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Rotorua NOW Home®: Interim Performance Monitoring

Final

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About This Report

Title

Rotorua NOW Home®: Interim Performance Monitoring

Authors

Jaques, R.¹, Mathews, I.¹, Pollard, A.¹

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¹ *BRANZ Ltd, Private Bag 50908, Porirua*

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1 Executive Summary

Beacon, in partnership with HNZC, have a research project based on a NOW Home® in the Rotorua suburb of Fordlands. BRANZ have conducted performance monitoring of the house since it was occupied in October 2006 by HNZC tenants. This document serves as an interim report for Beacon. It outlines the status of the performance monitoring dataset, as much analysis as possible on that dataset, a post-occupancy evaluation of the occupants during the first year of habitation and a comparative analysis with the experience of monitoring performance of the first Beacon NOW Home® in Waitakere.

1.1 Water Consumption

The average of the total water use over the monitored period for the Rotorua NOW Home® is around 798 litres per day. This compares to a total of 755 litres per day usage for the Waitakere NOW Home®. At this stage it is not possible to quantify the amount of water harvested by the rain tank and this will be reported in a later report.

1.2 Internal Environment

To gauge the internal conditions experienced by the occupants of the house the temperature and humidity were measured. As the monitoring has taken place predominantly during winter months the main area of investigation has been to examine whether the house has kept warm enough rather than avoiding overheating.

The temperature levels for the Rotorua NOW Home® are low, being below 16°C for at least 45% of the time over winter. However, the occupants have not explicitly complained of the cold. The temperature and humidity levels of the master bedroom are of particular concern.

1.3 Energy Consumption

The electrical energy consumption between October 2006 and October 2007 is approximately 6,800kWh, or approximately 96% of the general Hamilton/Tauranga figure of 7,095kWh according to HEEP data. All but 22% of the electricity energy end uses can be accounted for. It is too early to tell how much the solar hot water heater is providing in terms of the overall hot water energy use. The Rotorua NOW Home®'s fridge, jug and water pump all use approximately 5% each of the total electricity.

1.4 Post-occupancy Evaluation

There was an overall (but qualified) positive response in terms of the way the house was performing and how the occupants viewed the services being provided. A more clearly positive response emerged as outstanding construction issues had been resolved. Of the 35 specific

sustainability features examined, only four were given a near perfect or perfect score – considerably less than for the Waitakere NOW Home®. These four were:

- house being cool in the summer
- easy to get good air flow through the house
- good natural light (during the daytime), and
- no step shower tray.

1.5 Data Collection

A communications line was not established to the house until May 2007 and data has been collected from the house from this date. There have been some problems with the data collection and some performance aspects of the home were only measured intermittently for the first months of data collection.

2 Performance Characteristics of the NOW Home®

Physical (e.g. water end uses, water flow rates, comfort parameters, and electricity end uses) as well as social (e.g. what the house does and what it provides for the occupants) aspects of the Rotorua NOW Home® are examined in this section. A limited comparison with the previous NOW Home® is provided.

2.1 Water Use

A major sustainable feature regarding water use in the Rotorua NOW Home® is the use of a 4,000L polyethylene water tank that allows rain to be harvested from the roof so that it can be used at a later date. This tank has been buried. Water from the council’s street main feeds the potable water end uses (including the hot water) within the house. The other uses of water within the house, which are normally fed by the rain tank, have been identified as non-potable end uses in this report but may sometimes be supplied by the street main when the tank level is low.

The average of the total water use over the monitored period for the Rotorua NOW Home® is around 798 litres per day which is slightly higher than the 755 litres per day used in the Waitakere NOW Home®. The profiles of the Rotorua NOW Home® water consumption are shown below.

Figure 1 Average daily combined water use

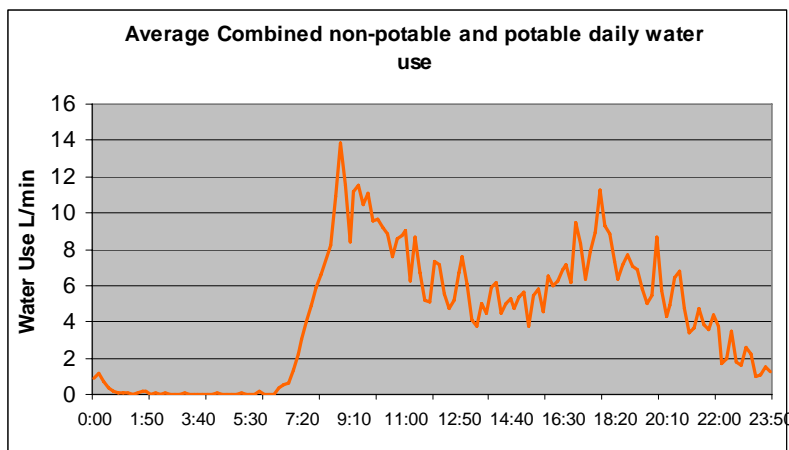
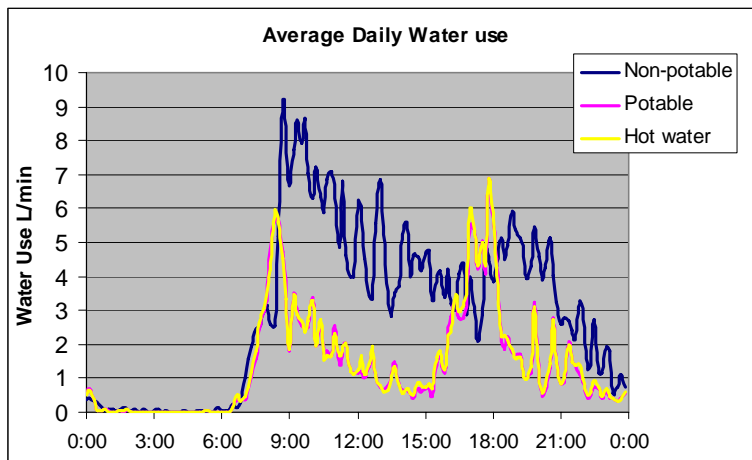


Figure 2 Average daily total water end use



The water use within a house depends greatly on the number of people within the house and water use figures have typically been expressed per person. The occupancy of the Rotorua NOW Home® has varied greatly over the monitoring period – guests have often stayed, a boarder occupied the garage for some time and several large gatherings have occurred where guests have stayed on. However, on most occasions there have been (approximately) four occupants and using this, the average potable and non-potable water use per person per day is 51 litres and 148 litres respectively resulting in a total water use of 199 litres per person per day.

The Waitakere NOW Home® occupants did not optimise their use of the water in the rain tank. For the Waitakere NOW Home®, when the rain water tank was empty it was necessary for the occupants to manually operate a bypass valve to provide mains water for the water end uses usually provided by the rain tank. Once the tank had sufficient water in it, this bypass valve could be switched over to again supply these end uses with tank water. The problem with the Waitakere NOW Home® was that this switching back to the tank water was delayed until there was a large quantity of water in the rain tank and that the occupants had confidence that the tank water was not going to run out again.

The Rotorua NOW Home® made use of an automatic valve called a rainbank which operates so that those water uses that are usually fed from the rain tank can be fed from the council’s street main automatically should the rain tank have insufficient water. The meter for the tank water was placed on the output of the rainbank (the non-potable use) so that analysis will need to be undertaken on the pump operation to determine the proportion of water from the street and from the rain tank and this will be undertaken in a later report.

The total water used by the solar hot water system over the period amounts to 187 litres per day. As this system is connected directly to the street supply it means that 92% of the potable water supplied to the house is heated by the solar water heating system.

Table 1 shows the various flow rates for the two showers in the house. It should be noted that they provide a poor level of service as a result – as a comparison, efficient low flow showers are

expected to have flow rates in the region of 6 litres per minute. Further investigation is recommended to determine its causes.

Table 1 Shower flow rates

End use	Warm flow rate
Disabled shower	1.8L/min
Standard shower	1.6L/min

2.2 Internal Environment

2.2.1 Temperatures

To gauge the internal conditions experienced by the occupants of the house the temperature and humidity were measured. As the monitoring has taken place predominantly during winter months the main area of investigation has been to examine whether the house has kept warm enough rather than avoiding overheating.

Cold indoor winter temperatures have been a problem in New Zealand. To measure the Rotorua NOW Home®'s performance during this period, four temperature/humidity sensors were placed throughout the house as shown in the floor plan in Figure 3. The intention with the Rotorua NOW Home® temperature/humidity monitoring was to capture the ranges of temperature and humidity in the living zones rather than measuring each room as was undertaken for the Waitakere NOW Home®. The main living area had two temperature sensors placed at different heights to explore if there were any temperature stratification issues. Two extremes from the bedrooms were taken, one from the north side (master bedroom) with the other from the south side bedroom. Unlike the Waitakere NOW Home®, no measurements from the bathrooms were made.

Figure 3 Floor plan of the Rotorua NOW Home® showing temperature sensor locations

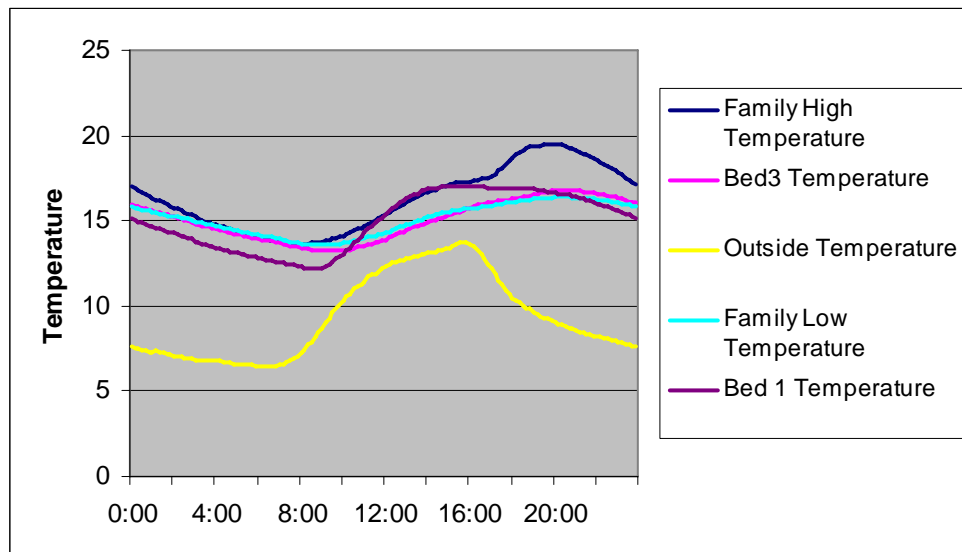


The period of data collection for this report was from 7 May–8 October 2007. However, due to the data collection issues discussed in Section 4, data from 10–18 May 2007, 20–28 June 2007 and from 14 July–19 August 2007 were not able to be collected.

The average temperatures over this period show the house to be kept at a range of 5–10°C greater than the outside ambient temperature. This results in acceptable temperatures throughout the house during the daytime period when averages are kept between 15°C and 20°C. However, this is not adequate to keep the house warm at night. The master bedroom in particular seems cold with an average temperature of about 12°C at 8.30 am.

Figure 4 shows the daily average temperatures in each of the monitored locations.

Figure 4 Average daily temperatures



The following tables (Tables 2 and 3) show how temperatures regularly drop below the 16°C recommended for keeping occupants healthy and that the comfort range of between 20°C and 25°C is only achieved for a small proportion of the time. Occupants have thus far not complained about night-time temperatures.

Table 2 Proportion of the time temperatures are of concern for health reasons

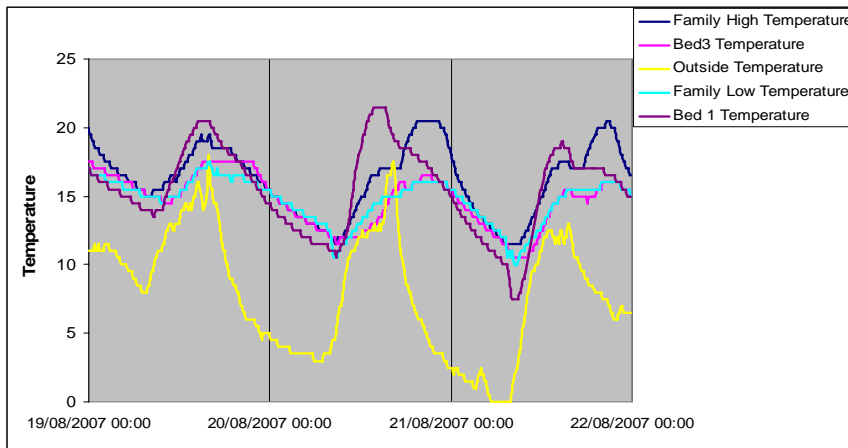
Room	Below 16°C	16–18°C	Above 18°C
Family room (High)	46%	26%	29%
Bedroom 3	62%	29%	9%
Family room (Low)	62%	33%	5%
Bedroom 1	59%	24%	17%

Table 3 Proportion of the time temperatures are within comfort limits

Room	Below 20°C	20–25°C	Above 25°C
Family room (High)	88%	12%	0%
Bedroom 3	99%	1%	0%
Family room (Low)	100%	0%	0%
Bedroom 1	97%	3%	0%

The picture given by analysis of the coldest three days (19–21 August 2007) is concerning with a low of 7°C reached within the master bedroom on 21 August. However, it is likely that the operation of the pellet heater improves the family room temperatures and further analysis of the pellet burner will be provided in the future.

Figure 5: Temperatures from 19–21 August 2007



2.2.2 Relative Humidity

Relative humidity (RH) measurements were taken at one minute intervals by the same loggers used to measure temperatures. Relative humidity affects the comfort and health of the occupants of the house. Acceptable levels of humidity within a house vary dependant on temperature. However levels between 20–70% relative humidity are generally classed as acceptable.

The average daily humidity level over the 7 May–8 October 2007 monitoring period is shown in Figure 6 where it can be seen that the most of the average humidities are below the 70% level. The exception is the master bedroom where the relative humidity in the early morning is above 70%.

Figure 6: Average daily relative humidity

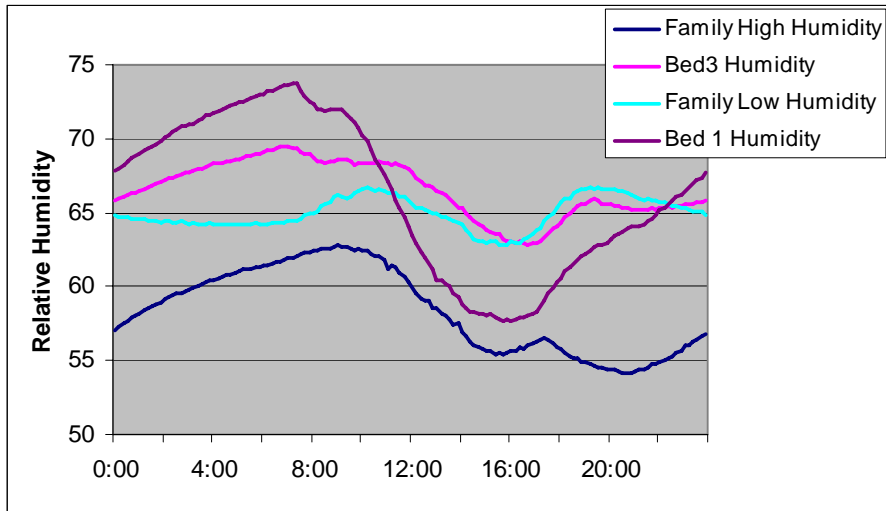


Table 4 shows the proportion of time the relative humidity is between 20–70% and above 70%. Below 20% has not been included in the table as the minimum for all rooms is above 20%. The upper bound is breached quite regularly in the master bedroom but there are also many times when the humidity in bedroom 3 and the lower part of the living room are outside this recommended health and comfort band.

Table 4: Proportion of time humidity is of concern

Room	20–70%	Above 70%
Family room (High)	97%	3%
Bedroom 3	74%	26%
Family room (Low)	78%	22%
Bedroom 1	60%	40%

It should be noted that the occupants did not complain of any condensation problems in the house, as part of the Post-occupancy Evaluation.

2.3 Electricity Energy Use

Electricity use for the Rotorua NOW Home® was evaluated over the period of late September 2006 through to mid October 2007, accounting for just over a year's operation (381 days in total). The breakdown of the energy end uses, in percentage and absolute values, can be seen in Table 5 along with a comparison to the first year of monitoring of the Waitakere NOW Home®. A graphical comparison of this data is given in Figure 7. The values have been scaled down to give annual figures.

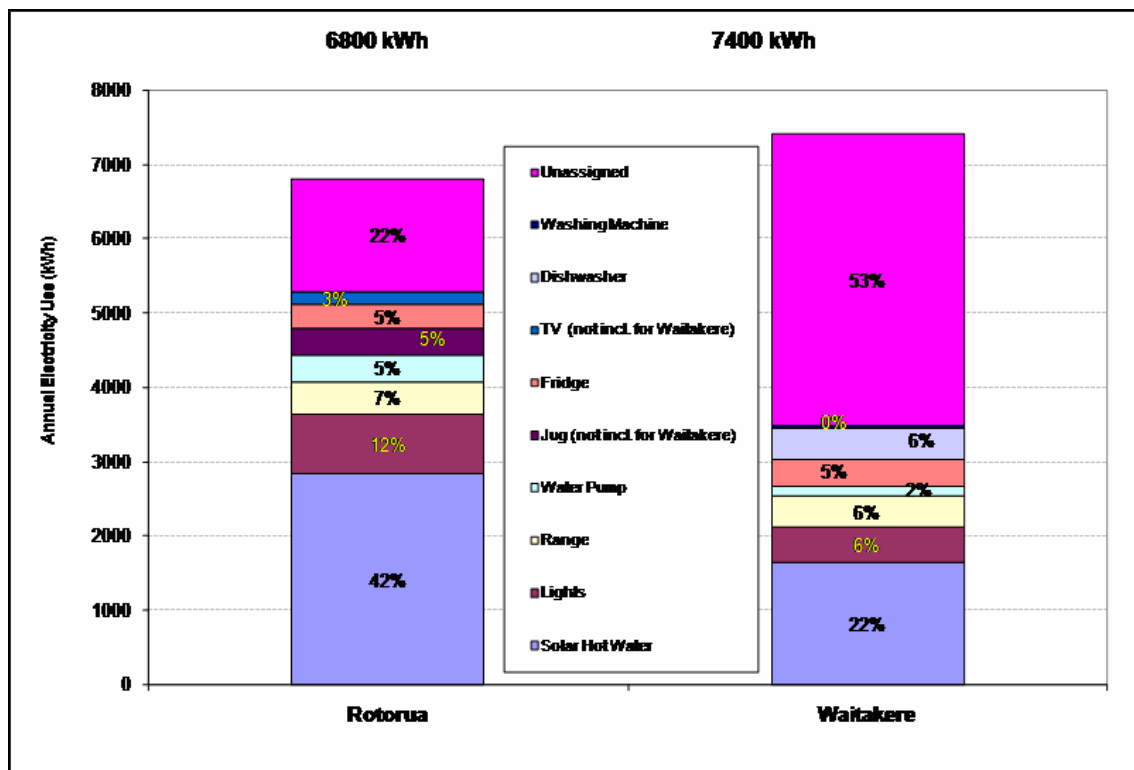
Table 5: Electricity end uses over year period (by percentage and absolute values)

End Use	Rotorua NOW Home®		Waitakere NOW Home® Year 1	
	Percentage	kWh/yr	Percentage	kWh/yr
Hot water	41	2,827	22	1,640
Lights	12	802	6	466
Range	7	445	6	414
Water pump	5	358	2	139
Jug	5	355	na [†]	
TV	3	177	na [†]	
Dishwasher	- [‡]	- [‡]	6	426
Fridge	5	320	5	360
Computer	na		na	
Washing Machine	na		Na	30
Unassigned	22	1,514	53	3,926
TOTAL	100	6,798	100	7401

[†] The TV and Jug were not separately monitored so are included in the Waitakere NOW Home®'s unassigned category

[‡] The Rotorua NOW Home® does not have a dishwasher

Figure 7 Electrical end use comparison between the Rotorua and Waitakere NOW Homes®



The following issues stand out when comparing the electricity usage between the Rotorua NOW Home® and the first year of the Waitakere NOW Home®:

- The **solar water heater** is using a much higher proportion of the electricity in the Rotorua NOW Home® than is the case for the Waitakere NOW Home®.
- The **water pump energy use figures** are considerable, approximately equal to that of the jug and fridge energy requirements. In straight energy terms, this is the equivalent of running a 40W bulb continuously for a whole year. When compared against the product literature figures that came with the pump, there is a large discrepancy between quoted and actual values. As a comparison, the Waitakere NOW Home®, which has a similar overall annual energy use, only used 2% on pumping water.
- The **percentage of “other” electricity end uses** is considerably reduced compared to the Waitakere NOW Home® – down from 53% to 22% of the all electricity energy end uses breakdown. This is encouraging, as it means that by far the majority of the energy end uses is being captured. Over the next monitoring period, this gap will reduce as further monitoring equipment has been installed on other appliances.
- The percentage of end use energy attributable to **lighting** (at 12%) is considerably more for the Rotorua NOW Home® than the Waitakere NOW Home® (at 6%). This difference could be due to the differing lighting arrangements or to differences in occupant behaviour.

- It is estimated that running the **pellet burner** over the “winter time” (more accurately described as the “heating season” as it is longer than just three months) makes up a sizable portion of the “other” end uses. Testing has shown that the pellet burner requires a minimum of 250W – to power the control panel, the fan and the auger. In addition, approximately twice this amount of power is required during the ignition process – however this process is relatively short lived.

3 Post-occupancy Evaluation

3.1 Overview

Quarterly post-occupancy evaluation (POE) surveys have been carried out for the Rotorua NOW Home® in Fordlands, as part of the one year longitudinal (monitoring) studies being conducted over the 2006/07 year period. The POE surveys used in the Waitakere NOW Home® were of the same methodology as those applied to the Rotorua NOW Home®. The objective seeks to determine the more difficult to quantify sustainability issues which are more social and qualitative in nature, and complement the intense physical (quantitative) monitoring of the building.

Issues being examined by the POE include:

- use of local transportation facilities
- use of local amenities in close proximity
- use of landscape for food
- occupants' comfort
- occupants' perceived security
- occupants' mould-risk behaviour

In addition to capturing the occupants' opinions and relating them to the measured physical performance, the emphasis of the POE for the Rotorua NOW Home® is also on ensuring that we have a practical, repeatable methodology which can be applied in a cost-effective manner to all future NOW Homes®.

3.2 Method

There were several key goals that the research project wanted to achieve. These included:

- building upon the research methodology and findings of the Queensland Research House and the Waitakere NOW Home®
- making the data collection as easy as possible, while gathering maximum information
- being as minimally intrusive to the occupants as possible, e.g. ensuring the quarterly survey could be easily completed within an hour by the occupants
- allowing for the option to refine after the first interview by slipstreaming further interviews with a particular set of interviewees, yet initially applicable for a wide range of subjects so that the template can be used for all NOW Home® occupants.

The questionnaire methodology was based on that by J. Aronson, 1994, detailed in 'A pragmatic view of thematic analysis'². This approach, used by the Queensland Research House social

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² *The Qualitative Report. Vol. 2 No. 1.* (www.nova.edu/ssss/BackIssues/QR2-1/aronson.html)

scientists, was fine-tuned by social scientist and research psychologist Stephen McKernon³, using the well recognised social systems-based “differences and effects” based-questions.

The first occupant interview was carried out in November 2006 approximately six weeks after occupation. Due to extreme difficulties in contacting the occupants to arrange interviews, only the principal adult resident was interviewed for the four quarterly surveys.

The interviews were usually about 35–45 minutes long, thereby fulfilling one of the design objectives of ensuring that the surveys were less than one hour in length. There were a range of questions asked of the occupants. They can be grouped into:

- 1) **Simply quantitative**, for example, “How many people have lived in your household for the last three months?”
- 2) **Generic and open ended**, such as, “How do you feel about the house and living in it overall?” A longer answer would be expected here, as an introduction to the next set of questions.
- 3) **Specific and quantitative**, assessing the differences and effects. i.e. “Which specific features are making a difference for you and how do you rate it on a scale?” A short scale (1–10) was used as an indicator.

In all, the 35 specific features were examined. The features can be grouped into the following categories⁴:

aesthetics	noise
space	security
privacy	running costs
comfort	water
airy	ways of dealing with rubbish
lighting	things that the household does

In all, four interviews (i.e. surveys) were undertaken as part of this review over nearly the period of a year, using the same questions and approach as for the Waitakere NOW Home® occupants.

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3 Of Supplejack Consultancy.

4 Unlike the University of Queensland approach, where recurring themes were combined and catalogued into sub-themes, the NOW Home® research already had identified 12 categories.

3.3 Findings

In terms of how the house has been performing and the services provided by (and surrounding) it, the tenants gave mixed views. When asked about the house and living in it overall, a rating of 10 was given – representing “extremely different”. The differences in the house itself which were repeatedly mentioned were:

- good large bathroom
- sunlight coming through the whole house
- no dampness (excepting the temporary leak to the roof)
- quite warm throughout the house when sunny
- the indoor/outdoor connection to the outside
- its looks from the outside

Of the 35 specific features examined, most features (on average) were making a positive difference for the tenants (as represented by the principal adult). The areas which were making a positive difference were:

- aesthetics (looks from the outside, looks from the inside)
- space use (interior layout, indoor/outdoor flow)
- comfort (cool in summer)
- airy (fresh/airy feel, easy to get good airflow)
- lighting (natural light, artificial light)
- ways of dealing with rubbish (composting, recycling)
- other features (no step shower tray, extractor fans)
- things that the house does (walking to shops, schools, etc)

The areas in which the tenant had mixed or negative feelings, in terms of making a difference, were:

- space use (spaciousness)
- privacy (privacy from neighbours and people outside, and privacy for personal times and places within the house)
- security (feeling safe and secure)
- other features (wide doorways, extractor fans, concrete floor)
- things that the house does (using the clothesline)

Perfect or near perfect (positive) scores (i.e. a 9 or 10) for *all* of the interviews were given to the following specific features of the house⁵:

- cool in summer
- easy to get good air flow
- _____

5 It should be noted that the responses to some issues varied considerably, due to the changes made while occupying the house – e.g. the extract fan installation and the fixing of the pellet burner.

- good natural light (daytime)
- no step shower tray

Compared to the Waitakere NOW Home®, considerably more of the 35 specific features were given the perfect or near perfect scores – with 19 of them achieving a 9 or a 10 rating for all interviews during their first year of occupancy. To overview the thematic areas of the specific features, refer to Table 6.

Table 6: Summary of overall response by thematic area

Feature	Overall Response
Aesthetics	positive
Space	positive
Privacy	neutral
Comfort	positive
Airy	positive
Lighting	positive
Noise	positive
Security	negative
Running costs	unknown
Water	unknown
Ways of dealing with rubbish	positive
Other features	negative
Things the house does	positive

The least appreciated house features were:

- **The overall quality of the work.** There were a number of finishing-related faults, many probably due to the very compressed nature of the construction period and compounded by the perhaps overly fussy nature of the tenant. These included:
 - extractor fan over hob was not finished until several months after the building
 - an improperly cured slab floor polyurethane finish which is easily marked, scuffed and scratched by the tenant, resulting in a shabby look
 - poorly built divider (trellis) fence which is both an eyesore and fragile and which has not been correctly lined up with the house

- unfinished paint covering to the skirting, and blotchy paintwork in the hallway
- door handles coming loose and not working properly
- a clothes line which is poorly positioned and unusable *without* a step ladder and a safety hazard *with* a step ladder

■ **Other functionality issues of the house.** These included:

- a pressure drop while showering when someone turns a tap on
- slow/low pressure taps (taking a very long time to fill a jug or bath)
- security issues – the main road boundary fence is too low, making it too easy for people to walk over it
- restricted storage space (which is probably more reflective of the occupant, who collects like a magpie)

In all, the house is/was liked by the occupants, though to a considerably lesser extent than the Waitakere NOW Home® owners like theirs. Another notable feature is the more dynamic nature of the occupants of the Rotorua NOW Home® – largely a reflection of the construction-related troubleshooting that was carried out several months after occupation. Examples of this included:

- the hob air extract being connected
- the various door handles and taps that were loose or quickly worked loose
- the leak in the internal gutter system
- lack of section fencing

3.4 Conclusions

After approximately a year's dwelling in the Rotorua NOW Home®, there is a fair degree of satisfaction experienced by the principal adult occupant. Aspects of the home's space usage, airiness, aesthetics and light (amongst others) were very much appreciated. However, there were several aspects of its finish and day-to-day performance that the occupants thought were lacking, especially in the care with which the coatings were finished, privacy and security. Some of these issues could be remedied easily, while others would require significant investment in resources to change.

In terms of how the Rotorua NOW Home® compares with the Waitakere NOW Home®, it seems that the Waitakere occupants like their house considerably more than their Rotorua counterparts. Certainly, looking at the specific features of the NOW Homes®, the Rotorua representative gave only four perfect or near perfect scores, versus nineteen for the Waitakere representative.

4 NOW Home® Data Monitoring

The Rotorua NOW Home® is a first stage in simplifying the monitoring setup for the NOW Homes® and a comparison of the range of measurements between the Waitakere NOW Home® and the Rotorua NOW Home® is shown in Table 7. The Rotorua NOW Home® will provide valuable benchmarking data for other housing projects and there is much to be gained from comparisons between the Waitakere and Rotorua NOW Homes® as well as other households. This comparison is best done on data that has been collected at the same time as broader national influences (electricity shortages, higher interest rates) can be discounted.

Table 7 Comparison of the monitoring between the first two NOW Homes®

	Waitakere NOW Home®	Rotorua NOW Home®
Temperature/ humidity	Two in family room, one in each main living room, & one in main bathroom (14 channels)	Two in family room, plus two to cover bedrooms (8 channels)
Water	Each end use separately metered (24 channels)	Street (potable), tank or street supply if required (non-potable) and solar (3 channels)
Electricity	Total, SHW supplementary heating, range, lights, refrigerator freezer, solar pump, dishwasher, tank pump, monitoring equipment, washing machine, four appliances (14 channels)	Total, SHW supplementary heating, range, lights, refrigerator freezer, rainbank, monitoring equipment, two appliances (9 channels)
Other temperatures	Hot water, cold water, tempered, cylinder, solar feed, solar return, north wall framing, south wall framing, outside temperature and humidity, reference junction (11 channels)	Hot water, cold water, outside temperature and humidity (4 channels)
Other measurements	Family room CO ₂ levels, solar insolation, tank level, security system, south & north wall framing conductivities, hot water availability (14 channels)	-
Total data channels	77	24

The operation of the wireless data collection technology in the Waitakere NOW Home® has generally been pleasing and is used more extensively within the Rotorua NOW Home®. The electricity and water data, which were measured with a sophisticated Agilent® 34980A Data Logger in the Waitakere NOW Home®, were instead measured using the Point 6 wireless system in the Rotorua NOW Home®. Other differences were the use of a thermistor to record the use of the pellet burner and the use of a USB thermocouple card to record the supply and return temperatures of the solar water heater accurately.

A key improvement between the Waitakere NOW Home® and the Rotorua NOW Home® has been the improved accessibility of the equipment. In the Waitakere NOW Home® the computer system and Agilent Data logger were placed under a shelf in the hot water cupboard as seen in Figure 8 which made adjustments of wiring difficult. The accessibility of the Rotorua NOW Home® computer (Figure 9) has been improved with greater space available as well as having the cupboard located in the garage which is less intrusive for the occupants of the house.

Figure 8 *The accessibility of the monitoring equipment in the Waitakere NOW Home® is difficult and working on the computer for more than one hour is difficult*



Figure 9 *The accessibility of the Rotorua NOW Home® monitoring equipment has been much improved*



The computer system in the Waitakere NOW Home® was set to email data from the house back to BRANZ on a daily basis. As it continued to operate, the system failed to reliably send information back to BRANZ with the daily data files being accumulated on the computer. While no data was being lost, feedback on the status of the monitoring of the Waitakere NOW Home® was limited to the site visits made. In looking to improve on this system for the Rotorua NOW Home®, in addition to the process of sending the daily data files, the Rotorua NOW Home® was configured (post occupancy) for “Remote Desktop Connection” which allows full control of the computer to be undertaken from a remote site, such as the BRANZ laboratories, and allows for software reconfigurations, some diagnostics as well as the data files to be retrieved without the need for a site visit.

An internet connection was an integral component of the data collection process and with the delays of having a phone line installed this seriously delayed the start of the monitoring programme. Monitoring requirements such as the provision of a phone line need to be clearly identified at an early stage within the project.

The monitoring equipment in a NOW Home® is a key component of the house and allowance must be made between the completion of the house and when the house is occupied so that the monitoring equipment can be installed and fully tested before access is restricted by having to make allowance for the occupants of the house. The original intention in the Rotorua NOW Home® was to have a two week period between completion and occupation. However, this period had to be compressed into approximately a two and a half day period around when the house was occupied. The lack of a full testing period has had knock-on effects for the project as a whole. Some of the problems that could have been more quickly resolved given a longer testing period caused were:

- the Point 6 server software, which has operated very reliably in the Waitakere NOW Home®, causing unexplained intermittent faults resulting in sporadic data collection
- connection problems between the Point 6 pulse units and the Siemens meters
- connection problems between the computer and USB thermocouple card
- The thermistor recording the pellet burner use being damaged at time of installation and requiring replacement

Once the Rotorua NOW Home® was occupied there was still a need to visit the house to attend to the monitoring system. The ongoing and continual difficulty in reaching the principal occupant at any time has made forward planning for the research team (e.g. flight bookings) a real challenge.

5 Recommendations

As with any complex field research dealing with both physical and behavioural aspects, there are many challenges which are translated into useful learning opportunities. The Rotorua NOW Home® is no exception. The following overviews the key challenges encountered and provides some possible recommendations that could be implemented for subsequent studies of a similar nature.

Challenge #1: The trades (e.g. the plumber) didn't communicate to the research team when the installations would be carried out making determination of the plumbing diagrams (e.g. for the town versus rainwater monitoring, setting up the correct equipment) unnecessarily difficult and time consuming.

Recommendation: That specifications for future NOW Homes® have explicit requirements that all (monitoring) effected trades must inform the research team when critical construction milestones are achieved, to maximise the chances of effective co-ordination and facilitate the monitoring process. This could be further assisted by the research team having an explicit checklist of items which was available to all parties on site which could be checked off as the construction progressed.

Challenge #2: A research house that has a complex system of monitoring equipment demands a reasonable testing period, which needs to be carried out before occupancy. This is critical for testing, wired and wireless communications, internet connectivity and data capture.

Recommendation: All future NOW Homes® build a reasonable testing period into their timeline – specifically, between construction and occupation as a compulsory item. This would include a final inspection of the house – to check operational matters of the house itself. In addition, it is highly recommended that the research team liaise with the occupants to go over the monitoring equipment, to ensure that everyone is comfortable with any technology used.

Challenge #3: Communication with the occupants was hampered by unwillingness to respond to calls, therefore making any planning extremely difficult, especially when long travel is required by the monitoring team.

Recommendation: It is essential that suitable home dwellers are chosen as part of the vetting process. They must be willing participants and be reasonable at communicating (i.e. responding) to occasional requests for visits etc.

Challenge #4: The Rotorua NOW Home® did not have a landline phone connection due to HNZC policy, which was critical for the monitoring equipment.

Recommendation: That future NOW Homes® have a clear set of communication protocols that all partners understand and accept (preferably within a formal contract) early in the research project, to minimise compromises later due to time/resource/political or other constraints.

Challenge #5: The under performance of the Rotorua NOW Home® with regard to specific services (hot water system having unacceptably low flow rates and the pellet burner having considerable operational problems).

Recommendation: A “technical” review of the house before, to ensure that the systems (e.g. plumbing, heating), products (e.g. concrete floor coating) and technologies (e.g. solar hot water system, pellet burner) are operating correctly with a high level of efficiency.