URBAN SUSTAINABILITY AND HOUSEHOLD ENERGY EFFICIENCY
INEQUITIES, IMPACTS AND WAYS FORWARD

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ABSTRACT

Improving household energy efficiency is a key aspect of a transition to sustainable urban settlements. However significant differences exist in the energy use of low income households compared to higher income households. This relates to the energy efficiency of dwellings and the ways energy is used and conserved within homes.

In general, low income households in Australia use less energy and generate less carbon than higher income households. However, household expenditure on energy in low income households is far greater proportionally than in higher income households. Although many low income households have made energy saving changes in their homes, many face significant barriers to achieving savings.

Policies aiming to address climate change, in particular through pricing mechanisms can create differential outcomes for low income households. This is problematic on social equity grounds.

Researchers at the Brotherhood of St Laurence have sought to understand the processes creating these dynamics and the action needed to enable low income households to achieve their energy efficiency and sustainability aspirations in a way that contributes to urban sustainability. This paper presents data outlining existing energy consumption in low income households, which is mostly lower than for wealthier households. It also identifies high energy using low income households. The existing information on household characteristics and factors driving their energy consumption, including appliance ownership, is presented.

The paper then addresses a significant knowledge gap. This paper presents evidence of links between low income, and home comfort, health and financial hardship in a group of households participating in a home energy efficiency program.

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INTRODUCTION

Since 2007 researchers at the Brotherhood of St Laurence have sought to understand the impacts of climate change and sustainability policy on people on low income. This is because people on a low income are likely to suffer from the negative impacts of climate change and are less able to afford the energy price increases that are occurring, in part, due to climate change and climate policy. For example people in poorly insulated homes are likely to be more exposed to heatwaves. Furthermore people on a low income are less able to improve the energy efficiency of their homes and appliances because the upfront costs of many energy efficiency activities, for example home insulation or upgrading to a solar hot-water service, are unaffordable. Improving residential energy efficiency provides a simple and effective means to reduce exposure to rising and energy prices, and reduce exposure to climate change extremes such as increased heatwaves.

Household energy efficiency is a key aspect of a transition to more sustainable urban settlements, but low income households are being left behind. If Australia seeks to lower the carbon footprint of urban settlements, people on low incomes will require assistance to achieve their sustainability goals (Sullivan and Lee 2010).

This paper presents results of analysis of a number of data sets available, in order to answer the following questions:

- Does household energy use differ between lower and higher income households in Australia?
- What are the factors influencing this difference?
- What impacts does poor energy efficiency have in low income households?
- What can be done to improve the energy efficiency of low income households?

The information used to explore these questions comes from a number of sources.

The differences in energy use according to income is drawn from the Independent Pricing and Regulatory Tribunal of New South Wales (IPART), *Residential energy and water use in Sydney, the Blue Mountains and Illawarra: results from the 2010 household survey* and the Department of Human Services, Roy Morgan Research, *Victorian Utility Consumption Household Survey 2008*.

Along with these, the Department of the Environment Water Heritage and the Arts (DEWHA), *Energy Use in the Australian Residential Sector 1986 – 2020* informs the discussion of housing and appliance factors influencing home energy consumption.

Finally, data collected by the researchers, as part of the Solar Cities project is presented to indicate some of the impacts of poor household energy efficiency in low income homes in the urban area of the City of Moreland.

Results of these analyses are presented in the following sections. The paper concludes with an outline of the policy implications and suggestions addressing the issues raised in this paper to best assist low income households achieve their sustainability goals.

THE INFLUENCE OF INCOME ON ENERGY CONSUMPTION

The energy consumption of the average household has remained relatively constant in Australia since 1990 and is projected to decline by about 6% to 2020 this change reflects a shift towards a larger number of small households including single person households and existing and planned energy efficiency programs.

However on a consumption per-person basis, average energy use shows a 20% increase over this period, due in part to a decreasing number of persons per household (DEWHA 2008 p.ix).

Household income is one factor, which contributes to the amount of energy a household uses. Fig 1 indicates low income households in Sydney, NSW, consume less energy than wealthier households.

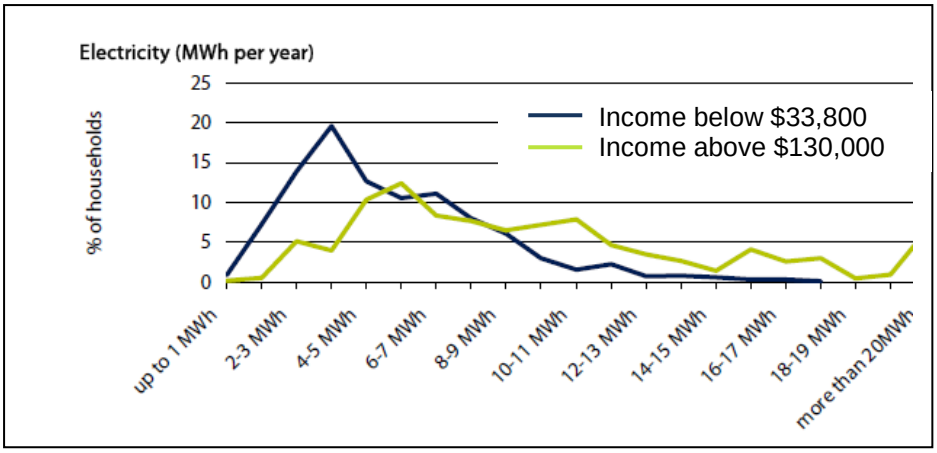


Figure 1: Frequency distribution of electricity consumption, by consumption band, for low income and high income households (IPART, 2010)

The IPART data demonstrates a higher proportion of lower income households than high income households in the lower consumption bands, up to around 5 MWh per year and a higher proportion of high income households than low income households in the higher consumption bands, from 10MWh upward.

Furthermore, 39 percent of low electricity users (using less than 4MWh per annum) are on low incomes (household income below $33,800 per annum) compared to just 6% being from high income households (above $130,000).

Conversely, high electricity users (using more than 12MWh per annum) are more likely to be from a high income household (31%) than a low income household (6%).

This is a pattern that is replicated in Victoria (Roy Morgan research, 2008) (and possibly other Australian States) and internationally, for example the UK (Druckman & Jackson 2008 p.3183).

The link between household income and energy consumption in part reflects the large number of single person households on low income and higher incomes in households with multiple wage earners.

OTHER HOUSHEOLD FACTORS INFLUENCING ENERGY CONSUMPTION

However, income is not the only household factor influencing consumption. We now turn to some of the other household factors that influence consumption.

Household Size

The number of occupants in the home is a key factor influencing household energy consumption. And low income households tend to be smaller than higher income households. For example in Sydney, low electricity use is associated with households without children (79%) and conversely, high electricity use is associated with households containing couples with children (79%) (IPART 2010).

Fuel Choice

Households in rural Victoria (who do not have access to mains gas) use more electricity than those in Melbourne (Roy Morgan Research 2008). The ability to switch to gas also has cost implications, as natural gas is less expensive and less polluting than electricity (Reardon et al. 2008). LPG gas, available in cylinders in rural areas costs almost twice that of natural (mains) gas (Reardon et al. 2008).

Tenure

Another important factor is tenure and renters are a particularly vulnerable population when it comes to energy policy. IPART (2010), for example, indicates that private renters are significantly more likely to enter energy hardship programs than owner occupiers, this may reflect higher non-energy costs such as rent. One example of this vulnerability is that private renters have much lower rates of insulation than owner occupiers as indicated in Table 1.1 below. This reflects a problematic trend in insulation in rental properties. However the impact may not be as bad as it appears from this data, as many of these households will be in apartments which while not being insulated will have better thermal performance than stand alone dwellings.

Table 1 Insulation by tenure and income (Victoria) (ABS, 2010b)

	Dwelling has insulation	Dwelling does not have insulation	Don't know whether dwelling has insulation
Tenure type			
Owned outright	85.9	8.2	5.9
Being paid off	85.1	7.1	7.8
Rented	36.8	19.9	43.3
Total	72.2	11.0	16.8

Health

The Victorian Utility Household Consumption Survey indicates six percent of households had a health problem (most commonly asthma and arthritis) affecting their electricity usage and five percent their gas usage. For most of these households (61%), additional energy use relates to heating to maintain a constant temperature in the home (Roy Morgan Research 2008 p.185).

Behaviour and Knowledge

A northern European study by Verhallen and van Raaij (1981) found that 26% of the variance in household energy use could be attributed to the behaviour of householders. Understanding of and attitudes toward home energy use vary widely in the community and are an area requiring significantly more research (Shipworth 2000). We have seen this in our own research. We have also observed significant variation in peoples' understanding of which behaviours will have the most impact on energy consumption.

DWELLING AND APPLIANCE FACTORS INFLUENCING ENERGY CONSUMPTION

Heating and cooling account for just under 40% of the energy used in Australian homes (Reardon et al. 2008 p.13) this suggests the thermal performance of a home is a key element of energy efficiency. The main factors influencing thermal performance are:

- Orientation of the home
- Shading
- Passive heating and cooling
- Insulation
- Thermal mass of structure
- Glazing
- Skylights
- Whether it is a single or multi unit development (Reardon et al. 2008). For example in Sydney, 53% of low energy users lived in a flat and conversely, 96% of high energy users lived in free-standing homes (IPART 2010).

Not all of these factors are modifiable, but some are.

Home Insulation

Insulation is a key cost effective measure, which when installed correctly can decrease winter heating load and summer cooling needs. Low income households, in all states with data available, are less likely to have insulation than wealthier households as indicated in Fig. 2 below[1].

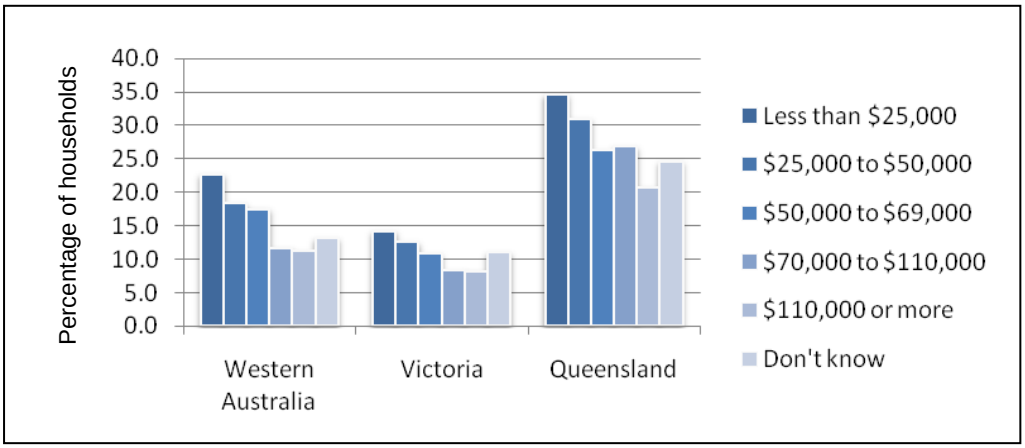


Figure 2 Households without insulation by income, WA, VIC and QLD (ABS, 2010a, b, c)

Even in Victoria, which has higher levels of insulation than other states, low income households have proportionately lower rates of insulation.

In Sydney in 2010, low income households had a higher rate of insulation installation in the past 12 months than other households, which most likely reflects their participation in the Home Insulation Program (IPART (2010) also see Hawke 2010).

Appliance Ownership and Efficiency

There are two key factors influencing home energy consumption in relation to major appliances. One is the number of appliances owned; in general the more appliances in a home the greater the household's energy usage. In low income households there tends to be fewer appliances than in higher income households.
The second is the efficiency of the appliances owned, which for low income households tends to be poorer than for higher income homes. Therefore, in low income households, there are likely to be consumption effects in both directions.

Hot Water

Hot water is one of the largest energy users in most homes but the energy used by water heating is projected to decrease overall due to replacement of static electric with gas or solar water heating systems (DEWHA 2008).

Households dependent on electric hot water are likely to have higher electricity consumption than others (see IPART 2010). Consequently their overall energy bills are likely to be higher because electricity is generally more expensive and less efficient than gas. The increased electricity consumption reflects both the reliance on electric hot water and the increased likelihood that the household relies on electricity for either heating or cooking (IPART 2010).

Low income households are more likely to have electric hot water than high income households. For example in Sydney 66% of low income households have electric hot water compared to 42% of higher income households and in Victoria 21% of concession card holders have electric hot water compared to 16% of non-concession card holding Victorians this means low income households will be paying proportionally more to heat water than higher income households.

[1] The Commonwealth's Home Insulation Program, which ran for one year from early 2009 until early 2010 is not fully covered by this data. The impacts of the Home Insulation Program, that may have increased rates of insulation in low income homes, may not be fully reflected.

Heating and Cooling

Energy use from heating is projected to increase into the future due to dwelling size increases (but only modest building shell performance standards), decreasing occupancy rates and a rise in the share of dwellings with whole-house heating systems (DEWHA 2008).

In Victoria, Roy Morgan Research (2008) reports no large differences between concession and non-concession households. They do however report small percentage differences that will make a large impact on certain households. For example:

- 5% of non-aged concession holding households use portable electric heaters as their main form of heating
- Another 5% use a built in electric heater as the main form of heating
- Another 1% have no main heater

Increased usage of residential air conditioners is projected to be a key contributor to increases in future energy demand including peak period demand. The factors leading to an increase in the energy used for cooling are the same as for heating, with the additional note that the share of dwellings with space cooling projected to rise significantly (DEWHA 2008).

As a key contributor to rising peak demand, increased use of air conditioners has flow on effects to generation costs that are borne by all consumers, regardless of whether or not they have air-conditioning in their home.

In Victoria, the incidence of air conditioning and air cooling (excluding fans) has risen dramatically from 40 percent of homes in 1996 to 62 percent in 2007 (Roy Morgan Research 2008) . Some 72% of people with an aged concession have air-conditioning or cooling, compared to 70% of people with no concession and 66% of people with non-aged concessions (p.115). In relation to home comfort levels, the high incidence of cooling for older people who are less able to tolerate heat is positive; however the cost of operating cooling systems is high and may be significant in homes where insulation is not present.

There is a considerable diversity in the effectiveness and efficiency of different forms of air conditioners. Given their importance to health and well being it would be useful to look in more detail at the efficiency of air conditioners in different types of households.

Refrigerators

Almost all households in Australia own a refrigerator. Refrigerators are the third largest end-use for stationary energy consumption in most households (behind hot water and heating and cooling). They make up approximately 10% of the average household's energy consumption (this is likely to be higher in low income households who have fewer appliances). While there is no reliable data on the efficiency of refrigerators in low income households we do have a very clear pointer through the age of refrigerators.
As a result of Minimum Energy Performance Standards and mandatory labelling requirements, new refrigerators are substantially more efficient than old refrigerators. The Equipment Energy Efficiency Committee (EES 2006) reports, across all refrigerator types, an average:

- 3.9% annual decrease in energy consumption of refrigerators from 1993 to 2005.
- 4.6% annual improvement in energy efficiency (taking into account volume of the refrigerator).

However, low income households have substantially higher incidences than higher income households of owning older refrigerators which are less efficient.

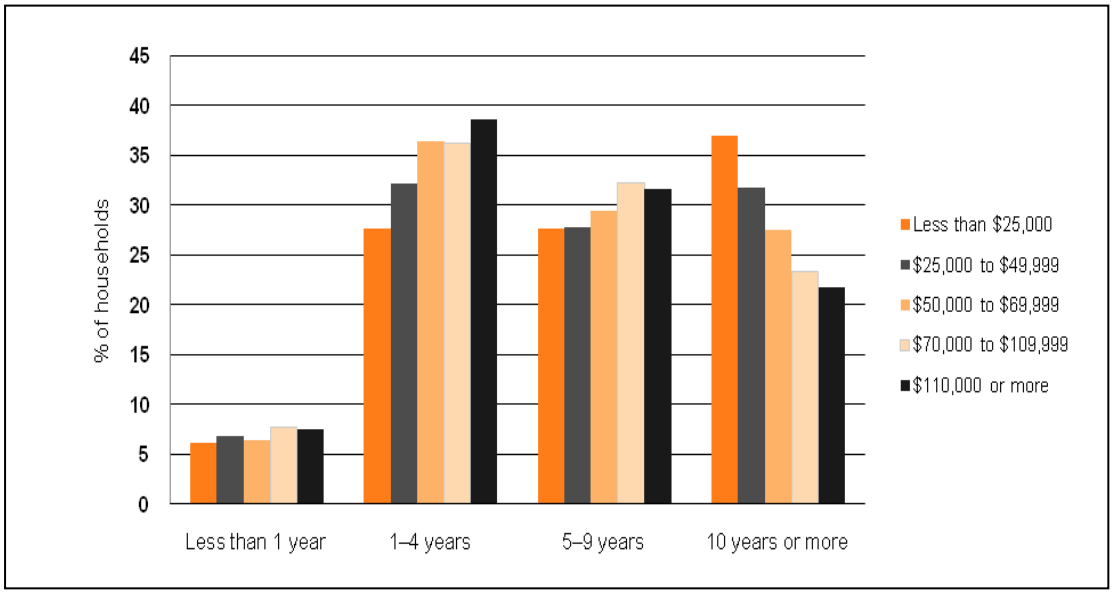


Figure 3 Age of main refrigerators by annual income, Victoria, 2009 (data sourced from ABS 2010b)

Fig 3 indicates that more than one-third of low income households have refrigerators that are 10 years or older. These households do not benefit from more recent (and significant) energy efficiency gains made in 2005 and 1999 (EES 2006).

Trends in Consumption for Lighting and Other Appliances

The energy consumed by Information Technology (IT) equipment is projected to increase due to a significant growth in the levels of ownership of home computers (PCs and laptops) and an increase in their hours of use. The on-mode energy consumption of PCs has doubled and will continue to increase (DEWHA 2008).

There is also projected to be a rapid increase in energy consumption for home entertainment such as televisions, games and set-top boxes. On-mode consumption is growing rapidly with increasing screen sizes; from 65W in 1986 to a projected 230W in 2020 (DEWHA 2008).

As noted above, low income households have less appliances than higher income households (Roy Morgan Research 2008) and this is likely to include IT and entertainment equipment. Given low income households also have older appliances; the higher energy consumption of newer appliances associated with on-mode consumption and screen size is less likely to affect this group. While this may be positive in relation to energy use, it may represent disadvantage in relation to access to IT and the information and other benefits flowing from it.

Lighting is projected to have both upward and downward consumption pressures relating to the replacement of incandescent lighting with inefficient and densely installed Quartz Halogen lighting or efficient Compact Fluorescent lighting. Further research is required to identify the influence of this in households with low income.

LOW INCOME HOUSEHOLDS WITH HIGH CONSUMPTION

Despite people on a low income generally using less energy than those on higher incomes, there is a small group of low income, high energy using households who are potentially facing significant financial hardship.

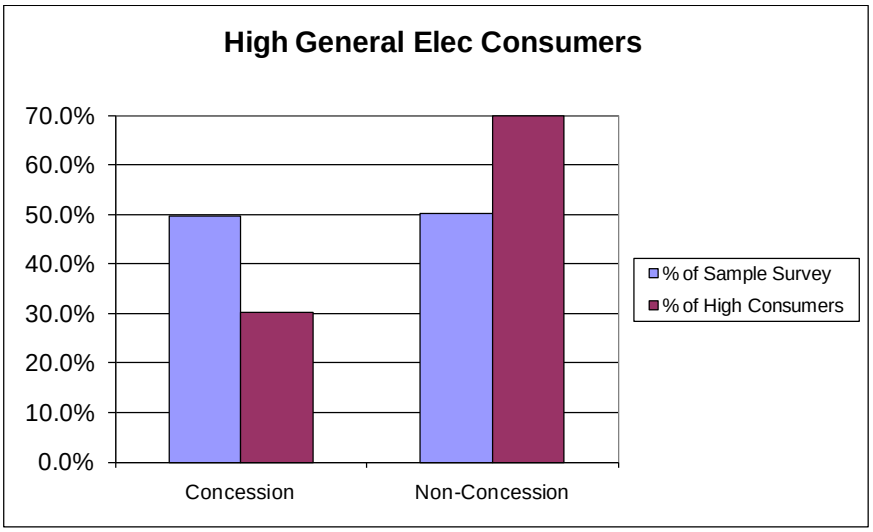


Figure 4 High electricity consumers; concession and non-concession, 2001 (n=2,006) (McNicol, 2002)

Analysis of the DHS Victorian utility survey by Ian McNicol of Sustainability Victoria clearly indicates concession card holders are underrepresented as high electricity users. Nonetheless there is a small group of people with a concession who are part of the high use group, using an average of 9,549 KwH/year.

As mentioned previously, in Sydney, about 6% of the high energy use group (those consuming 12 MwH pa) are on a low income.

There is not a lot of information about these households currently available, however based on the data presented in this paper, the following observations may explain some of the characteristics of this group:

- Living in poor quality housing that requires large amounts of heating (and inefficient heating)
- Using an electric hot water service and an old refrigerator
- Large household size
- A chronic illness, especially those that include problems with thermo regulation such as MS or an ABI that requires home space-conditioning, or other needs for medical equipment that uses electricity
- Being unfamiliar with the way electricity and utility billing works

ENERGY EFFICIENCY HOME COMFORT, HEALTH AND FINANCIAL HARDSHIP

The data presented above indicates significant inequities between higher and lower income households in relation to energy use and energy efficiency. However, there is a lack of data that identifies the impacts of these differences within homes or the steps needed to address these inequities. In order to address this gap, Researchers at the brotherhood of St Laurence are currently conducting a study to try to better understand the impacts of a home energy audit and retrofit program delivered in partnership with the Moreland Energy Foundation, Moreland City Council and Sustainability Victoria. It is a free service for Commonwealth concession card holders residing in the City of Moreland. The program consists of a home energy audit, recommendations for actions householders can take to reduce their energy use and assistance to implement some recommendations such as ceiling insulation, tap aerators, draught seals and low energy light globes.

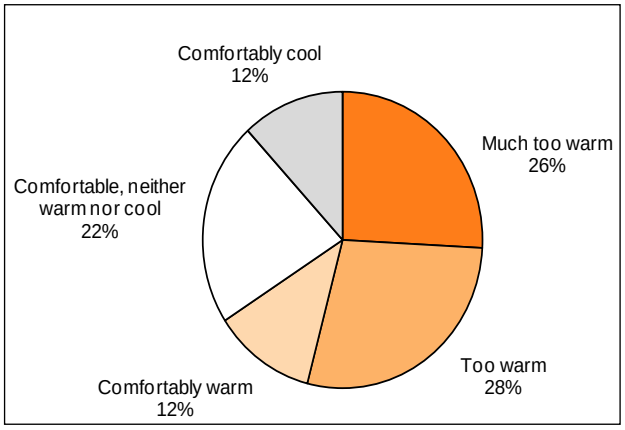
The objective of the research is to identify social impacts within households of the Warm Home Cool Home program. Specifically, the research investigates relationships between the audit/retrofit, energy use and energy use behaviour change. It will measure impacts on aspects of home comfort, financial hardship and health of low-income households.

The baseline data presents interesting information about links between low-income, energy use, home comfort, health and financial hardship (see Johnson and Sullivan 2011). This data is presented in the following sections.

Home Comfort

A number of thermal comfort measures are available, with the ASHRAE scale and Bedford scale being commonly used (see for example Hong et al. undated; Wong & Khoo 2003).The Bedford scale has been selected for this study, partly because it is simple to use and can be self-reported in an interview. Moreover the Bedford scale has been identified as superior to the ASHRAE scale (Wong & Khoo 2003) because people not only rate their thermal sensation (cool, warm) as in the ASHRAE scale, but also identify whether they are comfortable or experiencing too much of the sensation (for example, too warm, much too warm).

People were asked to describe their usual level of comfort in their home during summer and during winter (see Fig. 5 and Fig. 6).



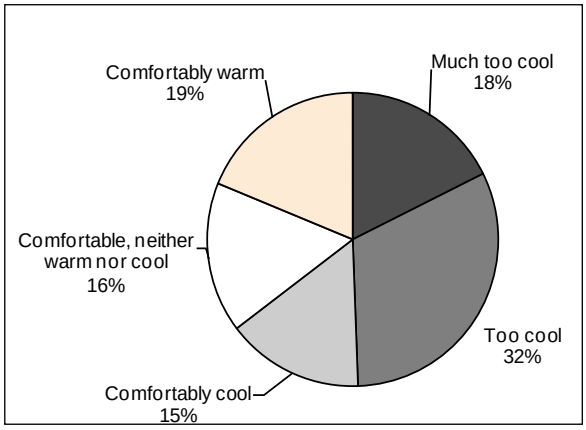


Figure 5 Thermal comfort summer (n=85)

Figure 6 Thermal comfort winter (n=85)

Fig. 5 shows that more than half the sample (54.1%) report that during summer their home is usually too warm or much too warm, and therefore uncomfortable. Conversely during winter, almost half the sample (49.4%) report home comfort levels that are too cool or much too cool, as Fig. 6 shows. Just over half the sample (50.6%) report their home is comfortable during winter. This indicates that for the low income households participating in this research, more than half the sample usually experience thermal discomfort in their homes. Further analysis is needed to identify seasonal impacts influencing these responses

Financial Hardship

The research uses two measures of financial hardship. One is a hardship measure (Butterworth & Crosier 2006) based on the Household Income and Labour Dynamics Australia (HILDA) data (Melbourne Institute 2011). This measure asks people to indicate whether they experienced any of the following situations in the last six months due to a shortage of money:

1. Were unable to pay gas, electricity or telephone bills on time
2. Could not pay the mortgage or rent on time
3. Adults or children went without meals
4. Were unable to heat or cool your home (when needed)
5. Pawned or sold something
6. Sought assistance from a welfare or community organisation.
7. Sought financial help from family or friends

The measure used in this analysis is a count of how many of these ‘hardships’ the households experienced. It ranges from zero to seven.

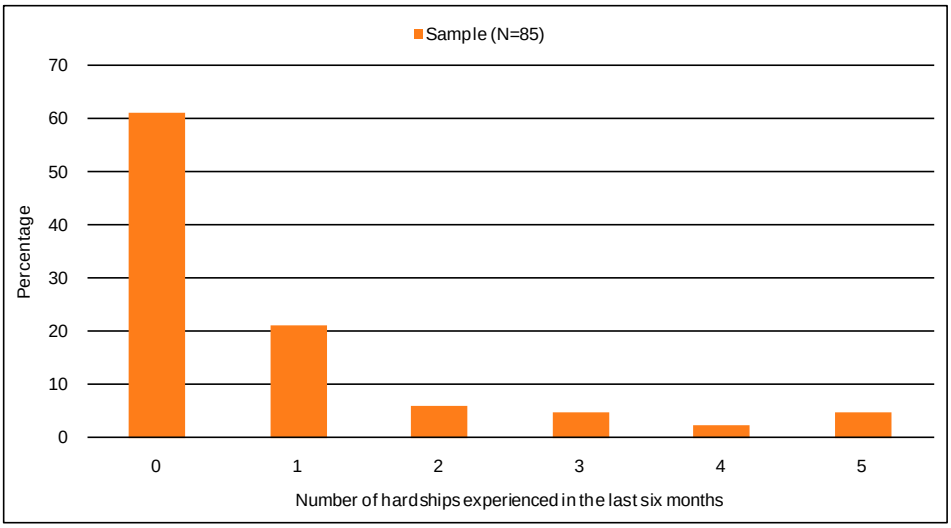


Figure 7 Financial hardship

Fig. 7 indicates 61% of the sample did not report experiencing any of the HILDA hardship measures. Just over 20% experienced one, and small numbers of participants experienced multiple stressors during the preceding six months. Interviewees in four households (5% of the sample) reported experiencing all five of the tested hardships.

An important factor influencing this result is that 55% of the sample owns their home outright and hence the variable 'could not pay rent or mortgage on time' is not applicable for them.

A second measure, a measure of fuel poverty used in a UK study (Green & Gilbertson 2008) of a program similar to Warm Home Cool Home, was also used. Interviewees were asked:

> *Over the past six months, how easy or difficult has it been for you to find the money to pay for electricity, gas and other fuel? (very easy, somewhat easy, neither easy or difficult, somewhat difficult, very difficult)*

The data in Fig. 8 below indicates 31% of the sample reporting paying for energy as somewhat difficult, followed by 24% reporting it as neither easy nor difficult and 24% reporting it as very easy. Several people noted that because they paid their utility bills using Centrepay[2] it was not difficult. Others stated that such bills are always paid first, so they may not have difficulty paying utility bills but other spending may be significantly constrained.

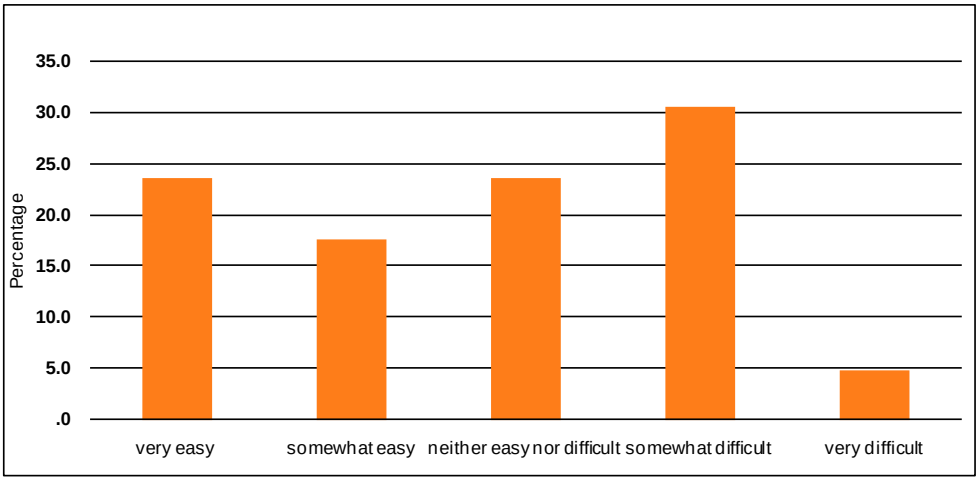


Figure 8 Fuel poverty measure

[2] Centrepay is a free direct bill paying service available to customers who receive a Centrelink payment (see <http://www.centrelink.gov.au/internet/internet.nsf/forms/sa325.htm>.

A correlation of these two measures (using Pearson's r) indicates a significant positive correlation between the financial hardship score and the fuel poverty score (expressed as a scale) r=.493 p<0.01. This means that the higher the number of financial hardship factors reported, the greater the reported difficulty in finding the money to pay fuel bills. However the r^2=0.243 indicates only 24% of the variability in financial hardship score is shared by the fuel poverty score (76% of the variability is accounted for by other things).

Health

Green & Gilbertson (2008) and Howden-Chapman et al (2007) indicate a number of different health impacts of home energy retrofitting programs. These include overall self-reported health, respiratory health, chronic pain and stress. Improvements in respiratory and chronic pain conditions were related to improvements in insulation and in some cases heating. Improvements in stress were primarily a secondary benefit resulting from improved financial and or medical conditions (Green & Gilbertson 2008). These aspects of health are being assessed in the Warm Home Cool Home research.

The baseline data for overall self-assessed health is illustrated alongside national figures from the National Health Survey (NHS) for 2007–08 (ABS 2010d) in Fig. 9.

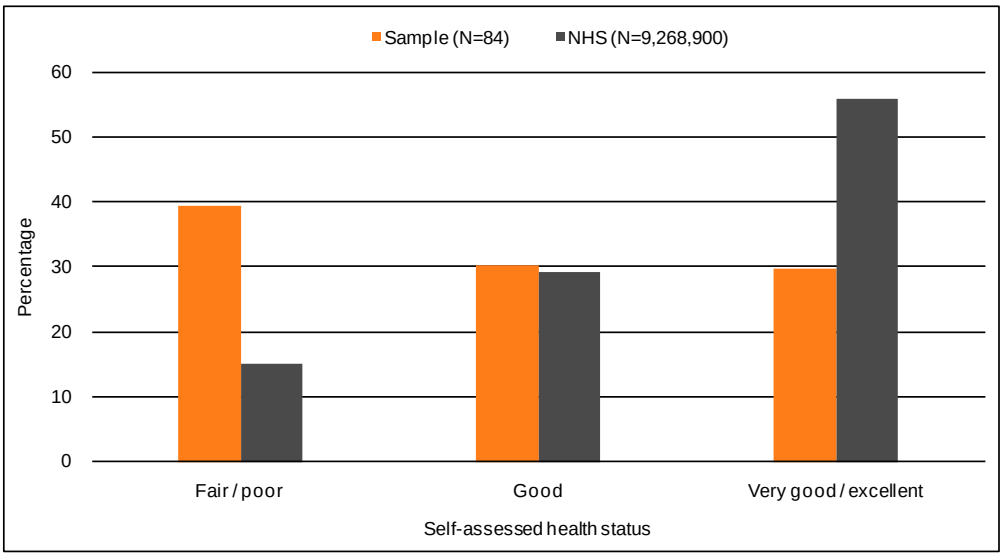


Figure 9 Self-assessed Health

Around one-third of the sample reported being in good health, with almost 40% rating their health as fair or poor and 29% rating their health more highly, as very good or excellent. One person did not provide a rating of their health. In comparison, the NHS indicates a similar proportion of the population reporting their health as good (29%), but a much higher proportion of the sample reports very good or excellent health (56%) and only 15% rate their health as fair or poor (ABS 2010d). This suggests a higher burden of health in the Warm Home Cool Home sample than in the general population.

In relation to specific health conditions, 39% of the sample reported themselves or a member of their household as suffering from a respiratory condition, with 33% of the sample having experienced symptoms in the four weeks prior to the interview. Chronic pain conditions, such as arthritis, back pain and pain associated with multiple sclerosis, endometriosis and fibromyalgia were common in the sample, being experienced by 62% of the interviewees (or member of their household). Some 59% of the sample had experienced pain symptoms in the past four weeks.

Interviewees were also asked whether anyone in their household had any other chronic illness or disability that affected their electricity or gas use. Some 24% of the sample reported this was the case. The types of special energy use reported included requirements for oxygen, recharging of electric wheelchairs, air-conditioning and heating for people with thermoregulatory problems associated with multiple sclerosis and acquired brain injury and additional lighting due to vision impairment. For one person, the causes were less clear. She explained her son's high usage of heating as due to mental illness:

> He keeps the heater on because he says he's cold; I'm not sure what's wrong with him. I need to take him back to the doctor.

Just over one-quarter of the sample (27%) reported illness affecting themselves or a household member, that was caused, or made worse, by extreme heat the previous summer. In almost one-third of cases (30%) the illness was severe (requiring medical advice or attention). In 52% of cases it was moderate and in 8% it was mild.

In summary these figures suggest that in this sample there is a high proportion of people on a low income experiencing compounding disadvantage through poor thermal comfort of their homes, difficulty paying energy bills and poor health. These factors all interrelate and are predicted to be influenced by the energy efficiency of homes and appliances. In the next stages of this research we will assess the responsiveness of these factors to the home energy audit and retrofit provided to these households through the Moreland Solar Cities program.

CONCLUSION

In this paper we have presented data indicating an energy efficiency gap between people on a low income and those on higher incomes. This relates to the efficiency of individual dwellings, the prevalence and efficiency of appliances within homes and the ways in which energy is used and conserved by household members.

In some cases these factors may be causing higher energy use, with likely follow on impacts of higher energy bills and the potential for energy related financial hardship. Poor energy efficiency may also be compromising home comfort. All of these factors may be impacting negatively on some people's health.

Despite improvements in the energy efficiency of many appliances, people on a low income are not getting equitable access to these efficiencies and are falling behind. There is a need for Governments to step in to assist.

In the context of the proposed introduction of a carbon price, this research indicates a need for energy efficiency programs for low income and other vulnerable households to address the energy efficiency gap and assist households in the transition to urban sustainability.

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