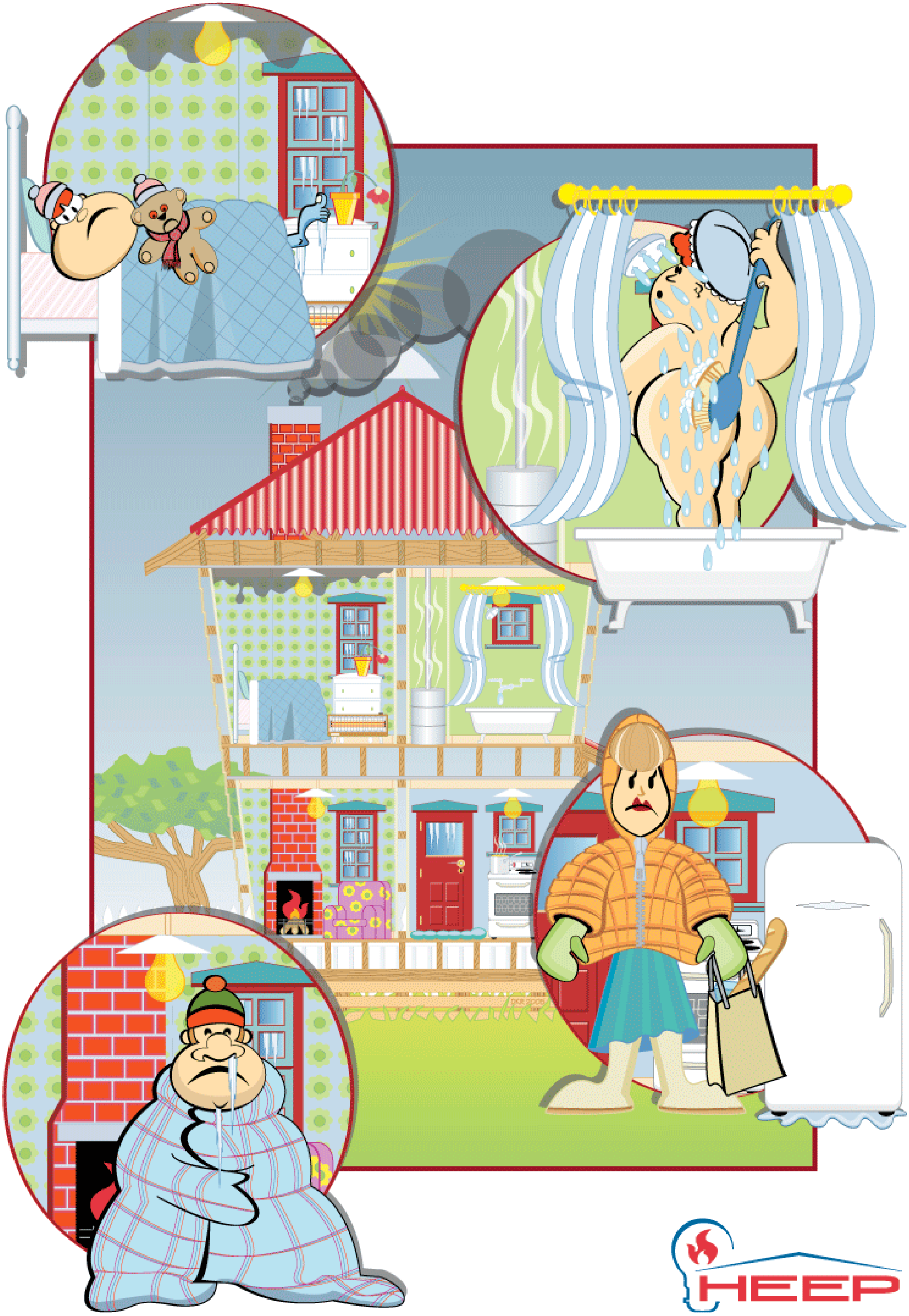
ALPHA 134

The energy we use in New Zealand homes



HEEP

Science is often thought of as something that is carried out in laboratories, in remote jungles, under the sea or high up in space. We often overlook the science under our noses – for example, we know more about the living conditions of astronauts than we do about the houses in which we live. This ALPHA uses science to explore the ways we use energy in our houses and ask questions about the energy issues that face New Zealand in the future.

It provides some sample data from the Household Energy End-use Project (HEEP) to allow you to explore how the energy use in your house compares to other houses.

Buildings

Buildings modify the natural environment to better meet our needs. These needs can be summarised under four headings:

Hygrothermal – temperature (warm, cool), humidity

Visual - light, glare, work, romance, darkness

Acoustic - speech, noise, warnings, music

Indoor Air Quality (IAQ) – ventilation to provide clean, fresh air,

Although many of these needs can be met by the building structure (such as walls in the right place, roof to keep the rain out) and components (glazing to let in daylight, doors to let in fresh air), others require we make use of energy to quickly adapt to deal with the excesses of nature, or met our needs and wants.

For example, if you want to read at night time, artificial light replaces the sun of the daytime – and although society has used candles, oil, gas and even trees to make light, nowadays we mainly use electricity.

Houses are a special type of building –in use both day and night, the demands of the occupants drive the energy use. Unlike the many different industrial or commercial processes, most people have similar needs but with wide variations. Although we need to be 'comfortable', exactly what this means can differ from person to person, and so does the amount of energy that is required to maintain comfortable temperatures.

Fuels and Energy

Much of New Zealand's recent energy debate has been over electricity supply. Electricity is a very important fuel, but it is not the only fuel. 'Energy' and 'fuel' are different – fuel transports energy, but needs to be transformed to be useful. For example, the burning of coal (fuel) releases heat (energy). Uniquely, electricity is both fuel and energy – it can be transformed into heat or used directly (e.g. for a computer).

'Energy' can be thought of in terms of what it does – the 'end-uses'. To boil water, heat to reach 100°C is needed; to cook a cake needs heat over 100°C; while electronics need electricity. Heat can be provided by a wide range of fuels – natural gas, electricity, LPG, wood, coal, oil, geothermal or even the sun. Electricity can be generated from an even wider range of sources e.g. from fuels used in a thermal power station, falling water etc.

We can measure (monitor) fuel use with specialist equipment. Electricity meters are found in almost all New Zealand houses while only houses with piped gas have gas meters. Until the HEEP research no one had tried to measure the use of solid fuel (wood or coal), oil and portable LPG.

We can also monitor the services or end-uses that the energy supplies. The type of monitoring differs depending on the end-use, but includes: temperature (air and water); hours of operation (e.g. lights, television); number of times used (e.g. dishwasher, washing machine); or quantity used (e.g. hot water).

Many of these measurements can be made with simple tools or existing household meters. You may wish to explore some of these household energy uses and end-uses yourselves. The HEEP results provide you with a basis for comparison and may help you undertake you own scientific investigations in that under utilised research laboratory – your home.

What do we use energy for?

The HEEP study found that on average, electricity was 69% of total fuel use, 20% was as solid fuel (wood or coal), 9% gas, 2% LPG, and less than one percent was other fuels such as heating oil (Figure 1).

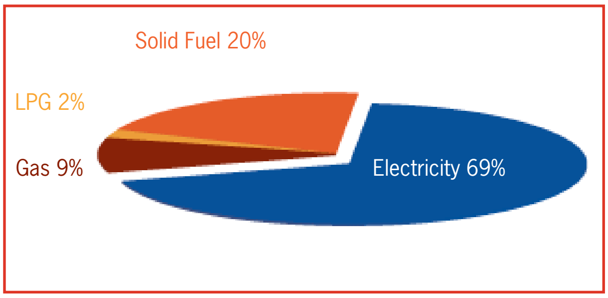


Figure 1: Total energy use by fuel type

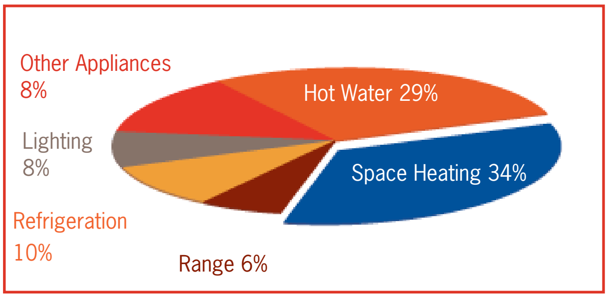


Figure 2: Total energy use by end-use

Figure 2 splits this energy use by end-uses. Not surprisingly, space heating uses the largest proportion of our total energy use, some 34% on average. This is followed by hot water at 29% and refrigeration, lighting, other appliance and our cooking (stoves, ovens, hobs) at around 10% each. The relative proportions do vary significantly by location, with less space heating used in warm areas, and much more (up to 70% of total energy use) in colder climates, although proportions also differ between houses and households. The amount of actual energy used also differs over the seasons, with increased space heating, stove use, lighting and hot water heating over the winter months.

What is clear is that changing the temperature – heating air (space heating), water (hot water) or food (range) or cooling food (refrigeration) are the big uses of energy in our homes.

Does your house use a lot of energy?

Without specialist equipment, it is very difficult to measure how much energy we use, but in most houses the tools are there – you just need to know how to use them. Electricity and gas are monitored by the meters used for billing. Although modern electronic meters are easy to read, older mechanical meters can be difficult. Electricity and gas suppliers give instruction on their web sites.

The easiest way to find out how much energy your house uses is to collect a year of bills, and add up the energy (Electricity is reported in kiloWatt hours (kWh) while gas is in kWh or MegaJoules (MJ) (1 kWh = 3.6 MJ).[1] You can also record the meter reading on two separate days – the energy use will be the difference. Electricity meters give kWh but gas meters report the volume of use (normally m^3) which needs to be converted to energy using the formula given in the monthly gas bill.

You can calculate how much LPG is used based on the number and weight of 'bottles' you use. 1 kg is approximately equivalent to 49.8 MJ of energy (Gross Calorific Value[2]).

At the end of this ALPHA there is a table which gives energy use per half hour for an 'average' New Zealand house for summer and winter. You can compare your house's energy use – is it higher or lower than the mean? The energy use is given as average Watts (W) for each of the 48 half hours in a day. To convert into energy (Wh) multiply by the number of hours (1,000 W = 1 kW).

1 Kilo = 1,000, Mega = 1,000,000

2 Gross Calorific Value: The heat produced by combusting a specific quantity and volume of fuel in an oxygen-bomb calorimeter under specific conditions

For example, if the living room has five 100 W light bulbs and they are turned on from 6 pm to 11 pm, together they would use 2.5 kWh (5 x 100W = 5 x 0.1 kW x 5 hr = 2.5 kWh). If this was the only lighting energy used in the house that day, then it would be an average of 2.5 kWh/24 hr = 0.104 kW = 104 W. The average summer lighting energy is 71 W while in winter it is 126 W. The difference is not due to an increase in the number of lights, but an increase in the length of time they are switched on.

If you plot the data, you can see a strong pattern over the day, but this is more noticeable in the winter due to heating energy use than the summer. When people get up they turn on the lights and heating. There is another increase in energy use in the early evening, and then it falls away as the night become early morning. You could explore this in your own house by taking meter readings (gas or electricity) over the day.

Things have changed

The last time anyone tried to understand even part of household energy use was over 35 years ago – and even then the 1971/72 study only dealt with electricity use, ignoring other fuels (including town gas, wood and coal). Our energy usage (both the fuels and end-uses) has changed significantly since that time. For example, when insulation became mandatory in 1978, less energy was needed for space heating in new houses.

Other changes can be traced indirectly. For example we know from Statistics New Zealand's Household Economic Survey (HES) that the percentage of households having portable electric heaters has dropped from 89% of houses in 1984 to 71% of houses in 2001. Non-electric heating technology has also changed – although 11% of households in 1984 had portable kerosene heaters, in the 2004 HES this was less than 1%. The more recent technology of portable LPG heaters increased from being found in only 2% of houses in 1984 to 34% of houses in 2004. Many open fires and older wood or coal burners have now been replaced with efficient solid fuel burners, which combust fuel more efficiently and direct more heat into the room space rather than losing it up the chimney or flue as smoke or particulates.

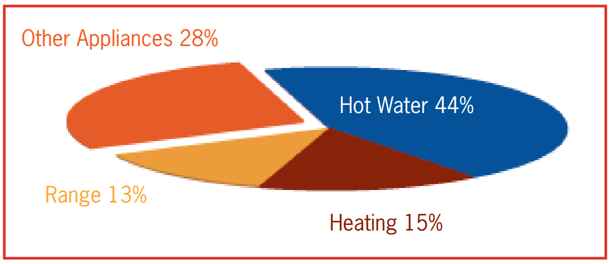


Figure 3: Electricity uses 1971/72
8,400 kWh pa

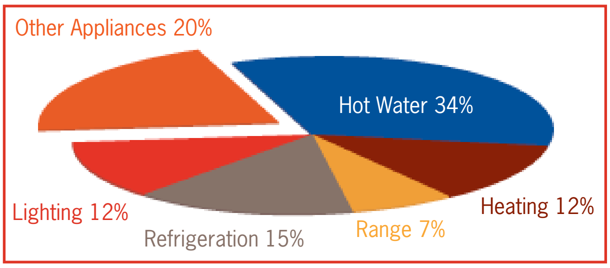
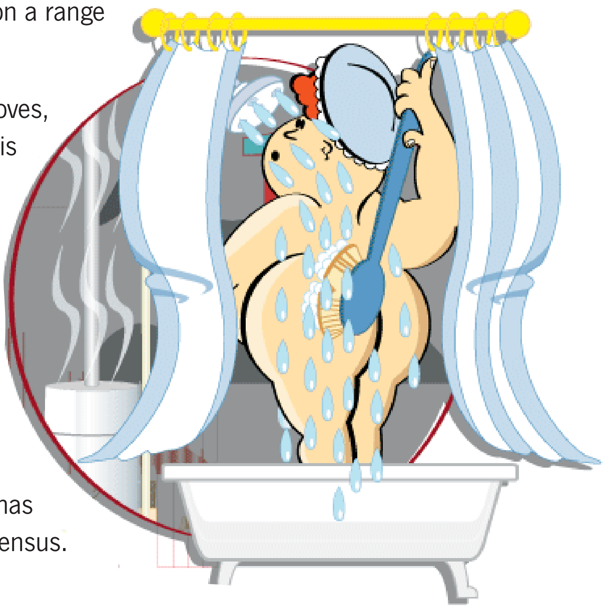


Figure 4: Electricity uses HEEP
7,240 kWh pa

Figure 3 shows the electricity uses found in 1971/2, while Figure 4 shows the situation today from the HEEP research. The 1971/72 study was limited by their monitoring equipment – they collected only broad category monitoring data weekly, while HEEP computer based dataloggers collected 10 minute data on a range of individual appliances.



One interesting change is the electricity use by the 'range' (this includes stoves, ovens and hobs) which has reduced from 13% to 7% of electricity use. This drop may be due to the appliance being more efficient, but it is also likely to link to changes in house design and use. The kitchen stove in 1970s was often the main source of electric power sockets for the kitchen. These sockets typically operated the toaster and kettle, or less frequently a cake mixer or even an electric heater. More than 35 years later the kitchen is stocked with power sockets independent of the range. In addition, our baking habits have changed with an increase in factory prepared meals and snacks such as biscuits, reducing the usage of the range for roasting, baking etc.

Another major change is the average number of occupants per house; this has dropped from 3.55 per house in the 1971 Census to 2.72 in the 2006 Census.

So while electricity consumption has remained stable per household, the amount used per person has risen from 2,365 kWh/year in 1971 to 2,690 kWh/year in 2005. In addition, town gas is no longer made, but some 14% of houses are now on reticulated natural gas and many others use bottled LPG, which wasn't available in the early 1970s.

Space heating

One unexpected finding was that houses heated by some fuels are not as warm as others. Table 1 shows that houses heated by open fires, portable electric and LPG heaters are the least warm, while houses with central heating or enclosed solid-fuel burners are the warmest.

Heater type	Temperature	Std. error of mean	Sample count
	°C	°C	
Open solid fuel	16.0	0.6	11
Electric	16.9	0.3	83
LPG	17.0	0.2	54
Fixed electric	17.8	0.3	18
Heat pump	18.0	0.4	4
Gas	18.1	0.5	28
Gas central	18.3	0.6	8
Solid or liquid fuel central	18.5	0.7	2
Enclosed solid fuel	18.8	0.2	142

Table 1: Winter living room evening temperatures by heater type

In some cases the difference may be due to the heater size – for example, plug-in electric heaters can at most produce 2.4 kW of heat output. In other cases it must related to the way in which the occupants use the heaters – for example, LPG heaters can produce up to 5 kW, but most LPG heaters are used sparingly and at lower power outputs, possibly due to the high fuel costs. Most solid fuel burners can produce over 10 kW – more than enough to heat most New Zealand homes to comfortable temperatures, but they mostly are used at 2 to 5 kW settings.

One of the most significant and surprising findings from the HEEP study was the amount of solid fuel (wood and coal) which is used to heat our home environments - a staggering 56% of space heating and 5% of water heating energy is provided by solid fuel. This is far more than previously thought and differs significantly from the official national energy statistics previously published by the Ministry of Economic Development. The HEEP finding has led to a change of these official statistics since 2006. Indeed, if domestic solid fuel heaters were removed from the energy equation tomorrow, New Zealand would need another power station at least half the size of Huntly and there would be a resulting major strain on existing electricity distribution networks (Figure 5).

Figure 5: A power station was hiding in the wood shed

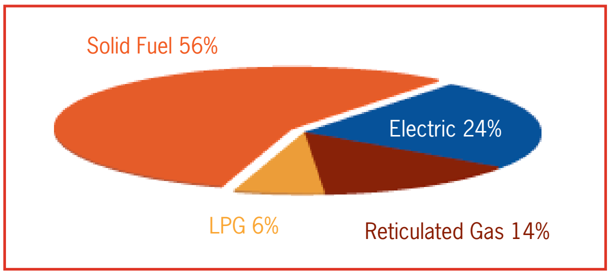


Figure 6: NZ Space heating gross energy by fuel

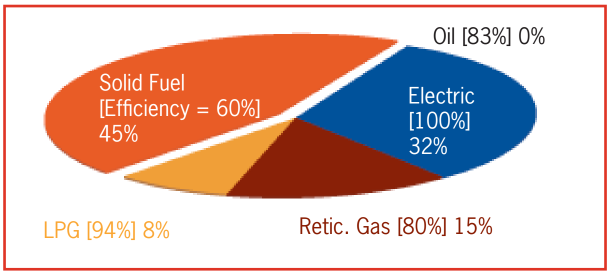


Figure 7: Space heating delivered energy by fuel. Nominal appliance efficiency in [ ].

Figure 6 provides a breakdown by fuel type of New Zealand household space heating energy use. This is based on the energy that is actually delivered to the house, and so doesn't take into account the efficiency of the appliance. Figure 7 takes the same data, and applies some assumed appliance efficiencies. Solid fuel remains the most important space heating fuel in New Zealand homes, followed by electricity, reticulated gas and then portable LPG heaters.

Unflued gas heaters, such as portable LPG heaters, put the products of combustion directly into the house air – leading to higher levels of condensation due to the water and a need for adequate ventilation to support full combustion and remove the carbon dioxide.

$$CH_4 + 2O_2 = 2H_2O + CO_2 + \text{heat}$$

If there is inadequate oxygen for full combustion, the very toxic Carbon Monoxide (CO) is produced. The water vapour in the flue gases can be 'condensed', extracting latent heat. This is the basis of modern 'condensing' boilers.

Understanding the Census

Table 2 is taken from the 2006, 2001 and 1996 Censuses, and at first glance provides a contrast to Figure 7 – but the two report very different data. Figure 7 is reporting the use of heating fuels while Table 2 is concerned with how many homes make use of the different heating fuels. Bringing the two sets of information together suggest that while many homes (74.8% in 2006 Census) have electric heaters, Figure 7 suggests they are not necessarily the main means of heating. A smaller proportion of homes (40.9% had wood and 7% coal in 2006 Census) used solid fuel, but Figure 7 suggests these are the principal means of heating. There has been fall in the proportion of houses using electric heating (77% to 75%) and in wood (49% to 41%) and coal (13% to 7%) over the three censuses while there has been an increase in those using LPG bottled gas (22% to 28%).

Summer and Winter Temperatures

From 1 April 1978 all new houses were required to be insulated – thermal insulation was added to the roof, wall and under the floor. Fourier's Law shows that increasing thermal insulation (R-value) will result in warmer temperatures for the same energy, or the same temperatures for less energy.

Fuel types (%)	1996	2001	2006
Electricity	77.2	72.0	74.8
Mains gas	11.6	13.5	13.2
Bottled gas	22.3	28.3	27.7
Wood	48.7	44.7	40.9
Coal	13.0	9.3	7.0
Solar power	0.7	0.9	1.1
No fuels used in this dwelling	0.9	2.8	2.4
Other fuel(s)	1.9	1.1	2.1

Table 2: Percentage of Fuel Types Used to Heat Private Occupied Dwellings (total responses)

HEEP found that post-1978 houses are warmer than pre-1978 houses. The post-1978 living rooms were on average 1°C warmer during the winter evenings than the pre-1978 living rooms. However, the most interesting difference was that the post-1978 bedrooms were on average 1.3°C warmer overnight than the pre-1978 bedrooms. We use some interesting heaters in our bedrooms – cats, dogs, television set, clock radios and of course people. Most New Zealand bedrooms are unheated, so this increased temperature uses little, if any, additional purchased energy.

A detailed analysis of heating energy use suggests that mandatory insulation has lead to warmer homes as well as reduced space heating energy use. Note that HEEP is a 'snap shot' study (measures what is there) rather than a longitudinal study (measures change over time), so provides no new knowledge on what happens when insulation is added to houses.

Although it was expected that newer homes would be warmer in winter, it was surprising to find that they are also warmer in summer. The reasons for this are not clear, but could relate to changes in design, the use of eaves or overhangs to keep out the summer sun, greater use of glass, increased airtightness due to new building materials and construction techniques, different occupant behaviour or thermal insulation.

Fourier's Law

Fourier's Law relates the flow of heat to the temperature difference between the inside (warmer) and outside (cooler). If the average outside temperature is 15°C, and the inside is heated to 18°C, the heating energy needed to maintain this 3°C difference relates to the level of thermal resistance between the inside and outside. If the outside temperature drops, or the inside temperature rises, by 1°C the result is a 33% increase in the heating energy use, assuming the thermal resistance is unchanged.

Fourier's Law is expressed as:

$Q = \Delta T/R$

Heat flow = Temp difference/Thermal resistance

Using the above example

18°C (inside) - 15°C (outside) = 3°C = ΔT

If we keep the thermal resistance unchanged but increase the inside temperature to 19°C, the ΔT becomes 4°C, a 33% increase in energy use to achieve a 1°C rise in temperature (3°C increases to 4°C).

If all households decided to be just a little warmer in winter without increasing the thermal resistance, the implications for national energy use, the cost of energy to the consumer, and New Zealand's greenhouse gas emissions would be considerable if fossil fuels (e.g. natural gas fuel power station) are used to fuel the increase.

Hot water

Heating our hot water uses on average 29% of household energy – hot water cylinders are often the largest energy users for any single appliance. The energy used to power our hot water is mainly electricity (75%), followed by gas (20%), wetbacks (5%) and oil at less than 1% (Isaacs et al, 2007).

The way we use hot water has changed – most noticeably the change in just one generation from baths to showers. In 1971/72 only 41% of people used to use the shower as their main form of washing, now, in our fast moving society, 94% use the shower rather than the bath.

Compared to other countries where data is available, New Zealand stands out as having the highest use of electric hot water storage systems at 88%. The next closest countries are Canada and Australia, both having around 51% of their domestic hot water systems electric. By comparison, England has 76% of its domestic hot water systems fuelled by natural gas, and only 21% by electricity.

There are still improvements that households can make in ensuring their hot water temperatures are set at appropriate levels. In the HEEP study, five out of the 440 electric hot water cylinders (1.1%) delivered hot water at temperatures over 90°C – hot enough to make a cup of tea or coffee straight from the tap, or worse seriously burn your skin. The majority of electric water heaters provided hot water to the tap at unsafe temperatures (over 50 °C).

Standby and baseload power

HEEP also was the world's first national study of baseload and standby electricity uses. Standby is the electricity used by an appliance when it is waiting to be used, while baseload is the electricity used by appliances that are on all the time. Baseload appliances are typically appliances such as heated towel rails, and electric clocks, and items on standby typically include anything with a light on such as TVs, VCR, DVDs, stereos, clothes dryers, dishwashers, microwaves, portable phones, instantaneous gas water heater and computers. HEEP found that on average, New Zealand households use about the same electric energy for baseload and standby as for electric space heating.

Big x Small = Small x Big

A small load turned on and used for a long time (for example, a heated towel rail at 100 W operating all day, all year) uses as much energy as a large load turned on for a comparatively short time (for example, an 2.3 kW electric clothes dryer used 60 minutes daily). A heated towel rail used continuously consumes about 700 kWh per annum, this can represent up to 10% of a household's electricity bill.

Clothes Dryer: 2.3 kW x 1 hr/day x 365 days = 840 kWh

Heated Towel Rail: 0.1 kW x 24 hr /day x 365 days = 876 kWh

On standby power alone, on average New Zealand households use 57 W continuously. For a full year (8760 hours) with electricity costing 18 cents per kWh, this translates into approximately $90 per year on a household electricity bill. It is even possible for an appliance to use more electricity in standby that it uses for its real purpose!

Faulty refrigerators

Another surprising result of the HEEP study was the high number of faulty refrigeration appliances in New Zealand homes.

About 16% (1 in 6) refrigeration appliances were faulty. The owners are probably unaware there is a problem, as the fridge still makes a noise and food might be kept cold (sometimes too cold - frozen lettuces are one hint!). But the cabinet insulation can degrade or get wet, the compressor coolant can leak, door seals can fail, or the thermostat or controller can fail, all causing the appliance compressor to run continuously or in a faulty manner with poor temperature control.

HEEP analysis has found that these faulty refrigerators added on average 15±10 W of continuous load per house. Repair or replacement with modern efficient appliances would remove this unnecessary drain on our electricity network.

Interestingly, although some older refrigerators were faulty, there was a spike of faulty 1990 refrigerators. A potentially alarming finding given that modern refrigerator appliances are expected to have a working life of more than 10 years. No refrigerators from the 2000 decade (that is less than 5 years old) were found to be faulty.

Where has all this new knowledge come from?

This ALPHA presented some of the findings of the recently completed HEEP study (Isaacs et al, 2006) which started in 1995. HEEP (Household Energy End-use Project) surveyed some 400 randomly selected households from Invercargill to Kaikohe. Over a ten year period the project explored the variety of different energy sources people used to fuel their homes, including electricity, natural gas, LPG, solid fuel, oil and solar energy for water heating, and the services these energy types provide which included space temperature, hot water, cooking, lights, and appliances etc.

Over the lifetime of the study HEEP monitored 440 hot water cylinders, 65 wetbacks, 206 solid fuel burners, 7 solid fuel ranges, 42 open fires, 175 portable LPG heaters, as well as all the normal household appliances - stoves, fridges, fridge/freezers, televisions, stereos and so on. Every electric appliance in the house was documented, and if 'plugged in' its power use recorded. These datasets now holds details on energy use and location of over 10,000 appliances. Data was recorded every ten minutes for the total of all fuels and hot water systems used in the study houses. In all houses, temperatures in the bedroom and living room were also recorded every ten minutes – about 1,200 temperature files.

As part of the installation the team undertook a detailed household energy audit, physical inspection and occupant survey.

Collecting and verifying all this raw data collected was a massive undertaking, involving field workers installing monitoring equipment and collecting the data each month, and then at our base checking that every month's worth of data was correct.

Where is the knowledge going?

Powerful statistical tools have been used to explore these datasets, and to extract algorithms which have been used to create the Household Energy End-use Resource Assessment (HEERA) model.

A model is a mathematical or systematic description of something that happens in real life. Usually there are many different variables (or things which affect the system) in any real life system or phenomenon, a model allows us to approximate what might happen in real life if we alter any of these variables.

As well as all the usual energy variables, the HEERA model includes variables such as aspects of the house (climate, region, floor area) and the occupants (whether they rent or own the home, their income, the number of occupants, and how old they are). The HEERA model aims to help find ways to improve our overall energy efficiency, reduce greenhouse gas emissions and identifying new energy efficiency opportunities in the residential sector. An early version has already been use to explore at the national and regional levels, the impact of electricity efficiency on the electricity system.

The HEERA model supports a wide range of 'what-if' type questions. Some of the interesting questions included looking at the impact of mandatory insulation in 1978, and what would happen if older houses were required to be insulated. The model has shown that while insulation may have led to improvements in energy efficiency this did not necessarily translate into energy savings or reductions, as newer houses often have larger floor areas. In addition, insulation may have reduced space heating energy, but most of these energy reductions have come from non-electric fuels.

As well as developing the HEERA model, the datasets are being used to understand social impacts on solid fuel use; temperature and energy use in households; analysis of summer and winter indoor temperatures; and standby and baseload electricity use.

Early results of the HEEP research have been used to identify previously unforeseen market opportunities – such as how to improve the energy wasted on standby power, hot water energy losses, and house heat loss. The research is also providing a baseline for a wide range of other research, including health impacts studies.

Who did all the work?

The HEEP project was a multi-disciplinary research project, bringing together the skills of social science, statistics, physics, building science, mathematics, computer modelling and of course a wide range of computer and other analysis tools that have been invented and developed by other people. Long term members of the research team were:

- BRANZ (Data collection & analysis): Nigel Isaacs (programme leader), Michael Camilleri, Lisa French, Lynda Amitrano, Andrew Pollard & Albrecht Stoecklein
- CRESA (Social science): Ruth Fraser, Kay Saville-Smith
- CRL Energy Ltd (Modelling): Pieter Rossouw
- John Jowett (Statistical support)

HEEP funding support has come from the Foundation for Research, Science and Technology (FRST) and Building Research, with additional support from EECA, Transpower, WEL Energy Trust, Ministry of Social Development and Fisher & Paykel Ltd.

HEEP officially finished at the end of September 2007. There has been significant national and international interest in the research results. Results from the study are already in use by New Zealand's Government, industry and academia and the data is fuelling our knowledge about how, why, where and when we use energy in our homes. It will help the Government make decisions about how much electricity we will need to generate in the future, and help them to make policies and identify ways in which we can all improve our energy efficiency. Energy efficiencies might be found in the ways we build our houses through to the way we make and run our appliances.

For more information

The Executive Summary, full annual reports and published papers are available for free download from the BRANZ website, or at a charge for the hard copy from the BRANZ Bookshop (search for HEEP) on the web site: www.branz.co.nz

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Acknowledgements:

Author: Louise Thomas

Reviewed by: Nigel Isaacs, Michael Camilleri, Lisa French BRANZ

Editor: RSNZ

ISSN: 0111-1957 2007

Winter and Summer energy use table definitions:

This table can be 'cut and pasted' into a spreadsheet for analysis. The definitions used are:

Units	*Average power (in W) over the half hour after the Time (e.g. 8:00 am to 8:29 am)*
Electricity	*Electricity per house (includes houses with electric heating and electric hot water)*
Hot Water	*Hot water energy use per house (includes natural gas and electric hot water)*
Lighting	*Electric lighting per house (fixed wire)*
Range	*Energy used for cooking (range, hobs) per house (includes houses with electric, gas and LPG)*
Solid Fuel	*Solid fuel heater energy per appliance*
Refrigeration	*Refrigerators and freezers energy use per appliance*
TV	*TV energy use per appliance*

The values are ‘purchased’ or provided energy, not the service produced. They do not take into account the appliance efficiency.

Note that other household appliances also use energy (mainly electric) but are not presented here as space is limited.

To work out the approximate energy use for an appliance, take the ‘name plate rating’ (often given on a small plate on the appliance) and multiply it by the number of hours it is turned on each day.

	Summer energy use (average W)							Winter energy use (average W)						
	per House				per appliance			per House				per appliance		
Time	Elec-tric	Hot Water	Light-ing	Range	Solid Fuel	Refrig-eration	TV	Electric	Hot Water	Light-ing	Range	Solid Fuel	Refrig-eration	TV
0:00	626	281	60	7	28	77	9	951	360	73	7	1,164	60	9
0:29	555	229	46	5	23	74	8	858	301	58	5	1,028	57	8
1:00	506	194	37	4	20	74	7	791	254	47	4	898	57	7
1:30	459	160	32	4	17	74	6	748	221	40	3	788	57	7
1:59	434	142	29	4	16	73	6	710	196	36	3	694	56	7
2:30	416	130	27	3	14	72	6	675	176	35	3	611	56	7
3:00	410	129	26	4	12	70	6	653	165	34	4	542	54	6
3:29	405	126	26	3	11	71	6	645	153	34	3	482	55	6
4:00	404	122	26	3	9	72	6	641	150	34	3	432	54	6
4:30	407	123	26	3	8	70	6	642	142	34	5	396	55	6
4:59	427	137	28	6	7	69	6	662	144	35	6	364	53	6
5:30	471	172	37	9	6	68	6	713	187	44	9	347	53	7
6:00	557	236	55	15	5	69	6	839	286	70	15	338	57	8
6:29	672	313	73	26	7	71	8	1,062	425	110	40	353	53	8
7:00	818	420	84	38	7	73	10	1,294	566	157	56	408	54	12
7:30	906	492	70	39	8	69	12	1,399	625	145	37	484	54	15
7:59	899	493	53	43	9	69	12	1,324	641	108	47	550	55	17
8:30	892	487	43	52	10	72	12	1,279	659	82	62	586	58	16
9:00	867	463	41	53	11	73	12	1,240	642	69	62	603	55	14
9:29	838	440	40	55	12	74	12	1,196	630	61	63	619	56	13
10:00	804	405	37	51	13	75	13	1,150	596	58	63	635	58	11
10:30	760	368	37	50	14	76	14	1,096	553	54	67	633	57	12
10:59	739	336	36	67	13	77	15	1,060	494	52	89	632	57	13
11:30	728	301	35	80	16	78	15	1,045	454	48	95	634	61	13
12:00	726	283	35	81	18	79	17	1,029	422	47	112	649	60	15
12:29	717	278	35	72	18	81	17	991	402	45	89	663	62	16
13:00	714	289	35	55	18	81	17	977	393	45	74	673	60	15
13:30	684	258	35	52	18	82	17	938	366	46	64	687	62	15
13:59	664	240	33	50	18	83	19	916	347	46	62	692	61	14
14:30	656	227	32	55	18	82	19	904	320	47	64	718	63	14
15:00	651	208	33	64	18	84	17	916	308	50	84	772	64	16
15:29	669	214	33	73	19	84	18	961	312	56	108	852	62	19
16:00	710	218	36	102	22	84	20	1,055	331	71	159	987	63	20
16:30	781	236	40	187	23	85	22	1,240	385	108	243	1,204	64	21
16:59	882	272	46	211	26	85	26	1,518	405	199	272	1,536	61	23
17:30	965	307	57	234	32	85	30	1,740	414	309	317	1,896	64	28
18:00	1,019	324	78	228	40	84	40	1,859	430	377	306	2,170	65	38
18:29	1,044	364	107	186	46	87	42	1,859	468	399	224	2,317	64	39
19:00	1,028	378	132	144	53	85	38	1,814	469	392	151	2,352	61	39
19:30	1,001	368	157	100	57	84	39	1,774	475	373	105	2,354	63	39
19:59	995	353	196	68	57	80	39	1,726	486	358	76	2,301	63	40
20:30	1,020	344	237	60	58	82	37	1,661	476	337	47	2,230	62	39
21:00	1,006	324	250	41	58	82	36	1,568	455	309	35	2,122	64	36
21:29	973	324	238	34	58	80	32	1,458	445	275	25	2,009	62	31
22:00	891	313	207	28	53	80	27	1,310	424	233	18	1,836	60	26
22:30	798	294	165	21	46	80	20	1,166	395	189	16	1,658	59	19
22:59	762	331	122	16	40	78	15	1,130	422	141	12	1,477	68	13
23:30	660	280	85	10	34	77	11	1,009	366	101	9	1,305	57	10
Mean	729	286	71	58	24	77	17	1,129	390	127	71	1,035	59	17