CONFERENCE PAPER

No. 123 (2006)

Winter Temperatures in New Zealand Houses

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Presented at the 2006 Windsor Conference 'Comfort and Energy Use in Buildings – Getting Them Right', Cumberland Lodge, Windsor, United Kingdom
(27–30 April 2006)

The science reported here was funded by the Building Research Levy and the Foundation for Research, Science and Technology.

FUNDED BY THE BUILDING RESEARCH LEVY

ISSN: 0111-7505

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Keywords: winter, temperature, residential, New Zealand

Abstract

Living room winter temperatures are explored using data from 397 randomly selected houses from the Household Energy End-use Project (HEEP). HEEP has collected energy and temperature data on a statistically representative sample of New Zealand houses (Latitudes 35°S–46°S).

Initial analysis of the winter (June-August) living room temperatures shows that heating type, climate, and house age are important drivers of indoor temperatures. On average, houses heated by solid fuel are the warmest, with houses heated by portable LPG and electric heaters the coldest. On average, over the three winter months living rooms are below 20°C for 83% of the time – and the living room is typically the warmest room. Space heating is mainly unit heaters, with central heating in 5% of houses. Based on monitored energy use and temperature data, the heating seasons and heating schedules were able to be determined and compared to occupant reports.

Introduction

Understanding household energy use requires the collection of not only energy data, but also data on the services for which it is used. In the average New Zealand house, the largest single use of energy is for space conditioning. This paper reports an analysis of temperature data collected as part of a house energy research project.

The HEEP project holds data on 397 houses from the far north (Kaikohe) to the far south (Invercargill) giving a statistically representative sample of New Zealand (Stoecklein et al 2001) – see map in Figure 2. Full monitoring of random houses commenced in 1999 and was completed in 2005. All fuel uses (natural gas, solid fuel, LPG, diesel, solar, wetbacks, oil and electricity) were monitored along with living room and bedroom temperatures. Information was also collected on appliances and their use, house construction, hot water systems and occupants. The HEEP annual reports have provided preliminary results throughout the project (e.g. Isaacs et al 2005).[1]

Figure 1: Temperature loggers

HEEP monitoring records temperatures every 10 minutes at two different heights in the living room and one in the master bedroom. The self-contained temperature loggers (see Figure 1) are placed out of direct sunlight and away from heating sources. Each month data was downloaded from each logger, checked thoroughly to remove any inaccuracies, and then stored in a central database. Monitoring of each house was carried out for approximately one year, with 100 houses monitored in each of the last three years of monitoring. Each logger was calibrated annually (see Pollard 2001).

New Zealand’s climate

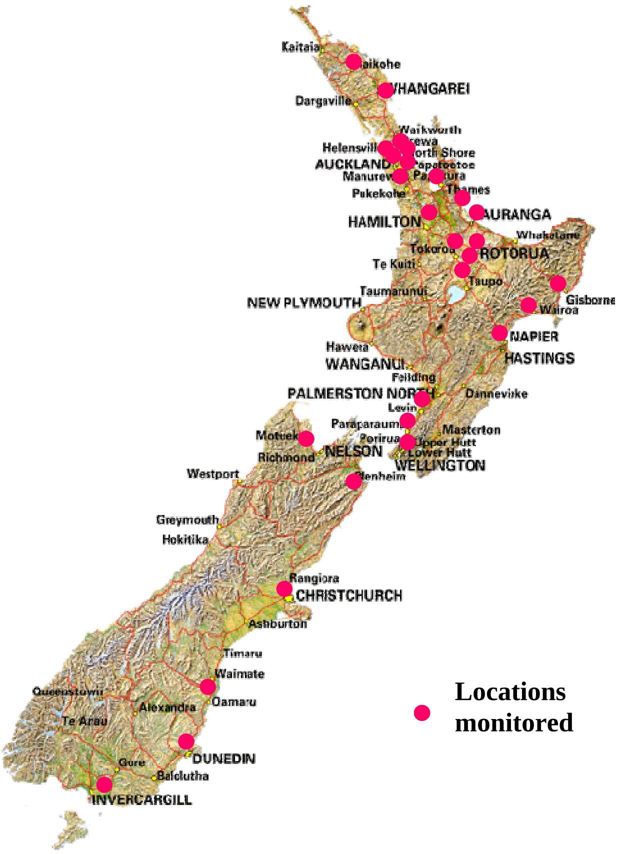

Figure 2: Map of monitored locations

New Zealand is long and narrow, some 1,600 km in length, with a land area of 270,000 sq km (Statistics NZ 2005). The far south is cooler than the far north. For example, the 24 hour average winter temperature in Invercargill (in the far south) is 6.2°C compared to 11.9°C in Kaikohe (in the far north). These and the other HEEP monitoring locations are shown by a ‘dot’ on Figure 2.

The annual range of monthly mean temperature (difference between the mean temperature of the warmest and coldest months) is relatively small. In the top of the North Island (Northland) and in western districts of both islands it is about 8°C, while for the remainder of the North Island and east coast districts of the South Island it is 9°C to 10°C.

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[1] For further information and report see the BRANZ Ltd website: www.branz.co.nz.

Further inland, the annual range can exceed 11°C, reaching a maximum of 14°C in Central Otago (MetService 2006).

The winter season in New Zealand (a Southern Hemisphere country) is during the months of June, July and August. The majority of homes are in a coastal type climate, but the central areas of both islands are more continental.

New Zealand Building Code

New Zealand has required thermal insulation in new houses since 1 April 1978. These modest requirements were increased slightly for houses in the central North Island and all the South Island (Zone 3) in 1996. The other two climate zones cover the remaining area of the North Island (Zones 1 and 2). Table 1 sets out thermal resistance requirements for common combinations of roof, wall and floor (Isaacs 1993 and 1999).

Table 1: Building Code thermal performance requirements 1978 to current

Year commence	Standard	Coverage	R-values (m^2 °C/W)		
			Ceiling	Wall	Floor
1978	NZS 4218P:1978	New Zealand	1.9	1.5	0.9
1996	NZS 4218:1996	Zones 1 and 2	1.9	1.5	1.3
		Zone 3	2.5	1.9	1.3

These thermal insulation requirements apply only to new houses. Older houses are not required to upgrade to the current standard, but in some cases roof and floor insulation has been installed.

Heating the New Zealand home

Only 5% of New Zealand houses have central heating (Statistics NZ 2004), with most houses only heating one or two rooms. Occupants tend to turn a heater on when they arrive, and off when they leave, or the room is warm enough. As a result, temperatures that would be considered comfortable elsewhere in the temperate world are often not achieved. Occupant comments such as “we do quite well with heating considering the house” or “we just watch TV in bed if it’s too cold” are not uncommon.

The most commonly heated room is the living room (see Table 2) in the evenings (see Table 2 and Table 3). Both tables give occupant reported heated schedules, which match closely to the schedules determined from analysis of monitored data.

Table 2: House rooms by heating schedule (time-of-day and day-of-week)						
Heating schedule	**Living room (%)**		**Bedrooms (%)**		**Utility rooms (%)**	
	Weekday	**Weekend**	**Weekday**	**Weekend**	**Weekday**	**Weekend**
Morning	1.6	1.8	3.3	2.6	3.1	2.6
All day	0.8	1.8	0.3	0.8	0.8	1.0
Evening	**46**	**37.7**	**21.9**	**19.6**	**11.8**	**9.3**
Night	1.6	1.6	6.4	6.2	1.3	1.3
Morning/Day	0.0	0.0	0.3	0.0	0.3	0.3
Morning/Evening	14.5	11.4	6.2	4.9	3.9	2.8
Morning/Night	1.0	1.0	0.3	0.3	0.0	0.0
Morning/Day/Evening	9.0	12.2	1.5	2.3	3.1	4.4
Morning/Evening/Night	0.3	0.3	0.0	0.0	0.8	0.5
Day/Evening	4.7	10.4	1.0	2.1	2.3	3.1
Day/Evening/Night	0.5	0.8	0.0	0.3	0.3	0.5
Day/Night	0.0	0.0	0.0	0.3	0.0	0.0
Evening/Night	3.4	2.9	3.9	3.9	1.0	0.8
Constant	10.9	10.9	5.1	4.9	4.9	4.9
No heating	5.9	7.3	49.9	51.9	66.6	68.4

Table 3: Living room heating schedules by region (weekdays)					
Region (north to south)	**No heating (%)**	**Evening heating (%)**	**Morning and evening (%)**	**Constant (%)**	**Sample count**
Northland	17	53	10	7	40
Auckland	11	46	20	6	102
BOP	7	71	7	4	54
Waikato	0	32	19	25	36
Gisborne/Hawkes Bay	0	41	0	22	27
Taranaki/Manawatu-Wanganui	0	78	0	0	17
Wellington	0	57	18	6	45
Tasman/Nelson/Marlborough	6	53	6	6	17
Canterbury	0	41	18	6	35
Otago/Southland	11	14	11	25	19
National average	**5.9**	**46**	**14.5**	**10.9**	**392**

Note that Table 3 does not report all heating schedule options, so row sums may not equal 100%. The national averages present an overview of the winter living room heating behaviour – with 5.9% not heating at all and only 10.9% heating constantly.

The months of heating are reported by occupants in the occupant survey, although (as would be expected) some are unsure, reporting that it depends on the weather.

Accurate heating months could be determined, based on measured energy and temperature data, for 302 houses. These houses are spread around the country, averaging 80% of the houses in each monitored area. This sample is thus considered to be representative.

The start and the finish months of the heating season based on the monitored data are shown in Figure 3 Previous HEEP analysis (e.g. Isaacs et al 2004) was based on occupant reported heating months, but it has been found that there is a statistically significant difference, with occupants reporting on average 1.1 months less heating than actually occurred. Reasons for this are unknown but could possibly include: occupants only in the house for a short period of time; or the occupants being unaware of when they actually heat.

Figure 4 shows the length of the heating by the month in which heating starts – note that 12 houses (approximately 4% of the sample) heat the entire year. In general, these tend to be in the cooler parts of the country (Central North Island and South Island). Conversely, 10 houses in the sample do not appear to heat at all (3%), but in general these tend to be in the warmer parts of the country (Auckland and north).

There are 10 houses (4%) that apparently do not heat at all, but these are not included in the following graphs or tables.

Table 4 divides the houses by Regional Council or groups of these (councils are ordered from north to south). It shows the average starting and finishing month, both as named months and decimal parts of the month, while the length of the average heating season is given as the number of months. The reported standard deviation and the count of houses in each region provide guidance about the confidence limits.

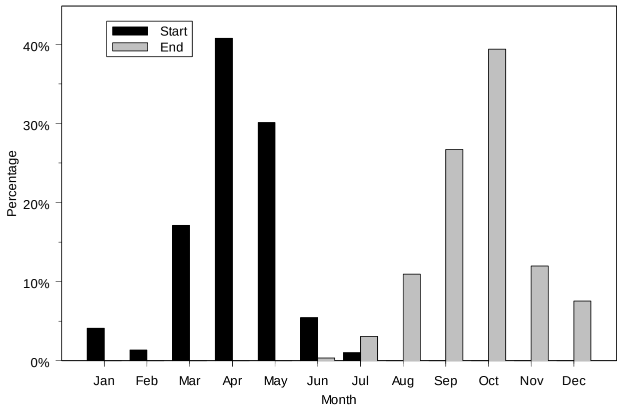

Figure 3: Heating months – start and finish

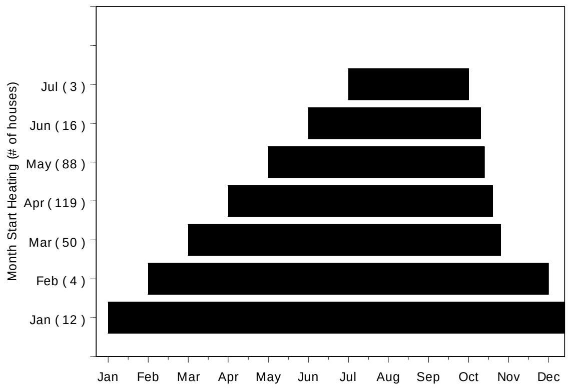

Figure 4: Length of heating season

Table 4: Heating start and end month by region

Region	Start month		Finish month		Length	Std dev	Count
Northland	April	4.9	September	9.4	5.5	0.3	19
Auckland	April	4.5	September	9.2	5.7	0.2	79
Bay of Plenty (BOP)	April	4.2	September	9.6	6.4	0.2	23
Waikato	March	3.8	October	10.2	7.4	0.3	41
Gisborne/Hawkes Bay	March	3.9	September	9.7	6.8	0.3	26
Taranaki/Manawatu–Wanganui	April	4.2	September	9.8	6.6	0.8	9
Wellington	April	4.2	September	9.4	6.1	0.2	28
Tasman/Nelson/Marlborough	March	3.6	September	9.9	7.3	0.6	13
Canterbury	March	3.9	September	9.5	6.6	0.3	27
Otago/Southland	March	3.3	October	10.8	8.6	0.5	27

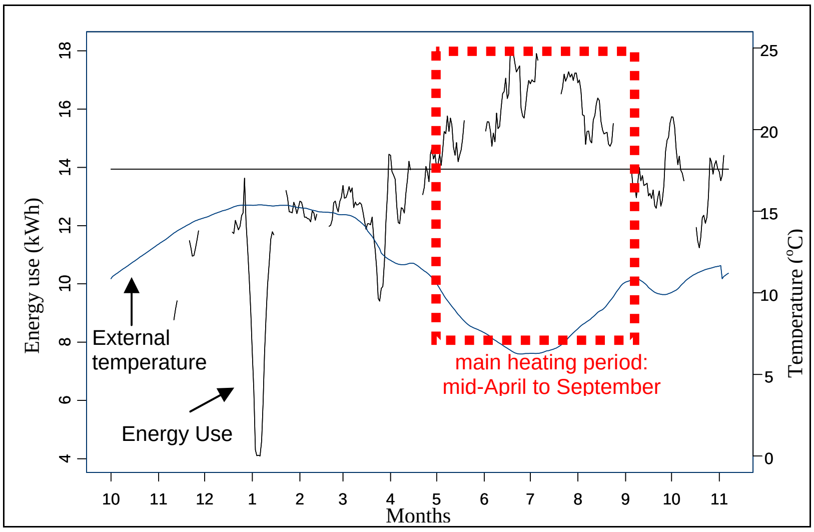

Figure 5: External temperature and heating season energy use

In order to determine the drivers of the start of heating, the average monthly external temperature was calculated based on temperature data from the New Zealand 'National Climate Database'.[2]

Figure 5 shows the external temperature and energy use for a sample house. Heating occurs during the time outlined by the dotted line – mid-April to September – which is also when the external temperature is coldest. The data is smoothed by a seven-day rolling average. Note the graph commences in October (month 10).

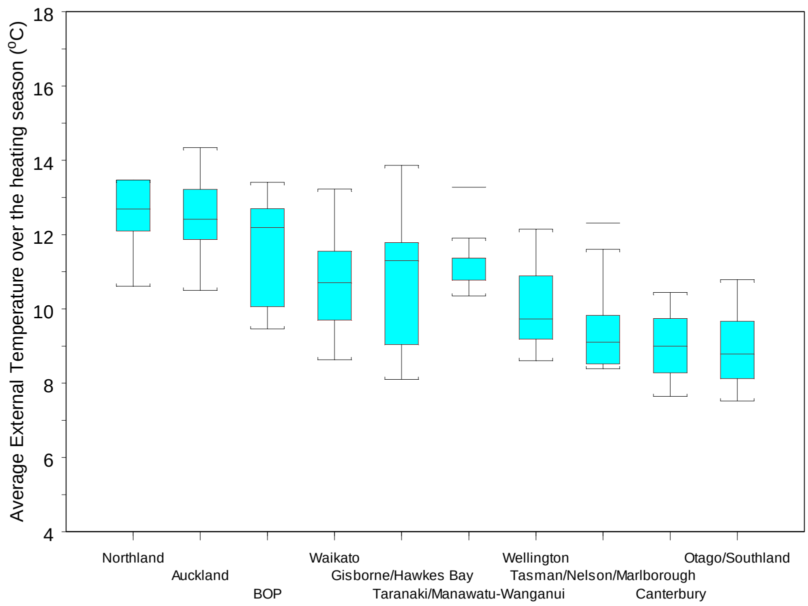

Figure 6: Average external temperature for heating season

As the external temperature drops, heating energy use increases in most houses – although there are still some that manage the winter without heating beyond that provided by appliance energy use and the live bodies. There is no doubt that the further south, the cooler the external temperature before heating starts.

The temperature ranges are given in Figure 6 by region. The average summer air temperature for Invercargill (south) is below the threshold for winter heating in Auckland (north)! This may be moderated by the benefits of summer solar gains in Invercargill, but still suggests the driver of the start of heating is not a simple temperature value.

[2] See: www.niwascience.co.nz/ncc/data or http://cliflo.niwa.co.nz/

The relationship between the region and the temperature at which houses start to heat or finish heating is statistically significant at a 1% level.

Winter temperatures

Table 2 showed that space heating is most common in the evening. For the purpose of the following analysis, the 'winter evening' (between 5 pm and 11 pm from June to August inclusive) is used as the baseline. Unless otherwise specified, the temperatures reported are for the living room (the part of the house most commonly heated) and are in the evening.

Figure 7 shows the distribution of living room evening temperatures over the winter months. The mean and median temperature is 17.9°C. The maximum mean is 23.8°C and the minimum mean temperature is just 10°C.

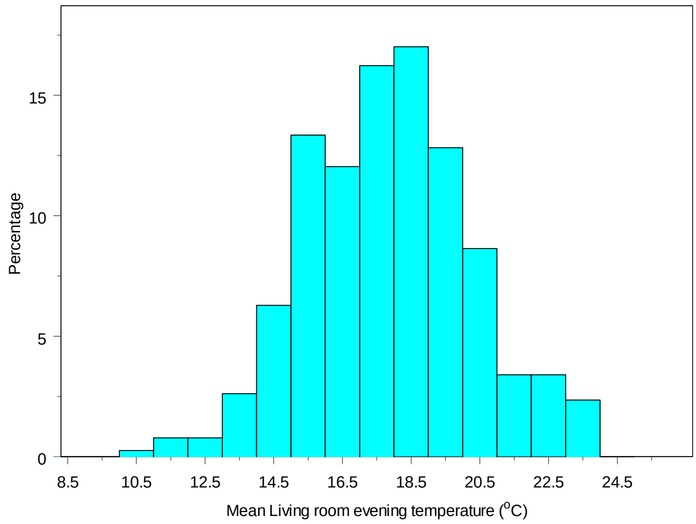

Figure 7: Distribution of evening living room temperatures

Table 5 gives the mean temperatures for the four different periods during the day for the living room, bedroom and ambient temperature. This illustrates just how cold New Zealand living rooms and bedrooms are. During the day the bedroom is only a couple of degrees warmer than outside, and the living room is not much better, averaging 3.8°C warmer than outside.

The mornings are the coldest time inside the average New Zealand house, although the coldest time outside is overnight. The evenings are the warmest (this is also the most common heating time). The bedrooms on average always seem to be slightly lower than the living rooms – at the most there is a difference of 3.8°C which occurs during the evening. This is most likely caused by heating occurring in the living room and typically very little or no heating in the bedrooms. The time periods are:

- morning: 7 am to 9 am
- day: 9 am to 5 pm
- evening: 5 pm to 11 pm
- night: midnight to 7 am.

Table 5: Mean temperatures: living room, bedroom and ambient

	Mean temperatures (°C)			
Room	**Morning**	**Day**	**Evening**	**Night**
Living room	13.5	15.8	17.8	14.8
Bedroom	12.6	14.2	15.0	13.6
Ambient	7.8	12.0	9.4	7.6

Table 5 shows the mean temperatures in winter and can be used to explore the changes between different periods of the day for the average living room, the average bedroom and the mean external temperatures. The mean living room temperature increases during the morning and day periods, but drops in the evening and overnight. This is slightly delayed from the ambient temperature where the temperature drops between day and evening, and drops again between evening and night. During the day the peak ambient temperature occurs, while the peak living room temperature generally occurs during the evening period. The average time the peak temperature is reached in all houses is 5.48 pm, and there is little regional variation.

The evening heating results in increasing temperatures during both the day and evening. Only 15% of houses heat the bedroom during the night, but when coupled with the small heat gains from the occupants (and the television, clock radio, any pets etc) the bedroom temperatures become closer to the living room temperatures overnight and during the morning. During the day the temperature difference between the two rooms is 1.6^{o}C.

New Zealand houses are considered low thermal mass, with most of the HEEP houses being of light timber construction. There are only two houses in the HEEP sample that have concrete block construction for walls. The effects of heat storage are shown by the delayed change in temperature in the house when the ambient is changing – this is most noticeable during the day to evening period. Internal heat gains during this period are also expected to be high e.g. meals being cooked, lights being turned on, occupants home from work/school etc.

Influences on temperatures

Occupants heat their houses, so the heating schedule plays a big part in the internal temperatures. The climate, the fuel and the heater type used in the house are also important for achieving higher temperatures, as is the age of the house and the level of thermal insulation. Other factors such as household income have been examined, and they show no significant correlation between income and mean living room temperatures (Isaacs et al 2004). Further analysis using the equivalised income (taking into account household size) also found no significant correlation between income and the mean living room temperature (Isaacs et al 2005).

Climate

Figure 8 shows the mean evening living room temperatures and the ambient evening temperature by region from north to south. Figure 8 shows a trend from north to south, although it is not straightforward. There are statistically significant differences between the regions, but these are not only related to the climate.

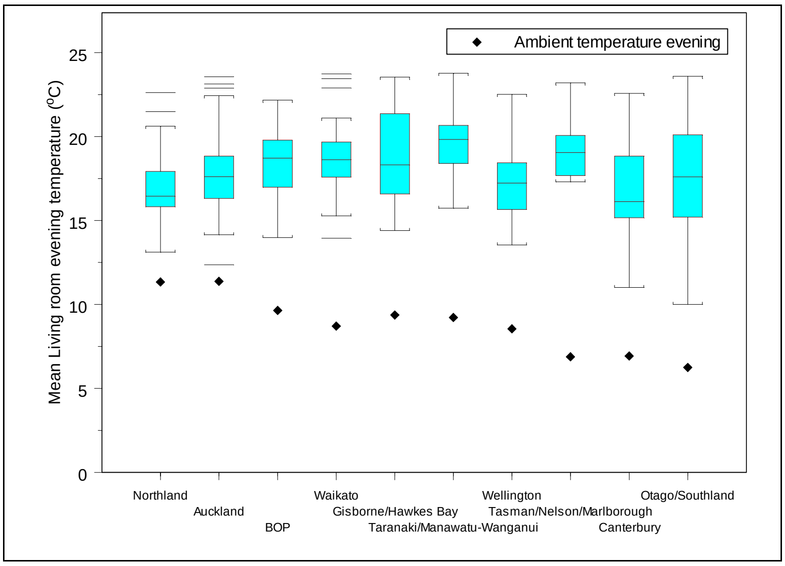

Figure 8: Mean winter evening living room and ambient temperatures by Regional Council

Northland (sub-tropical climate) has a lower median evening temperature than the Otago/Southland area, which in turn has a heating season of over eight months and a lower mean temperature, as shown by the black diamonds on Figure 8. Houses in the north heat for a much shorter time than those in the south. They also generally have less efficient (open fires) and less powerful heaters.

There is a significant difference between the Regional Councils (p-value = 0.0000022).

Heating fuel and heater type

The mean living room evening temperature is also affected by the heating system (especially if it is a powerful system such as a solid fuel burner). Often the heating fuel is determined by the appliance selection of the original house owners or builder.

Table 6 shows for each heating fuel type the percentage of time the average winter evening living room spends below 16°C, in the range of 16°C to 20°C and above 20°C. The heating system may be unit heaters (e.g. a free-standing LPG heater) or whole-house central heating (e.g. natural gas ducted air central heating).

Table 6: Living room winter evening temperature distribution

Heater fuel	<16°C (%)	Std dev	16–20°C (%)	Std dev	>20°C (%)	Std dev	Count
LPG	34%	3%	53%	3%	13%	2%	54
Electricity	33%	3%	51%	2%	16%	2%	103
Natural gas	22%	5%	51%	4%	27%	5%	35
Solid fuel	23%	2%	41%	2%	36%	2%	151
All houses	28%		47%		25%		328
NA	34%	4%	46%	3%	19%	4%	39

Table 6 shows that houses heated by solid fuel burners are the warmest for the longest, with 77% of the time above 16°C. LPG houses are the coolest, with houses being above 16°C only 66% of the time. Houses heated by LPG or electricity are the coolest.

A plug-in electric heater costs 15.4c per kWh of heat delivered, while a heat pump delivers warmth at 5.1 per kWh. Electricity 'lines charges' add 92.9c per day. Natural gas delivers heat at about 8.6c per kWh, to which is added a daily 'pipe' charge of 112.3c. A reasonably efficient wood burner delivers heat at about 10c per kWh. These prices are for Wellington which, apart from the high daily charge for gas, is about average for the country. The wood burner is based on 71% efficiency, heat pump 300%, night store and plug-in heater 100%, flued natural gas 80% (Consumer 2005).

Although the costs of the different fuels may be relevant, the 'size' of the heater is likely to be of greater importance. Solid fuel burners are capable of producing large amounts of heat output, although it is difficult to control. Typically, solid fuel burner heat output ranges from 4 kW to 25 kW, but this is in ideal conditions. Normally the HEEP houses were found to run their solid fuel burners between 3–5 kW. This would explain the high numbers of solid fuel houses spending time above 20^{o}C.

The highest living room winter temperature measured in a HEEP house was 42^{o}C – which is warmer than any temperature reached during summer – and this house was heated by a solid fuel burner.

Just under one in five houses (18.5%) reached maximum temperatures above 30^{o}C in winter (81% of these had enclosed solid fuel burners). Almost half the houses (44.5%) reached maximum winter evening temperatures above 25^{o}C.

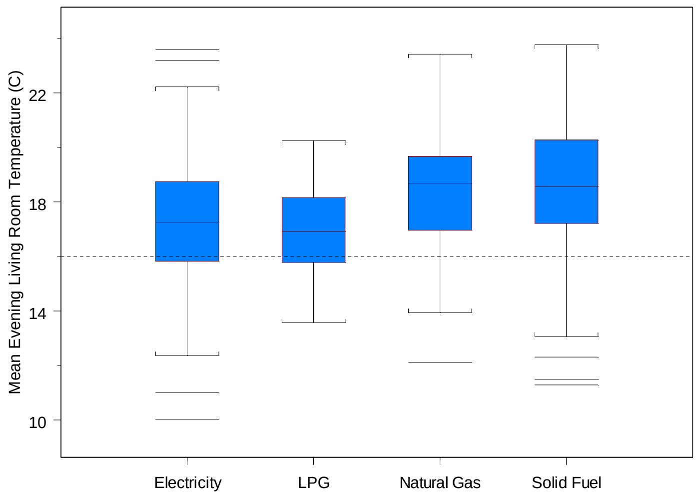

Figure 9: Mean living room evening temperature by heating fuel

Table 6 and Figure 9 illustrate that houses heated with gas or solid fuel are significantly warmer than electric and LPG-heated houses. Note that 'Natural Gas' includes reticulated gas and the large home gas (45 kg LPG) cylinders. The LPG in the figures and tables is only the portable cabinet type LPG heaters, generally with a 9 kg gas bottle.

Table 7 shows the heater type with the average winter evening living room temperature. Living rooms heated by open solid fuel burners are coolest, with an average temperature of 16°C, while those heated by enclosed solid fuel burners are the warmest, with an average temperature of 18.8°C. The main heater is occupant reported, but generally it is the heater that is used for the most hours per week and most often is in the living room.

Table 7: Winter living room evening temperatures by heater type			
Heater type	**Temperature (°C)**	**Std dev (°C)**	**Sample count**
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

Figure 10 illustrates some common types of solid fuel burners. The common heater types are:

- open solid fuel – these are generally very inefficient. Often 85% of the heat will be lost through the flue (Isaacs et al 2005)
- electric – generally small portable heaters, no more than 2.4 kW
- LPG – portable cabinet type unflued LPG heaters are used by about 38% of New Zealand households. Maximum outputs are about 4.8 kW, although most are used on the lowest setting ~1.5 kW (Isaacs et al 2004)
- fixed electric – such as electric panel heaters and electric fan heaters
- heat pump – electric heat pumps ~4.8 kW efficiencies of 300% (Consumer 2005). There are only four heat pumps in the HEEP sample, but the demand for them has grown significantly since HEEP monitoring started (Ninness 2005)
- gas – natural gas heaters both flued and unflued, plug-in and permanently connected. Largely used for room heating
- solid or liquid fuel central – uncommon, with only two in the HEEP sample
- enclosed solid fuel burners – wood or coal burners that are enclosed. A typical minimum output is 4 kW, a typical maximum is 25 kW, and the biggest maximum is 25 kW. However, this is under ideal conditions and most burners in HEEP are found to operate at 3–5 kW for the majority of the time (Isaacs et al 2005).

		
Open fire	Enclosed burner	Free-standing

		
Free-standing	Pot belly stove	Chip heater

Figure 10: Examples of solid fuel burners

House age

There is a strong relationship between house age and the living room evening temperature (Figure 11). This plot shows a steady increase in temperature as the houses become younger, i.e. the older houses tend to be colder. There is an average rate of fall $0.20 \pm 0.05^{o}C$ per decade. This result has a very high statistical significance (p-value 0.000045). This is without considering retrofitting of thermal insulation into the house, the heating fuel, region or occupants' heating patterns.

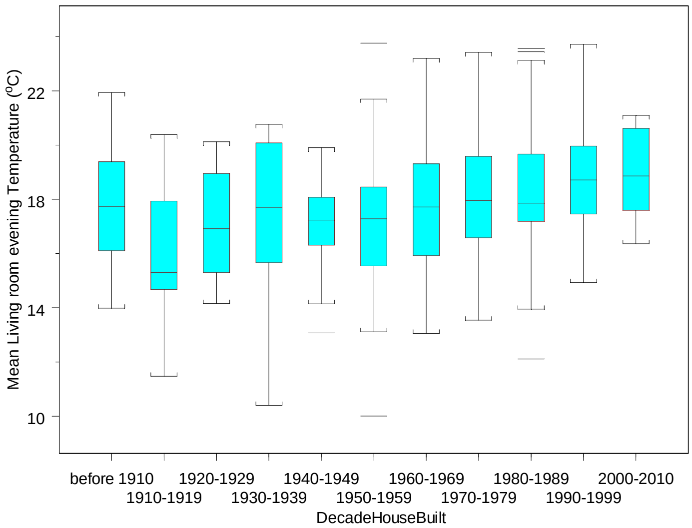

Figure 11: Winter evening living room temperatures by year built

The housing stock in the Otago/Southland area is older with only 11% of houses being post-1978 (see Table 8). The average Regional Council will have 25% of its houses built post-1978. The older housing stock, along with climate, would help explain the low winter temperatures for some of the houses in Otago/Southland.

There are a number of changes to house design and construction that may have led to higher winter temperatures, including:

- higher insulation R-values – a requirement for new houses since 1978
- possibly better orientation of windows for passive solar heating (although no clear indication of this can be found in the HEEP sample)

- airtightness – newer houses are less ‘leaky’
- increased amount of glazing
- lower ceiling levels leading to lower room volumes
- reduced or no eaves due to architectural trends
- occupied by people with higher incomes
- newer houses are more likely to be built in a warmer climate (northward shift).

Impact of thermal insulation

Houses built after 1 April 1978 (see Table 1) were required to include a minimum level of insulation, but the retrofitting of thermal insulation was not required in older houses. As seen in Table 8 there is a 1.0°C difference in living room evening temperatures between pre- and post-1978 houses. This pattern is still seen when the houses are separated by region.

Table 8: Winter temperatures by insulation level

House age group	Average winter evening living room (°C)	Std dev (°C)	Sample count	Bedroom overnight (°C)	Std dev (°C)	Sample count
Pre-1978	17.6	0.1	265	13.2	0.1	243
Post-1978	18.6	0.2	99	14.5	0.2	95

The same pattern can be seen in bedrooms as living rooms in the pre- and post-1978 houses (see Table 8), although as discussed bedrooms are seldom heated.

Discussion

The houses in the HEEP sample are heated on average for 6.6 months. However, there were 10 houses (3.3%) that did not heat at all and 12 (4%) that heated for the whole year. The heating season length varies from 5.5 to 8.6 months, although this depends on location.

New Zealand houses are cold compared to temperatures expected in other temperate climates. The average winter evening temperature is 17.9°C, while the mean range is from 10°C to 23.8°C.

Only 5% of houses have central heating systems. In the other houses, the tendency is to zone heat, with the most common room heated being the living room and the most common time of heating being the winter evening.

Solid fuel burners heat the houses well but with little control – they can reach very high temperatures. Houses heated by open fires (solid fuel) and portable electric heaters are the coolest, with mean living room evening temperatures of 16°C and 16.9°C. Houses heated by enclosed solid fuel burners are the warmest, with a mean living room evening temperature of 18.8°C.

Newer houses are warmer during winter than older houses; reasons for this may include higher levels of thermal insulation and increased airtightness.

Comparing pre- and post-1978 houses, the winter evening living room temperatures in the newer houses are on average 1°C warmer – 1978 is when the first mandatory regulations were introduced for insulation in houses. This temperature difference increases to 1.3°C in the bedrooms which seldom have formal heating appliances – the main heating sources are human bodies, televisions, clock radios and pets.

Acknowledgements

We would like to acknowledge the support and assistance of the various HEEP field staff, contractors and house occupants for making it such a successful project. HEEP has financial support from a number of organisations – the Foundation for Research, Science and Technology, Building Research and the Building Research Levy, ECCA, Transpower and a range of other government and industry supporters.

References

Consumers' Institute. 2005. 'Shivering Timbers' *Consumer Magazine* 447: 38–40.

Isaacs NP. 1993. *Thermal Efficiency in New Zealand Buildings: A Historical Overview*. Centre for the Building Performance Research, Victoria University of Wellington, New Zealand.

Isaacs NP. 1999. 'Performance Based Building Energy Efficiency Code'. *Proceedings Global Building Model in the Next Millennium Conference.* Melbourne 12–15 April 1999. (*BRANZ Ltd Conference Paper* 63: 108–118).

Isaacs NP, Amitrano L, Camilleri M, Pollard A and Stoecklein A. 2002. 'Energy Use in New Zealand Households: Report on the Year 6 Analysis for the Household Energy End-use Project (HEEP)'. *BRANZ Ltd Study Report 115*, Judgeford, New Zealand.

Isaacs NP, Amitrano L, Camilleri M, French L, Pollard, A, Saville-Smith K, Fraser R and Rossouw P. 2004. 'Energy Use in New Zealand Households: Report on the Year 8 Analysis for the Household Energy End-use Project (HEEP)'. *BRANZ Ltd Study Report 133*, Judgeford, New Zealand.

Isaacs NP, Camilleri M, French L, Pollard, A, Saville-Smith K, Fraser R and Rossouw P. 2005. 'Energy Use in New Zealand Households: Report on the Year 9 Analysis for the Household Energy End-use Project (HEEP)'. *BRANZ Ltd Study Report 141*, Judgeford, New Zealand.

Meteorological Service of New Zealand Ltd (MetService). 2006. *The Climate of New Zealand* (www.metservice.co.nz/default/index.php?alias=learningcentre accessed 9 February 2006).

National Institute of Water and Atmospheric Research (NIWA). 2006. *Climate Summaries* (www.niwascience.co.nz/edu/resources/climate/summary accessed 9 February 2006).

Ninness G. 2006. 'Demand Running Hot for Cool Comfort', *Sunday Star Times* (12 February 2006, Page D5).

Penny AC. 2003. *Climate Database (CLIDB) User's Manual* (5th edn). NIWA, Wellington (www.niwascience.co.nz/services/clidb/ accessed 9 January 2006).

Pollard AR. 2001. *Investigating the Characterisation of Temperatures within New Zealand Buildings*. Masters Thesis, Massey University, Palmerston North, New Zealand.

Statistics NZ. 2004. *Household Economic Survey* (Year Ended 30 June 2004). Wellington, New Zealand (www.statistics.govt.nz accessed 9 January 2006).

Statistics NZ. 2005. *Profile of New Zealand* (www.stats.govt.nz/quick-facts/default.htm accessed 9 January 2006).

Stoecklein A, Pollard A, Camilleri M, Amitrano L, Isaacs N, Pool F and Clark S (ed). 2001. 'Energy Use in New Zealand Households: Report on the Year 5 Analysis for the Household Energy End-use Project (HEEP)'. *BRANZ Ltd Study Report 111*, Judgeford, Wellington.