CONFERENCE PAPER

CP161

Clawback of energy efficiency upgrades in New Zealand households

A.R.Pollard and N.R. Buckett

Presented at the 5th Australasian Housing Researchers' Conference
November 2010, Auckland, New Zealand
17th to 19th November 2010

The work reported here was funded by Beacon Pathway Limited.

Clawback of energy efficiency upgrades in New Zealand households

A R Pollard & N R Buckett
BRANZ, Private Bag 50908, Porirua, New Zealand
Andrew.Pollard@branz.co.nz & Nikki.Buckett@branz.co.nz
Phone: +64 4 237 1170; Fax: 237 1171

Keywords: Clawback; takeback; space heating; occupant behaviour.

Abstract

It is well known that both the dwelling and its occupants are factors in the overall energy consumption of a particular household. It is possible to have a low energy using household, even if the dwelling has poor levels of insulation, from the occupants choosing not to heat during winter so that the resulting indoor temperatures within the dwelling will be low. Likewise, it is also possible to have a high energy using household despite the fact that the dwelling may be well insulated, if the occupants are oblivious to their energy use and/or demand high levels of energy consuming services.

The change of occupant demand for energy services is particularly interesting when energy services could be provided more efficiently, such as when an energy efficiency upgrade is made to the dwelling or when the occupants move into a more efficient dwelling. The occupants have the option to take the improvements in efficiency as reduced energy use or 'clawback' the savings over a period of time as increased comfort.

Beacon Pathway's Papakowhai Renovation project measured energy services and the indoor temperatures from nine households subject to energy efficiency upgrades midway through the three-year monitoring period. The extent to which 'clawback' is occurring within these houses is examined using a graphical approach highlighting those houses for which increased temperatures are taken in preference to reduced space heating.

Energy efficient and warm homes?

The understanding of heating in New Zealand homes has been advanced with data collection and analysis from the Household Energy End-Use Project (HEEP) which recorded the energy use and indoor temperatures in a representative sample of around 400 households throughout New Zealand (Isaacs, et al 2010). HEEP has shown that the average New Zealand household uses little energy (gross energy for all energy types) for space heating, using around 3,800 kWh per year (Ibid, 2010). Colder areas of the country tend to use more, with Dunedin and Invercargill households using around 6,800 kWh.

Schipper et al (2000) noted that New Zealand's residential space heating energy use, once corrected for house size and climate (degree days), was the lowest in a selection of IEA countries in 1995.

While low space heating energy use may be as a result of good thermal envelope and efficient heating, it may also result from simply not heating to a sufficient level so that the house becomes (or remains) cold.

Cold and damp indoor conditions within houses can pose a risk to occupants. The World Health Organization (WHO) commented that room temperatures below 16°C with relative humidities of over 65% can lead to increased respiratory diseases and allergic reactions to dust mites, fungi, mould and other household pet allergens (WHO, 1987). It recommended that the minimum indoor temperature should remain above 18°C for healthy adults and 20°C for the very young and very old.

HEEP found that winter evening temperatures averaged 17.8°C in living rooms, but were below 16°C for around one-quarter of the households examined. The temperatures in the main bedrooms were also recorded, and in general these temperatures were lower with an average winter evening temperature of only 15°C.

Heating services

Space heating energy use is a by-product of the household service of providing for an acceptably warm environment within a household. The household service of providing for an acceptably warm environment depends on the insulation levels of the house as well as the operation of the heating systems (heaters) within the house.

People's use of heaters, and household services in general, is inherently variable and difficult to predict. A decision to use a household service may not be thoroughly rationalised and may be influenced by any number of personal or social factors, including financial and domestic circumstances and attitudes towards comfort.

Programmes looking to reduce residential energy use need to be aware of the interaction between efficiency improvements and occupants' behaviour towards household energy services. Energy savings from applying an energy efficiency intervention may not be fully realised as the occupants choose to have a greater utility from that energy service. For example, space heating energy savings from increasing the thermal envelope insulation levels of a house may not be fully realised as the occupants may choose to heat more and operate their house at a higher temperature.

The terminology of such effects is applied differently for each discipline and is not consistent within the literature.

Economic approaches focus on the efficiency interventions making the price of the energy service cheaper (Greening et al, 2000). The direct 'rebound' effect is then the proportion of the effective savings offset by the cost of the greater usage of that energy service. An indirect rebound effect can also be defined where savings from one energy efficiency intervention results in increased spending on other energy services. An example of this may occur where a heat pump is installed to replace a lower efficiency space heater. Direct monetary savings may be made with reduced winter-time space heating energy use if heating patterns are similar. However if the heat pump is used to provide summer-time cooling when previously no mechanical cooling was used, overall space conditioning energy use may not have reduced as much as expected and indirect rebound may occur.

Building evaluation work frequently uses 'takeback' as an analogous term to the direct rebound effect. Takeback refers specifically to trading off energy savings, with increased provision of services doing away with price as an intermediary.

It would be convenient to consider takeback as a step process; after an intervention the occupants immediately establish a new level of demand for that household energy service. Occupant behaviour however is more complicated than this and takes some time to adjust. While the immediate response after an intervention may be expected to achieve a high proportion of the expected energy savings, new levels of energy service demand may evolve from a range of feedbacks, many of which are infrequent, such as monthly or two-monthly energy bills.

Direct measurements of the use of household services and their resultant energy use have a high degree of variability, changing greatly from day-to-day. It is not clear for how long, or for what time after an energy intervention, that takeback should be assessed. To emphasise this vagueness, and the slow process of the eroding of expected energy savings, an alternate term of 'clawback' could be used in preference to the exactness and immediacy suggested by the term 'takeback'. The term 'clawback' will be used for the rest of this paper.

Clawback and energy efficiency

This work presents an assessment of one of the unintended consequences of performing energy efficiency interventions surrounding space heating services in houses – the clawback of an increased level of temperature within the house.

Clawback may or may not occur after an energy efficiency intervention for a number of reasons such as:

- Whether the system is capable of delivering to a level of service that the occupants desire and are able to afford. Efficiency improvements frequently also increase the capacity of systems. For example, upgraded thermal envelope insulation may make it easier for an existing space heating system to provide comfortable conditions, and so the heating is used more frequently.
- The system being used more extensively within the house. For example, where previously occupants may have only heated the family room in the evenings, after an intervention they may heat more of the bedrooms and other rooms of the house as well.
- The characteristics of the service delivered. Where there is a subjective assessment of the acceptability of the service provided, there may be variations after an intervention. For example, space heating is applied to counter the occupants not feeling sufficiently warm. The acceptability of a heating system which has a high radiant component, which provides a feeling of being heated more readily, may have a different use than a convective-type heating system which provides a more consistent temperature and is less noticeable to the occupants.
- The amount of active engagement the occupants have with the mechanisms of providing the energy service.

Space heating systems in New Zealand have traditionally had a high degree of user engagement. It is frequently left up to the occupants to turn on or off heaters within the appropriate rooms as required. Many traditional heating types, such as woodburners, have limited thermostatic control and may be prone to either under or over-heating.

Moves to less user involved heating systems may impact on how much comfort people expect the systems to deliver. The greater use of timers, ducted systems, room thermostats, heat pump systems which also deliver cooling (French, 2008) will all impact on how people respond to the service levels their heating systems are delivering.

Real-life clawback

The clawback of the space heating service is analysed from a Beacon Pathway research project, the Papakowhai Renovation Project (Burgess et al, 2008).

This examined the impact of a number of sustainability upgrades in a set of nine existing 1970s houses in the Porirua suburb of Papakowhai. A range of measures were employed in these houses, ranging from simple roof insulation top-ups to full retrofitting of roof, floor and wall insulation, the installation of double-glazing and the upgrading of heating systems. The Papakowhai Renovation houses were closely monitored with energy use and indoor temperatures measured and provide a useful dataset to examine the impacts of thermal envelope and heating system improvements (Burgess, et al, 2008).

Heater changes

Of the nine houses in the Papakowhai Renovation Project, six had woodburners, while only three relied entirely on reticulated energy for applied space heating. Some appliances were due for replacement, and so in line with the efficiency improvement, air pollution reduction, and indoor environmental quality improvement ideals of the Papakowhai Renovation Project, some of the high-intervention houses had their main heater replaced. The changes are noted in Table 1.

The most extensive changes to the space heating within one house occurred in P03, where the dilapidated woodburner and a room heat pump were replaced with a new woodburner and a ducted central heat pump system.

House	Heaters/heat transfer before renovations	Changes
P01	Woodburner, oil column heaters	Pellet burner replaced woodburner. Heat transfer system installed
P02	Woodburner, oil column heaters	-
P03	Heat pump, dilapidated woodburner, fan heater	New woodburner replaced old woodburner. Central heat pump system replaced living room heat pump
P05	Open gas fire, electric convection heater	Heat transfer system installed
P06	Woodburner, LPG cabinet heater, oil column heaters	-
P07	Woodburner, heat transfer system	Heat transfer system thermostat moved, ducting extended
P08	Electric underfloor heating, nightstore heaters	-
P09	Halogen radiant heater, fan heater	Heat pump replaced halogen radiant plug-in heater
P10	Dilapidated woodburner, electric column heaters	New woodburner (with wetback) replaced old woodburner

Table 1: Space heater changes in the Papakowhai Renovation Project

Thermal envelope changes

The changes to the thermal envelope for each of the Papakowhai houses are listed in Table 2. The largest changes were full envelope insulation (double-glazed windows plus roof, wall, and floor insulation wherever possible) in P03 and P10, while the least changes were to P06, which received ceiling insulation only.

House	Roof	Walls	Floor	Windows
P01	R5 fibreglass insulation installed	-	R2 insulation installed	-
P02	Existing insulation rearranged, new layer added	-	R2 insulation installed	-
P03	R5 fibreglass insulation installed	Old thin fibreglass segment insulation replaced with R2.4	R2 insulation installed where possible	Single-glazed aluminium replaced with double-glazed aluminium
P05	Existing insulation rearranged, topped up	-	R2 insulation installed where possible	-
P06	Existing insulation rearranged, topped up	-	-	-
P07	Existing insulation rearranged, topped up	-	R2 insulation installed where possible	-
P08	Existing insulation rearranged, topped up	Walls backing onto sub-floor insulated	R2 insulation installed where possible	Modern aluminium frames retrofitted with double-glazed panes
P09	R2.6 installed over existing original fibreglass	-	R2 insulation installed where possible	-
P10	Double layers of R2.6 installed throughout	Walls insulated with R2.4	R2 insulation installed where possible	Single-glazed aluminium replaced with double-glazed aluminium

Table 2: Insulation changes in the Papakowhai Renovation Project

Performance

Measuring the total heating energy use is not straightforward as the energy use of each individual heater needs to be measured. For houses with many portable electric heaters, measuring the energy use of each heater becomes arduous and expensive, and so only fixed and higher output heating appliances were monitored where possible.

The Papakowhai Renovation project recorded (Burgess et al, 2008) the energy use of the solid fuel burners present (using the HEEP methodologies; see Isaacs et al, 2010), both portable and fixed gas heating, as well as measuring the electricity use of some of the larger electrical heaters that were on dedicated electrical circuits. Small portable electric heaters were not monitored. The Papakowhai Renovation Project also recorded the overall total reticulated energy (electricity and gas) usage for each house, as well as the living room and bedroom temperatures. Hot water energy use was also separately monitored.

Table 3 is taken from Burgess et al (2008) and indicates the change in winter season energy use and indoor temperatures after the interventions in the nine houses participating in the Papakowhai Renovation Project. The total energy column is the sum of the reticulated energy (electricity and gas), energy from unflued LPG gas heaters and energy from solid fuel heaters, but does not include the energy from solar water heating (P03, P08 and P10). The space heating energy column refers to the solid fuel burner usage, gas heater usage and the usage of separately monitored electric heaters.

The data reported here has been adjusted to account for variation in the external temperature. The method of adjustment for this data was to plot short-term averages of the variable under consideration for each year against short-term averages of the external temperature. The average long-term winter external temperature for Wellington for this period (9.5°C) was then used to determine adjusted values for each year for the variable being considered.

Summary of winter season changes in energy and temperatures							
	Energy					**Temperatures**	
House	Energy intervention cost (excl GST)	Total reticulated energy	Space heating energy	Total energy	Total reticulated hot water energy	Average 24 hr family room temps	Average 24 hr bedroom 1 temps
'High' package homes							
P03	$74,350	Less	Less	Less	Less	Higher	Higher
P10	$71,990	Less	More	More	Less	Higher	Higher
P08	$22,980	Less	Less	Less	Less	Lower	Unchanged
'Standard' package homes							
P01	$19,270	Less	Unchanged	Unchanged	Less	Higher	Higher
P05	$7,415	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Higher
P09	$6,995	Less	Unchanged	Less	Less	Higher	Higher
P07	$5,335	Less	Unchanged	Unchanged	Less	Higher	Higher
'Basic' package home							
P02	$875	Less	Unchanged	Less	Less	Higher	Higher
'Contrast' home							
P06	$1,380	Less	Unchanged	Less	Less	Lower	Lower

Table 3: Statistically significant changes in energy and temperatures

Only in P06 and P08 were the indoor temperatures lower after the intervention. The fall in P06's temperatures can be explained by the presence of five adult members of the household in the first year, reducing to three in the middle year, and two in the final year. There was also absence of the homeowners over extended periods, leaving either one occupant or no-one living in the house. The reason for the fall in the temperatures of P08 were likewise due to occupancy changes, with one occupant leaving home, another spending weekends away, and a reasonably long period where the occupants were away from the house after the renovations had taken place.

The temperatures were higher in the remaining houses after the energy interventions, except for P05 where the temperature in the living room was unchanged. The bedroom temperatures in P05 did show an increase, but all of the energy measures – total energy, reticulated (electricity and gas) energy, space heating energy and hot water energy – in this house were unchanged after the intervention.

After the interventions, the space heating energy use was unchanged except for in the high intervention houses (P03, P08 and P10), each of which also had pre-intervention temperatures higher than average. The space heating energy use was reduced in two of the high intervention houses (P03 and P08) while the third high intervention house (P10) had an increase in heating energy use. The changes (or lack of them) in space heating energy use are strongly connected with the provision of heating service, which will be examined in more detail in the next section.

Total energy increased for P10, but was unchanged or decreased for the other households. The total reticulated energy was less for all houses except for P05 where it remained unchanged.

Observed heating and temperature changes

While there is information to be gained from examining the energy/heating and indoor temperature changes separately, clawback and a fuller picture of the building performance and occupant behaviour is achieved by considering the space heating and indoor temperatures together.

The temperatures within a house will increase, not only from space heater use occurring within the house, but also from the heat given off from other energy uses such as cooking, lighting and other appliances. All energy transformations ultimately end up as heat. However not all of these contribute to increasing the temperatures within a building, for example, a large proportion of the energy going into heating water ends up down the drain.

The interaction between heating and temperatures can be examined by plotting them on a graph with total heating energy on one axis and the indoor temperatures on the other axis. Figure 1 shows some examples. Consider first a house which before an energy intervention used 4,000 kWh of heating and had an indoor temperature of 16.5°C. This could be identified as point X in Figure 1. After the energy intervention, the house could be located at any number of points. Figure 1 presents three alternatives: A, B and C.

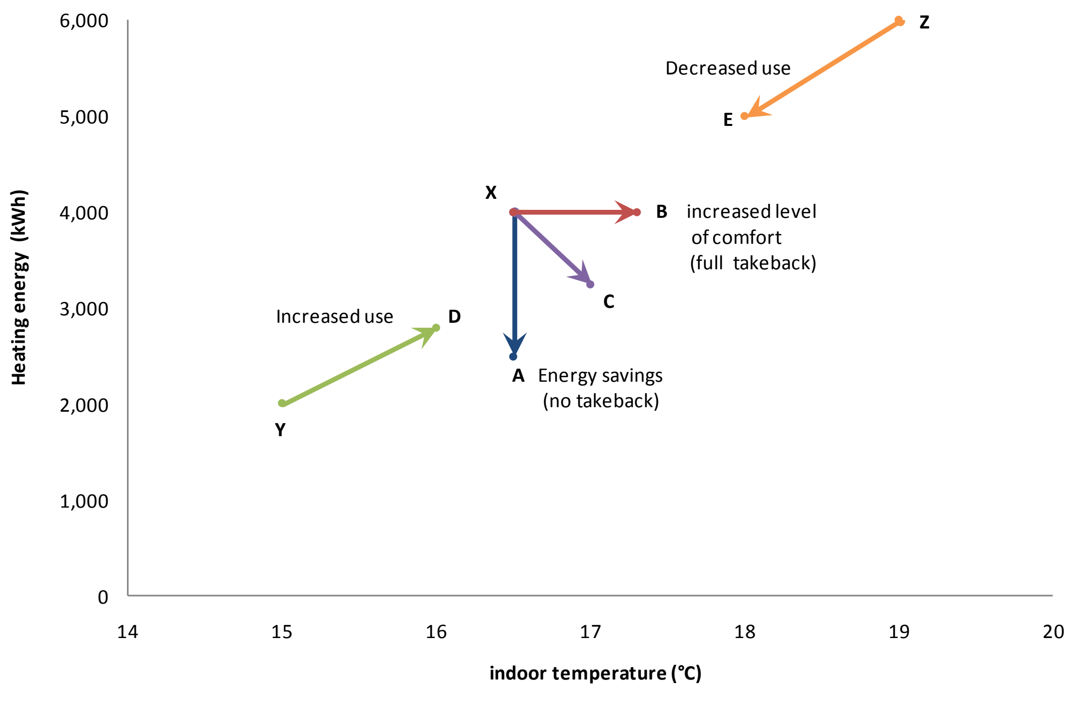

Figure 1: Example changes from hypothetical energy interventions

The first alternative would be to end up at point A. This is where the potential resulting from the energy intervention is fully realised as energy savings, and the upgraded house is heated less to achieve the same temperature levels as before. Consequently, the heating energy used is lower. This outcome results in no clawback of the energy intervention as an improved level of comfort.

The second alternative, B, would be to continue to use the same amount of heating as before which, with the improved building performance, will result in higher indoor air temperatures. This outcome is full clawback of the energy intervention as an improved level of comfort.

The third alternative, C, is the partial clawback case where both the heating energy is reduced and indoor temperatures are increased, but both below the possible levels achievable in either direction if the effort is directed only towards one outcome.

These simple examples assume that the effect of the external conditions before and after the intervention have been taken into account. This is to prevent an outcome such as an increase in indoor temperature after energy efficiency intervention, simply because the outside temperature is warmer, rather than the improved performance of the building and the heating system.

The other variable to consider is the occupant demand for the level of heating service. For example the house at point Y in Figure 1, has a low amount of heating (2,000 kWh) but also reaches a low indoor temperature of 15°C. Should the occupants choose to heat the house more after the intervention, then it may be the case that the house would end up at point D, where more heating energy is used but a higher indoor temperature is achieved. This could be identified as ‘increased use’.

The converse situation is also possible when a house at say point Z, may look to reduce their level of heating service which lowers their heating energy used as well as lowering the indoor temperature, ending up at point E. This would be the case for ‘decreased use’.

Movement to the top and left in Figure 1 would reflect increasing heating energy use and lower temperatures. This unusual situation may reflect a lessening of the building performance or reduced effectiveness of the heating system. The heating system may be less effective if the area being heating is increased so that localised temperatures may be lower. This is not necessarily a bad outcome provided that the localised temperatures are sufficiently warm. Overall this impact could be summarised as ‘changing dynamics’.

The total space heating energy for the Papakowhai houses is calculated as the total energy less the energy going into water heating. The total heating energy use and mean indoor temperature was recorded over the winter season (May to September) and has been adjusted for the varying climates for each year.

Figure 2 shows the change in total space heating energy use and indoor temperatures for each of the Papakowhai houses. The average indoor temperature was constructed from weighting the family room temperature and the bedroom temperature to better represent the temperature throughout the house. The heavy line for each house indicates the changes in total heating energy and average indoor temperature between the first year (before intervention) and the third year after the intervention. The two-step dotted line shows the changes for the intermediate year.

This intermediate year was part-way through the intervention and was more complete for some than for others so cannot be treated consistently. Except for P08, the intermediate year does not deviate greatly from the transition between year one and three, shown by the solid line. In P08 there were major changes to the structure of the household affecting the occupancy of the house as mentioned previously. Table 4 summarises the overall size of the changes and the extent to which clawback or changes in levels of service was observed.

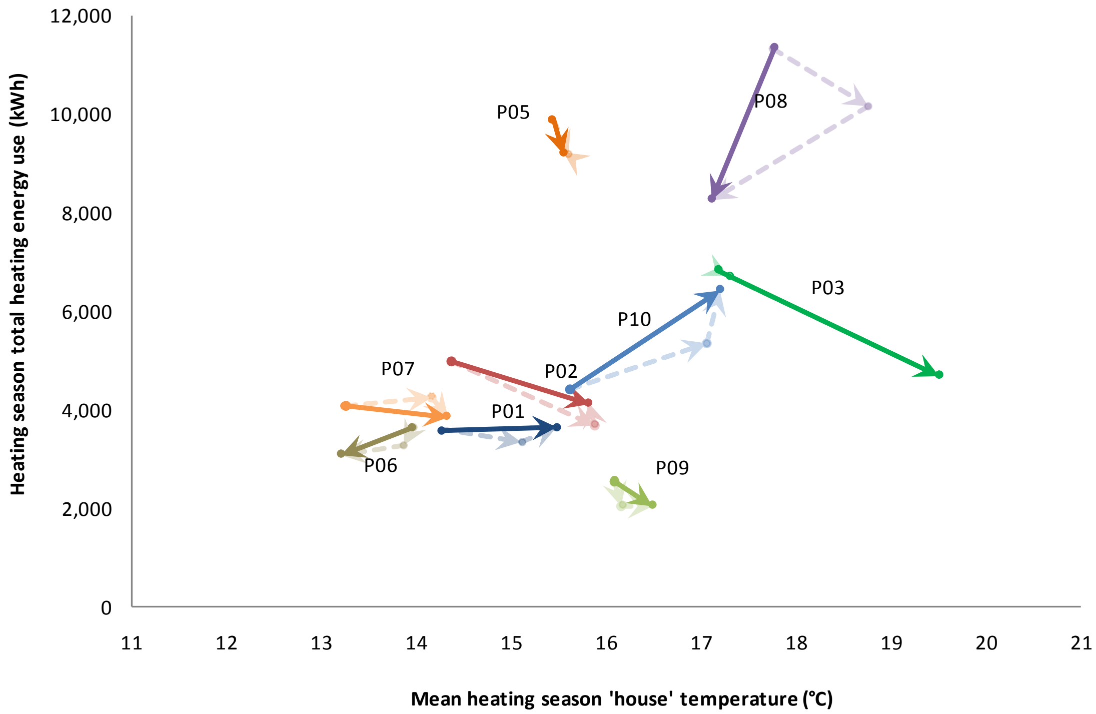

Figure 2: The heating season total space heating energy use and the mean heating season indoor temperature before and after the interventions

House	Size of movement	Change in energy	Change in temperature	Type of movement
'High' package homes				
P03	Large	Less	Higher	Partial clawback
P10	Large	More	Higher	Increased use
P08	Large	Less	Lower	Decreased use
'Standard' package homes				
P01	Medium	Less	Higher	Full clawback
P05	Small	Less	Higher	-
P09	Small	Less	Higher	-
P07	Large	Less	Higher	Full clawback
'Basic' package home				
P02	Medium	Less	Higher	Partial clawback
'Contrast' home				
P06	Medium	Less	Lower	Decreased use

Table 4 Summary of changes in energy and temperature

There are many interesting features in Figure 2 which is dominated by the large movements seen in houses P02, P03, P08 and P10. Except for P02, these are all the high intervention houses, indicating the greater potential for more extensive interventions to make a bigger impact.

The large increase in temperature for P02 with a small reduction in heating energy usage is surprising, given that this house was only subject to a basic upgrade involving ceiling and underfloor insulation. Changing heating habits and reduced moisture levels could be contributing factors in the improved temperatures seen in the house.

The three high intervention houses have overall changes in different directions. P03 shows the typical increasing temperatures and decreasing energy use reflecting an effective upgrade. These changes have been observed despite the fact that P03 had a central heat pump system replace the family room heat pump so that a greater area of the house would have been heated than prior to the intervention.

The shift in P08's total heating energy use and indoor temperatures were from a high base, with the occupants tending to heat a lot using electrical heating methods compared to the other homes. The overall shift involved a decrease of total heating energy use as well as a decrease of indoor temperature. This shift is characteristic of a decrease of service which is matched by the observed reduction in the occupancy of the house in the second year, as mentioned previously. During the first year, noticeably increasing temperatures and decreasing energy, characteristic of an effective energy efficiency upgrade, were observed.

The movement in the P10's total heating energy use and indoor temperatures was in a direction of increasing level of heating service with increased temperatures and increased heating energy use. The pre-renovation woodburner in P10 was in a dilapidated state, and the occupants were reluctant to use it, suggesting that the household was under-serviced by the space heating system.

The renovation package included a new woodburner chosen because of its high efficiency, low emissions, and that it had a wetback system that could complement the solar water heating system. This woodburner was one of the lower output burners available, and was too big for the space unless the wetback was put on. This particular woodburner was unusual in the respect that is had a high ratio of heat-to-water at 50%, so approximately one-half of its maximum heat output would go into water, while the other half would heat the air. Other woodburners were generally 20% or lower, leaving the heat-to-air ratio too high to optimally operate the woodburner. It would have to be run at a low level to avoid overheating, which may result in incomplete combustion and air quality problems.

In addition to P02 and P03, increasing space temperatures with reduced heating energy use is seen in houses P01, P07 and, to a smaller degree, P09.

The calibration of the energy use of the solid fuel burners varies in the level of accuracy from house to house. For P01, the analysis was based on a challenging calibration for the original solid fuel burner, and so the space heating estimates for P01 may be more uncertain than for other houses.

The changes in both P01 and P07 are shown in Figure 2 as reasonably flat (horizontal), indicating the clawback of energy efficiency improvements as increased comfort may be taking place. Both of these households had indoor temperatures that were amongst the coolest in the project.

A pellet burner was installed into P01 during the renovations to replace an old woodburner. The occupants found it to be effective and easy to use, and as a result they began to use it more intensively than their old woodburner. This increased use was ultimately tempered by the higher operating costs of the burner.

The occupants of P07 had described their house as being like a "fridge" (Easton, 2009) before the interventions, with family room temperatures being the lowest of the nine Papakowhai houses. Not surprisingly the data after the interventions showed increased average indoor temperatures suggesting that potential energy savings have been taken up as improved comfort.

The household with the lowest overall total heating energy in the project was the sole occupant of P09. This house had temperatures in the middle of the range seen before the interventions. The effect of the insulation upgrades and the installation of a heat pump to replace an electric plug in heater was a small increase in the average indoor temperatures, while making a sizable reduction in the total space heating energy use for the small amount of initial usage.

P06 experienced a decrease in heating service with reductions in both family room temperature and total space heating energy. As previously discussed, this reflects the reduced occupancy of the house at the end of the study as compared with the start.

The largely unchanged results in P05 could be due to consistency of habits. The top-up of ceiling insulation, however, would be expected to produce higher family room temperatures. This additional heat may have been used to heat the house more extensively. A heat transfer system was installed, but failed to operate as hoped due to the room not being heated to a high enough level to trigger the thermostat-controlled switch. (Further investigation confirmed it was installed and operating correctly.)

Space heating system replacements

The success of a space heating appliance in maintaining adequate indoor space air temperatures – provided that it is of sufficient capacity – is dependent upon the user. All of the houses in the Papakowhai study were considered to have adequately-sized heaters after the retrofit. However the way heating appliances were operated varied. Family room and bedroom temperatures were frequently kept at low temperatures. Although the existing woodburners in P02, P06 and P07 were capable of reasonable outputs, they were not utilised to their full capacity. Upon talking to the occupants, there were three main reasons for under-utilising heating systems:

1. *Budget constraints.* The cost of operating a heating system to a comfortable level can be high. Where fuel for heating has to be purchased separately, this may bring the amount of heating under greater focus and control. P01 did not utilise the pellet burner to the extent they would have liked to as they needed to purchase pellets for the pellet burner where they had previously been receiving free wood for their old woodburner.
2. *Preserving fuel.* Some occupants preferred to preserve their fuel for a variety of reasons, from perceived environmental pollution from burning the wood, through to the “keep for best” (when guests came over) or “keep for a rainy day” (when it gets very cold) mentalities.
3. *‘Comfort’ at cooler temperatures.* Some occupants preferred living in a cool house. In the comfort surveys it became apparent that what occupants called neither cold nor warm (neutral) did not necessarily mean they were content with the temperature (Smith, 2008). Many responses where occupants had said they were neutral also included a report that they would have preferred the room temperature to be a little higher. The Papakowhai Renovation Project illustrated quite well that the “put on another jersey” mentality is alive and well in many New Zealand homes.

As a side note, it was interesting to observe the use of the woodburners in many of the houses. Often, woodburners were used on a low or medium burn rate, when the highest efficiency and lowest particulate emissions generally occur at high burn rates. It appeared that many of the existing woodburners were over-sized and/or under-utilised, and that people may be installing larger woodburners than are required as they perceive it will be better. In reality, a woodburner that is sized for the particular circumstance it is put in will be far more efficient and less polluting. Even today, when looking at woodburners, most retailers have vague guides as to how much space the woodburner can heat. This information appears to be generic around the country, while in reality a woodburner in Auckland could afford to have a far lower output than one, for example, in Invercargill.

Discussion

The amount of clawback of space heating present within the Papakowhai Renovation Project houses is difficult to quantify. The monitoring in the third year, well after the interventions have taken place, ensures that experiences with the change in the performance of the building have settled in. This longer term picture is also subject to households which have a structural change of occupants joining or leaving the household. These changes in the composition of the household are a major factor on the space heating service levels within the household. Studies looking at clawback should pay careful attention to any changes of composition of the household taking place during the period being assessed.

The households with the highest level of increased insulation also tended to be amongst the warmer houses to begin with. These households had the largest changes in energy use and indoor temperatures but these changes were not always in the expected direction. Increased service levels were seen in one of the houses, while another had reduced service levels due to a reduction in occupancy. The extent of the intervention does not seem to be a factor in whether clawback of space heating services takes place.

Those households tending to exhibit clawback, which can be seen as predominantly horizontal movement in Figure 2 (higher indoor temperatures with little change in the space heating energy use), were all amongst the cooler houses before the interventions took place. This is not an unexpected result.

Conclusions

When energy efficiency improvements are made to a household energy service, the energy savings may be realised as energy savings or clawed back by the occupants as an increased level of service over time. This clawback process of taking a higher level of service evolves slowly so needs to be examined over a long period. The extent to which clawback takes place varies considerably.

Space heating services are strongly influenced by the changing household compositions and these need to be understood first.

The households which have lower temperatures are more likely to experience clawback, with their occupants choosing to have warmer houses than those houses which have a higher indoor space temperature.

Extensive upgrades to thermal envelope insulation levels are more likely to see large-scale changes to the space heating energy use and indoor temperatures. This is independent of whether their occupants choose to take a higher level of comfort or not.

The full value of potential reductions in space heating energy use due to improved energy efficiency were not delivered from the homes assessed due to householders clawing back savings as improved comfort and improved levels of service.

It is important to consider the role of clawback in large-scale energy savings programmes and whether these programmes will deliver the savings expected over the long term.

It is postulated that it will only be once the New Zealand housing stock has been improved to provide high levels of comfort and service, that energy efficiency upgrade programmes will deliver the reduced demand that they promise.

References

Burgess, J.C. (Ed)., Buckett, N.R., Camilleri, M.J.T., French, L.J., Pollard, A.R. & Hancock, P.J., (2008). Papakowhai Renovation: Final Analysis. Report for Beacon Pathway, Auckland, New Zealand.

Easton, L. (Ed)., (2009). Papakowhai Renovations: Project Summary and Case Studies. Report TE106/18 for Beacon Pathway Limited, Auckland, New Zealand.

French, L., (2008). Active Cooling and Heat Pump Use in New Zealand – Survey Results. BRANZ Study Report 186. BRANZ Ltd, Judgeford, New Zealand.

Greening, L.A., Greene, D.A. & Difiglio, C., (2000). Energy Efficiency and Consumption – The Rebound Effect – A Survey. Energy Policy, 28, 389-401.

Isaacs, N., Camilleri, M., Burrough, L., Pollard, A., Saville Smith, K., Fraser, R., Rossouw, P. & Jowett, J., (2010). Energy Use in New Zealand Households: Final Report on the Household Energy End-Use Project (HEEP). BRANZ Study Report 221. BRANZ Ltd, Judgeford, New Zealand.

Schipper, L., Unander, F,, Marie-Lilliu, C., Walker, I. & Murtishaw, S., (2000). Indicators of Energy Use and Efficiency in New Zealand in an International Perspective: Comparison of Trends Through 1995. Technical Report, International Energy Agency and Lawrence Berkeley National Laboratory, Paris and Berkeley, France and USA.

Smith, N., (2008). Thermal Comfort – A Pilot Field Study of Thermal Comfort in New Zealand Households. Honours Thesis, Victoria University of Wellington, New Zealand.

World Health Organization., (1987). Health Impact of Low Indoor Temperatures. Report on a WHO meeting, Copenhagen (11-14 November 1985), 19-20.