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BRANZ Household Energy End-use Project

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The BRANZ Household Energy End-use Project (HEEP) research was designed to show how, where and when we use energy in our houses.

Started in 1997, HEEP investigated 400 houses from Kaikohe to Invercargill.

This *Bulletin* provides a brief background to the study. It also uses the findings to show how designers and builders can provide homes which give their owners the benefits of energy efficiency or energy conservation.

1.0 INTRODUCTION

1.0.1 The BRANZ *Household Energy End-use Project* (HEEP) research was designed to show how, where and when we use energy in our houses.

1.0.2 Started in 1997, HEEP investigated 400 houses from Kaikohe to Invercargill. Most of the monitoring (300 houses) was carried out from 2002 to 2005, so it provides a good sample of current behaviour and appliances.

1.0.3 This *Bulletin* provides a background to the study. It also uses the findings to show how designers and builders can provide homes which give their owners the benefits of energy efficiency (getting more services for the same amount of energy) or energy conservation (using less energy).

2.0 OVERVIEW OF THE PROJECT

2.0.1 The researchers selected a representative sample of New Zealand houses. Each house was monitored over a year for fuel used (electricity, natural gas, LPG, wood, coal, oil), hot water use, and living room and bedroom temperatures. In one quarter of the houses, the energy use of appliances such as refrigerator, television and stereo was also measured.

2.0.2 A survey collected information on the house occupants, and an energy audit covered house layout and construction, the hot water system, the heating system and the number and type of appliances (including any noted faults).

2.0.3 HEEP houses had over 1,200 occupants. The 12 field staff travelled over 126,000 km. HEEP holds data on 441 hot water cylinders, 65 wet-backs, 206 solid fuel burners, seven solid fuel ranges, 42 open fires, 175 portable LPG heaters, and nearly 14,000 appliances, with label details from a further 6,000 appliances.

3.0 HEEP'S OVERALL FINDINGS

3.0.1 Electricity is the most widely used fuel (Figure 1), followed by solid fuel such as wood or coal, and then natural gas. Piped natural gas is only found in about 14% of houses, and these are only in parts of the North Island.

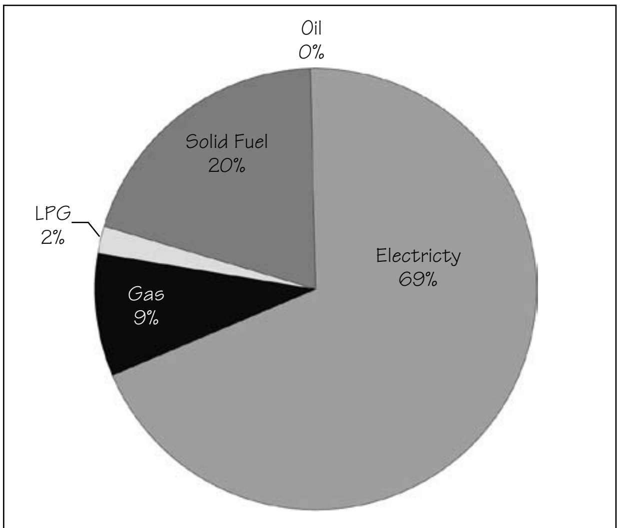

Figure 1. Total energy use by fuel type

Source: HEEP Year 10 report

3.0.2 The fuel only gives part of the story – how it is used is just as important. Figure 2 breaks down the services provided.

3.0.3 Household energy use splits into three almost equal areas: space heating (average 34%), hot water heating (29%) and all other uses (37%). There are some overlaps: for example, the stray heat from the "other uses" (lights, appliances) provides quite a lot of space heating.

3.0.4 These are averages over many house types and ages, construction types, and occupants – no single house will use exactly these proportions. Space heating is more variable than other energy uses due to location, thermal insulation and occupant behaviour. In the colder parts of the country up to half of the total energy used can go into heating.

3.1 BIG USERS

3.1.1 The top 20% of households by energy use consumed 36% of the energy while the bottom 20% used only 9%. The energy from all fuels used by the top 20% was over 14,400 kWh/year, while for the bottom 20% of users it was less than 6,900 kWh/year (New Zealand average household energy consumption is approximately 11,000 kWh/yr – the equivalent of running a 1.25 kW heater continuously).

3.1.2 Although the opportunities for energy efficiency and energy conservation are open to everyone, the potential benefits are larger in the higher use households.

4.0 SPACE HEATING

4.1 HEEP FINDINGS

4.1.1 Nearly three quarters (72%) of houses use space heating from April to October.

4.1.2 This heating is dominated by solid fuels (56%), with electricity coming a distant second at 24% (see Figure 3).

4.1.3 It was found that:

- houses built after 1978 (when thermal insulation became mandatory) are warmer than older houses, regardless of heating method

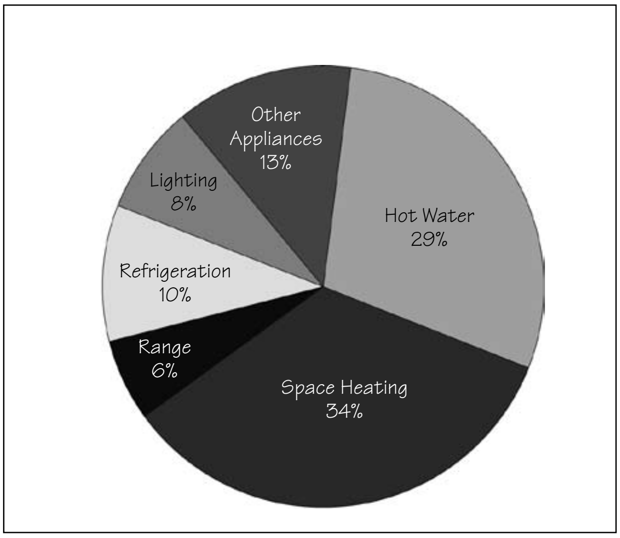

Figure 2. Total energy use by end-use

- many houses are too cold. 28% of HEEP houses had average winter evening living room temperatures below the World Health Organization's recommended minimum of 16°C
- many house occupants only heat small areas (e.g. living room)
- half of bedrooms are not heated, while about one quarter are only heated in the evening
- houses heated by open fires were the coldest
- houses heated by larger heating appliances (enclosed solid fuel, central gas or oil heating) tend to be warmer. Although the way people use the heaters is important, a small heater is unlikely to be able to lift a cold house to a comfortable temperature
- only about 5% of houses are centrally heated.

4.1.4 Being able to control a heater is as important as having the heater available. The warmest indoor temperatures were usually found in winter – temperatures over 35°C were often measured in rooms with solid fuel burners. The highest temperature was 41°C during a summer night in a house that used a solid fuel burner for water heating.

4.1.5 In a related area, only 4 % of HEEP homes had air-conditioning, too few for conclusions to be drawn. With the increasing installations of electric heat pumps for winter space heating, it is likely that this will change.

4.2 HEEP LESSONS

4.2.1 As a general principle, for the health of occupants, all habitable spaces should be maintained at a 16ºC minimum (preferably 18ºC) level, whether by passive or active heating.

4.2.2 HEEP results show that insulation in new houses, and adding insulation to old houses improves comfort. It is also clear that if the house is draughty, then weatherstripping windows and doors will be beneficial.

4.2.3 When planning the heating for a new or existing house, higher levels of thermal insulation will allow smaller, less expensive heaters to be used. The capital cost savings may pay for the insulation, and there will also be lower running costs. The BRANZ tool ALF3 provides one means of exploring this.

4.2.4 When working to reduce heat loss, make sure the design still allows ventilation to remove moisture and contaminants, particularly in bathrooms and kitchens. Houses built with strip construction (e.g. tongue-in-groove flooring) tend to have adequate levels of background ventilation, but take care not to reduce background ventilation too far in already air-tight houses.

4.2.5 Thermal mass, in conjunction with good insulation and glazing, can help keep houses comfortable with less energy use by reducing temperature fluctuations. Don't carpet concrete floor areas that receive lots of sunlight: let the floor absorb solar energy. For new design, consider adding additional thermal mass such as an exposed masonry wall.

4.2.6 More than one heating fuel and system is a good idea. Having an alternative heating system available that is not dependent on the electric grid, even if only for part of the house, is good insurance against electric power outages, particularly in colder areas.

4.2.7 Open fires are inefficient and highly polluting, and should be replaced with another heating source.

4.2.8 If possible, space heating should be controlled by a thermostat and, if appropriate, a timer.

5.0 WATER HEATING

5.1 HEEP FINDINGS

5.1.1 For water heating HEEP identified that:

- 75% of water heating energy comes from electricity, and most of these systems are low pressure. 20% comes from natural gas, which accounts for most of the mains pressure systems. 5% of water heating energy comes from wetbacks (see Figure 4). One household surveyed still used a fire-heated copper
- newer houses tend to have mains pressure systems. A low-pressure system warm shower averages 7 litres per minute while a mains pressure shower averages 12.5 litres per minute

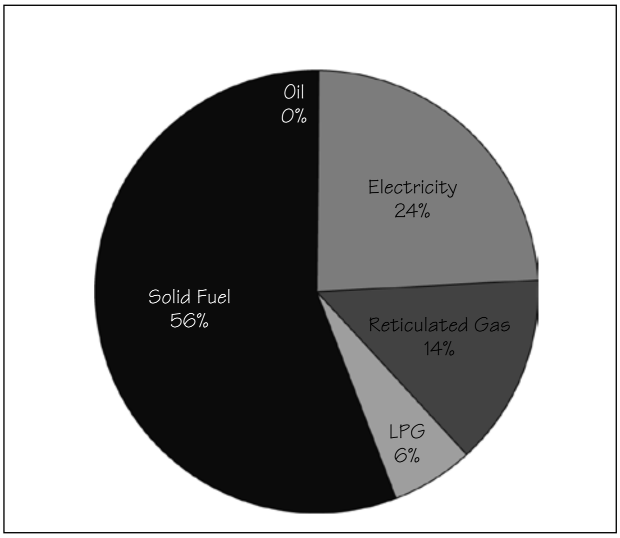

Figure 3. Space heating gross energy by fuel

Source: HEEP Year 10 Report

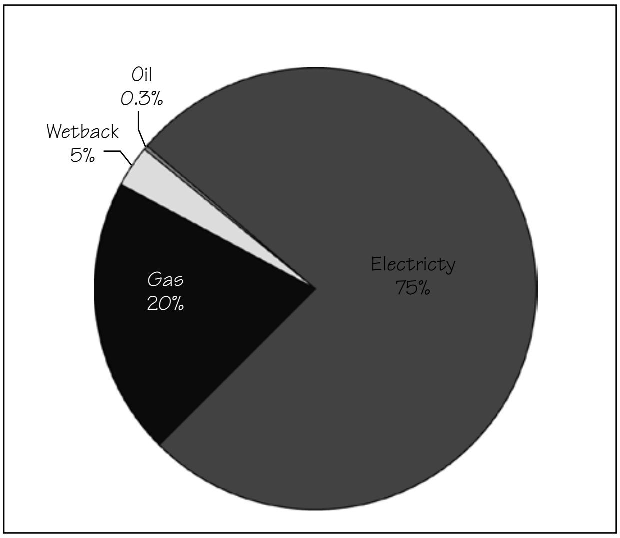

Figure 4. New Zealand domestic hot water fuels

Source: HEEP Year 10 Report

- 90% of households have one hot water cylinder, 9% have two and 1% have three
- 1% of hot water cylinders delivered water at over 90°C – a dangerous near-boiling temperature that will instantly give anyone a dangerous burn
- 80% of cylinders delivered water over 55°C. A child will get a full-depth burn in 10 seconds from water at this temperature.

5.2 HEEP LESSONS

5.2.1 To improve water heating performance, safety and efficiency:

- replace an old electric cylinder with a new A-grade cylinder – these have lower heat losses, equal to about a 90 W bulb. Older cylinders are closer to 120 W. Adding a cylinder wrap is also a simple option that can drop this to 70 W or less
- replace old bi-metallic thermostats with modern, more accurate capillary controls
- consider several smaller systems (electric, mains or LPG gas) in a large house. This makes it easier to produce hot water where it is required, minimising energy use and water waste from long runs of hot water piping
- add a tempering valve to an existing supply to moderate water temperature.

5.2.2 Ensure cylinder location and access makes it possible to easily replace the cylinder and thermostat because:

- over the life of the house the cylinder will have to be replaced at least once (1 in 5 modern cylinders were replaced in the first decade of the house existence, after three decades nearly 1 in 2 cylinders were replaced)
- an electric hot water thermostat is likely to require replacement before the cylinder

5.2.3 Low pressure, copper hot water cylinders last longer than glass-lined steel mains pressure cylinders under most conditions.

5.2.4 Install a hot water system that is sufficient for the house size and number of occupants. Turning up thermostats is often a result from households running out of hot water. For electric systems, one rule of thumb is to allow 45 litres of hot water per day per person, with the number of people being the number of bedrooms plus one. On this basis only half the HEEP houses had an adequate hot water system (see also BRANZ *House Condition Survey* 1999). The effective element size is larger in a gas system, requiring less storage than an electric system.

5.2.5 High water flow uses more water and more energy. Although the time taken for a shower is controlled by the user, the water flow is established by the system (low or mains pressure) and the shower head (low or high flow). The use of low flow shower heads, as well as limiting devices on often-used taps will limit water wastage and cost with mains pressure systems.

5.2.6 Specify appliances that heat their own water and only need a cold water supply. This reduces the need for pipes and can reduce energy losses.

6.0 OTHER ENERGY USE

6.1 HEEP FINDINGS

6.1.1 "Other energy" is that consumed by electric appliances – permanently wired or plug-in. The big three uses are cooking, refrigeration and lighting. Other appliances include televisions, radios, video or DVD recorders, stereos, clock radios, computers, dishwashers, washing machines, clothes dryers, heated towel rails etc.

- on average, each house had 1.4 televisions and 2.9 people – but the number of televisions is increasing and the number of people falling
- 7% of refrigeration appliances were faulty and 9% marginal. The compressor staying on-cycle for long periods was the most common fault
- the excess energy used by faulty refrigeration appliances is estimated at 3% of the household electricity use
- on average, each house had 20 incandescent lights, one compact fluorescent lamp and one halogen lamp. The largest number of lights found in one house was 143 and the least was 7, with newer houses having more lights. The numbers of compact fluorescent lamps is changing rapidly, as they replace incandescent bulbs
- excluding lights, the average number of appliances per household was 33. The house with the fewest had 7, the house with the most had 82
- baseload is an increasing part of household electricity use. Many appliances are now either on continuously (e.g. clock radio) or on standby (e.g. television) and this use adds up to about 112 W continuous in an average house – about 13% of the total electricity use.

6.2 HEEP LESSONS

6.2.1 Because each appliance left switched on tends to use little electricity by itself, they tend to be ignored. But this type of consumption can easily add up. A 100 W heated towel rail left on all day is equivalent to using a 2.4 kW clothes dryer for 1½ hours per day.

6.2.2 Designers should ensure that wall switches for appliances are readily accessible so appliances can be turned off when not required. Installing a timer on heated towel rails is a good idea. Under-floor heating systems should have a timer or combined timer-thermostat incorporated.

6.2.3 Energy efficient appliances may cost a little more initially but will save money over their life. Energy rating labels, now mandatory for many types of appliances, provide consistent information which can be used to compare the annual running cost for similar appliances.

6.2.4 When specifying lighting:

- halogens are not as efficient as fluorescents, and should be used only when their particular benefits are required. Although fluorescent direct replacements are becoming available, the halogen fixture is really limited to that type of bulb
- lights that are on for long periods (e.g. in a dark hallway) should be the most efficient – either

a compact fluorescent lamp (lamps with a warm tone are available) or fluorescent tube.

- make lights controllable, whether through the provision of switches (a whole bank of lights should not be on one switch) or dimmers
- specific task lighting should be used where appropriate – and need not be permanently wired or mounted
- security lights and lights that only need to be on for a short time should be on automatic control (both on and off).

7.0 OTHER IMPORTANT LESSONS

7.0.1 HEEP has identified the fuels and energy services we use. Our lifestyles are continually evolving. Not all the lessons are relevant for everyone, but the overall lessons will help create houses that better meet the needs of their occupants – providing a healthy, comfortable lifestyle at least cost.

7.0.2 HEEP data shows that solid fuel is still a major source of energy, particularly for space heating. (Solid fuel use for heating in 2005 was the equivalent of a 770 MW power station – 80% of Huntly power station.) A significant shift away from solid fuels to, for example, a greater use of electric heat pumps, would increase the load on the electricity system, and ultimately require new power stations.

7.0.3 Over the past 100 years, houses have got warmer both in winter and summer although there seems to be no single reason for this. Winter evening living room temperatures for houses built in 2000 are 2°C warmer than those built in 1900, while the summer day living room temperatures are 2.5°C warmer. Over this time, window areas have increased, the use of eaves and window shading has reduced, design has changed, construction has changed, building materials have changed, thermal insulation has become mandatory in new homes and renovations since the 1970s and airtightness has increased through the use of solid linings and floors.

7.0.4 Changes in households and lifestyles also have an impact on energy use. In 1971, 59% of households with electric hot water cylinders mainly used the bath to bathe. Today the figure has dropped to 4% as showers have become more popular. Since 1974, electricity consumption per household has grown more slowly (6%) than the per person electricity use (26%). It is assumed that this is due in part to the smaller number of people per household, larger house sizes and more electrical appliances.

7.0.5 These lessons fit with the other rules and guidance used by the building industry, and in the longer term will help support changes to the New Zealand Building Code, design practices and in building materials. HEEP has not examined every aspect of household energy use and it is not the end of exploration.

8.0 MORE INFORMATION

Full details on the HEEP research methodology are given in the HEEP annual reports – available on the website www.branz.co.nz

BRANZ *House Condition Survey* – www.branz.co.nz

ALF 3 A Design Tool for Energy Efficient Houses – www.branz.co.nz

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