

# **NO102/2**

## **WAITAKERE NOW HOME**

### **PERFORMANCE MONITORING –**

### **SIX MONTH REPORT**

**A REPORT PREPARED  
FOR BEACON PATHWAY LIMITED**

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# WAITAKERE NOW HOME PERFORMANCE MONITORING – SIX MONTH REPORT

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## REFERENCE

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## **1. EXECUTIVE SUMMARY**

The Waitakere NOW Home in New Lynn has now been occupied for approximately six months, over the 2005/6 summer. In a typical home there are seasonal variations in residential energy use with generally higher energy consumption in Winter than Summer (due to increased heating, lighting and the use of other services). It is expected that water use may also be subject to a seasonal patterns. As the monitored period for the NOW Home has been predominantly over the summer period, accurate annual estimates of the NOW Home energy and water use can not be made, however in order to provide some indication of how the NOW Home is performing, estimated figures of the energy and water use are provided. It should, however, be remembered that these estimated figures are preliminary and may be subject to change. This report provides a high-level view of the basic performance of the home and its sustainability features for this period, and also the views of the occupants via the first of four post-occupancy evaluations.

### **1.1 Energy Consumption**

The annualised indicative energy consumption is approximately 6000kWh, approximately half the general Auckland figure of 11800 kWh (annual Auckland figure includes all purchased sources of energy, including solid fuel, gas, etc).

All the hot water needs are currently being met with energy from the sun via the Solar Water Heater.

There is a broad range of appliance use within the NOW Home and further equipment and analysis to examine this may be beneficial.

### **1.2 Water Consumption**

The water use in the NOW Home has varied considerably over the monitored period. The average of the total water use over the monitored period for the Now Home is around 820 Litres per day. Water harvesting from the roof supplied approximately 270 Litres per day over this period thereby reducing the water required from the council water main to approximately 550 Litres per day reflecting approximately 25% less water consumption from the council supply than the average home.

### **1.3 Internal Comfort**

A vertical temperature array was placed in the living room of the NOW Home during February. This contained six temperature sensors spaced at different heights from the ground. Whilst "comfort" is a difficult measure to define in reproducible scientific terms, the measurements obtained suggested that the room air was well-mixed and of even temperature. Temperature sensors throughout the rest of the home also indicated that there were no strong systematic temperature variations throughout the house.

The temperature levels for the NOW Home appear to be sometimes high however the occupants report that they find the NOW Home comfortable making use of the large folding glass doors when the temperature is warm.

### **1.4 Post-Occupancy Evaluation**

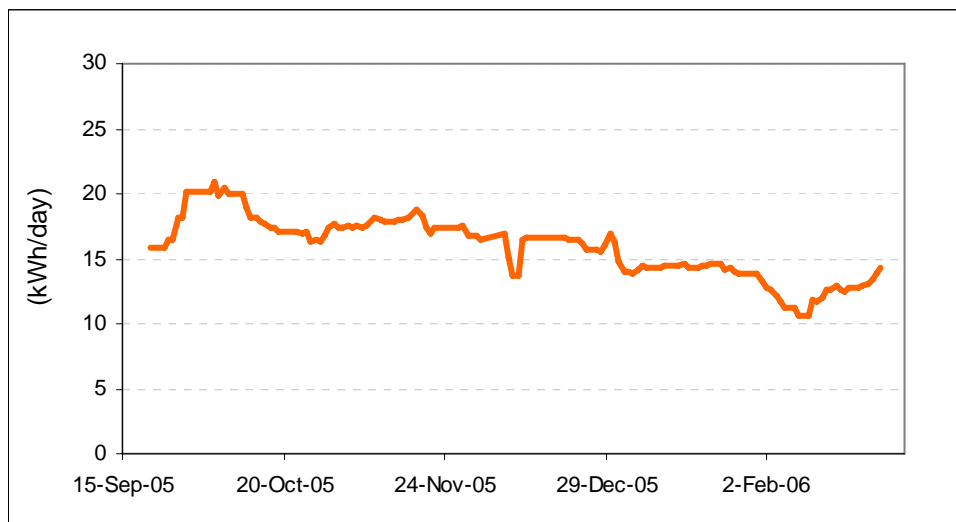
There was an overwhelming vote of confidence for the way the house was performing, and the services surrounding it. Of the 35 specific features examined, for example, only two were seen as making a negative difference for them (there were three others that were termed 'not applicable'. The responses for the other features were either a very positive or perfect.

Currently, (in the first 4 months of operation) there is a very high satisfaction by the occupants in the everyday performance of the Waitakere NOW Home. Even though this is an initial report produced after only a few months of building occupancy, the findings for this live-in, real world family are encouraging. For scientific completeness, it should however be noted that these results may change with time.

## 2. PERFORMANCE CHARACTERISTICS OF THE NOW HOME

BRANZ experience with the HEEP project provides substantial insight into the difficulties of predicting the energy consumption of a household based on measurements undertaken over a short duration. The summer/winter temperature differences in NZ are sufficiently high to require heating in the winter months in most of the country's dwellings. However, given that the NOW Home is designed to minimise the need for additional heating and cooling, additional winter heating load for the NOW Home should not be large. It is expected that there will be additional winter electricity usage for lighting and there may be other additional electricity use due to increased use of other services. The results of the Post-Occupancy Evaluation presented below give some weight to this: the home would seem to be performing as designed.

Overall energy consumption is an important measure of residential sustainability and Figure 1 gives the trend of the daily electricity consumption of the NOW Home over the first six months of monitoring. From examining this trend, a likely annual electricity consumption, assuming no large increase in winter consumption, may be of the order of 6000 kWh per year. The NOW Home monitoring equipment uses an additional 4 kWh per day which has been removed from this estimate however this level of 'free heat' will be generated within the house.

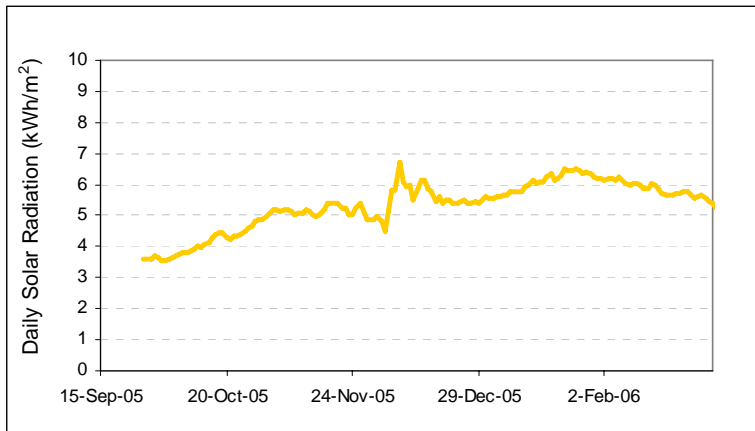


**Figure 1 Trend of the daily total electricity use (some missing data)**

Isaacs (2004) reported that the average electricity consumption for the Auckland sample of the Household Energy End-use Project (HEEP) was approximately 7900 kWh per year. It is important to consider the total energy use of a household as many other energy sources are used (especially for space heating, water heating and cooking) in addition to electricity. Isaacs, et. al (2006) states that nationally 67% of the energy used in households is electricity with the remainder including solid fuel, natural gas, LPG and oil. Using this fraction and the Auckland electricity use figure, provides an estimate of the total household energy use in Auckland as 11800 kWh per year. The NOW Home could then be said to be using approximately half the purchased energy than the average home in Auckland. It should however be remembered that this HEEP figure includes houses of all ages and that it may be expected that newly constructed houses would perform better from a space heating and cooling perspective.

Water heating is typically a major component of electricity use in New Zealand households. Isaacs (2004) reports that 28% of the electricity consumed in the Auckland HEEP sample is used for water heating. The NOW Home makes use of a solar water heater to reduce its water heating requirements and this solar water heater is currently providing all of the water heating needs without the need for

any electrical boosting. A graph of the trend of the solar radiation measured adjacent to the Now Home solar collector is shown in Figure 2. As the house moves into cooler weather, the solar radiation available to heat the water will reduce and use of electric boosting is likely to be required.



**Figure 2 Trend of the daily solar radiation received**

There are a high number of energy services (ie lights ,cooking, refrigeration) within the NOW Home and it must be remembered that each of these services will have an energy consumption regardless of how efficient the appliances are that are delivering the service. For example, the NOW Home includes a dish washer, an appliance which is not always present in house<sup>1</sup>, but which consumes more energy than the NOW Home refrigerator, an appliance type which is closely examined for energy performance.

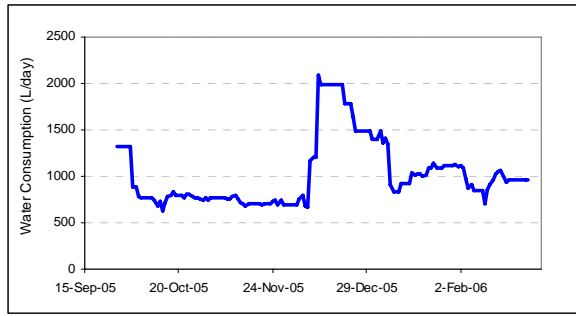
The occupants play an important role in determining how much energy is used within a house, particularly how appliances are used. The high appliance use within the NOW Home was not anticipated. Measurements were focused on the ‘fixed’ appliances (and services) such as the range, lights, refrigerator, dish washer and the pump for the rain tank water and it may be beneficial to extend the appliance monitoring to better understand the electricity use in the NOW Home.

## 2.1 Water Use

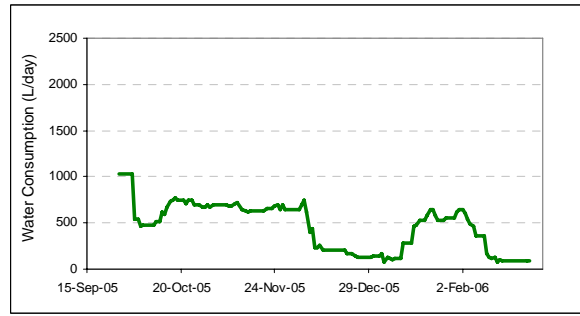
The NOW Home has a 13500 L water tank that allows rain to be harvested from the roof so that it can be used at a later date. Water from the council’s street main is fed straight to a number of outlets in the house (such as the kitchen sink), while other outlets, such as the outside taps, are fed from the rain tank. When the tank level gets low a manual valve can be operated so that those water uses that are usually fed from the rain tank can be fed from the council’s street main.

The trend of the daily water consumption is given in Figure 3. It should be noted that the day to day variation about this trend line is large. The trend itself is also subject to a large variation reflecting varied water use by the NOW Home occupants. The use of the tank water is shown in Figure 4 and also similar variations.

<sup>1</sup> 39% of households in 2001 had dishwashers - see p27 in Isaacs et al, 2002



**Figure 3 Trend of the daily total water use**



**Figure 4 Trend of the tank water use**

There is little information available on the average consumption of water for households. The Auckland Water Management Plan (Water Care Limited, 2004) notes that residential consumption per person is around 183 Litres per day so for an average four person household in Auckland, 730 Litres of water per day may be expected to be used.

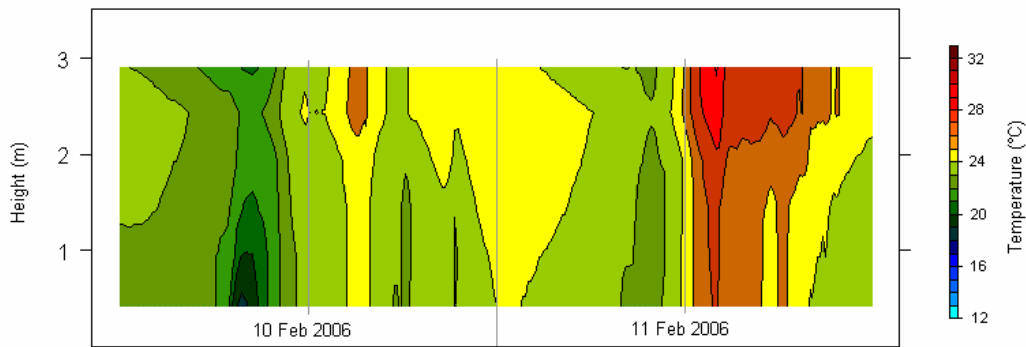
With the large variations in the daily water use it is currently difficult to estimate the amount of water used in the NOW Home, although these variations will become less of a feature as more data is collected. The average of the total water use over the monitored period for the NOW Home is around 820 Litres per day. However the water harvesting from the roof supplied approximately 270 Litres per day over this period thereby reducing the water required from the council water main to approximately 550 Litres per day reflecting approximately 25% less water consumption from the council supply than the average home.

## 2.2 Temperatures

Summertime overheating in New Zealand houses is becoming an increasingly important topic. A series of temperature sensors were placed at different heights inside the living room of the NOW Home during February. Figure 5 shows the temperature (given by a colour shade matching the scale on the right) at a variety of heights over the course of two days (read from left to right for elapsed time – midnight is at the edges and in the centre of the plot). While there are some periods of elevated temperatures, the temperatures appear to be reasonably uniform with height and there are not large temperature differences between the sensors at 0.4 m above the ground and the sensors at 2.9 m above the ground.

The NOW Home has a large amount of glazing that can be opened (folding doors) which may assist with improving comfort conditions when the house is subject to elevated temperatures. The post occupancy evaluation (POE), revealed no dissatisfaction of the occupants with the thermal environment so this control strategy seems to be effective

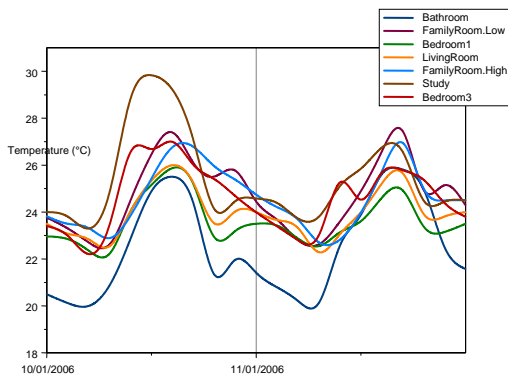




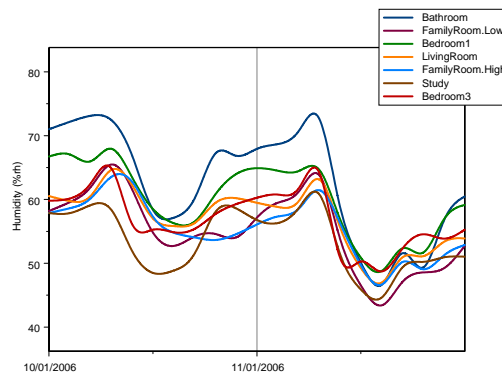
**Figure 5 Vertical temperature profile within the living room of the NOW Home**

The temperatures throughout the NOW Home over the same two days in February are given in Figure 6. The relative humidities for these two days are also given in Figure 7. While the temperatures and relative humidities appear to follow the external weather trends there are some variations depending on where the sensor is located. The sensor in the bathroom as expected tends to have a lower temperature and higher relative humidity than the other sensors however during the afternoon of the 12<sup>th</sup> February is comparable.

Other than temperatures being too hot or too cold, dissatisfaction with the thermal environment can arise when there are large temperature differences between within a room between room surfaces and between rooms which does not appear to be the case in the NOW Home.



**Figure 6 Temperatures throughout the NOW Home over the course of two days**



**Figure 7 Relative Humidities throughout the NOW Home over the course of two days**

### 3. POST OCCUPANCY EVALUATION 1

#### 3.1 Overview

Quarterly post occupancy evaluations (POE) are being carried out for the NOW Home in New Lynn, as part of the 2 year longitudinal (monitoring) studies being conducted. The objective seeks to determine the more difficult to quantify 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 the;

- 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
- etc

In addition to capturing the occupant's opinions and relating them to the measured physical performance, the emphasis of the POE for the New Lynn 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 Approach

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

- to build upon the research methodology and findings of the Queensland Research House
- to make the data collection as easy as possible, while gathering maximum information.
- to be minimally intrusive to the occupants as possible, e.g. ensuring the quarterly survey could be easily completed within an hour by the occupants

to be able to be refineable after the first interview to slipstream 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 Aronson, J. 1994. '*A pragmatic view of thematic analysis*'<sup>2</sup>. This approach used by the Queensland Research House social scientists was fine tuned by social scientist and research psychologist Stephen McKernon<sup>3</sup>, using the well recognised social systems-based 'differences and effects' based-questions.

The first occupant interview was carried out in early December 2005, with both the adult residents of the NOW Home being interviewed together. The next interview is due in early March 2006. Only the adult occupants were interviewed as both children are currently considered to be too young.

#### 3.3 Details

The first interview was a little over an hour long – it is envisioned that the next interviews will be significantly less than that, therefore fulfilling one of the design objectives. There were a range of questions asked of the occupants. They can be grouped into:

1. Straight factual e.g. "*how many people have lived in your household for the last 3 months?*"
2. Generic and open ended; i.e. "*how do you feel about the house and living in it overall?*". A longer answer expected here, as an introduction to the next set of questions.

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<sup>2</sup> The Qualitative Report. Vol. 2 No. 1. ([www.nova.edu/ssss/BackIssues/QR2-1/aronson.html](http://www.nova.edu/ssss/BackIssues/QR2-1/aronson.html))

<sup>3</sup> Of Supplejack consultancy.

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 categories<sup>4</sup>:

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

### 3.4 Findings

There was an overwhelming vote of confidence for the way the house was performing, and the services surrounding it. Of the 35 specific features examined, for example, only two were seen as making a negative difference for them (there were three others that were termed ‘not applicable’. The responses for the other features were either a very positive or perfect.

The house features that were most appreciated were:

- The layout of the rooms and use of spaces. The occupants especially liked the open plan nature of the layout, both in terms of how open it feels and the benefit of not having a corridor for transition between areas - “everything seems bigger”. There is a real appreciation of how the spaces relate and an overall sense of greater freedom of movement. The spaciousness was described as “fantastic” – quite surprising given the small footprint of the house. Associated with this was the indoor-outdoor flow – which they all enjoyed as a family. In terms of layout, the occupants wouldn’t change a thing and said it was the best house they had ever lived in.
- The thermal performance aspects of the house. Although the occupants arrived at the tail end of 2005 winter, they didn’t even unpack either their space heater or dehumidifier – both of which were used continuously at their previous Auckland house. They now described themselves as the ‘Pink Batts family’ (after the TV advert), due to not wanting to leave the house in inclement weather. The concrete floor was described in glowing terms – both with respect to its ability to keep clean and heat storage capacity. Only the occasional scratching proved to be a negative. They noticed that the internal temperature remained very even. They stated they haven’t used the clothes drier since they moved in as the clothes horse in the garage worked extremely well, with the warm car engine having enough heat to dry their clothes very quickly. On the other end of the spectrum, good cooling was enabled just through opening the windows and doors to the exterior.

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<sup>4</sup> 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.

The house features which were least appreciated were:

- tracking the small pathway stones into the house
- the quality of some of the build work which they are still having to deal with the lack of communication access jacks. But they were far and away minor issues in comparison.

In all, the benefits were seen to far outweigh the negative features of the house. The next interview will be carried out in early March 2006.

## 4. CONCLUSIONS

Currently, (in the first 4 months of operation) there is a very high satisfaction by the occupants in the everyday performance of the Waitakere NOW Home. Even though this is an initial report produced after only a few months of building occupancy, the findings for this live-in, real world family are encouraging. It should be noted that these results may change with time.

### 4.1 NOW Home Data Monitoring Equipment

The equipment used to monitor the NOW Home is a collection of innovative and practical technologies. A central computer is used to collect approximately 80 channels of data every minute from a variety of sensors throughout the house, collecting over one hundred thousand data-points in total each day. This is an innovative approach, and has had teething troubles, initially centred around persistent power spikes (for the first three months, cured by installing an uninterruptible power supply) and more latterly from occasional non-reads of some of the data stream. At the time of writing, many data acquisition issues have been addressed and significant progress made towards a totally continuous data stream. However, the occasional hiccup occasionally occurs, and data is lost. The effect of these occasional data outages is reduced as the experiment progresses, however, both by comprehensive data recovery analyses and also statistically, as more comprehensive data continues to be collected.

The sensors have been chosen to have as minimal impact on the occupants as possible, for example a number of temperature and humidity sensors are used to measure the conditions within each of the spaces within the house. These sensors use radio communications back to the data collection computer allowing the sensors can be placed anywhere with the room rather than being constrained by needing to wire the sensors back to the computer.

Data from the data collection computer in the NOW Home is automatically emailed to BRANZ Ltd on a daily basis for processing and analysis.

## 5. REFERENCES

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