a low flow rate (less than ten litres per minute) so it was not necessary to install new showerheads to improve efficiency. The houses have full pressure connections, but whatever the flow rate is from tap sources (other than the showers) it appears that efficient water usage is being actively managed by residents to keep costs down.

Grey water usage shifts, with more going to food gardening

Prior to the interventions, households primarily disposed of their grey water down a shower or sink drain connected to the sewer, or into their own yards, or into the stream where it may have posed a pollution risk. After the retrofit these practices continued to a slightly lesser degree, but notably 20% of households report that they now use grey water to irrigate their food gardens. This change in behaviour indicates that community training did have an impact on awareness and action.

Note: For more information on the impact of solar water heaters and rainwater tanks, please see Appendix 3.

9. Nutrition and the value of food gardens

Food gardens were installed alongside the vast majority of Green Street houses, wherever there was space available. Most homes have cooked meals using home-grown vegetables already. Nutritious food at the doorstep is a particularly important benefit for poor households where health problems like HIV AIDS are prevalent, as is the case in Cato Manor.

The general consensus reported in the post-project survey is that food gardens are useful and have the potential to produce income from selling home grown food. So far residents have grown vegetables such as spinach, brinjal, green pepper and beetroot, with 60% reporting savings on food expenditure since the project. People can also save on transport time and grocery bills. It will take a while yet for the fruit trees to bear fruit, but the likes of paw-paw and banana (which grow fast in the sub-tropical climate of Durban) will offer good nutrition value.

Although residents say that they are deriving benefits from the food gardens and that they are maintaining them with regular watering, a number of gardens were not in good condition when the post-project survey took place. Some reported that the plants got 'burned' in Durban's excessive summer heat. Maintenance and overall food output should be tracked over a longer period to gauge the effectiveness of this intervention.




Wherever there was space available, food gardens were installed alongside houses.
Many container gardens were also established.

10. Vegetation and local area upgrade

Clean up and rehabilitation of the nearby stream

The stream alongside Cato Manor's Green Street had become heavily polluted. The street is too narrow for refuse removal trucks to access easily, so residents tended to dump their waste into the stream area, rather than dispose of it at the collection point at the end of the road. Litter was piled high and grey water was being poured into the stream, further polluting water that had already been contaminated by informal settlements upstream.

Flooding occurs regularly in this area and had taken its toll on the river bank, which was badly eroded and starting to threaten both informal structures and formal housing. Older, more established trees which had once held the river banks in place, had been cut down for firewood, while invasive plants like Lantana were taking over the stream banks and sucking up precious water resources.

In collaboration with eThekwini Municipality and other volunteer organisations such as Adopt-a-River, teams cleared the alien plants and litter. This made way for new plantings of indigenous flora and fruit trees to help prevent erosion.

Multiple benefits of indigenous plants

The hundreds of indigenous plants supplied by the Botanical Society (and planted with the help of volunteers from Greenpop) provide obvious environmental benefits such as producing oxygen, providing shade and absorbing carbon dioxide. But, they were also selected for their medicinal properties, their historical or cultural value, an important environmental function, or their potential to be used for income generation. For example, an indigenous reed was specially planted alongside the stream to help secure the bank and naturally clean the polluted water that flows past. This reed can also be harvested and used by the community for crafts like basket and mat weaving, which in turn can be used to generate an income. The value of indigenous plants which can thrive in local climatic conditions should not be under-estimated.

Solid waste disposal has doubled

Residents have doubled their solid waste disposal since the Green Street intervention, according to the household surveys.

Waste disposal quantities per week	Pre survey	Post survey
1 bag or less	77%	53%
2 bags	17%	33%
3 or more	7%	13%

Figure 5: Solid waste disposal trends pre and post the intervention

This change in behaviour may well have been prompted by the project's training and the intensive clean-up campaign which targeted the entire street and its surrounds, including the litter-choked stream and a grassy bank at the end of the street which had been used as a general dumping ground. It is likely that the more pleasant surroundings have instilled a general desire among residents to uphold and maintain the improved state of their local environment.

Rather than throwing their rubbish on the streets, residents may now consider waste bags a more acceptable means of disposal. This could account for the dramatic increase in the number of bags compared to the figures gathered during the pre-intervention survey. A recycling initiative is planned for this street in Phase 2, in conjunction with the eThekwini Municipality's Solid Waste Department and a local NGO.

Increased pride in homes, street and community 'ownership'

Residents are clearly taking pride in their revamped homes and community. The stream and litter clean up and planting programme has created a more pleasant outdoor environment, to match the improvements in the houses. Anecdotally, a follow up visit to three previously messy and unhygienic households showed that they were neat and well-maintained, which points to a positive psychological effect. Residents are using and benefitting from the interventions, and have been generally committed to playing their part in the on-going success of the project. Their 'buy in' and pride is also notably reflected by the fact that the street, which was previously nameless, is now going through an official naming process. The name the community has chosen is 'Isimosezulu (meaning 'climate') COP17 Place'.

11. Awareness and advocacy value

The project has successfully served as a strong awareness-raising tool to demonstrate the benefits of integrating sustainable design principles and resource-efficiency practices into low income housing. Media coverage has been positive and broadly published, including newspaper and magazine articles, radio interviews, television reports, internet website articles and blogs. This has amounted to about 3 million Rands' worth of public relations value, and has raised awareness in many sectors, both local and international.

On 5 December 2011, about 100 (external) invited local and international guests and a large group of local residents attended a jubilant project launch, which celebrated the transformation that had taken place in the newly established Green Street. Residents shared their stories inside their homes, and explained how the implementation had changed their lives for the better. To the sounds of live performances from local musicians, guests were able to experience for themselves the impact that this project has made on the community, including tasting food cooked in Wonderbags™.

Outside they learnt about the food gardens, indigenous plants and the stream upgrade. The national government minister of the Department of Public Works joined the celebration, and addressed the guests and residents. Many COP17 delegates commented that it was the best event they had attended at this COP, or at any of the many past COP side events in other countries.

While the project was timed and implemented specifically to coincide with COP17, it continues to draw visitors. Residents are trained to be tour guides, and signboards have been erected (see pages 39 and back page 55) to illustrate the upgrade and its benefits. In the first few months alone, a broad spectrum of both local and international organisations came to view the site in more than 10 different site tours. This included government officials and politicians (as well as local political committees), large public organisations (such as Eskom), media groups, diplomats, development and donor agencies, private sector companies (many involved in green products and services), NGOs, financiers, business associations and academics. Their impressions of the project have been overwhelmingly positive, and in many cases have resulted in significant review and reflection on related subjects in their realms of influence.

(Left) Resident Deliwe Nobekwa explains how her home & life have changed to Minister Spellman of UK Dept of Development, Environment and Rural Affairs and British High Commissioner Dame Brewer.

(Below left) A site tour group learns about the food gardens

(Below) Address by Minister Nxesi of Dept of Public Works

12. Scaling up the benefits

Cost-benefit analysis for savings, payback periods

This project has shown that households can save up to 25% of their electricity bill. For many this saving has meant that they can now purchase electricity for additional services which they couldn't afford before (otherwise known as 'suppressed demand'), or spend the savings on other necessities.

A cost benefit evaluation was conducted for key water and electricity saving interventions in the Cato Manor Green Street. The methodology is based on household energy and thermal modelling approaches, or typical savings figures, as determined by more detailed and longer-term studies in other areas of South Africa. It calculates how long the intervention will take to pay for itself in terms of savings made over time, which is defined as the payback period. (Note that end users will not necessarily be footing the bill. This is simply a means of determining the cost effectiveness of the interventions themselves.)

The key areas of saving that were modelled and analysed were:

Intervention	Kind of saving
Insulated ceilings	Reduced need for heating in winter and cooling in summer
Solar water heaters	Less frequent use of a kettle to boil water, but a possible increase in water usage
Efficient lights	Reduced consumption of electricity at night
Heat insulation cookers	Reduced cooking time and energy costs
Rainwater tank	Reduced use of municipal water
Food gardens	Smaller grocery bill and a possible reduction in transport costs

Figure 6: Interventions and their expected savings

Note: Potential health and well-being cost savings should also result from these interventions, but it is extremely difficult to determine which benefits can be directly attributed. Similarly the safety and security-related costs borne by private households and public-provided services are also complex to measure. Therefore these factors were omitted from the analysis.

The combined interventions can save a household in the region of R90 per month for electricity and water, or more. This is an important saving for a low-income family. It should be noted that savings on insulated ceilings are the lowest in the country due to KwaZulu Natal's mild winters. Ceiling benefits are significantly higher (around ten times) in colder inland areas.

CFLs efficient lighting and heat insulation cookers make excellent financial sense to the end user, with payback periods of under a year.

Insulated ceilings, SWHs and rainwater tanks have longer payback periods, from 11 to more than 25 years.

Avoided electricity generation costs

From a government based perspective, it is useful to consider the cost of each energy efficiency intervention against the electricity it saves over its lifetime. This figure (R/kWh saved or avoided) is a useful comparison to the cost of electricity generation technologies (R/kWh generated). It is often the case that energy efficiency interventions are less expensive to implement per unit of energy than running the country's power plants. The following figures, normalised to equivalent lifespan costs, apply to KwaZulu Natal[5]:

Intervention	Capital cost of the initiative per kWh saved. (Avoided generation of electricity compared with Eskom's cost of generating this electricity which is 95c/kWh.)	Comparison over the average 30 year lifespan of a power station
Insulated Ceilings	60c/kWh saved	One ceiling is likely to last 30 years
SWH	238c/kWh saved	2 systems over 30 years
Efficient lights	54c/kWh saved	9 light bulbs over 30 years
Insulation heat cookers	17.4c/kWh saved	3 cookers over 30 years
Eskom average generation = cost + externalities[6]	95c/kWh generated (40c generation + 55c externalities)	30 years

Figure 7: Avoided generation costs[7]

From this perspective, it can be concluded that:

CFLs, heat insulation cookers and ceilings are a relevant intervention from a national cost benefit perspective, as they are cheaper than typical average electricity generation costs.

National scale implementation: energy, water and carbon savings and employment creation

The benefits demonstrated through the Cato Manor Green Street retrofit could have great impact value at national scale, if a retrofit just like this was conducted for the approximately 3 million existing low-cost houses.

The savings from electricity and water alone are estimated to be worth about R3 billion per year (at current tariffs)[8]. This is money that would go back into the pockets of poor people, and be retained in the local economy which sorely needs it.

The electricity saving would be over 3400 gigawatt hours (GWH), which is the equivalent to a third of what a city the size of Durban or Cape Town use. It's worth 11% of what a typical 'six pack' power station generates per year (and 8% of what the new Medupi power station would produce). This is particularly significant as South Africa faces a medium-term electricity supply shortage. It also has the potential to impact positively on greenhouse gas emissions and save on water used in the generation process.

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[5] To calculate the avoided electricity generation cost, the capital cost of having the energy efficiency intervention in the house for 30 years is divided by the total number of kilowatt hours of electricity which is saved or avoided by that intervention over this period, giving a c/kWh figure. (Essentially the capital cost for each kWh saved). The Eskom cost of generating electricity used here is a figure for running South Africa's currently predominantly coal-fired power stations, but it excludes the cost of building new power stations which would make it much higher. The 30 year period is used to compare the intervention to the average life span of a power station. E.g. Lights may have to be replaced up to 9 times over 30 years, and these costs must be added up, while a ceiling will in all likelihood not need to be replaced.

[6] External cost of electricity generation: Contribution to the Integrated Resource Plan 2, for Electricity, ERC (UCT), July 2010 – Key externality costs are for greenhouse gas emissions and impact on health

[7]This has not been calculated using a 'supressed demand' methodology.

[8]This calculation is based on installing an insulated ceiling, SWH, efficient lighting and a heat-insulation cooker (as per this project), as well as a rain-water harvesting system for each house. Note that a 'suppressed demand' methodology has been used to calculate the savings on the insulated ceiling impact.

The breakdown of the annual savings impact from a potential national rollout of the key interventions in 3 million homes would be as follows:

Insulated ceiling		SWH		Efficient lights		Insulation cooker		Total electricity		Rainwater tank	
GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	Ml	R (mil)
822	R 670	1188	R 968	846	R 689	608	R 496	3464	R 2 823	30600	R 344

Figure 8: Annual savings for nationwide rollout to 3 million houses (based on current eThekwini tariffs)

Based on this electricity saving, approximately 1.15 tonnes of CO_2 will be saved per household per year in Cato Manor. This excludes any further carbon reduction from other interventions like absorption by the trees or plants, or reduced transport, or from less electricity used for municipal water supply and wastewater treatment systems etc.

At a national scale, some 3.45 million tonnes of CO_2 would be avoided per annum from the electricity savings, as a reduction in the country's carbon footprint. This is also equivalent to reducing a third of the carbon emissions produced by annual electricity consumed by a city the size of Durban or Cape Town.

For the purposes of generating revenue on international carbon markets, almost 10 million tonnes worth of carbon credits are possible per year (9,720,000 tonnes.)This is according to the 'suppressed demand' methodology which was accepted by the United Nation system and the Clean Development Mechanism (CDM) for the Kuyasa energy efficiency project in Khayelitsha, Cape Town which was the first approved Gold Standard CDM project in the world. (The conservative estimate of 3.24 tonnes per house is used for a national retrofit, bearing in mind very different climatic conditions around the country.)

In terms of employment potential, about 36.5 million person days' worth of work could be generated if retrofit upgrades just like this were done for all existing low-cost houses[9]. This is the equivalent of just over 165,000 years of work (165,909 person years). Translated, this is over 165,000 people working for a year, or more people working for a shorter period, which would be the case for retrofits done with involvement from local residents who are trained.

This would be a tremendous contribution to South Africa's drive towards a 'green economy'. In Kuyasa the energy efficiency retrofit of 2,309 low-cost homes was done in 17 months, using a public-works style job creation methodology. It achieved over 65,000 person days of labour within the beneficiary community. Similarly in Zanemvula 24 people were employed over an 18 month period to install SWH on 1,263 homes.

Greening projects of this nature can be implemented on a large scale as public works and job creation related programmes, and they are also ideal opportunities for growing small contracting businesses. Community members can be trained and employed to install a range of technologies and related reticulation and greening initiatives, including: SWHs, insulated ceilings, electrical rewiring, food gardening and recycling. Community liaison officers also gain valuable experience that can translate into job opportunities.

Mexico, through its Nationally Appropriate Mitigation Action (NAMA) programme, is tackling climate change on a national scale by subsidising energy efficiency improvements in private homes. See the section below on policy recommendations for South Africa to scale up the greening of low-cost housing.

Note: For further detail on the cost benefit analysis, please see Appendix 4.

Note: The savings above do not include the significant potential private and public savings from improved health & safety, reduced transport and other quality of life factors which are not easily quantifiable.

[9] The assumption made was that larger-scale projects would not generate the same rate of work because, for example, they would not require such intensive stakeholder engagement and would not necessarily include the kind of extensive river and litter clean-up work.

13. Implementation challenges and lessons learned

Executing a retrofit, like most projects, means having to deal with some challenges. For example, active stakeholder engagement was necessary throughout the project, particularly with the community of local residents, and the project team had to work with poorly constructed, under maintained houses. Lessons learned during this process are summarised below, in the interest of assisting future retrofit projects and greening of new housing construction.

Technical issues

- **Measurement of energy savings is very difficult in a low-income context.** For example, low-income households use less electricity than they need or would like, because they simply can't afford more. When financial savings are realised form energy efficiency measures, the 'spare' money is often used to purchase more electricity for other household needs- so consumption doesn't drop even though the value of the electrical services has increased and quality of live has improved. This is an international phenomena called the 'rebound effect' or 'suppressed demand'. Linked to this is the following factor:

- **It cannot be assumed that residents of a low-cost house are the only electricity users linked to that household meter.** There could be one or more informal dwellings close by that are using the same electricity source. The homeowner might be giving electricity to extended family members, or selling it on to tenants and non-electrified neighbouring houses. The number of occupants on these properties can vary significantly, which will also affect any studies of metered data.

- **Impact measurement needs to be set up in advance and undertaken over a longer term,** for at least a year after installation.

- **Insulated ceilings in sub-tropical climates can tend to trap heat that is built up during the day**, unless there is effective ventilation and sufficient levels of insulation or heat moderation (through methods that keep summer radiant heat out).

- **Different technologies will be most valued or effective in different climatic areas.** Solar water heaters (SWHs) were the most popular intervention in Cato Manor, whereas in the Kuyasa project in Cape Town, ceilings were preferred.

- **Electrical rewiring is often required for a retrofit**, especially in low income housing where many installations are not compliant with safety standards.

- **Low-cost houses are typically not equipped with guttering, or built in such a way to make gutter retrofits simple for rainwater harvesting purposes**. Innovative guttering systems may need to be devised for retrofits, but these often have functionality problems and may not last as long as conventional gutter systems. For example, in Cato Manor a flexible agricultural pipe was fitted over the edge of the roof sheeting, but in some cases this leaked onto the doorway due to uneven roof levels.

- **Poor quality roofing can pose a significant hazard** to workers installing SWHs, and can impact the potential success of the SWH installation. Roof structures are often cracked and brittle. Workers on the roof have to take great care to prevent further breakage and to protect themselves from falling through the roof, which poses a danger to both people and property.

- **Roof leaks need to be repaired before insulated ceilings are installed**. Rainwater leaking through cracks or holes created during construction tends to pool above the new ceiling and can cause electrical shorts in light fittings, as well as damage to the ceiling. Budget should be set aside for repair of leaks or replacement of broken roof panels.

- **Ensuring the high quality of the solar water heater product and installation method is essential.**

- **Pest control measures are recommended when ceilings are installed**. A few residents reported that rats were gnawing at the ceiling material (Isoboard) and this should be prevented.

Financial

Raising finance through sale of reduced carbon emissions is possible, but limited. For the purposes of generating income from selling carbon credits, the energy efficiency interventions in the 30 houses in Cato Manor have been estimated to reduce carbon emissions by 104.7 tonnes of CO_2 per year, using an approved Clean Development Mechanism methodology[10]. This represents a relatively very small number of carbon credits that will generate just a few thousand Rands per year. However, the sale of these carbon credits has important symbolic value because the revenue will be fed back into the community for maintenance and other project benefits (through a trusted institutional arrangement).

The carbon credits have been registered on the voluntary carbon markets by Credible Carbon, which is an independently audited registry. The credits are to be purchased by an organisation which will not require third party verification, as this would reduce the revenue available for the community. Similar projects like Kuyasa have shown that carbon finance revenue through the Clean Development Mechanism, and even through voluntary markets, is not generally enough to cover more than a minority portion of costs and is only really worthwhile for very large-scale programmes. There is still value from the sale of carbon on voluntary markets, however, because it does offer the opportunity for at least some funds to be channeled to community development, such as on-going maintenance on the 'green' equipment or food gardens.

Stakeholder and community engagement, education and cohesion

- **Active and intensive stakeholder engagement is required**, and adequate resources have to be directed towards this process. Collaboration with municipal departments such as Electricity, Environment and Architecture helps to broaden the achievement of project goals. Relationship building with the community through clear communication with the local councillor/s and committees is essential for the smooth running of the project.
- **Three important roles are:**
  - **Project facilitation** – ensuring political and community support, liaising with key municipal departments, and overall project management.
  - **Field management** – dealing with day to day project issues that don't require intervention through local political structures or municipal engagement, managing the local liaison officer, and facilitating training.
  - **Local community liaison** – the community's eyes and ears, and a link between the contractor and the local labourers
- **There could be a variety of local community issues or dynamics that need to be dealt with as and when they arise.** These cannot always be predicted. Disputes or poor relationships between semi-detached households or neighbours can hinder the project. For example, disputes occurred over the placement of rainwater tanks and the space required for food gardens.
- **Community briefing and training sessions need to be staggered over time**. This way, residents have time to get to grips with the issues or subject matter in manageable, 'bite sized' chunks and are not overwhelmed by too much input at once. A set of shorter sessions at a local venue are preferable to fewer, longer training sessions.
- **Social cohesion is essential for community 'ownership' and on-going maintenance of interventions which have collective benefits**. Where the intervention goes beyond the private home (e.g. common areas upgraded, litter cleaning and plant landscaping), good relationships between community members and collective management systems are key if these features are to be well maintained.

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[10] This was calculated using a 'suppressed demand' methodology established earlier through the Kuyasa project by South South North (SSN) and Credible Carbon, which is an independently audited registry. It is a methodology approved by the United Nations and the Clean Development Mechanism (CDM) which approved Kuyasa as the first Gold Standard CDM project.

14. Recommendations for future policy, programmes and legislation

South Africa has recognised the imperative to respond to the state of rapidly dwindling natural resources, environmental pressures and climate change, which pose a fundamental threat to economies and human survival in this country and worldwide. Policy development and planning is gaining momentum to shift to a lower-carbon and greener development path. Government's green policies and programmes of action are being established in close alignment with the strategic intent of current national policy, most notably the New Growth Path, the Industrial Policy Action Plan (IPAP) 2 (which over the next 5 years allocates R25 billion for investment in the green economy, R 10 billion for job creation, and R 500 million for an energy efficiency fund), the White paper on a Climate Change Response Strategy, and the Medium-Term Strategic Framework. These are also informed by international frameworks. The first government Green Economy Summit was held in May 2010 and the Department of Environmental Affairs called for Expressions of Interest in Green Economy Programmes in 2010/11.

Energy efficiency measures have been introduced into the National Building Regulations and will be enforced for all new buildings through SANS 10400 Part XA, which was promulgated in November 2011. The degree of this enforcement in respect of low cost housing remains to be seen, as it is yet to be integrated into the National Housing Code (NHC) which is the building standard for low-cost housing construction. The NHC would need to be amended to reflect the new changes before any budget from National Treasury can be allocated. Agreement about which interventions are to be included in the NHC still needs to be reached with the Department of Human Settlements, which is also aiming to keep new building costs down. Indications are that insulated ceilings and rendered walls (which are the most beneficial of the part XA energy efficiency requirements) will be enforced as a minimum.

A further water efficiency addition to the building regulations is expected to be tabled in the medium term, and this would be part XB of the same standard. The standard will be further developed to incorporate other aspects of sustainability beyond energy and water in future.

There are a range of government-led programmes or projects which are already directed at low-income communities, such as: the roll out of 1 million solar water heaters (led by Department of Economic Development with contributions from many other departments); improving non-motorised and public transport options; livelihood resilience through rainwater harvesting; and the Working for Water and Energy public works programmes to create employment. Departments such as Environment Affairs (DEA) are also contributing to short-term green projects in low-income areas conducted through the Expanded Public Works Programme. For example DEA is involved in three projects in the Western Cape: the energy efficiency retrofit in Kuyasa, solar water heater installations in Stellenbosch and adding trees and parks in Delft. Some Provinces are also taking proactive steps. For example, the Western Cape Department of Human Settlements are in the process of incorporating sustainability criteria (water, energy, waste and general resource efficiency) in their planning processes of sustainable delivery of low-income housing in the province.

Government is looking for ways to promote a 'green economy' that will have far reaching environmental, economic and societal benefits, and the Cato Manor Green Street and other flagship projects in this arena are strongly aligned with this intent. The retrofit interventions, skills training and job creation achieved by this project, are a demonstration of the potential impact that similar measures could make if implemented en masse in South Africa. The greening of public buildings is also a possible avenue where people skilled in retrofits could be employed.

A carbon financing programme aimed at subsidising a suite of low income household energy efficiency interventions is being pursued. This could be set up as a Nationally Appropriate Mitigation Action (NAMA), or a standard Clean Development Mechanism (CDM) programme, based on the relevant international protocols/ frameworks. The establishment of what is called a Sustainable Settlements Facility (SSF) to house such a programme is provided for in the 2011 White Paper on Climate Change. Such an entity could be based at the Development Bank of Southern Africa (DBSA). It would need to be large-scale programme to cover considerable registration and monitoring costs, and, since carbon financing will only cover a small portion of implementation costs, it would need to secure additional funding or financing to make the rollout of interventions viable.

Based on the experience and outcomes of this project, a set of recommendations for future policy, programmes and legislation relating to the greening of new and existing low income houses is summarised in the table below:

Key Interventions	Existing policy, legislation or large-scale programmes	Actions required	Departments/Bodies to be addressed
A) FOR NEW BUILD :			
Key energy efficiency (EE) features such as: Insulated ceilings and walls, with locally appropriate measures for ventilation Larger window area N-S orientation Overhangs on north facing windows	New building standards introduced in November 2011. SANS 10400 XA enforces these features for all new buildings, but it is unclear if these will be fully enforced for low cost housing delivery level. There is a government subsidy of an additional R15,000 per house which has been put in place for adding insulated ceilings and wall plastering to new low-cost houses that are built in a coastal belt across a few provinces where the condensation problem is greatest.	Rapid and comprehensive compliance with SANS 10400 XA, and future additions to this. Ensure provincial and national Human Settlements Departments engage with SABS and NBRC regarding the new standards, and allow opportunity for these to be revised with their input. Area-appropriate ventilation should also be addressed. Ensure local employment, knowledge transfer and skills development is addressed throughout this rollout.	Dept. of Human Settlements to include EE interventions into the National Housing Code to ensure that future low cost housing receives these features. Implement Construction SETA/FET college/CSI programmes to ensure that knowledge transfer and skills development takes place.
Water conservation and efficiency: Rainwater tank Efficient showerheads	Currently no explicit national policy exists, although some municipalities like Cape Town have regulated efficiencies such as shower flow rates (not to exceed 10 litres per minute). However, SANS 10400 XB will legislate for water efficiency in the future. It is not yet clear what these requirements will be or when legislation will be promulgated.	The financial benefit of a rainwater tank still requires further research to determine efficacy over a lengthy period. If rainwater tanks are proven viable in certain rainfall areas, provision for guttering systems must be made in new build housing there. Efficient showerheads should replace existing high pressure fittings wherever practical and appropriate. They have high cost-benefit returns.	Dept. of Trade and Industry to feed information on rainwater tanks to the SANS 10400 technical committee on water efficiency. Water efficiency education and awareness programmes to inform built environment professionals and communities about existing regulations and cost-benefits.
Urban greening and food gardens	The Department of Human Settlements has Urban Greening Guidelines, and the Department of Water Affairs and Forestry's Urban Greening Strategy (2005) supports the development of urban forestry.	At least one tree planted with each new low-cost house- either an indigenous, deciduous tree planted on the North side of the house, or a fruit tree. As part of urban greening programmes. Local level nurseries established, with skills training.	National, Provincial and Local and other government entities involved with the decision-making and implementation of low-cost housing construction and urban agriculture, especially Human Settlements, Agriculture and municipalities

Key Interventions	Existing policy, legislation or large-scale programme(s)	Actions required	Departments/Bodies to be addressed
FOR RETROFIT OF EXISTING BUILDINGS/ AREAS:			
Insulated Ceilings with R values that conform to national specification, and take into account variations in different climatic areas.	Ad hoc local government and private industry programmes exist.	South Africa must address the fact that there is a backlog of about three million houses without ceilings. The cost of installing ceilings country-wide is lower than the expense for generating electricity to heat/cool homes. Put a national target for ceiling retrofits in place, and allocate national budget for this. Local employment and skills development should be incorporated.	The Dept. of Energy has the potential to co-ordinate a national ceiling retrofit programme. The Working for Energy programme could implement the retrofit and/or partner with municipalities to facilitate rollout. Implement Construction SETA/CSI programmes to ensure that skills development takes place. The SSF, if realised, will reduce costs through carbon finance.
FOR NEW BUILD AND RETROFIT:			
Solar water heaters (SWHs)	The Dept. of Energy has set a national SWH target of 1 million by 2014/15. This programme has received national budget allocation. Eskom is tasked with the rollout.	Local employment and skills development should be incorporated wherever possible, ensured by the departments which are running solar programmes.	Implement Construction SETA/CSI programmes to ensure that skills development takes place. The Sustainable Settlements Facility (SSF), if realised, will reduce costs through Carbon finance.
Heat insulation cookers	No policy exists. The owners of Wonderbag™ are in the final phases of approval for an international carbon financing programme. They are co-ordinating large scale Wonderbag™ rollouts through municipalities and corporates.	Significant financial and carbon reduction benefits make heat insulation cookers a strong case for a national rollout programme. Government to set a national target and get budget allocation. If a successful carbon programme is registered by Natural Balance, there is also potential for mass-scale rollout.	The Dept. of Energy could co-ordinate the national provision of heat insulation cookers. This could be implemented through the Working for Energy programme, municipalities and / or corporate social investment programmes.
Efficient lighting	The Eskom Integrated Demand Management (IDM) CFL rollout is currently in place. It provides free CFL replacements for incandescent bulbs.	Encourage Eskom to make distribution mechanisms more effective. Better consumer education about the benefits of efficient lighting also required to prevent a return to using incandescent lights.	Continue with CFL rollout on the Integrated Demand Management (IDM) agenda, and ensure that the programme continues to improve and scale up.

Key Interventions	Existing policy, legislation or large-scale programme(s)	Actions required	Departments/Bodies to be addressed
National Carbon Finance Programme	No policy or institutional arrangement exists yet, but a NAMA or the National Carbon finance programme is being set up through the SSF which features in the recent 2011 National Climate Change Response White Paper.	Establish a national carbon finance programme to reduce the cost of implementing interventions.	The SSF, if realised, can reduce costs through a national CDM or NAMA programme. NAMAs can subsidise or fully fund interventions.
Skills and employment generation	Skills training takes place through: The Construction SETA FET colleges Corporate social investment (CSI) initiatives. There is some indication from government that there could be some subsidy or grant funding allocation towards this kind of technical skills training, but it is not clear yet.	Work towards establishing sustainable small contracting businesses that provide services such as SWH installation and maintenance, plumbing, ceiling retrofits and carpentry, safe electrical wiring, recycling services and food gardening. Create or assign responsibility to a national overarching body or initiative that works to establish sustainable micro-businesses or works programmes, ensuring that they receive the necessary skills training or accreditation to perform their functions competently. This need not be a government organisation. Under this umbrella, larger scale programmes should integrate skills training and offer related learnerships and entrepreneurship support. Budget provision also needs to be allocated by government entities and possibly added to by private sector player.	It is the Construction SETA's responsibility to ensure that correct training courses are available for skills transfer in this sector. FET colleges need to link directly with large scale programme rollouts of plumbing (SWHs), carpentry (ceilings, truss reinforcement) and electrical (rewiring) services. National funding sources to be approached, including the SETA's funding for approved learnerships and skills programmes (which fall under the Department of Higher Education and Training). The Department of Energy's 'Working for Energy' programme could also play a valuable role as a 'home' for large-scale rollouts. Private sector Corporate Social Investment initiatives (such as Growthpoint's Property Point division) can provide learnerships, entrepreneurship support programmes and co-funding of SETA courses.

Key Interventions	Existing policy, legislation or large-scale programme(s)	Actions required	Departments/Bodies to be addressed
Food gardens and urban greening and agriculture	The Department of Human Settlements has Urban Greening Guidelines, and the Department of Water Affairs and Forestry's Urban Greening Strategy (2005) supports the development of urban forestry. Some municipalities and provinces have urban agriculture policies and programmes e.g. City of Cape Town's 2007 policy focusing on poverty alleviation and food security, and some like eThekwini have active urban agriculture units set up. The Department of Human Settlements Urban Greening Guidelines provides a list of funding options for greener developments e.g. Neighbourhood Development Partnership Grant(Treasury), Programme for the Provision of Social and Economic Activities (DoHS), and the Municipal Infrastructure Grant. Donor-funding can also be accessed e.g. Buffelsdraai landfill site rehabilitation done by eThekwini which supported community nurseries ('Treepreneurs) with the help of donor funds	At least one tree planted with each new low-cost house- either an indigenous, deciduous tree planted on the North side of the house, or a fruit tree. (Other plants can also assist with shading, glare and cooling) Plan for and allocate space in new housing developments for food gardens- including correct orientation with sufficient sunlight on the property. Food gardens established in all school-, to supplement the state national feeding scheme as well as act as a practical training site for teachers &learners. Food gardens to be integrated into the curriculum in theory &practice Local level nurseries to be established, with skills training. Effective implementation of existing greening and agriculture programmes run and funded by government, and scale this up. Include urban agriculture activities in land use and spatial planning and management, and build into IDPs. Integrate it into strategies such as poverty alleviation, urban renewal, skills and economic development and HIV/AIDS awareness. Establish consultative platforms for role players to develop support programmes for micro scale urban farmers and tree planting. Identify and release state-owned land parcels for agriculture activities[11].	National, Provincial and Local and other government entities involved with the decision-making and implementation of low-cost housing construction, urban agriculture and schools. In particular Departments such as Human Settlements, Agriculture, Education, Environment and Land and Rural Development- and those entities which are running public works type programmes.
Behaviour change and community education	Community education occurs ad hoc, usually on a project by project basis.	Provide training on the effective use of the green interventions received. Raise awareness and provide skills training on a range of greening and water and food security issues, including practical aspects such as composting and food gardening	Provincial Housing Department's Consumer Awareness programmes to include a resource-efficiency component in beneficiary handover process. Dept. of Energy to include community awareness training as part of their SWH, ceiling and heat insulation cooker rollouts.

[11] E.g.through sale at market prices, leasing of under-utilised land or by declaring it commonage land in terms of the Land Reform Programme.

Government official technical training	Numerous policy documents and programmes exist.	Provide continued capacity and skills building for government staff so that they are equipped to implement and enforce applicable legislation.	Municipal planning departments need to ensure that SANS 10400 XA is correctly enforced. Provincial and municipal Housing departments need to work on policy development and implementation. This requires support from the national departments of Energy, Economic Development, Water and Forestry, and Trade and Industry.

Please note that there are a number of other government and green economy or housing related projects and programmes which have not been directly referred to, in the interests of brevity.

Conclusion

The Cato Manor Green Street retrofit has been nothing short of life changing for its residents. People have hot water on tap for the first time, without having the costs associated with traditional electrical geysers. The interventions have resulted in energy savings of up to 25% and greater energy services.

Interior human comfort levels, health, safety and aesthetics have been improved. Peak summer temperatures have been reduced by up to 8 degrees Celcius. Less need for fuels like paraffin, coal and wood mean reduced health problems and fire safety risks for these homes. Unsafe electrical wiring was replaced, and (efficient) security lights were installed above the front door of each house.

Rainwater storage has enhanced water security and provided water for food gardens, which will now produce nutritious fruit and vegetables at the community's doorstep. 60% of households report that they are saving on food costs already.

Employment was generated for local residents, while training has given households practical skills and a better understanding of sustainability. Many are doing their part to realise significant benefits for themselves and for our environment. Thanks to extensive planting and clean-up programmes, the local area and the stream have also been upgraded.

The Cato Manor Green Street has been established as a permanent demonstration site and a living example of how greening interventions in low cost housing can improve quality of life for residents and provide multiple benefits for the country. The rich learning from this project points to policy recommendations for the construction of new homes, the retrofitting of existing houses, and the scaling up of key interventions.

Ceiling retrofits of the roughly 3 million existing low cost houses should be strongly considered as a national investment priority, as they are more financially beneficial than the cost of generating electricity, even in sub-tropical areas where the winter heating energy savings are lowest. The same argument can be applied for the provision of heat insulation cookers and efficient lighting. Wonderbags™ are likely to be rolled out on a large scale through a privately established carbon finance programme, and CFLs have been largely addressed by the Eskom-managed programme which distributes free CFL light bulbs.

There is great potential for skills transfer and sustainable employment creation in both 'new build' and retrofit programmes. Particular focus in the area of sustainable business development and support through the Construction SETA (CETA), FET colleges and the private sector's corporate social investment programmes would be beneficial. Significant employment opportunities can be realised through the growth of businesses in the areas of ceiling and SWH installation and maintenance. Food gardens in the water-rich KZN area are also a viable business proposition, as are recycling businesses. Opportunities to align in these areas with national programmes such as the Working for Energy programme (Department of Energy) should be explored.

This project has been successful at raising awareness so far. Excellent media coverage from a wide variety of sources has reached different sectors, both locally and internationally. Many site tours have already also demonstrated what the project confirms: there are significant socio-economic, environmental and financial benefits to be reaped from the greening of low-cost housing throughout South Africa, and in other developing nations.

CoP 17 delegates visit the Green Street

If retrofits just like this were done for 3 million existing low-cost houses, then the scaled up benefits are significant. Savings from electricity and water are estimated to be worth about R 3 billion per year (at current tariffs). This is money that would go back into the pockets of poor people and be retained in the local economy. The electricity saving would be the equivalent to a third of what a city the size of Durban or Cape Town uses. Some 3.45 million tonnes of CO_2 would be saved per annum and 9.72 tonnes sold on the carbon markets to generate revenue for community development.

In terms of employment, it's estimated that about 36.5 million days of work could be created, which is equivalent to employing over 165,000 people for a year of work (or more people working for shorter periods, which would be the case for retrofits done with involvement from local residents who are trained).

What was once an ordinary, nameless, township cul-de-sac is now a showcase example of green principles in action. It is a place where the development agenda and the green agenda meet- a COP17 legacy project which shows how low-carbon development can improve lives in a resource-efficient way. It is no surprise that residents have proudly named their street 'Isimosezulu (which means 'climate') COP17 Place'.

Acknowledgements

The Green Building Council of SA would like to acknowledge and extend sincere thanks to the wide range of stakeholders who were integrally involved in the design, implementation and ultimate success of the project through the sharing of their invaluable expertise, time, services, knowledge, experience, facilitation, endorsement, financial contributions and 'in kind' sponsorships. In particular:

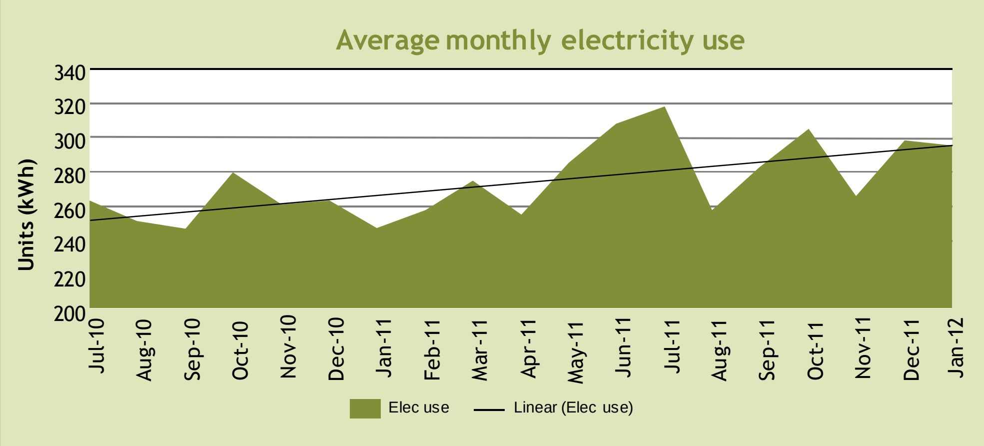
- The British High Commission who generously funded the bulk of the project, and the Australian High Commission which has committed to fund Phase 2 which will retrofit more homes in the area.
- The Department of Environmental Affairs who endorsed the project.
- eThekwini Municipality for their collaboration - from elected politicians and officials across several Departments - which provided technical support, training, facilitation through local political structures and engagement with the community. Most notably Councillor Mngadi from Ward 29 and the following Departments: Agriculture Management Unit; City Architects; Communication; Electricity; Energy Unit; Public Participation and Solid Waste.
- The World Green Building Council and the United States Green Building Council who contributed financial and in kind support.
- Carbon Programmes, the overall project implementers on behalf of the Green Building Council of South Africa, and Khanyisa Projects the local project managers.
- Eskom's Integrated Demand Management Division for funding a monitoring and verification exercise, and energy efficiency equipment such as CLF light bulbs.
- Iso Foam for full sponsorship of the Isoboard insulated ceilings.
- ASCAS for sponsoring the installation of 13 LED street light fittings in the area.
- Property Point, an enterprise development initiative of Growthpoint property company, which has committed to further training and business development support for those who worked on this project so that they can start their own small enterprises.
- The South African Botanical Society for advising on and sponsoring numerous indigenous trees and plants, which were planted in collaboration with the community and volunteers from Greenpop.
- Natural Balance for the sponsorship of every home's Wonderbag™, and for the catering at the launch.
- Cosmo Dec for the sponsorship of Sno-Cote roof insulation paint on two demonstration houses.
- The Clean Air Factory for donation of furniture and fittings made entirely from recycled materials.
- Community members who played key roles in local liaison and engagement –Jabulani Ngcobo and Deliwe Nobekwa.
- Sustainable Energy Africa for their research and development of this case study material.
- Willem De Lange took the professional photographs of this Phase 1 project (most of the images in this document), and there was additional reworking on the images done by John Armstrong.
- This initiative was project managed by Sarah Rushmere at the GBCSA, with direction and support from the GBCSA team.

APPENDIX 1 – Impact on household electricity use

Good electricity purchase data, which also reflected consumption levels, was available from the municipality's pre-paid meter system for 26 of the 30 households, although there was not full information over longer period of time for all of them. The effect of the following factors on the quality and usefulness of the data was assessed:

- Electricity usage patterns may have been affected by the poor quality of electricity supply services during this period. This was highlighted in a recent Certificate of Compliance report, which showed defective wiring, burnt electric components and variable power supply strength in several of the Cato Manor homes.
- Durban's extremely hot summer months may have forced an increase in household electricity consumption, both for fridges which must work harder in summer, and electric fans used for cooling.
- Occupancy may have increased, altering the figures of electricity use per head.
- An inefficient outhouse on the property could skew usage data.
- Electrical theft or on-selling to nearby informal dwellings would result in artificially high consumption figures.
- Some of the houses have informal, small or micro businesses running from the premises. This is a common occurrence in a low-income urban context, but it does mean that an undetermined percentage of the total electricity consumption is, strictly speaking, non-residential.
- The relatively short monitoring period was insufficient to determine the long term impact of the interventions.
- Analysis of the data showed that:
- There is no clear link in the data between the houses where electricity consumption has increased, and houses where there are fridges.
- There is no link in the data between the houses where electricity consumption has increased and houses where occupancy numbers have increased.
- Electricity use per head increased slightly, although changes in electricity use varied greatly amongst households.
- Separating and analysing households with outhouses and those without show that average electricity usage increases similarly over a monthly period.

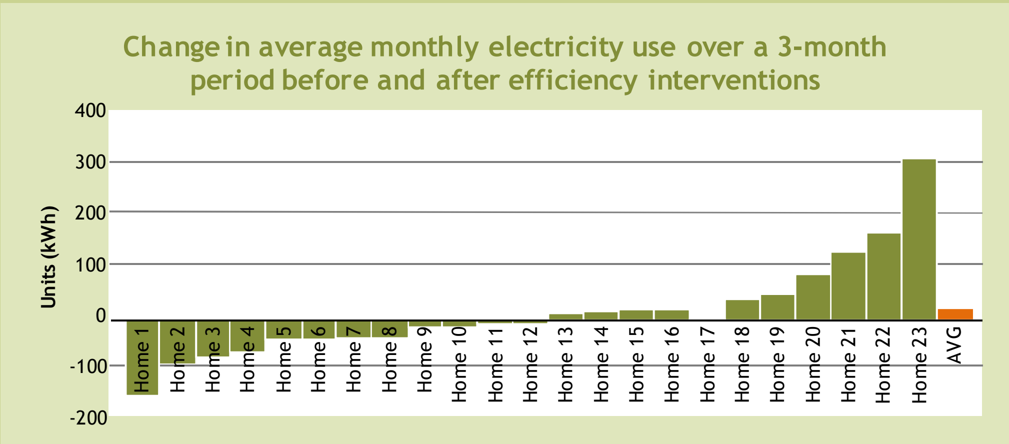
The electricity efficiency interventions were installed in November 2011. Undoubtedly, these measures would have created energy savings, and this is indicated by the dip in usage in November. And yet, the average monthly electricity use (from the 21 households that had complete data over this period) continued to increase over time.



Appendix 1, Figure 1: Average monthly electricity use of 21 Cato Manor households

Usage peaks in winter could indicate the use of more electricity for heating, while spikes in summer could be associated with cooling functions or holiday-related festivities. Overall though, the graph above shows an increase in electricity use over time, as shown by the linear trend-line, despite the electricity efficiency interventions. The dip in average electricity use across all households in November 2011 could be attributed to the energy efficiency technologies installed, as well as behaviour change caused by raised awareness.

Electricity use before and after



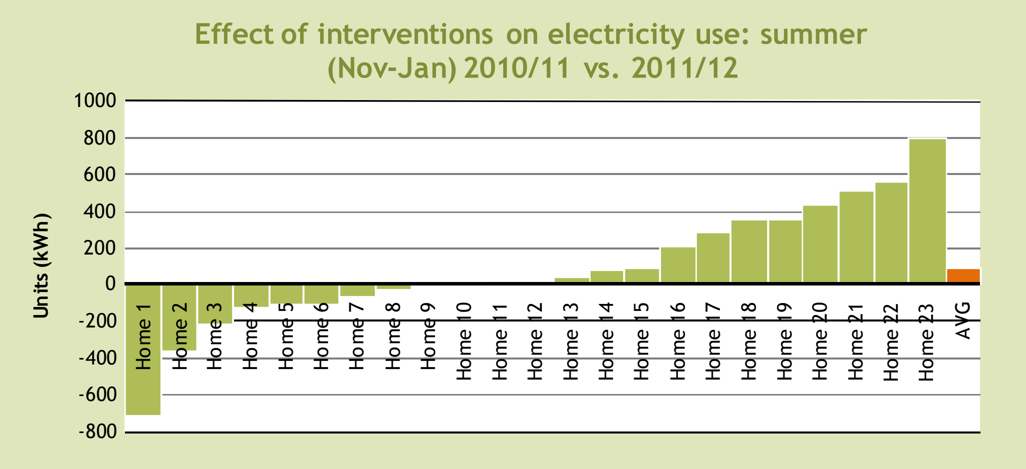
Appendix 1, Figure 2:

Change in total electricity use for each household from Aug-Oct 2011 and Nov 2011-Jan 2012

Electricity usage was measured three months before the interventions, from August to October 2011, and then again after the interventions, from November to January 2012. Overall there was an average increase in consumption, however it is important to note that results for individual households varied widely. Fifty percent of the households showed electricity savings, which matches the results of the second qualitative household survey, where 50% of households reported they were spending less on electricity. Residents also reported that they weren't using their kettles as often because solar water heaters were providing hot water. Wonderbags™ were reducing electricity costs associated with cooking, and the CFLs were mostly still in use.

Comparison of electricity use against the same period the previous year

Changes in electricity use from November 2010 to January 2011 (pre-electricity efficiency interventions), compared to November 2011 to January 2012 (post-interventions) varies widely. On average, a slight increase in electricity use occurred, despite electricity efficiency interventions.



Appendix 1, Figure 3:

Change in electricity use between summer 2010/2011 compared to the same period in 2011/2012

Conclusions

The impact of installing energy efficient interventions is not clearly evident in the electricity purchase/use data. When consumption from August to October 2011 is compared to November 2011 to January 2012, average consumption increases, despite 50% of homes reporting savings.

The annual July electricity tariff increase did not cause a downward trend in electricity use. Likewise, the presence of formal extensions and/or informal outhouses made little difference to overall electricity usage trends.

All previous energy efficiency research and experience in similar projects indicates that savings must have been realized from the interventions, particularly efficient lighting, solar water heaters and Wonderbags™. For example, in Zanemvula electricity use for water heating definitely dropped, and in Cosmo City 100% of residents reported electricity savings from the SWH and ceilings installed, calculated as an average saving of R1,154.94 per house, per year. However the minimal change in the majority of electricity usage patterns is probably due to what is called the 'rebound effect' or 'suppressed demand'. These terms explain a common phenomenon in South Africa and other developing countries when a household uses less electricity than it needs or desires because it simply cannot afford to use more. When financial savings are realised, the 'spare' money is often used to purchase more electricity for other household needs. It is important to note that some households have shown a marked decrease in electricity use since the interventions and are now reaping the rewards of their self-discipline.

Not enough time has passed to gather sufficient data for reliable analysis. Clearer trends may result if it were possible to compare an entire year's worth of post-intervention electricity use to that of a year's pre-intervention data. Electricity savings are more likely to be realised in the colder winter months when ceilings should provide insulation and reduce the need for space heaters. SWHs should also reduce the need for electrically heated water. Sub-metering might be useful in analysing the data further to understand why and where more or less energy is consumed by home owners.

APPENDIX 2 - Impact on household temperature and relative humidity

All the households received insulated ceilings, while two also received Sno-Cote reflective insulation roof paint as a pilot test. Two studies were undertaken to measure their impact:

Impact of insulated ceilings in summer: Two control houses in Cato Manor with similar orientation but no interventions were compared to two of the project houses, which had ceilings but did not have Sno-Cote, over a 17 day period (February to March 2012).[12]

Impact of Sno-coat: A house with a ceiling but without Sno-Cote was compared to one with a ceiling and Sno-Cote over a two month period (15 November 2011 to 10 January 2012).

These studies were designed to gauge the degree to which the interventions helped to make interior living conditions more comfortable. A tool called the Human Discomfort Index (HDI) was used to assess and measure the results. The South African Weather Service uses this tool to issue warnings for dangerous temperature and humidity levels in the country[13]. Results fall into the following categories:

- Human discomfort Index of 80-89: moderately uncomfortable
- Human discomfort Index of 90-99: very uncomfortable
- Human discomfort Index of 100-109: extremely uncomfortable
- Human discomfort Index of >110: hazardous to health[14]

Impact of insulated ceilings

Houses with insulated ceilings were more comfortable that houses without, according to the Human Discomfort Index. They had lower internal temperatures, although the relative humidity was higher. (It should be noted that a reduction in temperature does typically result in increased humidity.)

The effects were greatest in an East-West oriented house. The average impact of the ceiling at peak temperatures (around 3pm) over a 17 day period was as follows:

Orientation	Reduced temperature	Increased relative humidity	Reduced HDI level
NW/SE	-4.2 °C	+4.1 %	-9.1
E/W	-6.7 °C	+15.4 %	-12.0

Appendix 2, Figure 1: Effect of insulated ceilings on temperature, humidity and discomfort, according to orientation

From these results, which reflect extreme summer conditions, the insulated ceiling improves the internal household environment, shifting it from ‘hazardous to health’ to ‘extremely uncomfortable’ in the HDI.

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[12] It should be noted that both of these studies would have benefitted from longer monitoring periods, preferably a year. Even so, some useful information can be derived from the captured data.

[13]The green building standard for assessing the quality of living conditions is the Predicted Mean Vote. This measure includes ventilation and heat radiation levels, not just temperature and humidity levels. However this data was not available for the study, so the HDI was used instead.

[14] Courtesy of the South African Weather Service

It should be noted that while the insulated ceiling provides a significant benefit at the hottest time of the day, the retrofitted homes were not able to dissipate the heat as easily in the evening. Buildings with ceilings were not as ‘leaky’ as they were before, and as a result, those without ceilings were found to be slightly more comfortable at night (1.7 to 3.7 points lower on the HDI) during the summer.

Hr	Effect of ceiling (evening and night)					
	Temp°C)		Humidity (%)		Discomfort Index	
	NW-SE	E-W	NW-SE	E-W	NW-SE	E-W
19:00	1.19	-0.73	-6.09	6.03	1.52	-0.05
21:00	1.46	0.39	-8.85	4.09	1.54	2.33
23:00	1.52	1.08	-9.50	3.41	1.62	3.99
1:00	2.27	1.55	-10.82	1.53	3.37	4.74
3:00	1.59	1.92	-12.35	0.15	1.25	5.41
5:00	1.53	2.00	-13.59	-0.29	0.83	5.50
AVG	1.59	1.04	-10.20	2.49	1.69	3.65

Appendix 2, Figure 2: Effect of insulated ceiling on the HDI in N-S and E-W orientated houses at night

Impact of Sno-Cote

Sno-Cote further decreased the temperature in a North-South oriented house by an average of 2°C, whilst increasing humidity by 8%. Overall, the effect of the decreased temperature was great enough to counteract the increased humidity, and the Human Discomfort Index was on average four points lower than a house with a ceiling but no Sno-Cote at the hottest point of the day.

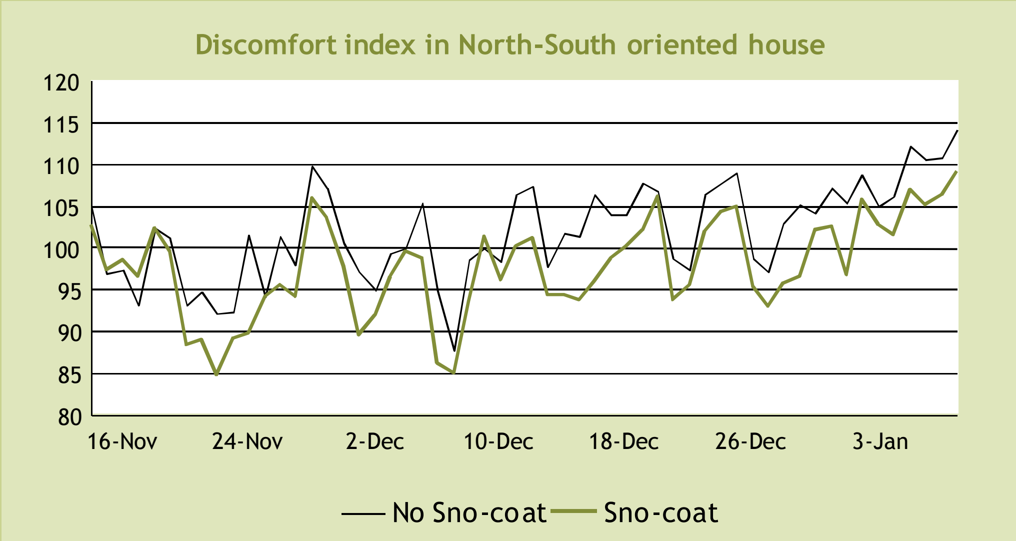


Figure 10:

Effect of Sno-Cote on the Human Discomfort Index in N-S oriented houses

Qualitative input on household temperature and comfort levels

Fan usage appears to have increased over the survey period. This is probably due to the hot summer conditions between the pre and post surveys, rather than being a reflection on the thermal performance changes of the households.

With regards to the temperature and comfort levels in the homes, 70% of households noted that comfort levels had improved and said they were happy with the results. In an apparent contradiction, 67% of the households indicated that the temperature in the house was hotter, and 23% said it was cooler. This is not in keeping with the monitored data which demonstrated a significant drop in temperature during the day. It is likely that the prevailing hot weather conditions were the reason for comments about increased temperature.

Conclusions

Data shows that the presence of an insulated ceiling with an R value of 1 resulted in decreased temperatures and increased relative humidity levels. Comfort levels improved from 'hazardous' to 'very uncomfortable' according to the Human Discomfort Index.

Better ventilation and ceilings with higher R values would improve comfort levels further, particularly in Durban's extreme summer heat.

Additional data on ventilation and radiation levels would allow a more accurate assessment of internal comfort using the Predicted Mean Vote (PMV) method.

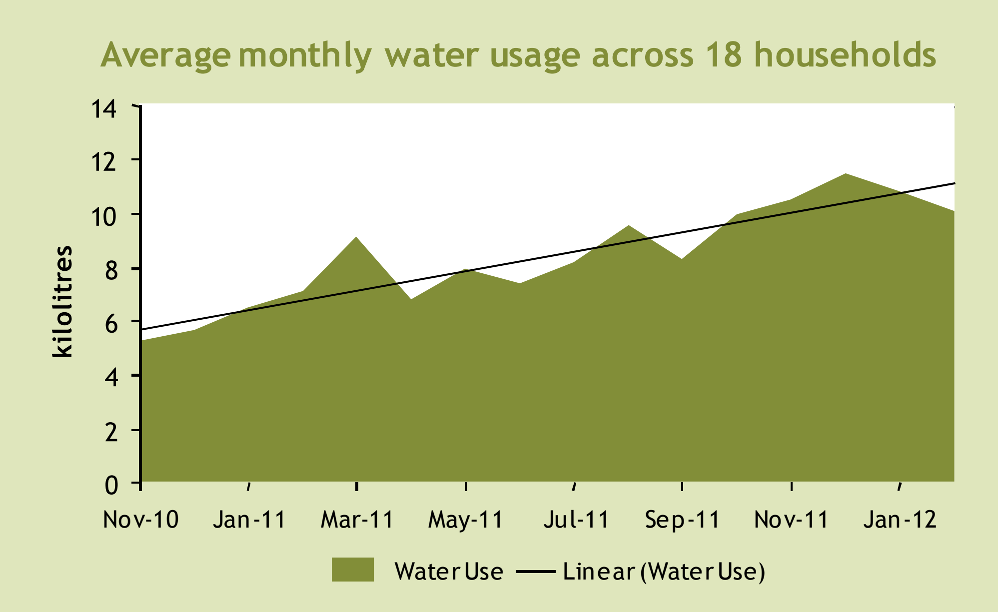
In the evening, internal heat is not dissipated as quickly in a house with a ceiling. Houses without ceilings are slightly more comfortable at night, due to the leaky nature of the roofs.

Sno-coat improved comfort levels by decreasing inside temperature, although it did increase relative humidity levels.

Most of these houses have very poor ventilation. They were not built with air bricks, and many have enclosed their windows by building an extension onto the side of the house. The remaining windows are generally kept closed for security reasons, as they do not have burglar bars. If these homes had better ventilation, the heat and humidity would not build up as much during the hot summer months, and comfort levels would improve.

APPENDIX 3 - Impact of solar water heaters and rainwater tanks on water usage

Average water use data provided by the eThekwini Municipality indicates an upward trend over the past two years in Cato Manor. From October 2011 onwards, average consumption exceeded the 9kl free basic water allocation per household, so several residents would have started receiving municipal water bills.

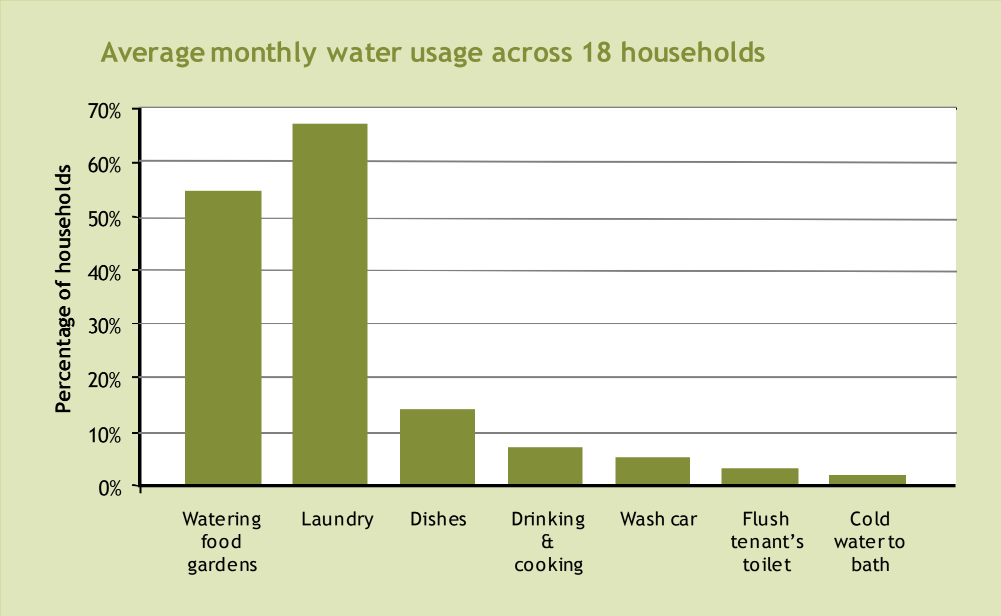


Appendix 3, Figure 1:

Average monthly water use for 18 Cato Manor houses with complete water billing data from November 2010 to January 2012

Water usage was expected to increase after the installation of solar water heaters, as there would no longer be a cost involved in heating the water. In training sessions, residents were warned about the need to use water efficiently if they were to avoid increased water costs. As anticipated, there was a slight increase in consumption over November and December 2011 (5% and 9% respectively), but a reduction of 6% occurred in January 2012, and a further 6% in February 2012. This downward trend over the last two months of readings appears to indicate that residents adjusted their water usage habits to stay within the free 9kl per month allocation.

The post- project household survey found that residents were using the rainwater tanks primarily for laundry and watering their food gardens, and to a lesser extent for dishwashing. There is no information on the amount of water being used for these purposes, but a saving is clearly being realised in this area.



Appendix 3, Figure 2: Rainwater tank usage

Conclusions

The installation of solar water heaters has not had a marked effect on average monthly water use. In the preceding year there had been a general upward trend in water use, which was slightly accelerated through the installation of solar water heaters in the first two months, but decreased in the following two months.

Interestingly, residents are just starting to have to pay for water, as since October 2011 they are on average exceeding the 9kl/month free basic water allocation. This could account for the drop experienced between January and February 2012, where some residents may have actively reduced their consumption in an effort to cut monthly costs. It is likely that rainwater tank usage would have increased to compensate for this.

The rainwater harvesting tank is being used in areas that previously only had access to municipal water. Although there is no information about the extent to which these tanks are being used, it is safe to say that whatever rainwater is captured and consumed represents a saving.

APPENDIX 4 – Cost benefit analysis

Overview of interventions and cost

The interventions in Cato Manor's Green Street were intended to create financial savings for the residents, improve their living conditions, and reduce greenhouse gas emissions and water use. The expected areas of saving were as follows:

Intervention	Expected saving
Insulated ceilings	Reduced need for heating in winter and cooling in summer
Solar water heaters	Less frequent use of a kettle to boil water, but a possible increase in water usage
Efficient lights	Reduced consumption of electricity at night
Heat insulation cookers	Reduced cooking time and energy costs
Rainwater tank	Reduced use of municipal water
Food gardens	Smaller grocery bill and a possible reduction in transport costs

Appendix 4, Figure 1: Interventions and their expected savings

Note: Potential health and well-being cost savings should also result from these interventions, but it is extremely difficult to determine which benefits can be attributed directly to the interventions. Too many external factors are involved, including levels of personal and environmental cleanliness, water quality, local disease, health service delivery, depression and substance abuse. For these reasons health has been omitted from this cost benefit analysis. Similarly the safety and security-related costs borne by private households and public-provided services (such as treating burn victims, emergency services to deal with fires and crime) are too complex to measure and have not been included in this calculation.

Limited quantitative data is available for the analysis of electricity consumption in the Cato Manor Green Street. Average monthly usage patterns do not appear to have changed substantially since the retrofit interventions in November 2011. If anything, they have increased slightly. This is likely due to suppressed demand or the rebound effect, as described earlier in the report. To quantify the benefits of a single intervention from electricity data alone is, therefore, not a feasible approach. A true picture can only be established through on-going detailed monitoring and surveys for at least a year following the intervention.

Consequently, the cost benefit methodology utilised for this report has been based on household energy modelling approaches, or typical savings figures – as determined by more detailed studies in other areas of South Africa. The analysis determines how long the intervention will take to pay for itself. This is defined as the payback period. End users will not necessarily be footing the bill; this is simply a means of determining the cost effectiveness of the interventions themselves.

Insulated Ceilings

The Cato Manor project installed 30mm thick Isoboard ceilings in all the Green Street houses. Isoboard is a useful material as it has substantially better insulation properties than a typical gypsum ceiling, and is light and easy to install. Installing an insulated ceiling into a household that previously had none will result in cooler indoor temperatures during summer highs, and warmer indoor temperatures during winter lows. This implies that less energy will be utilised for cooling and heating in the household over these periods.

Using thermal modelling software (Energy Plus), a typical Cato Manor household was modelled with and without an Isoboard ceiling to determine the thermal impact of the intervention. The software also calculated the amount of heating energy required to keep the house warm (21 degree set point) from May to September over the occupancy periods 6-8am and 5-9pm.This essentially calculates the heating energy required to keep the house comfortable in winter during prime occupancy periods. The resulting figure is a suppressed demand baseline, which is a good indicator of potential energy saving.

kWh used per month for heating*						
	Ceiling		**No ceiling**		**Savings**	
Month	**West House**	**East House**	**West House**	**East House**	**West House**	**East House**
May	50	50	96	96	46	46
Jun	78	79	148	149	70	71
Jul	78	79	153	155	74	76
Aug	60	61	110	111	50	50
Sep	51	52	85	86	34	34
Total kWh	317	320	591	597	274	277

*Assumptions: Concrete floor, 100mm brick wall, ceiling R value of 1, heating periods 6-8am and5-9pm

Appendix 4, Figure 2: Monthly energy consumption for heating

Based on these figures, a maximum potential saving of R223 per year from space heating is possible as a result of the insulated ceiling. The payback period would therefore be in the region of 11 years.

Current Electricity Rate (c/kWh)	**Savings (kWh)**	**Savings (R)**
81.5	274	R223.31

Appendix 4, Figure 3: Electricity savings

Note that space cooling was also considered, which in the case of this Cato Manor context is the use of fans in Summer months. There is no research data available on usage patterns of the fans which are owned in this community (typically with a power rating of 40W), so estimates were calculated on what was assumed to be a likely usage scenario during certain periods of the year given the impact of insulated ceilings. Based on this basic estimation, it was found that an annual saving of 20kWh is possible, which equates to about R 15 per year. This is a minimal addition to the savings realised from less heating required in winter because of having an insulated ceiling (only about 7% of that value). Given the relatively small impact of this change of fan use, and the lack of reliable data, this element of savings from space cooling was therefore not included in the cost-benefit calculation.

Solar Water Heaters

The Cato Manor survey did not assess the amount of hot water used per day prior to and after the SWH installation. However, in another similar study in Kuyasa, Cape Town, the SWH was found to typically replace 12 litres of boiled kettle water per day. If this figure is applied to Cato Manor, it equates to a saving of R27 (33kWh) per month. The cost of providing and installing the SWH was R7,098, so the SWH will pay for itself after 13 years. It is assumed that the end user will not foot this bill, so a poverty alleviation mechanism of R324 per year will be achieved through this intervention.

EE Lighting

On average, four 11W CFLs replaced existing 60W incandescent bulbs in each household. Assuming that four lights burn for an average of four hours per night, a monthly saving of 23.5kWh or R19.16 per household is possible. Considering each CFL costs approximately R20, payback for this intervention will take in the region of four months. CFLs typically last 5 times longer than incandescent globes, so additional future savings will also be achieved.

Heat insulation cookers

For many years heat insulation cookers, such as the Wonderbags™ used in this project (or 'hotboxes' used in other areas), have been considered an effective energy saving resource for the residential sector, and a means to address energy poverty in the low income sector in particular.

Data provided by the qualitative survey shows that 26% use the hot box once a week, 50% twice a week and 5% every day. This equates to 36 meals per week. No detail on the period of cooking time saved by the hot box is provided. The assumption has been made that the hot box can provide a saving of 563Wh per meal, which equates to 45minutes of simmer time on a stove plate at 750W.

The current cost of an insulation heat cooker is around R120. Based on a saving of 563Wh per day, this equates to a monthly saving of R13.77, which will provide payback in less than a year.

Rainwater tank

Each house received a 2500 litre rainwater tank. Harvested rainwater has been used for watering food gardens, laundry and washing dishes. Assuming the average household uses 10 litres every day for dishes and 70 litres twice a week for laundry, this equates to 850 litres per month, or a saving of R9.55 per month. This only applies for water consumption over and above the free basic water allocation. The payback for a rainwater tank is longer than 20 years, so it is unlikely that low-income communities will purchase them. This is not a financially attractive option for government either. To complicate the matter, the restrictive construction design of many low income houses may also require adapted guttering systems, which are unlikely to last 20 years. A detailed study of municipal water saved through a rainwater tank use will be useful, as it has the potential to save up to three times as much per month, if used effectively.

Food Garden

The survey does not provide information on the amount of food being produced in the gardens. Vegetables such as beetroot, spinach, brinjals and green peppers are being grown, and residents are reporting a cost saving in their groceries as a result. However, without the quantification, the cost benefits cannot be ascertained. Longer term research in this area is recommended, including the cost savings on using less transport to go shopping.

Savings summary

The table below shows a cost benefit summary of the interventions analysed, indicating a maximum potential average monthly saving of R78.42 for electricity and R9.55 for water.

It should be noted that savings on ceilings are the lowest in the country due to KwaZulu Natal's mild winters. Ceiling benefits are significantly higher (around ten times) in colder inland areas.

									Total monthly savings			
	Insulated ceiling		SWH		Efficient lights		Insulation cooker		Total electricity		Rainwater tank	
											850	R 9.55
Apr	0	R 0.00	33	R 26.90	23.5	R 19.15	16.89	R 13.77	73.39	R 59.81	850	R 9.55
May	46	R 37.49	33	R 26.90	23.5	R 19.15	16.89	R 13.77	119.39	R 97.30	850	R 9.55
Jun	70	R 57.05	33	R 26.90	23.5	R 19.15	16.89	R 13.77	143.39	R 116.86	850	R 9.55
Jul	74	R 60.31	33	R 26.90	23.5	R 19.15	16.89	R 13.77	147.39	R 120.12	850	R 9.55
Aug	50	R 40.75	33	R 26.90	23.5	R 19.15	16.89	R 13.77	123.39	R 100.56	850	R 9.55
Sep	34	R 27.71	33	R 26.90	23.5	R 19.15	16.89	R 13.77	107.39	R 87.52	850	R 9.55
Oct	0	R 0.00	33	R 26.90	23.5	R 19.15	16.89	R 13.77	73.39	R 59.81	850	R 9.55
Nov	0	R 0.00	33	R 26.90	23.5	R 19.15	16.89	R 13.77	73.39	R 59.81	850	R 9.55
Dec	0	R 0.00	33	R 26.90	23.5	R 19.15	16.89	R 13.77	73.39	R 59.81	850	R 9.55
Average	**22.83**	**R 18.61**	**33**	**R 26.90**	**23.5**	**R 19.15**	**16.89**	**R 13.77**	**96.22**	**R 78.42**	**850**	**R 9.55**
Annual savings	**274**	**R 223.31**	**396**	**R 322.74**	**282**	**R 229.83**	**203**	**R 165.18**	**1155**	**R 941.06**	**10200**	**R 114.60**
Payback (yrs)	**11**		**13**		**0.33**		**0.75**				**20**	

Appendix 4, Figure 5: Cost benefit summary

The following annual savings can be realised if the above figures are extrapolated to reflect a potential national rollout of the same interventions to three million households:

Appendix 4, Figure 6: Annual savings for nationwide rollout to 3 million houses (based on current eThekwini tariffs)

Insulated ceiling		SWH		Efficient lights		Insulation cooker		Total electricity		Rainwater tank	
GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	GWh	R (mil)	Ml	R (mil)
822	R 670	1188	R 968	846	R 689	608	R 496	3464	R 2 823	30600	R 344

Conclusions

The combined interventions can potentially save a household in the region of R90 per month.

Ceilings, SWHs and rainwater tanks have long payback periods from 11 to more than 25 years.

CFLs and heat insulation cookers make excellent financial sense to the end user, with payback periods of under a year.

CFLs, heat insulation cookers and ceilings are a relevant intervention from a national cost benefit perspective, as they are cheaper than typical average generation costs.

Data gaps do not allow for specific Cato Manor analysis of certain interventions. These gaps have been included in the recommendations at the end of the report.

Note: The cost benefit analysis above does not include the significant potential private and public savings which could be realized from improved health, safety and convenience, reduced transport and other quality of life factors which are not easily quantifiable.

APPENDIX 5 - Future research recommendations

This project has exposed a number of important issues that require further research. For future initiatives of this nature, the following recommendation is made for gathering quantitative data:

Electricity consumption, water use, temperature, humidity, ventilation and radiant heat in control houses for at least a year post the interventions.

Kettle and stove use patterns prior to and post solar water heater implementation.

Heat radiation and ventilation figures to assess human discomfort levels, using the Predicted Mean Vote (PMV) method. We recommend PMV in future as it is commonly used to measure occupancy comfort in green building studies, and it would have been a more accurate than the Human Discomfort Index (HDI).

Paraffin, gas and coal use for cooking, heating and lighting.

Fan and fridge use.

Hot and cold water consumption, and the sources from which they come.

Short and long term maintenance of food gardens, including which crops are successful, what savings they offer and if produce is being sold.

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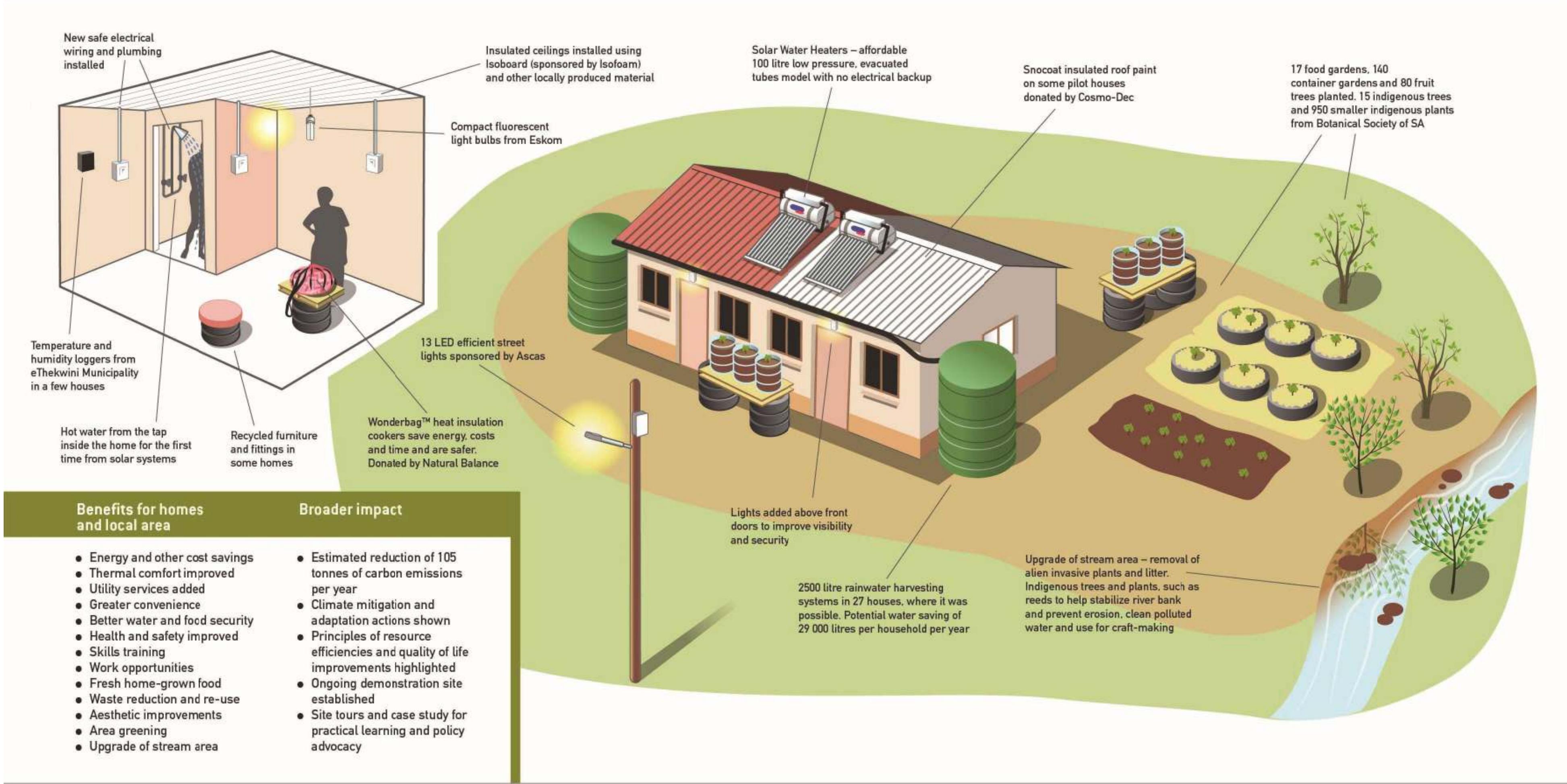
Cato Manor Green Street - Retrofit of 30 houses (Phase 1)



Benefits for homes and local area

- Energy and other cost savings
- Thermal comfort improved
- Utility services added
- Greater convenience
- Better water and food security
- Health and safety improved
- Skills training
- Work opportunities
- Fresh home-grown food
- Waste reduction and re-use
- Aesthetic improvements
- Area greening
- Upgrade of stream area

Broader impact

- Estimated reduction of 105 tonnes of carbon emissions per year
- Climate mitigation and adaptation actions shown
- Principles of resource efficiencies and quality of life improvements highlighted
- Ongoing demonstration site established
- Site tours and case study for practical learning and policy advocacy