

STUDY REPORT

No. 111 (2002)

Energy Use in New Zealand Households – Executive Summary

Report on the Year 5 Analysis for the
Household Energy End-use Project (HEEP)

Supported by:



The work reported here was jointly funded by the Building Research Levy, the Foundation for Research, Science and Technology from the Public Good Science Fund and the companies whose logos are shown above.

© BRANZ 2002

ISSN: 0113 3675

Energy Use in New Zealand Households

Report on Year 5 of the Household Energy End-use Project (HEEP)

June 2001

Executive Summary

This report covers the activities of the fifth full year of the **Household Energy End-use Project (HEEP)**. The project represents a major commitment by a number of funding and research organizations to develop, and make available, improved knowledge about the actual energy use of real New Zealand houses occupied by real families.

HEEP was established in late 1995 as a long-term research activity to create a scientifically and technically rigorous, up-to-date public knowledge base of energy use and end-uses, energy services provision and key occupant, building and appliance determinants of energy use in residential buildings.

Energy consumption is analysed both in terms of time-of-use across the day and over the year in order to examine daily and seasonal patterns. Focus is not solely on the technical aspects of energy use, but also on the physical and social characteristics of the house and occupants. The objective is to build a model based on the main drivers that determine household energy consumption patterns by establishing:

- **Energy consumption:** *how much energy is used by households*
- **Energy types:** *which types of energy are used by households*
- **Appliances:** *which household appliances use this energy*
- **Time periods:** *during which seasons and times of day energy is used*
- **Household types:** *how do different types of households use energy*
- **Occupant behaviour:** *what behaviours affect household energy use*
- **Energy service:** *what service is provided by the energy use*

The project has been designed to suit a wide range of possible participants, with particular analyses able to be tailored towards specific needs. For example, this year a group of 12 pensioner households in Hamilton has been monitored as a special study for the WEL Energy Trust. At the same time, all the data collected will contribute towards the overall understanding of the energy performance of households.

The first few years of the project focussed on the development and implementation of large-scale monitoring and data analysis methodology for the types of energy used in households, and other specific monitoring tasks. The areas of methodology investigated or underway since the beginning of the project are:

<i>Systems investigated or underway</i>	
<i>1996: Year 1</i>	<i>Electrical end-uses only</i>
<i>1997: Year 2</i>	<i>Solid fuel burners</i>
<i>1998: Year 3</i>	<i>Reticulated gas appliances</i>
<i>1999: Year 4</i>	<i>Random house selection monitoring Total level monitoring LPG trials</i>
<i>2000: Year 5</i>	<i>Refining of solid fuel monitoring and analysis techniques LPG monitoring</i>
<i>2001: Year 6</i>	<i>Remote logging development Development of methods for solar and wetbacks</i>

This work involved a series of selected households as pilot studies, as well as specific case studies that concentrated on particular areas or household types such as this year's pensioner study. Including these, selected households now total 66. Random selection of households started in 1999, with progress to date as follows on the target sample of 400:

Standing Losses from Electric Hot Water Cylinders

Hot water systems in New Zealand are generally not very efficient, with merely an estimated 5% of hot water cylinders meeting “A” Grade specifications. Consequently the potential for national energy savings, and Greenhouse Gas emission reductions, from improvements in hot water systems is likely to be large. Previous estimates of the electric hot water cylinder standing losses of about 30% appear to be confirmed by a random sample of HEEP households, which have an average standing loss of about 25-30% of hot water energy use. Standing losses for all of New Zealand’s electric hot water cylinders could amount to as much as 5 PJ.

New performance requirements under NZBC Clause H1, which became mandatory on 29th December 2000, will improve the overall performance of electric hot water cylinders in new homes, as will retrofitting of insulation wraps to existing cylinders. The application of Minimum Energy performance standards (MEPS) and energy labelling will result in improvements in existing homes as old cylinders are replaced.

The HEEP survey shows that about 20% of New Zealand houses sometimes run out of hot water. The reasons for this include small cylinder size for the household hot water use, which can only be resolved by fitting a larger cylinder. The early results are also suggesting that improving the cylinder and piping energy efficiency along with improved thermostat controls should help provide a better hot water service.

Influences on Hot Water Demand

Hot water demand is driven by a number of factors and work is still being undertaken to examine these. The water heating information from the HEEP database was examined against a number of potentially demand-influencing factors such as the ages of the occupants, type of hot water system, and the reported shower and bath usage. At this intermediate stage, the number of female teenagers appears to be an important influence on demand for hot water.

Hamilton Pensioner Case study: overall energy consumption

Energy consumption of pensioner and non-pensioner households are as follows:

- Yearly total energy per person
 - Non-pensioner 1900 kWh
 - Pensioner 2200 kWh
- Yearly hot water energy per person
 - Non-pensioner 930 kWh
 - *Hot water % of total* 48%
 - Pensioner 820 kWh
 - *Hot water % of total* 37%

The Hamilton pensioners in this study used more energy overall (including gas) per person than the non-pensioners, and slightly less energy for hot water per person. Temperatures during winter in living rooms and bedrooms were 1 to 2 °C higher in the pensioner households. Most pensioners achieved comfortable and healthy temperatures, while many non-pensioners did not, especially in bedrooms. The higher temperatures in the pensioner housing may be due to the thermal efficiency of their well-insulated units, which require only about 500 W of dedicated heating to maintain indoor temperatures 10°C above outside temperatures. In contrast, a group of pensioners living in poorly insulated units in Wellington had living room temperatures 6°C colder than the Hamilton pensioners, with average June temperatures of only 14.5°C. When the Wellington units were insulated the temperatures rose to around 17°C, still 3.5°C cooler than the Hamilton units. It is plausible that the cost of heating affects the living room temperatures of pensioners.

By New Zealand norms, this group of Hamilton pensioners are exceptional in that their units and hot water systems are highly thermally efficient, which makes a major contribution to both their low energy demand, and their indoor temperatures. Pensioners living in older, poorly insulated

units or in houses would likely have a higher energy demand and costs, and lower indoor temperatures as heating would be less affordable and less effective.

Standby Power and Losses

Standby power is drawn by an appliance when it is not in operation but is connected to the mains. Depending on the appliance type, this can range from nil to as much as 20 W or more. These power consumptions may seem trivial, but since most households have many such appliances, the actual energy consumption may be a significant fraction of the total energy consumption of a household. A survey of international studies reported that around 10% of domestic electricity consumption is from standby power consumption. Much of this consumption is a waste of money and energy, a source of unnecessary Greenhouse Gas emissions, and can be reduced through good electrical design.

If the average national baseload is similar to that found for the randomly selected Wellington and Hamilton households, then the total baseload is around 130 MW continuous, with a yearly consumption of 1,100 GWh, which has a retail price of approximately \$115 million, and CO₂ emissions of around 730,000 tonnes, if supplied by thermal generation. This is approximately 3% of New Zealand's total electricity generation, and up to 1% of New Zealand's total GHG emissions (if supplied by thermal power stations). Clearly, the potential reductions of baseload and standby consumption in NZ households are large, and has potential for Demand Side Management (DSM) and GHG reductions.

The largest five contributors to the household baseload are (from highest to lowest):

- fridge or fridge freezer
- television
- video
- washing machine
- microwave.

In rounded figures, HEEP standby and baseload estimates per house available to date may be summarised as follows:

• Average total baseload	103 W
• Standby from common appliances ²	36 W
• Standby from minor appliances	10 W
• Average consumption of heated towel rails	25 W
• Remaining unquantified baseload	32 W

For some appliance classes, such as televisions and VCRs, the future standby consumption demand may decrease, as modern appliances have lower standby power than older units, and the total number is not growing quickly. However, there are a host of other rapidly increasing appliances that may increase standby consumption and a proliferation of electronic and computer controls replacing manual control. Examples include computers, cable decoders, satellite decoders and receivers, video games, faxes, answering machines, cordless phones, and various battery chargers for portable devices. For whiteware in particular, computer controls are becoming more and more common. Unless measures are taken to reduce the standby power of these appliances, then standby and baseload losses may increase dramatically.

Indoor Temperatures

The 1971/72 Household Electricity Survey³ measured average winter (August-September 1971) temperatures in the kitchen, lounge and main bedroom. This confirmed that New Zealand houses

² Other studies do not include all of the power consumption during non-usage time for fridges and fridge freezers, videos and microwave, as the power is consumed for specific tasks (e.g. butter conditioner, microwave clocks).

³Department of Statistics, 1976. Survey of household electricity consumption 1971-72: Report on the temperature/insulation study. Government Printer. Wellington. New Zealand.

were then only heated to low levels. Although there was no measured evidence to support it, it has been assumed that nowadays occupants are demanding more comfortable temperatures, and that average temperatures have risen in response. Monitoring of randomly selected households in Wellington and Hamilton suggests this is not so. The average measured temperatures were about 1°C less than those measured almost 30 years ago.

There were also regional differences, with the Hamilton households showing higher average indoor temperatures than those in the Wellington sample. The spread of measured temperatures was higher for the Wellington sample, with about 25% having evening temperatures below 16°C.

Survey results indicate that only about 50% of New Zealand households consistently achieve comfortable temperatures during the winter. Correlations of these responses with measured average evening living room temperatures over the winter show a clear relationship between temperatures and comfort perception. The average temperature in houses, which were reportedly always comfortable, was approximately 19°C. Comparing the average winter evening temperatures with the decade in which the house was built also showed a clear relationship, with higher temperatures in houses built since the 1980s.

Solar Gains

Winter space heating is a large component of the energy used in New Zealand households. Heating energy requirements are determined by local climate, the physical properties of the building and the comfort expectations of the occupants. Requirements can be minimised with appropriate design that makes effective use of the available solar radiation. This year a typical house was investigated to assess the impact of solar radiation on indoor temperatures.

Indoor temperatures within buildings are dynamic. The vertical temperature distribution within the living room of the house under investigation was found to depend on the nature of the heating system employed. Convective heating produced a greater vertical temperature difference than radiant heating. Solar gains produced a radiant effect on the afternoon temperatures within the living room, with temperatures comparable to the evening temperatures when the radiant heater was used.

HEEP, Appliance Standards & Energy Labelling

As part of the HEEP project, the pattern and amount of energy use of appliances of all types, sizes, and ages used by real people in real houses is monitored in great detail, and appliance usage is also surveyed. These results are important to assist in understanding how codes and standards can underpin society's efficient use of energy. Mandatory minimum energy performance standards (MEPS) for appliances do not represent a 'good' energy efficiency goal, but are critical to minimise market failures. The availability of 'Better' and 'Best' standards, not only for building design, but also for significant energy using appliances, will provide support and guidance to those wishing to 'do better' than any mandatory minimums.

The New Zealand Building Code does not require existing buildings to meet the current standards for hot water systems when changes are made, and it is legal to replace an old hot water cylinder with one of any grade or age. The HEEP results will provide information on possible benefits of requiring that all replacement hot water systems meet current requirements, and the second hand market for non-complying hot water systems be stopped.

The HEEP results would support the inclusion of standby power consumption of appliances should be included in MEPS and energy labelling, as this can account for as much as 10% of domestic energy use but can be easily reduced. Any labelling programme should be accompanied by advertising and public education, training of retail staff, and the provision of readily available information, so that consumers know what the energy label is, how to interpret it, and how to use it. Monitoring and evaluation of consumers, retailers, manufacturers, and importers is also needed to gauge the effectiveness and success of the programme, otherwise opportunities for improvement will be lost.

Occupants' Perceptions

As each household is surveyed prior to monitoring actual energy use, results are now becoming available that provide insights into attitudes towards energy services. Based on analysis of households surveyed to date, some preliminary results are available.

It appears that, when asked to rank energy-consuming appliances in priority order, people are least willing to sacrifice heating and hot water heating. The easiest sacrifice appears to be electric blankets and lighting. This may suggest that efforts to improve the efficiency of lighting may be easier to achieve than changes in the use of heating and hot water.

Almost half of those surveyed did not always achieve what they perceive as comfortable temperatures in their houses. When assessed against recorded winter temperatures, a clear relationship was shown between perceived comfort and actual temperatures. Temperatures were also assessed against ages of houses. This showed a clear increase in temperatures over the decades, particularly in those houses built after the introduction of insulation standards in 1978. This suggests the level of takeback effects (in the form of warmer rooms) that might be expected when increasing the thermal performance of new houses.

Methodology

House Construction Types

HEEP plans over time include the evaluation of energy and comfort characteristics of a number of low volume wall construction styles. The objective is to understand the potential impact of emerging new wall construction types on the national energy consumption, and the consequences for the indoor environment. The selection criterion are based on the potential of the new construction method to become widespread as well as the extent to which it differs in thermal performance from timber frame construction. On this basis, the following construction types have been selected for monitoring:

- **Concrete masonry**
- **Tilt up slab wall**
- **Polystyrene block**
- **Solid timber**
- **Light steel frame**
- **Wood based panels**

Due to budget constraints, the monitoring sample of each of these low volume construction types is expected to be very small. Also, as well as the basic wall type, the design of all other construction elements and the occupants' behaviour influence the thermal performance of the buildings. In this context, the result of this sub-study is expected to provide a snapshot of some individual cases, rather than a general understanding of the performance differences of the different construction types.

New sample selection

Initially it was planned to base the order of regional data collection on practical and logistic circumstances, as well as on the willingness of the energy or lines companies to participate. The household proportion in the major electricity company areas was accordingly taken from power company customer record numbers based on 1996 data, including all those power companies with a residential customer base of more than 40,000 residential customers.

Since then it has become apparent that power company participation cannot be relied on to ultimately cover the whole country. Company areas are changing too frequently to use them as the basic regional selection unit. In addition, energy retailers are no longer geographically defined, making them unsuitable.

