The Effectiveness of Retrofitting Interventions in South Africa's Low-Cost Housing Sector

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Research paper for ECO3009F - Natural Resource Economics
April 2013

Abstract

This study assesses retrofitting interventions aiming to increase energy efficiency and comfort in low-cost housing. Financial, environmental and social performance in South African retrofit projects was compared. Ceiling insulation was found to be the most cost-effective in RDP housing. Results include better air-quality and a safer environment. Wonderbags™ and food gardens have considerable benefits but success depends on participant buy-in. Solar geysers and rainwater-tanks require large capital outlays. Solar geysers are effective as sufficient insolation is captured annually and warm water is high demand. Rainwater-tanks are less effective because water is captured when demand is low.

Keywords

Low-cost housing, retrofitting, carbon savings

The UCT Knowledge Co-op facilitated this collaborative project.

1. Introduction

The City of Cape Town, and South Africa, faces vast economic growth challenges, and more specifically, a housing crisis. The housing situation is constrained by funding shortages, high levels of poverty, and population growth.

Our economic growth depends on coal, creating a gap between the demand for affordable energy and its supply (Harris and Krueger, 2005). Energy efficiency in the low-income sector holds promise for the upliftment and empowerment of the poor (Winkler et al, 2002). Retrofitting offers part of the solution by increasing energy efficiency and comfort while decreasing financial and environmental costs in the long run (Winkler et al, 2002).

2. Literature Review

Since 1994, approximately 3 million RDP houses have been built by government to address the housing backlog (Holm et al., 2010). A disproportionate amount of poor household's expenditure is spent on energy and energy poverty is widespread among poor South Africans (Harris & Krueger, 2005). Winkler et al. (2006) and Harris and Krueger (2005) suggest that energy poverty has knock-on effects on health, education and employment and thus further disadvantage marginalised members of society. This is considered socially undesirable in given South Africa's aim to reduce inequality and improve the overall standard of living (Winkler et al., 2006).

The literature demonstrates clear international support for increased energy efficiency, with household savings being a key sector for demand reduction (Winkler et al., 2002). The involvement of international funders like the British High Commission, conventions like the Clean Development Mechanism and conferences like COP17, create an incentive for South Africa to prioritise energy efficient growth (Holm et al., 2010).

Although the methodologies of analysing sustainable technologies and retrofit interventions do vary, the basic premise of a cost-benefit analysis is common throughout the literature (Winkler et al., 2002). Although Winkler et al., (2002) do not specifically examine the social acceptability of interventions like Holm et al. (2008) does; there is a consensus which identifies the need for any intervention to receive buy-in from the local community in order to succeed (Goldman, 2010). Education programs, employment opportunities and minimal financial costs to residents seem to be the most attractive mechanisms through which to attain this approval (GBCSA, 2012; Goldman, 2010; Holm et al., 2010).

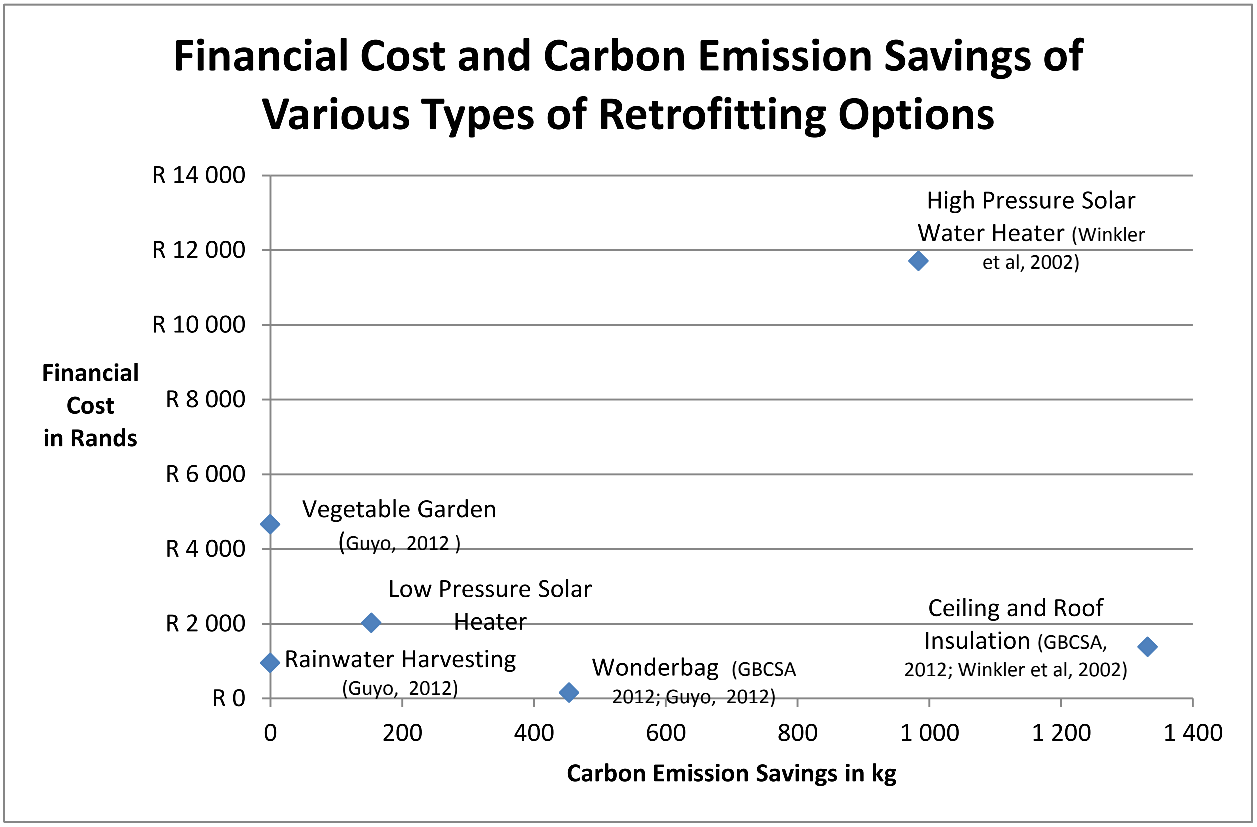
A considerable investigation has gone into assessing which interventions are accessible to low-income consumers and which provide the most environmental savings (Angrill et al., 2012; Wlokas, 2011). As the industry for sustainable technologies grows, e.g. through the expansion of local suppliers and manufacturers, an on-going re-evaluation of the costs of production and accreditation of new designs is necessary to ensure that poor consumers have access to the most efficient and cost effective products on the market (Gallagher, D, personal correspondence 2013, 19 March; Eskom, undated). This, hopefully, will reduce the relatively high barriers to entry faced by poor consumers (Harris and Krueger, 2005).

Unfortunately, the energy efficiency of low-cost houses is considered far below optimal by almost all stakeholders and thus represents a long term drain on scarce energy resources and the income of their residents (Harris and Krueger, 2005). Although more expensive than new sustainable builds, there are significant energy, social and financial gains to be made nationally and individually through retrofitting these houses (Harris and Krueger, 2005). This project analyses these gains using solar geysers, ceiling insulation, rainwater-tanks, Wonderbags™ and domestic food gardens. These interventions were selected on the basis of the most common interventions in the literature and those adopted by SEED.

3. Method

The analysis considers various retrofitting measures which could be added to a low-income home to increase energy efficiency, reducing the impact on the environment while improving the household's standard of living. The interventions considered are solar geysers, rainwater-tanks, ceilings and roof insulation, food gardens and Wonderbags™. These interventions have been evaluated separately, but case studies of South African low-income housing retrofit projects are into account, namely; the Sustainable Energy for Environment and Development Programme (SEED) in Rocklands, Kuyasa and Cato Manor. We created a graph comparing financial cost and the amount of carbon emissions saved by various forms of retrofitting. This was done by calculating the financial costs of the retrofitting measures and kilowatt hours (kWh) saved and converting the kWh into approximate carbon emissions per kilogram savings. To enable us to better quantify environmental and economic costs and benefits and to get a greater understanding of social gains, we visited and conducted interviews with a total of nine members of the Rocklands community, six of whom had SEED retrofitting interventions. Of this six, one participant was supplied with the "Ambassador" retrofit model which included the food garden and Wonderbag™, a rainwater-tank, solar cooker and solar geyser. Non-SEED participants were selected on the basis of their proximity to the SEED offices in Rocklands and the visibility of solar geysers on their roofs. Our survey sample is far too small to be representative of low-cost housing or even the entire Rocklands community, which is why other case studies were included as far as possible. The survey, however basic, does enable us to compare the perceptions and affects of this project on participants, which is relevant to SEED as a benchmarking exercise and useful to the discourse of efficiency versus socially acceptable interventions.

4. Discussion



The graph above shows total once-off financial costs for various retrofitting interventions and the amount of carbon dioxide they save, per year.

Data was taken from reports on low-cost housing developments with houses which are similar, but not identical. This graph indicates how effective different interventions are at reducing carbon emissions, but is by no means conclusive. Many factors have been omitted for in this graph including the water savings made by the interventions, and the environmental costs of producing, transporting, installing and disposing of the interventions. Financial costs are more accurate as costs are calculated and reported by companies. However the financial costs indicated on the graph are the initial lump-sums required and do not take financial savings into account. Depending on maintenance, all of the interventions have a useable life long enough to cover the initial financial costs and make substantial savings if used effectively. These factors should to be incorporated to provide a more holistic idea of costs and savings. The demand for energy and water saving interventions is assumed to be significant among the low-income sector due to basic needs such as electricity and water accounting for a substantial proportion of their incomes. The interventions, however, require large capital outlays from which benefits and savings are realized over several years after the initial outlay (Winkler et al., 2002).

From the graph, the most effective retrofitting intervention is ceiling and roof insulation. This is because a low financial cost provides large energy savings due to the poor thermal efficiency of the original houses (Holm et al., 2008). Increases in energy savings effectively result in less environmental pollution. Costs of solar geysers differ due to various types and sizes of heaters. This is due to some geysers being low-pressure geysers and others being high-pressure geysers. All solar geysers in this analysis are the evacuated tube type. Solar water geysers have been shown to be efficient in Cape Town (Winkler, 2002; Eskom, undated) due to large amounts of summer insolation we receive. Solar geysers are effective in providing warm water to areas where electricity is unaffordable or not in abundance (GBCSA, 2012). An additional cost that has not explicitly been taken into account in this study is maintenance, which ensures getting good life out of the appliance (Eskom, undated). A significant proportion of the heaters are currently imported from overseas (Eskom, undated) which along with maintenance and installation of these appliances have the potential to provide a substantial job market.

Wonderbags™ potentially offer substantial energy savings of approximately 400kg per bag per year, if utilized correctly and successfully incorporated into one's lifestyle (GBCSA, 2010). Wonderbags™ reduce carbon emissions by reducing required stove energy to cook. The effectiveness of the Wonderbag™ is directly influenced by time available and knowledge regarding how to use the bag. Small scale vegetable farms could contribute in a small way to mitigating carbon emissions, but this is unlikely to be a substantial carbon savings mechanism. Worm farms and greywater systems were included in the cost of the food gardens as these are part of the SEED model. Greywater has little financial cost and provides significant amounts of water which is especially useful with the introduction of a new garden. Greywater can also be used for flushing toilets in the absence of a garden or if preferred. Worm farms are also minor cost and supplement food gardens by providing additional nutrients to plants from organic waste matter that may have previously had into a landfill. Beyond the environmental costs there are, however, many social and health benefits that are not included in the graph. Similarly, rainwater-tanks only save emissions where water that would otherwise have been pumped and purified is no longer required as a direct result of the rainwater-tank (Angrill et al, 2011). Savings that have not been taken into account are the rubble removed from landfill sites that was used, along with concrete bricks, for the base of the water tanks. The effect of removing rubble from the landfill and reusing it should be incorporated in the assessment of the viability of rainwater-tanks.

When looking at social welfare projects like low-cost housing, social impacts help determine its usefulness. Although responses varied, the overall sentiment towards all interventions was positive. Four main improvements in human capital namely; health, skills, networks and self-perception, were found (GBCSA, 2012; Goldman, 2010; Holm et al., 2010).These studies address health through two channels. Firstly, by reducing air pollution as a result decreased demand for burning wood or paraffin to heat the home and water (Winkler et al., 2006). This is particularly relevant in the Southern Coastal Condensation Area, which Cape Town falls into, were mold and damp contribute to respiratory illnesses like colds and tuberculosis (Harris and Krueger, 2005). Thermal regulation through improved insulation reduced the prevalence such sickness in only three months (Holm et al., 2010). Secondly, food gardens promote healthier lifestyles by increasing access to higher-nutrient foods often substituted by the poor for cheaper, high-calorie options (Marsh, 1998). The survey found that, even after a short time participants noted increased quantities and variety of vegetables consumed. It is also important to note although there was little significant change in food expenditure, the increased variety and quantity is an indication of suppressed demand becoming less constrained, which leads to a greater level of utility (Winkler et al., 2002). These health benefits carry unquanitified savings in terms of health costs (to the individual and state) and also increase periods of productivity of residents by enabling them to attend school and work more often (Winkler et al., 2002).

Most low-cost housing interventions carry a level of community involvement and skills-training and some, like the Clean Development Mechanism, require them (Goldman, 2010). These do not often create long-term employment but the skills-upgrade does improve human capital. Participants are able to make informed decisions about resource spending, health and the environment, while learning practical skills like installation, maintenance or production, that present new avenues for employment (Holm et al., 2010). These interventions tend to create a more formal link between the poor and power structures potentially increasing access to employment networks (Goldman, 2010; Holm et al., 2010)

Participant responses in our survey and those of Goldman (2010) and Holm et al. (2010), suggest that all these interventions improve perceived quality of life. These perceived improvements are linked to the physical additions to the home (e.g. a geyser or a garden) which improve the perception of the environment and/or a sense of personal improvement and increased agency through learning new skills and producing tangible outcomes. These social impacts are essential to the efficiency of the interventions because if they do not appeal to communities and individuals there is little potential for project sustainability (Wlokas, 2011).

5. Recommendations:

This section will provide recommendations for insulation, food gardens, solar geysers and rain-tanks respectively and show how their utility can be maximized. Improved ceiling insulation is recommended as the best initial intervention to make in low-cost housing while food gardens, rainwater-tanks and solar geysers' efficiency varies according to context (Harris et al., 2005; Marsh, 1998).

Insulation is commonly considered the basic best-practice retrofit across the country and particularly in Cape Town, which falls inside the Southern Coastal Condensation Area (Guy, M, personal correspondence 2013, 8 April; Gallagher, D, personal correspondence 2013, 19 March; Holm et al., 2010; Harris and Krueger, 2005). Ceilings insulated with recycled materials have been assessed as the most cost-effective way of making significant thermal efficiency gains, although expensive wall reinforcements are more technically efficient (Gallagher, D, personal correspondence 2013, 19 March; Holm et al., 2010). A participant opted to prioritise insulating his home using scrap-wood flooring, over producing food from his well-established garden, is an example of how thermal efficiency priorities can arise organically, without any theoretical input.

Food gardens should not intend to replace other food sources, but rather to supplement them (Marsh, 1998). Through the establishment of private rather than communal gardens, SEED has arguably incentivised a more direct accountably system for gardens while maintaining communal benefits such as community co-operation in building and the sharing of excess produce. Increased accountability should increase commitment to the maintenance of such gardens at an individual level and increase productivity (Winkler et al., 2002). The fact that an unemployed man could reduce his monthly food expenditure by approximately R800, despite constraints of the council's indigent water supply show that interventions targeted at groups, trained, committed and able to putting in effort into gardens, can have tremendously positive results. Water is a key factor in garden projects and the systematic utilisation of greywater in both Cato Manor and Rocklands is an important less for similar projects as it increases the value of water and minimizes the cost of the intervention to participants.

The potential for economies of scale, for example in compost and seedling production, make the SEED model is expandable and replicable in the long run. Training and education is an area where SEED can significantly reduce costs through reusing now-developed training manuals, transport and food costs and potentially shortening the length of the workshop.

The Wonderbag™, distributed in the Cato Manor and SEED retrofits, provide an efficient and cost-effective, but underutilised technology (GBCSA, 2012). Uptake of Wonderbags™ varied from five times a week to never, providing an indeterminate indication of real efficacy (GBCSA, 2012). To optimise future distribution, as with gardens, research to determine the contexts in which Wonderbags™ are most frequently used is needed.

The overall response to solar geysers was universal acknowledgement of financial savings with varying degrees of satisfaction. Key to furthering the dissemination of solar geysers is the continued expansion of capital support channels like Eskom's rebates and housing-orientated micro-finance (Winkler et al., 2006). It is also essential for suppliers to realise the productivity gains made in this sector and ensure that, particularly poor consumers, have access to the most cost-effective products, including reliable maintenance (Eskom, undated). Solar geysers require less participation from the resident and so are potentially more applicable to those who do not have the time or interest to invest in gardens. Solar geysers supplied and manufactured locally have to potential to create a variety of jobs through both retrofits and new builds (Goldman, 2010; (Goldman, 2010; Gallagher, D, personal correspondence 2013, 19 March)).

Despite positive feedback from the SEED participant who did receive a rainwater-tank, the literature suggests that in the long run, the capital cost incurred to install a tank far exceeds the potential gains from reduced water demand (Angrill et al., 2012). This is important because it demonstrates that people do demand sub-optimal goods and investors must decide how to supply capital. For maximum per Rand gains, investors should approach other interventions before considering rainwater-tanks.

6. Conclusion:

Ultimately the benefits of retrofits for low-cost housing are clear. For RDP houses where thermal design is the largest energy leak, insulated ceilings and roofs are easily the most efficient options. Wonderbags™, food gardens, rainwater-tanks and solar geysers also save energy but to different degrees in different contexts, although solar geysers and Wonderbags™ save the most carbon emissions. For all interventions, it is essential to gain participant buy-in in order for the intervention to be maintained and provide the promised long-term savings. These findings and the literature which surrounds them are important in South Africa's attempt to combat climate change and find a development path which is sustainable, addresses inequality and is cost-effective going forward. The impact that such interventions have cannot be captured purely in price or carbon gains because low-cost housing fulfills a social need and thus must account for the perceived quality of life of participants.

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