COLD HOMES IN NEW ZEALAND – LOW HEATER CAPACITY OR LOW HEATER USE?

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ABSTRACT

The indoor climate was monitored in 36 dwellings that were in the Housing, Heating and Health Study, during the winter of 2006, in the Hutt Valley, New Zealand. Temperature was measured in the living room and the bedroom of the child with asthma. To quantify time of heater use and heater settings, thermocouple(s) connected to a microvolt logger were placed in front of each heater. For the electric heaters a pulse logger measured energy consumption. Twenty-one of these dwellings, in the intervention group, had a higher capacity replacement heater installed (flued gas heater, heat pump and/or wood pellet burner) while the remaining 15 dwellings, in the control group, continued to use their original heaters (generally unflued gas heaters). The dwellings with new heaters were warmer than the homes in the control group and the heat pumps seemed to be the most effective in heating more than one room in the house. The new heaters were operated for longer than the old heaters. With the old heaters the average living room and bedroom temperatures were 15.5^{o}C and 14.3^{o}C respectively, whilst with the new heater the temperatures were 17.8^{o}C and 15.6^{o}C respectively.

KEYWORDS

Heater use; temperature; heater capacity; power input.

ABBREVIATIONS USED IN THIS PAPER: unflued gas heater (UFGH), flued gas heater (FGH), heat pump (HP), wood pellet burner (WPB), New Zealand (NZ), Housing, Heating and Health Study (HHH Study), World Health Organisation (WHO).

INTRODUCTION

Houses in NZ are on average damp and cold (2004). About 24% of NZ households use UFGH (also called Liquefied Petroleum Gas cabinet or portable gas heater) and 70% use electric heaters as the main heating method (Wilton, 2005). Such heaters have low heat output - up to 2.5 kW for portable electric heaters and around 4.5 kW for UFGH. Furthermore, houses constructed before April 1978 were not subject to regulations for the insulation. Low building insulation level and low heating system capacity could contribute to low indoor temperatures.

The HHH Study is a community trial to investigate the relationship between domestic heaters and indoor environment and health. Four hundred and twelve families, with a child with doctor diagnosed asthma, who used UFGH or small electric heaters as their main type of heating, were enrolled in this study. The dwellings were insulated (roof and under floor) before the study started, according to the Energy Efficiency and Conservation Authority standard specifications (NZS 4218:2004). Baseline health and environmental parameters were measured in all homes in the winter of 2005, including average concentration of nitrogen dioxide (NO_2) with a passive sampler, temperature, twice daily forced expiratory volume measurements, symptoms reporting and monthly healthcare visits. For the second

monitoring period in the winter of 2006, half of the households, called the "intervention group", chose a higher heating capacity system: either WPB; HP; or FGH. The other half ("control group"), kept using their previous heating system (Howden-Chapman et al., 2006).

The main objectives of this paper are to measure the indoor climate during the winter of 2006 for some dwellings from the HHH study and to relate trends in indoor temperature to the heating capacity and duration of heater use.

METHOD

Intensive environmental monitoring was undertaken for 36 dwellings from the HHH Study in the Hutt Valley region (Greater Wellington, NZ). Parameters measured included NO_2 using the chemiluminescence method, formaldehyde, carbon monoxide, carbon dioxide, temperature, relative humidity and heater use. Each was continuously monitored for up to one week from mid June to early September 2006 (the winter period in NZ). Details of the methods are described by (Phipps et al., 2006).

The 36 dwellings comprised 15 control group dwellings and 21 intervention group dwellings. In the intervention group, the new heaters were installed in the living room, except for two houses where HPs were installed in the bedrooms. One of these later two households used a wood burner and the other an UFGH as the main heater in the living room. Another household, where a HP had been installed in the living room, preferred to use the old UFGH as their main heater.

Temperature measurement

For each dwelling, measurements of room temperature were carried out in the living room and the asthmatic child's bedroom, using a Gas Probe IAQ-4-DL sensor (BW® Technologies Ltd, Calgary, Canada). The loggers were set to monitor the temperature continuously every two minutes for up to one week. The sensor was placed in a custom made support structure which kept the probe at the desired height (1.10 m high from the floor) and prevented the instrument from being tampered with (Illustration 1). Tests conducted in a test room with the temperature sensor inside and outside the protective support structure showed the structure did not significantly affect the results.

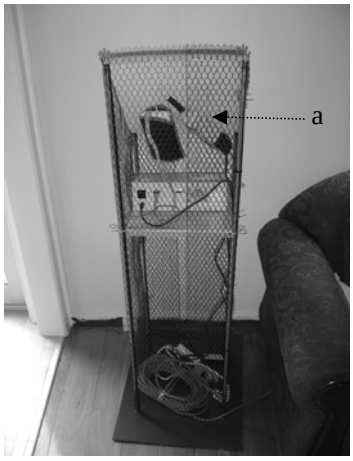

Illustration 1: Temperature sensor (a) in the protective structure.

Heater use recording

To assess the heater use type K thermocouple(s) were positioned in front of each heater (UFGH, FGH, HP, WPB and wood burner) and connected to a microvolt logger. A pulse logger was fitted on each electric heater to measure the energy consumption. These two recording devices were used to evaluate the time of heater use and the heater settings using the methodology developed by Camilleri et al (2000).

RESULTS

Table 1 gives the heater type which was used as main heating system in the living room. For the intervention group, the heat pump was the choice of most households, which was consistent with the main study (Howden–Chapman et al: *paper in prep*).

Designation	Number of dwellings
Unflued Gas Heater (UFGH)	15
Electric oil column	1
Heat Pump (HP)	12
Wood Pellet Burner (WPB)	3
Flued Gas Heater (FGH)	2
Wood burner	2
Missing data	1
Total	**36**

Table 1: Main heater types used in the living room during winter 2006

Indoor temperature

Figure 1 shows the weekly mean indoor temperature in the dwellings for each heater type. The temperature was always higher in the living room than in the bedroom. The dwellings where the UFGH was used as main heating source in the living room, showed a lower temperature (14.9°C in the living room) than the ones with the newly installed heaters (FGH, HP, WPB). Only the dwellings with HP heaters reached the WHO recommendations (18°C – 24°C) and the HPs seemed to be the most effective in heating more than one room in the house (16.8°C in the bedroom). The two houses with existing wood burners and the one using an electric column heater showed a temperature well above the ones using new heaters and were within the WHO recommendations.

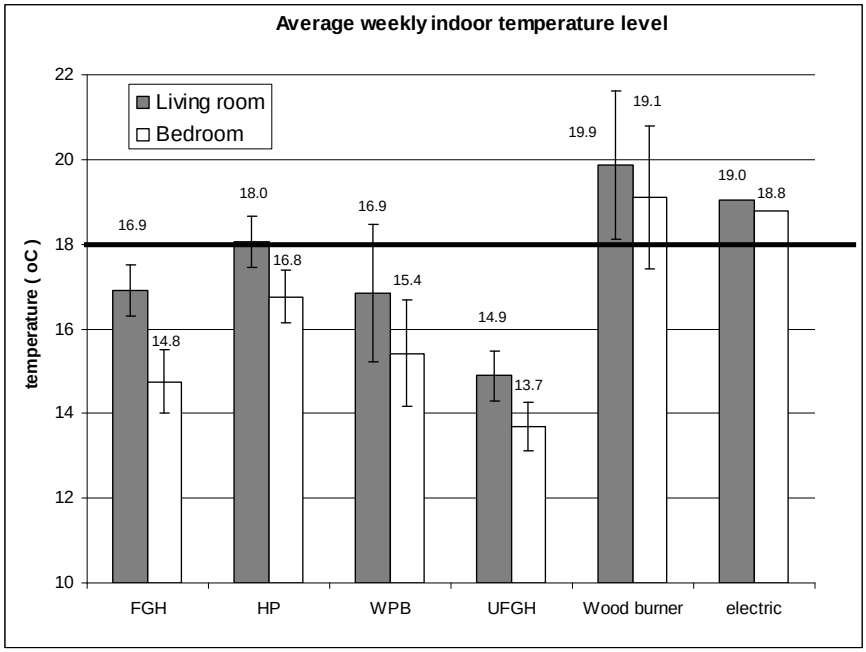

Figure 1: Indoor weekly mean temperature level with standard error for different heater types

Heater use

Figure 2 shows the mean hours of use per week for each heater type. HPs were operated for longer than the other new heating systems with a weekly average of 70 hours, followed by the FGH with a weekly average of 42 hours. WPB and UFGH showed a similar weekly heater use of around 25 hours a week (15% of the time). Three hypotheses could explain this result. First, the ease of use – HP and FGH start by pressing a button and there is no inconvenience of running out of fuel. The second is the timer program on HP and FGH which allows extended heater use periods without manual intervention. Thirdly, both UFGH and WPB rely on regular purchasing of fuel, usually weekly, and this may have restricted hours of heater use. The two families using a wood burner or an electric heater as their main heating source operated them for longer than dwellings with other heater types.

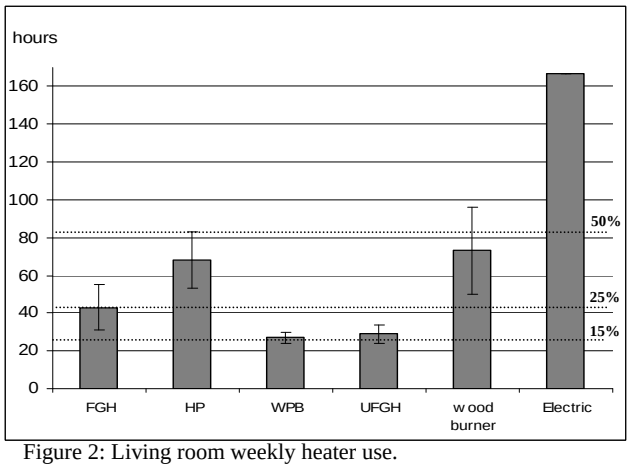

Figure 2: Living room weekly heater use.

Figure 3 shows the heater use profile over the day given as the average percentage of the total use in each half hour period. During the monitored week, the WPB, FGH and UFGH were mainly used twice a day: in the morning between 6 am and 9 am and in the evening for a longer period between 5 pm and 11 pm. These results are consistent with the HEEP study (Isaacs et al., 2002). For the HP dwellings, the two usage peaks are less obvious, consitent with the HPs being used for a more extended period each day.

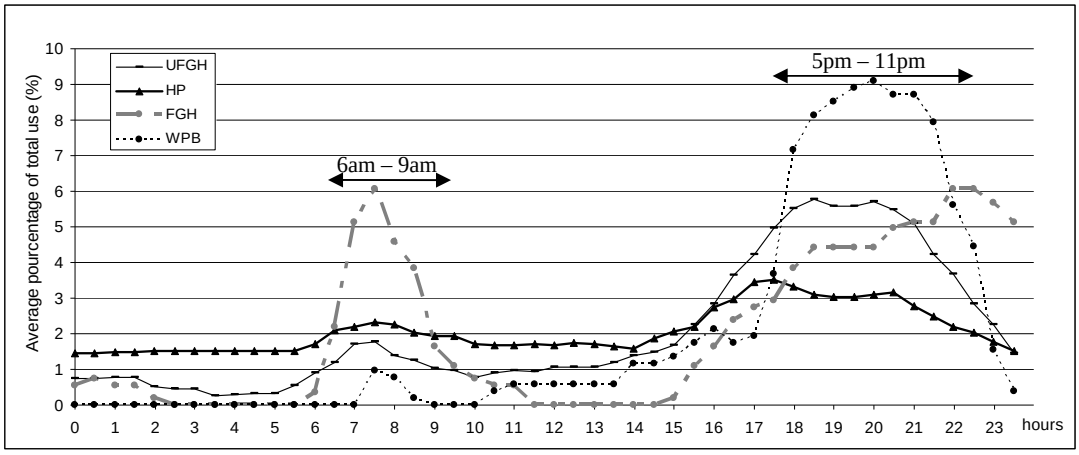

Figure 3: Half hourly contribution to total daily heater use

UFGH

Figure 4 shows the fractional weekly heater use of the 15 dwellings with UFGH. There were three broad levels of user: households using the UFGH less than one hour a day, those using the heater around five hours a day, and finally the intensive users who used the heater around ten hours a day. Figure 5 shows a weekly temperature profile in the living room, the corresponding heater use (kW) and the outdoor temperature for dwelling ID 281 which had the highest use of UFGH. The average outdoor temperature was 6.97 ± 0.08°C. Even with an intensive heater use (41% of the time), the indoor temperature was strongly correlated to the outdoor temperature and only for four short periods during the week was the living room temperature above the 18°C which is the recommended WHO temperature. This means that the UFGH was not sufficient to effectively warm the living room.

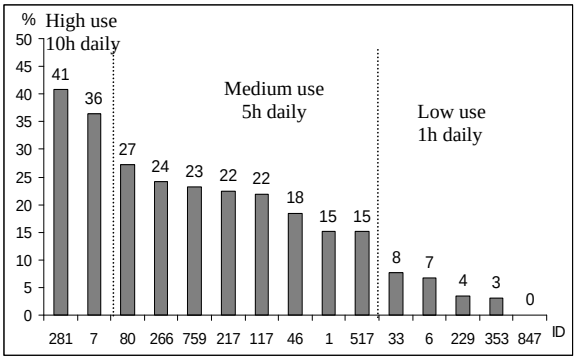

Figure 4: UFGH daily use percentage

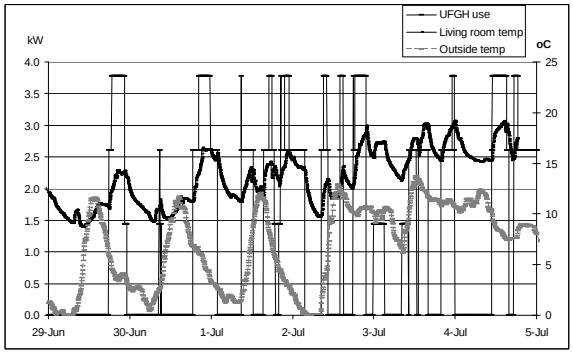

Figure 5: Weekly living room and outside temperature (ID 281)

HP

Figure 6 shows the daily fractional use for the 12 dwellings with HPs**.** As for the UFGH, there were three levels of users for the HP: households using the HP around three hours a day, those using it for 10 hours a day and the last group using it more than 80% of the time. Some famillies had indicated they considered their HP too expensive to operate therefore they prefered to switch the HP off.

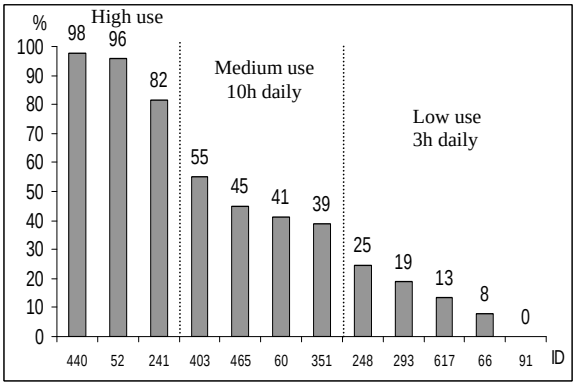

Figure 6: HP daily use percentage

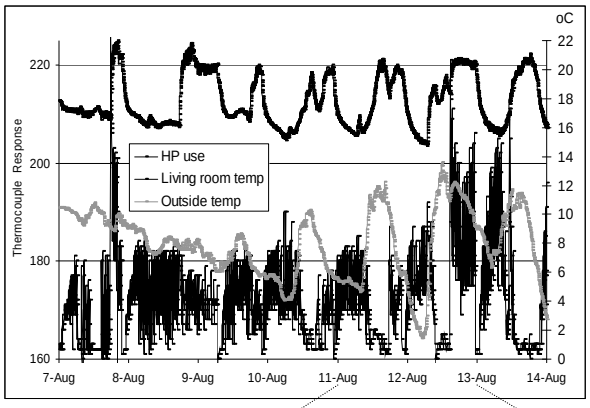

Figure 7: Weekly temperature vs. HP use (ID 241)

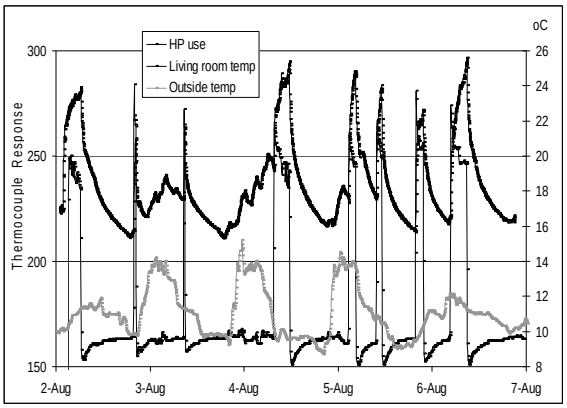

Figure 8: Weekly temperature vs. HP use (ID 293)

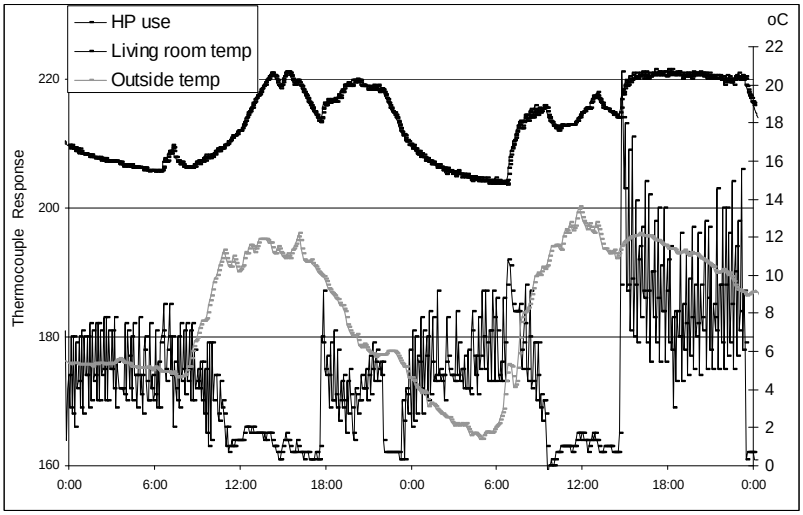

Figure 7 enlargement: 11Aug 00:00 – 13 Aug 00:00

Figure 7 and Figure 8 show the weekly temperature levels (living room and outside) for two dwellings with HPs with high and low use respectively (ID 241 and ID 293). The differences were due to both the frequency of usage and the way the HP was used. The living room temperature for dwelling ID 241 showed only small fluctuations (range of 5°C) whereas dwelling ID 293 had large temperature fluctuations (range of 10°C). Household ID 293 used the HP with a high thermostat setting resulting in a quick temperature increase (up to 26°C) and then switched the HP off. In contrast, in dwelling ID 241 the HP operated at a lower thermostat setting but was kept over a longer period and so operated at less than full capacity for a lot of the time. In both dwellings, the living room temperature levels were within the WHO recommendations. However, the weekly average outdoor temperature levels were very different: 7.73 ± 0.05°C for the area where the dwelling ID 241 was located and 10.80 ± 0.03°C for the area where the dwelling ID 293 was located, which would allow dwelling ID 293 to stay warmer despite lower HP use.

Heat output

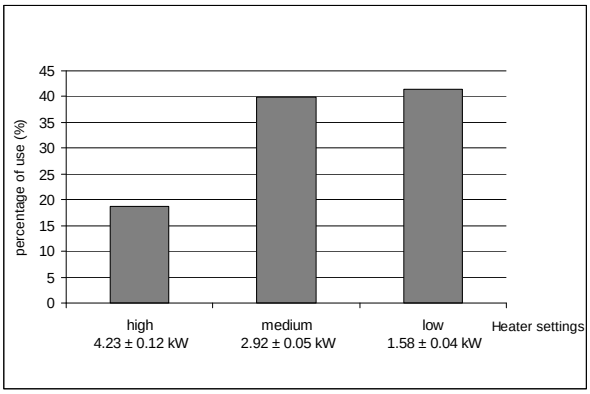

Figure 9: UFGH heating capacity as a function of heater settings.

Nominal heating capacity (kW)	Number of HP
8.1	1
6.8	2
6.0	2
5.9	4
4.0	3

Table 2: HP heating capacity.

The UFGH were used only 15% of the time on average (Figure 2) and were mainly on either a medium setting (40% of the time) or a low setting (42% of the time) as shown in Figure 9. Based on this behaviour, the weekly average heating capacity was 2.60 ± 0.21 kW. Isaacs et al (2004) found similar results in the HEEP study, where only 11% of the households operated UFGH using the high setting most frequently.
Table 2 shows the HPs nominal heating capacity in the 12 dwellings. If it is assumed that the HP always operated at the nominal capacity the average heating capacity was 6.01 ± 0.33 kW for the dwellings with HPs.

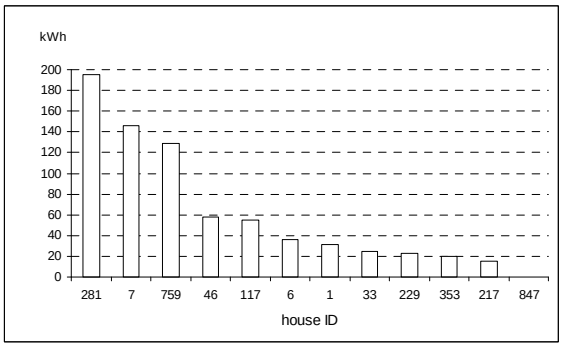

Figure 10: UFGH weekly heat output

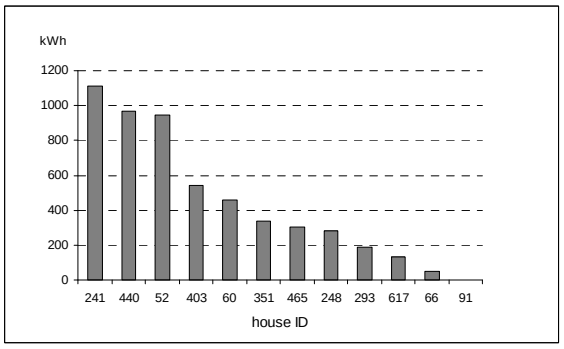

Figure 11: HP maximum weekly heat output

Figure 10 shows the total weekly heat output (kWh) for 12 of the 15 dwellings with UFGH based on the use and settings heat output. Figure 11 shows the total weekly maximum heat output for the 12 dwellings with HPs, based on a use on nominal heating capacity, but it should be noted that the HPs in many dwellings like ID 241 (Figure 7) would have operated at less than full capacity. Therefore the actual HP heat output was probably significantly overestimated. However, the higher average temperature in the dwellings with HPs is consistent with this apparent higher average heat output.

CONCLUSION

During the winter monitoring period the average indoor temperature was colder than the WHO guidelines, except for a few of the dwellings with HP, and the dwellings with a wood burner or the oil electric column heater.

Most households used their UFGH infrequently and mainly at medium or low setting. This UFGH use was not sufficient to warm the indoor environment to WHO recommendations levels even with prolonged use.

Only the few families that used HPs for extensive periods met the WHO recommendations and avoided significant temperature fluctuations. It is important that people are educated in how to use their HPs efficiently in order to avoid the behaviour of some families of switching the HP off for periods over the day, during the winter season, probably because of concern over heating costs. Future research conducted as part of the HHH Study will look at indoor temperatures achieved, in relation to energy costs.

ACKNOWLEDGEMENTS

Participating families are thanked for their valuable contribution to the study. The authors would like to thank Andrew Pollard from BRANZ Ltd for his technical help and Tamsin Mitchell from Greater Wellington Regional Council for providing the Hutt Valley's outdoor air data. This study was funded by Health Research Council of New Zealand and Building Research Ltd.

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