BEACON'S NOW HOMES® - BUILDING AND RENOVATING HOMES FOR SUSTAINABILITY

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ABSTRACT

The sustainability of the residential built environment is an important issue for New Zealand, as much of the energy and water consumed and waste produced in the country occurs in people's homes. Similarly the health of the indoor environment within homes has a significant impact on the overall health of the community, particularly as relates to respiratory conditions. Beacon, a FRST funded research consortium, aims to see the majority of New Zealand homes achieve a high standard of sustainability by 2012. As part of developing and testing approaches to increase the sustainability of New Zealand homes Beacon has built two NOW Homes® – resource efficient homes defined to be affordable to most New Zealanders, and is retrofitting nine "average" homes to increase their level of sustainability. The first NOW Home® in Waitakere is occupied by an "average" New Zealand family and has been monitored for 18 months. The data confirms the Beacon hypothesis about the ease of achieving an energy and water efficient home with today's technology. A further NOW Home® in Rotorua has also been built in partnership with Housing New Zealand and nine NOW Home® Renovations have been undertaken on existing homes in Papakowhai, Wellington. The learnings from these projects and implications of these for larger scale development and renovation to improve the wider sustainability of New Zealand's housing stock are discussed.

KEYWORDS:

Sustainable homes, new housing, renovation, efficiency, Beacon Pathway Limited

INTRODUCTION

The sustainability of the residential built environment is an important issue for New Zealand, as a significant proportion of the energy and water consumed (Statistics New Zealand, 2006) and waste produced (Kazor and Koppel, 2007) in the country occurs in people's homes. Similarly the health of the indoor environment within homes has a significant impact on the overall health of the community, particularly as relates to respiratory conditions.

Beacon Pathway is the vehicle chosen by a number of like-minded organisations that seek to radically change the design, construction and renovation of New Zealand's homes and neighbourhoods. Our goal is to significantly improve housing sustainability through scientific research, communication, information sharing, and advocacy, opinion forming and networking.

The Foundation for Research, Science and Technology matches funding from Beacon's shareholding partners, a unique mix of industry, local government and research organisations: Building Research, Scion, New Zealand Steel, Waitakere City Council and Fletcher Building.

Established in 2004, with a focus on new technology for new homes, it became quickly apparent the principal opportunity for Beacon to impact lies not with the 25,000 new homes we build each year, but in transforming our existing 1.6 million homes. A large proportion of these homes are poorly insulated, damp, and consume relatively high quantities of energy and water (Storey, Page, van Wyk, Collins and Kreil 2004).

As part of its applied research approach Beacon has built two resource efficient NOW Homes® in Waitakere and Rotorua and retrofitted nine "average" existing homes in Wellington. These homes have been monitored against benchmarks that Beacon has set around what defines a High Standard of Sustainability for homes. The homes are all occupied by ordinary families with no special training in sustainability behaviour.

In undertaking these research projects and addressing the challenge around how to see uptake of more sustainable approaches to housing it has become clear that:

- we have the technology to address the challenge to deliver warm, comfortable, resource efficient homes which are affordable to operate;
- most New Zealanders are not engaged in the "performance" of their homes;
- the data needed to accurately assess the sustainability of homes is disparate, poorly compiled and difficult to access;
- leadership from both the public and private sector is needed if we are to move rapidly towards improving the sustainability of the residential built environment.

BEACON'S HIGH STANDARD OF SUSTAINABILITY

In order to provide a framework for Beacon to measure the influence it is having on the sustainability of houses at a national level, and to provide a useful benchmark against which individual households can evaluate their home's performance, Beacon has developed benchmarks for a High Standard of Sustainability (HSS) in homes (Easton 2006). These benchmarks have focused on five key aspects of dwelling sustainability:

- Energy use
- Water use
- Indoor Environment Quality
- Waste
- Materials

Underpinning these five technical aspects of dwelling sustainability are the issues of affordability and future flexibility. When considering the individual household benchmarks at which the HSS performance indicators should be set, affordability was a significant consideration (Easton 2006). The benchmarks have therefore been set at levels where many of the features used to bring about their achievement are:

- low cost (eg simple measures such as fitting of draught stoppers and use of low-flow shower heads)
- Have a payback period estimated at less than 10 years (eg additional insulation or energy efficient appliances); or
- In the case of new development, can be undertaken at no or minimal extra cost (eg passive solar design).

The benchmarks developed represent a preliminary "line in the sand" for Beacon and are expected to be updated and refined over time, and as the research into the state of New Zealand's home performance continues. While detailed comparative work is still being undertaken, new homes built to achieve the Beacon HSS appear to be roughly comparable with a "good" rating (56-69 points) under the BRANZ Green Homes Scheme, or a Level 4 compliance with the UK Code for Sustainable Homes. This compares with, for example, the average new New Zealand home, which would score around 15 points under the BRANZ Green Homes Scheme and not achieve a rating on the UK Code for Sustainable Homes. In other words while the Beacon HSS benchmarks are significantly higher than the minimum requirements of the NZ Building Code, but are set to be within what is a considered to be able to be a reasonable target for all new homes to achieve by 2012.

Features to Achieve a Beacon HSS

A number of key features have been identified which would enable homes to be built to meet the HSS measures. While occupant behaviour will affect the actual outcome in terms of energy and water use, and the quality of the indoor environment, houses with these features can inherently be operated in a more sustainable manner. These features can be grouped into low, moderate and high categories which reflect both their impact on the sustainability of a home and the amount of capital investment required to be put in.

Basic low cost measures which will have a modest impact on the sustainability of the home include measures such as:

- Low flow shower head;
- Fluorescent light bulbs ;
- Dual flush toilet
- Outdoor clothesline;
- Hot water cylinder wrap & pipe lagging;
- Draught stopping;
- Ventilated fridge space;
- Opening windows;
- Incorporation of passive solar design into new homes and extensions to existing homes;
- Provision of space for recyclables storage;
- Provision of facility for collection and composting of organic waste;
- Use of materials for new homes and alterations to existing homes which have been selected with reference to a sustainability checklist;
- Elimination of unsustainable features such as – air conditioning for cooling purposes; in sink waste disposal units; and unflued gas heaters.
- Designing new homes and renovations using standard material sizes to minimise construction waste
- Sorting construction waste and recycling where possible

Moderate cost features which will have a significant impact on the sustainability of a home include the following measures:

- Mechanical venting of bathroom and kitchen;
- Ceiling, wall and underfloor insulation to meet “best” recommended values for each climate zone;
- Rainwater tanks supplying the garden;
- Windows with passive venting;
- Thermal curtains and pelmets;
- Water and energy efficient appliances

Depending on the type of home (new or existing, efficient or inefficiently designed, climatic conditions) some higher cost features may be required to fully meet the Beacon HSS.

Work is currently being undertaken by Beacon to develop clear procedures on the building and retrofitting of homes to achieve a HSS. These are then intended to be piloted during 2008 through the construction of 100 NOW Homes® and the retrofitting of 1000 existing homes across New Zealand.

BEACON'S NOW HOMES®

Beacon has developed two NOW Homes® – in Waitakere and Rotorua. The Waitakere NOW Home® was completed in August 2005 and the Rotorua NOW Home® in September 2006. Both homes were designed and built to budgets and constraints typical of "ordinary" New Zealand housing rather than aimed at the top 5% of the market more typical of other "ecohomes". The Rotorua NOW Home® was developed in conjunction with Housing New Zealand Corporation and was designed and built for a budget at the affordable end of the market.

Passive solar design, resource efficiency, minimisation of hazardous materials and future flexibility were all key considerations in designing and building the homes. As a result less than 2.5 tonnes of construction waste was produced in each home's construction. This compares with a Tauranga study of construction waste produced in the development of new 3 bedroom homes that found that each home produced 6 tonnes of construction waste (Kazor and Keppel, 2007).

Waitakere NOW Home®

The Waitakere NOW Home® uses timber weatherboards, fixed to a timber frame on a heavily-insulated concrete slab. The roof is concrete tile, and the ceilings and walls are heavily insulated. The entire building is double glazed (excluding the garage).

The building is sited to maximise the benefits of passive solar heating, using the highly insulated envelope to trap and retain the sun's warmth – mainly via the polished (no carpets) concrete slab. Passive ventilation is incorporated in the design to facilitate air changes without creating draughts – important for a healthy indoor environment.

A solar water heater is installed on the roof, and a water tank collects from the roof. The tank water is used for many non-potable water needs within the house. All light fittings are high-efficiency compact fluorescent types (where possible – for some fittings they are not available).

The majority of the appliances belong to the tenants, however the range, fridge, dishwasher and washing machine are new efficient items supplied as chattels.

The Waitakere NOW Home® has been occupied since September 2005 by a family of four (two adults, two children). At the start of the tenancy the two children were of pre school age.

There have been three monthly post occupancy evaluation survey visits which take about three half to quarters of an hour. These are to capture the occupants' experiences compared with the previous house they lived in (French, Heinrich, Jaques, Kane and Pollard, 2007).

Performance of the Waitakere NOW Home®

Monitoring of the Waitakere NOW Home® includes the collection of end use information for both the electricity and water use. Temperature and humidity are measured in each room as well as CO_2 in the living room. The water temperatures, solar radiation and water flows for the solar water heater were also measured (French et al, 2007).

Figure One shows the floor plan of the Waitakere NOW Home, and the location of monitoring sensors used in the home.

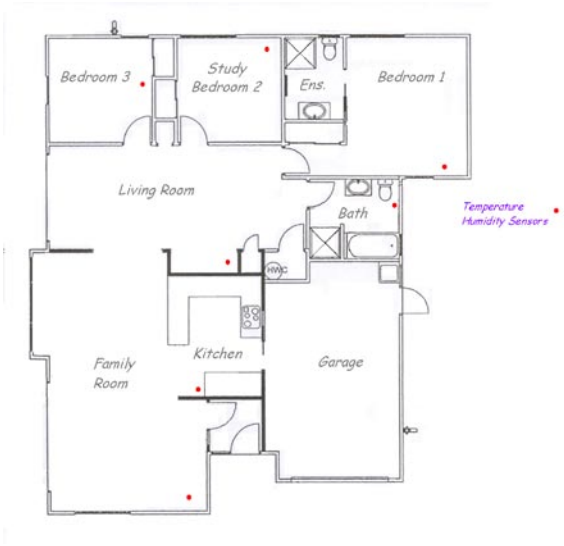

Figure One: Waitakere NOW Home Floor Plan

After twelve months of monitoring the Waitakere NOW Home®, it has been shown to perform well in terms of resource use, and meet the HSS benchmarks set by Beacon. In addition, the quality of the indoor environment and occupant satisfaction is very high, and the health of the family living there has improved (French et al, 2007).

In terms of resource efficiency, after one year of occupancy the household used 45% less energy than in their previous home and 40% less water per person than the surrounding area. The temperature and humidity means in bedrooms and living spaces all fell within the Beacon HSS benchmarks (French et al, 2007).

Rotorua NOW Home®

The Rotorua NOW Home® has been built on the same principles of design and material selection as the Waitakere house, with the benefit of subsequently available knowledge, as well as meeting Housing New Zealand Corporation requirements. The house is owned by Housing New Zealand Corporation and forms part of their rental housing portfolio.

The Rotorua NOW Home® uses preprimed timber plywood and prepainted steel for cladding, fixed to a timber frame on a heavily-insulated concrete slab. The roof is prepainted steel, and the ceilings and walls are heavily insulated. The entire building is double glazed.

A solar water heater is installed on the roof, and an underground water tank (a smaller 5000 litres in size as opposed to the Waitakere Home's 12,500 litres) collects from the roof. The tank water is used for toilet flushing and to supply the washing machine within the house. All light fittings are high-efficiency compact fluorescent types. Unlike the Waitakere Home, appliances were not supplied with the home, with the exception of the stove as HNZC policy is to not include whiteware.

Due to Rotorua's colder climate, the space heating requirement was four times that of the Waitakere NOW Home® and a low emission pellet burner was installed to provide supplementary heating.

The house was designed to provide for wheelchair access, and a second bathroom included was specifically designed for accessibility.

The home has been tenanted since September 2006, and results of the first year of performance monitoring are expected to be available in December 2007.

BEACON'S NOW HOME® RENOVATIONS

In order to research how to improve the sustainability of existing homes, over February – June 2007 nine homes in Papakowhai, Porirua have been retrofitted with different packages of interventions. The houses have been selected to provide case studies of "ordinary homes" in a middle income suburb. Middle income homes were chosen because an evaluation of existing retrofit programmes (McChesney and Amitrano, 2006) found that low income households were the major beneficiaries of current government and community sponsored retrofit programmes, and often where the householders suffer from respiratory health problems. While laudable programmes, the performance data collected from the retrofitted homes is not considered to be representative of the wider performance of New Zealand's housing stock as the homes are generally chronically under heated. In addition, research has found (McChesney and Amitrano, 2006) that because of the very low level of energy retrofits undertaken as part of the programmes, temperatures in the homes remain well below World Health Organisation standards (and the Beacon HSS benchmarks) and, unsurprisingly, significant take back occurs in any energy savings.

Accordingly Beacon is testing a range of retrofit packages aimed at determining what are the best (lowest cost, easiest to implement and most effective) packages of retrofit options which will substantially improve the resource use of a home and improve the indoor environment to meet Beacon HSS benchmarks. These retrofit packages address a number of core components which Beacon considers need to be included in a retrofit which will substantially improve the sustainability of a home. Different combinations of the following key features have been included in the packages:

- Significant increases in insulation (ceiling, underfloor and walls)
- Double glazing
- Solar hot water systems
- Fixed heat sources (heat pump, pellet burner and low emission wood burner)
- Water efficiency measures such as low flow fittings
- Mechanical ventilation of kitchen (rangehoods) and venting of driers
- Showerdomes (a device fitted over the top of the shower to prevent steam creation or release of moisture to air)
- Compost or worm bin
- Basic energy efficiency measures (draught stopping, compact fluorescent lightbulbs etc)

The pre-retrofit energy and water use, temperature and humidity of the homes have been monitored by BRANZ Ltd, and a pre-retrofit waste audit has been undertaken. The retrofits have been undertaken over the February – July 2007 period, and the first analysis of the pre and post retrofit monitoring data is expected to be available in December 2007, with monitoring continuing to the end of winter 2008.

Preliminary analysis of this indicates that winter time temperatures in all but one of the homes were below desired benchmark levels of 16 degrees in bedrooms and 18 degrees in living spaces. Average winter air temperatures in the living room ranged from 16.1^{o}C to 22.2^{o}C during the evening and 11.6^{0}C to 16.7^{0}C during the night in the main bedroom (Buckett, French, Zhao, Burgess and Hancock, 2007).

Detailed analysis of the pre-retrofit energy and water use has not yet been undertaken, but preliminary analysis indicates a wide range of energy use patterns influenced by a range of factors. The highest energy use occurred in a home with all electric heating, cooking and hot water (Buckett et al, 2007).

DISCUSSION

When considering how to move New Zealand homes towards a higher degree of sustainability, engagement of dwelling owners is a primary consideration. The vast majority of homes which will be in use over the next 50 years have already been built (Amitrano, Kirk and Page 2006). Yet, the BRANZ House Condition Survey indicates that New Zealanders already under-maintain their homes

(Clark et al 2005). When renovation data is considered, it is clear that much of the renovation undertaken is cosmetic in nature (Amitrano et al, 2006) and does not address the sustainability of New Zealanders' homes.

Compounding this issue is the increasing proportion of dwellings which are rented – home ownership rates decreased by 9% in the decade between 1991 and 2001 to 62% (Statistics New Zealand, 2001). Decisions on whether or not to make alterations to existing housing stock to increase their sustainability will therefore be increasingly made by landlords who will not receive the direct health and comfort benefits of such alterations and are therefore less likely to make such an investment.

The average age of home owners living in their own dwelling is increasing and families with young children are also increasingly living in rented accommodation (Amitrano et al, 2006). These are both the household types with some of the largest demands for energy and water, and one of those of greatest susceptibility to the negative effects of a poor quality indoor environment.

New Zealander's homes are the single largest investment that many people will make in their lifetime. They are also the place where many people spend most of their time. Yet when compared to a motor car, existing New Zealand homes have very few regulatory requirements placed upon them. A car requires a six monthly warrant of fitness and an annual registration, yet once they have achieved Code Compliance our homes do not require any kind of check, even at change of ownership or tenancy, to determine whether they are healthy, efficient or suitable for the household type who is proposing to live in them.

The Beacon NOW Home® and NOW Home® Renovation Projects aim to provide robust evidence around ways to improve the sustainability of New Zealand homes. While primarily research projects, there has been strong interest in the demonstration value of the homes – how ordinary New Zealanders can live ordinary lives but with a lesser impact on the environment, and in greater health and comfort than is currently the norm.

In order to encourage uptake of the research findings Beacon has recognised the need to upscale its NOW Home projects. Future projects planned include piloting the key principles and practices developed through the NOW Home® and NOW Home® Renovation Projects in two larger scale pilot projects – NOW 100 and Retrofit 1000. These projects aim to transfer Beacon's research findings into changes in practice through partnerships developed with mainstream developers, tradespeople and homeowners.

CONCLUSION

Beacon's applied research aims to determine ways in which ordinary New Zealand homes can become more sustainable. Target benchmarks have been set by Beacon against which the performance of its research homes is being monitored. The NOW Home® and NOW Home® Renovation research home projects have been developed using widely available and accessible technologies and sustainable building principles. Based on findings to date it is clear that substantial improvements to new and existing homes within New Zealand are able to be made with relative ease. The greatest challenges appear to lie in the understanding of the consumer and value chain of the need for change, removing the regulatory barriers, and to develop simple and easy ways for this change to be put in place.

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