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ASSESSING NZ HOUSEHOLDERS' ENERGY USE BEHAVIOURS: A PILOT SURVEY

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ABSTRACT

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In NZ, the government has developed the New Zealand Energy Strategy (NZES) to respond to the challenges of climate change and provide strategic directions for energy use in NZ. One of the target areas is "Energywise Homes" that provides a number of financial and other incentives for consumers to make them homes dryer and more energy efficient. Industry too, has been pro-active. For example, the Homestar™ Rating Tool, a new free online rating tool, was introduced in November 2010 through a joint venture between the NZ Green Building Council, BRANZ and Beacon Pathways to allow home owners to assess their home's performance in comfort, health and energy-efficiency.

This paper outlines the results of research carried out in NZ in 2011. Two parallel pilot surveys were conducted of various participants in the housing sector who are members of the Green Building Council of NZ. The full-scale survey of 4000 householders is underway, but the results are not yet available to report here. The broad aims of the research are to (i) examine the lifestyle choices of householders in relation to the homes that they live in, together with the motives behind these choices; (ii) identify and explain user behaviour in residential buildings in relation to the energy consumed, and (iii) evaluate the success of the Homestar™ rating tool in empowering householders to make their homes healthier and more energy efficient. The results from these pilot surveys help to identify where behavioural change is needed, and the methods to aid communication of sustainability measures that encourage behavior change, and increase the uptake of sustainability practices in homes that reduce greenhouse gas emissions from residential buildings.

1. BACKGROUND AND LITERATURE REVIEW

The Kyoto Protocol is an international environmental treaty intended to reduce greenhouse gas concentrations in the atmosphere to help tackle climate change. National limitations range from 0% reductions for New Zealand, to 8% for the European Union and permitted increases of 8% for Australia and 10% for Iceland. According to McKinsey and Company (2007) improving energy efficiency of buildings and appliances is the most cost effective way of reducing greenhouse gas (GHG) emissions.

1.1 Greenhouse Gas Emissions from Buildings

Buildings in New Zealand account for 17% of the country's greenhouse gas emissions.[1] According to Foliente et al. (2009), while the building sector is not the largest contributor to greenhouse gas emissions, it is one of the fastest-growing sources. Unfortunately, New Zealand's emissions since 1990 have increased by some 25 percent.[2] This rise is partly explained by New Zealand's unique greenhouse gas emissions profile. The two largest impacts are from agricultural, in the form of methane and nitrous oxide (48%) and transportation (20%). Both of these sectors face considerable difficulties in reducing their share of emissions. By comparison, other developed economies largest portion of their greenhouse gas emissions profile is due to combustion of fossil fuels, as is the case in Australia, which is more readily reduced through the switch to renewable energy sources.[3]

Energy usage in residential buildings accounts for around 10% of total carbon dioxide (CO2) emissions from all sources in NZ.[4] In terms of source of greenhouse gas emissions in the residential sector, over half comes from electrical

[1] By comparison, Australian buildings account for 23%, US buildings, 38% of America's GHG emissions, while the figure for the UK is around 42%.

[2] Ministry of Environment, *Projected Balance of Emissions Units During the First Commitment Period of the Kyoto Protocol*, September 2007.

[3] Based on 2007 data. Ministry for the Environment, *New Zealand's Greenhouse Gas Inventory 1990-2007: An Overview*, April 2009, New Zealand.

[4] MED (2006). Derived from direct emissions and indirect electricity emissions from *New Zealand Energy Greenhouse Gas Emissions 1990-2005.*

appliances, including lighting, selected by residents or persons outside the building sector, about a quarter comes from water heaters, and a fifth from space heating and cooling. In terms of home energy use the figures are similar but more is used in space heating and cooling (34%), followed by water heating (29%), with just over a third coming from electrical appliances (refrigeration 10%, lighting 8%, cooking 6%, other appliance 13%), (BRANZ, 2006).

It is not only the amount of energy used in homes that has an impact on the production greenhouse gas emissions but also the type of energy. Householders could reduce their carbon footprint by not only reducing the amount of energy they use in their homes but also by using energy from renewable and green sources. While New Zealand is fortunate that about three quarters of the electricity generated comes from renewable sources, predominantly hydropower, this percentage has been falling from a high of 91% in 1980 as shown in the following table:

Table 1 - Annual Electricity Generation, GWh.

Year	Hydro	Thermal	Geothermal	Wind	Total	% Renewable
1975	16,497	1,931	1,350	-	20,126	90%
1980	19,171	1,959	1,206	-	22,700	91%
1985	19,511	6,555	1,165	-	27,673	76%
1990	22,953	5,956	2,091	-	31,467	81%
1995	27,259	5,426	2,049	1	35,244	85%
2000	24,387	10,474	2,756	119	38,285	73%
2005	23,099	14,305	3,007	609	41,670	66%
2009	23,962	11,472	4,542	1,456	42,010	73%

Source: MED (2010). "New Zealand Energy Data File 2010", July.

Despite efforts to reduce energy consumption in homes, household electricity use per person has being rising due in part to larger dwelling sizes, decreasing average household size, more appliances and IT equipment per household as well as the increased use of heaters and coolers. The following sections outline the energy efficiency of NZ homes, actions taken by the New Zealand Government to help protect the environment and reduce GHGe, and strategies introduced to achieve a more energy efficient housing sector.

1.2 The Energy Efficiency of NZ Homes

The average size of new houses has grown significantly over the past twenty years to an average of 205m2 (QV, 2011), although according to Statistics NZ (2011) at the end of June 2011 it has fallen back for the first time in years to 196m2 (it was last 196m2 in 2009 and was 176m2 in 2003).[5] At the same time, average household size decreased to 2.7 persons per household according to the 2006 Census and this likely to decrease to 2.4 by 2021 (Statistics NZ, 2005).

Prior to 1978 there were no requirements in New Zealand (NZ) for thermal insulation to be included in the construction of new houses. According to McChesney and Amitrano (2006), about 65% of the housing stock (or about 0.9m dwellings) were estimated to have been built prior to any requirement for insulation. Of these, a small percentage would

[5] See Odams, G. (2011), Martin, P. (2009) "Home truths: Australia trumps US when it comes to McMansions", http://www.smh.com.au/national/home-truths-australia-trumps-us-when-it-comes-to-mcmansions-20091129-jyva.html, and Infometrics NZ for latest building statistics for Australia and New Zealand http://www.infometrics.co.nz/top10/art1719.htm [accessed 16 December 2010].

have had insulation installed when they were constructed and many others have subsequently been retrofitted with some form of insulation, mainly in the ceiling.

EECA completed consumer surveys to track the nation's views on energy efficiency and renewable energy. The sample of 750 from the general public is representative of the general population and is weighted back to the 2006 census, by age, gender and region and then by household income. The most current survey in 2010 indicate that 58% of respondents have ceiling insulation (12% didn't know), 26% have under floor insulation (11% didn't know), and 38% have wall insulation (20% didn't know). Under a third (31%) had hot water cylinder wraps, 42% use energy efficient light bulbs while 39% said some of their home had these. In terms of heating systems, 27% had heat pumps, 23% low emission wood burners, 19% flued gas heating and only 3% had pellet fires. Solar heating was installed in only 4% of homes, and only 2% had solar panels. Respondents were most willing to install insulation of all types: ceiling (30%), under floor (27%), and wall (24%) and least likely to install pellet fires (3%) and flued gas heaters (2%).

Many New Zealand houses have poor thermal performance due to little or no insulation, and poor ventilation, and as a result are cold, damp and expensive to heat in the cooler months (NZEECS, 2007). According to Lloyd (2006), in 2001 between 10% and 14% of total households in New Zealand are in "fuel poverty". This figure could rise to possibly as much as 32% in Dunedin in the lower South Island. A household is considered to be in "fuel poverty" if it would need to spend more than 10% of the total household income on all household fuels to achieve a satisfactory indoor environment. A satisfactory indoor environment is defined as being at temperatures of at least 21°C in the living areas and 18°C in other parts of the house (WHO 1987, 1989).

Studies have shown that poor housing affects health. For example, a study by the Universities of Otago, Massey, Victoria and Auckland, and BRANZ (Howden-Chapman et al., 2007) showed that by retrofitting homes of children with asthma with more effective and less polluting heaters had a positive impact on the health of the children and their families, as well as on the households' energy consumption. The average daily temperature increased between one and two degrees Celsius and people felt warmer, condensation was reduced, and levels of nitrogen dioxide that is associated with coughing in children and asthma were halved. Further, children with asthma reported less coughing and wheezing, children reported fewer episodes of cold and 'flu' and had on average one day less off school during the winter and fewer visits to the GP.

A study by Howden-Chapman et al., (2007) investigated the impacts of retrofitting low-income family homes with insulation on the health of occupants and indoor temperatures. They found that indoor temperature increased during winter (0.5°C), relative humidity decreased (2.3%), and energy consumption was only 81% of that in uninsulated homes. Insulating existing houses resulted in improved self rated health, and self reported wheezing. Days off school and work reduced by around 23% and 39%, respectively. Visits to general practitioners were less often reported and there was a trend for fewer hospital admissions for respiratory conditions, but the latter result was not statistically significant.

McChesney and Amitrano (2006) completed a desk top study of research programmes that address the benefits of retrofitting a house. They found that most programmes were aimed at low income households and include a "standard package" of measures - comprising ceiling insulation, basic under floor foil and draught-proofing of doors. From analyzing the results of these programmes, the authors concluded that a combined efficiency/heating appliance package appeared to provide better outcomes than a basic energy efficiency package alone, especially in colder parts of the country.

A 2005 House Condition Survey (Clarke et al, 2005) found that many homes were damp and poorly ventilated, and that extract ventilation in wet areas (bathrooms, kitchens) was lacking in a large number of houses. The Building Code has minimum requirements for ventilation: all the air in a home should be changed every three hours. Air in kitchens and bathrooms should be changed more regularly: kitchens every hour; bathrooms every two hours. New Zealand Standard NZS 4303 (1990) "Ventilation for Acceptable Indoor Air Quality" specifies a minimum residential ventilation rate with outdoor air of approximately one complete air change every three hours, to be distributed throughout the home.

As a result of poorly ventilated cold, damp homes in NZ ventilation systems have gained popularity. McChesney (2009) estimated that around 10% of New Zealand homes had some form of mechanical ventilation system installed. Positive pressure roof cavity systems made up the majority of these systems. However, in terms of meeting the Building Code requirements for home ventilation the Department of Building and Housing (DBH) states:

"…domestic ventilation systems draw air from the roof space, they are not directly drawing air from outside. Hence, they cannot be used to comply with the Building Code ventilation provisions. However, Building Code compliance is not generally an issue because domestic ventilation systems are installed in addition to opening windows.." (DBH, 2008).

Fitzgerald, et al. (2011) at Otago University carried out research in 2008 for ECCA to investigate the heating and cooling potential of roof space air using positive pressure ventilation systems. They found that the potential heating and cooling benefits from pumping air from the roof space into the living areas of some NZ houses were not large enough to significantly alter the indoor air temperature, on average. The researchers recommend that existing positive pressure mechanical ventilation systems should not be promoted and marketed on their heating and/or cooling potential. However, they do advise that the health and comfort benefits of using roof space air as a means of household humidity control were not investigated. As the primary purpose of ventilation is to regularly change the air to maintain good indoor air quality, this exclusion is seen as a major weakness of the study.

Positive pressure ventilation systems can still assist heating by drying houses. Boulic et al. (2010) investigated this aspect of positive pressure ventilation systems by assessing their efficiency during winter. They did this by measuring indoor climate change in terms of humidity (RH), temperature and pollutants (CO2 and formaldehyde, HCHO). Measurements were taken for a two week period in late winter/beginning spring 2008 every two minutes in the living room and master bedroom of twenty intervention homes that had a positive pressure ventilation system installed at the start of the second week of measurements. These measurements were compared to those taken in a control group of ten homes that did not have the ventilation system. Further, the results of the intervention homes were compared with the current health guidelines. Results indicated a statistically significant decrease in the weekly average level for both gases in the intervention homes whereas no significant difference were detected in the control group homes when comparing the first week and second week results. For example, the CO2 level, dropped by 24.5% in the living rooms and 31% in bedrooms of the intervention homes while relative humidity levels dropped by 4% in the living rooms, and 4.8% in the bedrooms.

The result from the Boulic et al. (2010) study provides evidence to support a homeowner's decision to install a positive pressure ventilation system in their home. Indoor humidity levels not only affect when condensation will form on colder objects, but it also affects the heat capacity of air, which changes the amount of energy required to heat a home. In general, the more moisture contained within the air, the harder it will be to heat. Thus, while the study by Fitzgerald et al (2011) does not support the use of positive pressure ventilation systems for their heating and cooling potential, the study by Boulic et al (2010) does support their use for controlling relative humidity that can make homes easier (and thus cheaper) to heat.

As much of the environmental impact of buildings is determined at the design stage it is critical that these be considered early in the design process. To overcome "fuel poverty", ill health from poor housing, and high energy consumption in homes a number of Government initiatives have been implemented to improve the energy efficiency of NZ homes (see section 1.3 below.).

1.3Government Actions to Reduce Greenhouse Gas Emissions from Buildings

1.3.1 Government Environmental Policy

The Labour Government has always been a proponent of good environmental management in New Zealand. In 1987, Deputy Prime Minister Geoffrey Palmer became the Minister for the Environment and initiated a comprehensive reform project for New Zealand's environmental and planning laws: the Resource Management Law Reform (RMLR). The Labour Party environment policy reform owed much to the Brundtland Commission's concept of "sustainable development".[6]

The Resource Management Act (RMA), passed in 1991, was the first statutory planning regime to incorporate the principle of sustainability (Smith, 1997). It incorporated 'sustainable management', as an explicitly stated purpose that directs all other policies, standards, plans and decision-making under the RMA. Having the purpose of the RMA at the apex of an unambiguous legislative hierarchy was a unique concept worldwide at the time of the law's inception (Fisher, 1991).

More recently, Labour Minister Helen Clark (in Parliament from Dec. 1999 to Nov. 2008) was pro-active in addressing climate change and environmental issues in NZ. She introduced a raft of sustainability initiatives such as the New

[6] Sustainable development is development hat "meets the needs of the present without compromising the ability of future generations to meet their own needs" Our Common Future (known as the Brundtland Report, from the United Nations World Commission on Environment and Development) (1987), Oxford: Oxford University Press. ISBN 0-19-282080-X Accessed 20 December 2010]

Zealand Emissions Trading Scheme (NZ ETS) and the Carbon Neutral Public Service (CNPS) program. This program grew out of the Labour-led Government's desire to make "sustainability central to New Zealand's unique national identity" (Clark, 2006).

When National came into power in November 2008, some of the subsidies set up under the Labour Government were removed. Climate Change Issues Minister, Nick Smith, scrapped the CNPS program in March 2009, stating:

> *"The Carbon Neutral Public Service was just a feel good slogan cooked up by the previous Government. Its only achievement was to cost this country millions of dollars. Ironically, since the programme was launched by the previous Government, emissions from the Ministry for the Environment increased..."* (Smith, 2009a)

Birchall et al. (2010) examined the evidence for Smith's implied assertion that the CNPS program delivered neither environmental nor economic benefits and found that it was not supported. Instead, the data suggests that as a result of participation in the CNPS program, the lead core agencies did experience both emission reductions and cost savings. They conclude that while some lead core agencies will continue to manage their carbon (on a reduced scale), without a direct mandate from central Government, carbon neutrality is no-longer a target for them.

Under the National Government, a target has been set of achieving 50% carbon equivalent emission reductions as compared to 1990 levels by 2050. National's strategy involves making climate change thinking "business as usual" in planning for Government (Smith, 2009b). The NZ ETS, introduced by the Labour government and amended by National, will help achieve these aims.

1.3.2 The Building Code

Recognising the need to improve the energy efficiency of NZ homes and overcome "fuel poverty" new requirements were introduced in October 2007 for all new homes in the coldest climatic Zone first: the South Island and North Island Central Plateau. The new requirements, NZ Building Code Clause H1 (Energy efficiency), were phased in throughout the rest of New Zealand, in 2008: Climate Zone 2, North Island districts south of Franklin and Thames-Coromandel Districts (excluding Central Plateau), in June and lastly Climate Zone 1, Districts north of Franklin and Thames-Coromandel Districts inclusive, in September.

The Building Code Clauses A2 and H1 3.2 changed to refine the definition of the building performance index (BPI), and to improve the thermal performance of houses. This effectively requires houses to use about 30% less heating energy than before and, in practice, means that most new houses will need better insulation (higher R-values, as outlined in NZS 4218: 2004). Further, the schedule method in NZS 4128:2004 can only be used when the glazing ratio is no greater than 30%, and the glazing ratio of the east, south and west faces is no greater than 30%. While double-glazing is not mandatory, it will likely be used extensively to meet the new H1 requirements. However, for some designs in some locations, the building performance index will not exceed 1.55 for a house with single glazing, making double glazing an optimal solution (Department of Building and Housing, 2008). The NZ Building Code tends to focus on new works, including major renovations and refurbishments. Existing structures, that may not meet the new standards unless refurbishment is carried out, has been largely ignored.

1.3.3 Government Environmental Policies for NZ Housing

In 2001, the NZ Government introduced The New Zealand Energy Efficiency and Conservation Strategy (NZEECS). "*The NZEECS is a detailed action plan for increasing the uptake of energy efficiency, conservation and renewable energy programmes across the economy and to make doing so part of the normal behaviour of New Zealanders," p.10.* A target was set to address all pre 1978 homes with a "suite of cost effective energy efficiency measures". At that stage it was believed that about 0.6M homes had no or inadequate insulation, with some 0.15M low income households being the primary focus to achieve health and welfare improvements (EECA & MfE, 2001).

The first five-year NZEEC Strategy was written in 2001, with a second version published in 2007. The 2007 NZEECS looked at the lessons learned under the previous Strategy. It outlines the barriers that prevent individuals and businesses from taking up energy efficiency and renewable energy that need addressing, as being:

> *Lack of information – Consumers are often unaware of the benefits of energy efficiency, conservation and renewable energy and how to realise them. Education and awareness-raising programmes, including labelling schemes, are designed to help overcome this.*
>
> *Weak price signals – Energy pricing does not yet fully reflect the environmental and economic cost of energy production and consumption. Decisions around cost-reflective pricing and incentive programmes can help overcome this barrier.*

Access to capital – Some consumers struggle to meet the initial costs of energy efficiency and renewable energy measures even though they are cost effective over time. Incentive programmes such as discounted products, and grants and loans can help overcome this.

Split incentives – Landlords who are responsible for paying for building improvements may not directly get the benefits, such as lower energy bills or increased comfort. Likewise, tenants may not want to invest in improving homes or buildings that they don't own or may not occupy for long periods.

Incentive programmes, such as assistance to landlords to insulate properties and the setting of minimum standards, can help overcome this. (NZEECS, 2007, p.11)

To address these barriers, and increase the uptake of energy efficient measures in homes the NZ Government developed a number of grants, funding and rebates, under a scheme called Energywise Homes (and replaced by the Warm Up NZ: Heat Smart Programme in June 2009), that aims to achieve warm dry healthy homes, improved air quality and reduced energy costs. From 2009 to 2013 more than 180,000 New Zealand homes will have access to grants for insulation and clean heating, as part of a major investment in household energy efficiency. The Government has budgeted $323.3 million over the four years to fit homes with insulation and clean heating devices such as heat pumps and approved wood burners. The scheme is open to owners and occupiers of houses built before 2000 and will provide grants up to $1,800, regardless of income. Specific targets include:

- *70,000 interest free loans for insulation, energy efficiency or clean heat loans by 2015*
- *65,000 insulation retrofits for low income families by 2012*
- *4,000 clean heating upgrades for low income families in areas of poor air quality by 2012*
- *15,000 – 20,000 solar water heating systems by 2010*
- *Minimum Energy Performance Standards (MEPS) on 17 additional product categories, and Energy Star labels on an additional 15, by 2012,* (NZEECS, 2007, p.12).

According to the NZEEC Strategy (2007) by improving the performance of 162,000 existing homes, it is estimated that Co2 emissions will be reduced by 0.3mt, and there will cost savings of $63.3million in energy and $97million in health per annum in 2025. For existing homes emissions will be reduced by 0.37Mt and there will be $47 million energy savings per annum in 2012. In terms of the products and appliance used in homes, if their energy performance were improved savings would be even greater, with 2.8Mt reduction in Co2 emissions and $230million energy savings per annum in 2025 (NZEECS, 2007, p.18 & 19).

ECCA (2011) indicates that more than 100,000 homes have been fitted with insulation and/or heating under the Warm Up NZ- Heat Smart programme since it began on 1 July 2009 to the end of June 2011. Table 2, below, shows these results:

Table 2 – Number of Homes Heated & Insulated

Insulation and/or Heating in Homes	**June 2011**	**Total (July 2009 - June 2011)**
Houses fitted with insulation only	4,915	90,458
Houses fitted with heating only	767	13,684
Houses fitted with insulation and heating	287	10,301
Total houses fitted with insulation and/or heating	**5,969**	**114,443**

A third edition of the NZEECS was released in 2011 and sets the Government's policies, objectives, and targets for the next five years (2011–2016) and outlines the means by which these will be achieved. In terms of housing, the objective remains much the same as the previous NZEECS, but is simplified to insulating 188,500 by 2013. Further, the Strategy specifically avoids providing a full list of Government energy efficiency initiatives, as the previous editions did, with the explanation "*As a statutory document with a five-year life, the NZEECS has been presented so as to ensure it won't be out-of-date as initiatives come and go over that period*", (NZEECS, 2011, p. 18). Note that the ENERGYWISE™ label is still used but describes the funding available under the Governments Warm Up New Zealand: Heat Smart programme. Given that over 100,000 homes have been insulated in the first two years of operating the Warm Up New Zealand: Heat Smart programme, it is likely the Government will reach their target of insulating 188,500 by 2013.

The third edition of the NZEECS Strategy states that Government will work with industry to identify and develop a range of market measures targeting the energy productivity of New Zealand's homes. It then acknowledges that the Government's support for industry to develop innovative voluntary solutions and specifies the Homestar™ rating tool, launched in November 2010, as a good example of this (see Section 1.3.3, below, for details). In terms of products, a

Strategy objective is to have greater business and consumer uptake of energy efficient products. The target to achieve this is to extend minimum energy performance standards, labelling and EnergyStar product coverage to remain in line with major trading partners by 2016.

1.3.4 Industry Initiatives to Encourage Energy Efficiency – The Homestar™ Rating Tool

Beacon Pathway, a consortium of the Building Research Association of NZ (BRANZ), Fletcher Building, NZ Steel, Scion and Waitakere City Council, was formed in 2004 to fulfil a six year research contract with the Foundation for Research Science and Technology (FRST), to investigate issues related to NZ housing and its sustainability performance. Two aspirational goals, "to bring 90% of NZ houses to a high standard of sustainability by 2012", and "to ensure that existing or redevelopment subdivisions from 2008 onwards, is executed with reference to a nationally recognized sustainability framework" drove the establishment of an extensive programme of demonstration projects, collaboration, and the development of practical solutions and tools. It included, for example, building two homes that were tenanted and performance-monitored (energy and water use, temperature, moisture); renovating and monitoring nine homes; assessing 650 homes assessed and given individualised renovation plans; developing and testing a tool to assess sustainability of greenfield and existing neighbourhoods, and analysing the indoor environment quality of forced air ventilation systems analysed. Subsequent to the ending of the six year contract, Beacon has since become an incorporated society.

In line with the goals of the NZEECS Strategy to aid improvements in the performance of NZ homes, a joint venture initiative has been undertaken by the Green Building Council of NZ, BRANZ, and Beacon Pathway to empower consumers to act more sustainability. The free online Homestar™ Rating Tool was launched in October 2010. The development of the tool also had the support of the building industry and key Government agencies: the Department of Building and Housing, and the Energy Efficiency and Conservation Authority (EECA). It allows owners to assess their home's performance in comfort, health and energy-efficiency. Further, it has an educational role, as it provides valuable information to help householders make informed decisions to improve the performance of their homes.

The NZ Homestar™ rating system follows similar initiatives internationally. Since 2007, houses in Britain have required an energy efficiency rating (Energy Performance Certificate) before they can be sold, and all new homes are required to be built to the Code for Sustainable Homes. In addition, the European Union has now made it mandatory for every home in Europe to have an energy efficiency rating by 2012. Australia is moving in a similar direction with mandatory reporting of the energy performance of both commercial and residential space. It is likely NZ may follow this trend.

Since its introduction in October 2010, more than 8000 NZ homes have gone through a voluntary online Homestar self-assessment, and ten homes are independently certified. The NZ Homestar™ rating is included in this study to determine market knowledge of the tool and to make respondents aware of the tool, if they do not know of it, to ascertain the tools use, application and success. The rating tool is seen as a vital step toward change in the energy performance of residential homes in NZ. The survey will raise awareness of the tool but also determine the level of engagement with it, and the steps needed to motivate householders to act more sustainably.

However, to ensure the overall target of warm, dry, more energy efficient and healthy homes is achieved notions of sustainability and energy efficiency must become priorities for homeowners. As reported by Howden-Chapman et al. (2009), increased energy efficiency can be frustrated by the complexity of human behaviour including "take-back" whereby people take advantage of the better thermal properties of more energy efficient homes, by using heaters more.

This literature review has outlined a number of studies that have been undertaken about both public perceptions and consumer attitudes towards sustainability, and the state of the NZ housing sector in this regard. Essentially, existing NZ homes are still performing poorly in terms of energy and water efficiency, despite improvements to the NZ Building Code and availability of subsidies and grants.

Previous research (for example Bond, 2010) shows that factors affecting the willingness of householders to undertake sustainability improvements and to behave in more environmentally sensitive ways, include the amount of time involved, effort required, level of comfort provided, and the cost and long pay-back periods. The research reported here will investigate consumers home use behaviours, and their level of motivation to act more sustainably but also assess the market penetration and success of the Homestar™ Rating Tool in its first year of operation. The research aligns with and contributes to the goals of NZ Government's NZ Energy Strategy to meeting its energy, climate change, sustainability and economic transformation.

2. RESEARCH

According to the NZEECS (2007) the energy used in homes is affected by the appliances used, householder behaviors and building design. The broad aims of this research are to identify and explain user behaviour in residential buildings

in relation to the energy consumed, and evaluate the success of the Homestar™ rating tool in empowering householders to make their homes healthier and more energy efficient. The results from these pilot surveys help to identify the methods to aid communication of sustainability measures that encourage behaviour change, and increase the uptake of sustainability practices in homes that reduce greenhouse gas emissions from residential buildings.

2.1 Methodology

The surveys were distributed by hand to attendees at a Green Building Council of NZ event, "Homestar™ Industry Forum", launching the new Homestar™ residential rating tool to industry professionals. The first event was held in Christchurch on the 1st June 2011 and the second in Wellington on the 7th June 2011. The written survey was distributed to this targeted group, as half the survey questions relate to the Homestar™ Rating tool and it was considered this group would have an interest in answering it, as we needed to achieve a high response rate. A covering letter describing the survey, the questionnaire, and a self-addressed prepaid envelope were distributed to the 48 Christchurch, and 47 Wellington attendees.

2.2 Survey Instrument

The questionnaire commenced by asking respondents about the home they live in: size, number and types of rooms, and construction details, and household composition. They were then asked about the appliances in their home: whether they consider the energy efficiency and water rating of these, their age and whether they are energy/water rated or not, whether they have sourced information on the sustainability of their home or energy/water efficiency measures. Next they were given a range of actions that have been identified as having a significant effect on household climate change emissions and asked to indicate the likelihood of them adopting the listed behaviours or actions in the next 12 months, together with reasons for not undertaking them, if they have not already done so.

Questions in the second half of the survey related to the new Homestar™ residential rating tool. Respondents were asked if they knew about the tool, how they found out about it, whether they had used it, and if so, what the results were, and whether they made changes based on this. If they made changes to their home, respondents were asked what difference the changes made to their energy/gas bill and comfort and whether they took advantage of available grants or subsidies.

Respondents were asked to identify from a range of options what they consider to be the most important benefits of incorporating energy efficient features within a home, what were the barriers in doing so, and what more can be done to improve the uptake of sustainable features. Finally, demographic questions were included at the end of the survey. The next section outlines a summary of results.

3. RESULTS

Of the 48 questionnaires distributed to Christchurch GBCNZ event attendees, 31.25% (15) were completed and returned. Of the 47 questionnaires distributed to the Wellington group 21.28% (10) were completed and returned. Nearly three quarters (72%) of respondents live in a home they own or are paying off.

3.1 Size of home, household composition and house construction

The size of respondents' homes varied a lot as can be seen in Table 3, below, with 29% having a home between 101-150m^2, 25% between 201-250m^2, and 25% under 100m^2.

Table 3: Size of the respondent's house

Size (m^2)	Frequency	Percent (%)	Valid Percent (%)
Less than 100	6	24.0	25.0
101 - 150	7	28.0	29.2
151 – 200	4	16.0	16.7
201 – 250	6	24.0	25.0
251 - 300	1	4.0	4.2
Over 300	0	0.0	0.0
Total	25	100	100

Nearly half of the respondent's homes have three bedrooms (48%), 24% have four bedrooms, while only 20% have two, despite 48% of households having only two persons living in them (36% have four-person households, and 8% each have one and three persons). The number of bathrooms in homes were evenly distributed between one and two (48%

each), and the same percent of homes had two living rooms. This number of rooms appears to be in line with data from QV (2011) that shows that the average home has grown to 205m2. This trend to smaller household sizes and larger homes presents a barrier to reducing impacts on the environment.

The majority of homes were constructed of either weatherboard (timber or composite materials) or masonry veneer (32%), 44% were on a concrete slab foundation, 24% were on timber floor with timber piles and 16% of homes has timber flooring on brick or stone footings. Over half (52%) of the respondents' homes have no air-conditioning, while 44% had a heat pump/air conditioner. Only 8.4% of the homes have a swimming pool and/or Jacuzzi. A question of heating types was not included as this has been well covered in previous studies, (see for example EECA, 2010).

As appliances make up about 40% of the average household's electricity bill (EECA, 2009), questions relating to choice and use of these were included in the survey. Further, as Energy Star is the global mark of energy efficiency, typically awarded to the top 25% most energy efficient products by category, respondents were asked whether they consider the energy efficiency or water star rating of appliances before purchasing them and nearly three quarters (72%) said they did, while 20% said they did only sometimes. In terms of the age of appliances and heating systems used in respondents' homes, respondents indicated that the systems that are commonly added to the house when it is built: hot water cylinder (HWC) and ceiling insulation, were generally older than five years, perhaps reflecting the age of the homes. However, appliances which tend to have a shorter life span and do not form part of the real estate were generally less than five years old. As older appliances then to be less energy efficient, it is a concern that over half (54%) of respondents' washing machines, and over a third of their fridges and dishwashers are more than five years old. Table 4 below, outlines these results.

Table 4: The age of appliances & heating systems

Years	HWC	Ceiling Insulation	Fridge	Washing Machine	Dishwasher
Less than 5 years old	16	36	60	41	48
More than 5 years old	72	40	36	54	35
Unsure of age	12	16	4	4	4
Not applicable		8			13

Only 12% of respondents indicated the energy rating of their fridge (between 3,5-4 stars out of 6) and 8% indicated the rating of their washing machines (between 2-3.5 stars out of 6). This indicates that respondents' fridges are more energy efficient than their washing machines. According to ECCA, a modern family fridge/freezer with a 3½ star energy rating label costs around $100 per year to run. A 10-year-old fridge of the same size could cost twice as much to run. ENERGY STAR-qualified washing machines can be about 50% more efficient than nonqualified models. They also use less energy and water (EECA, 2009*ibid*). This indicates the cost and energy saving benefits of buying energy efficient, star rated appliances.

Only just over half (52%) of respondents have sourced information on the sustainability of their home, including energy and water efficiency measures or rebates in the last twelve months. Of those that had, 38.5% had obtained it from a government website such as EECA or the Ministry for the Environment's sustainability section, and 25% had sourced it from a combination of a government website or another sustainability website such as Beacon Pathways or the Sustainable Living Trust.

When asked how motivated respondents are to reduce their personal climate change emissions, only 12% said they were highly motivated, with over half (54%) moderately so.

3.2 Likelihood of adopting no to low cost energy efficient behaviours

EECA provides a number of information sheets for consumers. One of these outlines the energy saving tips for the home (EECA, 2009). Simple actions suggested include: stopping draughts around doors and windows with draught stoppers, using thermostats and timers so heaters only come on when needed, and switching appliances off at the wall when not in use as they draw energy even when on standby. ECCA (2009), and NZEECS (2007), include the cost savings of taking some simple no cost, or low, cost actions, as outlined in Table 5, below:

Table 5: Simple Energy Saving Actions and Savings

Actions	Typical savings per annum

Using the sun to dry clothes, rather than a dryer	$200
Switching off or getting rid of a spare fridge	$100 - $300
Use heated towel rail for just a few hours day instead of leaving on permanently	$90
Replacing four most used light bulbs with energy efficient ones	$85
Wrap electric hot water cylinder so it stays warmer for longer. If cylinder is older (i.e. pre-1987)	$140
Turn appliance off rather than leaving them on standby	$75
Install good thermal backed curtains	$100
Install an efficient shower head	$200 - $720 (depending on flow rate of old one)
Turn down the hot water heating setting – it should be at 55 °C.	Turning down 10°C: $20 - $30
Use cold water for washing your clothes	4 loads/week: $50-$75

From a range of *no/low cost* actions, such as those outlined in Table 4, that have been identified as having a significant effect on household greenhouse gas emissions respondents were asked to indicate the *likelihood* of them adopting the listed behaviours or actions in the next 12 months: *already taking; most likely to take; unlikely to take*. Most respondents were already taking action for over half of the nineteen listed *no/low cost* options. The most common actions *already taken* were: turning lights off when not in the room and using natural light where possible; drying clothes on a clothesline rather than in an electric clothes dryer; turning down the hot water heater setting to 50-60ºC; washing clothes in cold water, and dressing appropriately rather than cooling/warming the whole room/house.

The *no/low cost* actions respondents were *most likely to take* included: avoiding halogen down-lights or replace them with lower wattage globes; installing water efficient tap fittings; insulating hot water pipes coming out of the water heater, and installing timers on appliances to turn them off when not in use. The actions they were *most unlikely to take* were: reducing showering time to less than four minutes; turning off all appliances at the wall when not in use, and installing a water efficient shower head and tap fittings. Given that all the listed actions are low or no cost it was surprising that more people would not take these actions.

3.3 Reasons for not taking no to low cost actions

A question was included to determine the reasons why respondents do to take action. The reasons given depended on the action. For example, some respondents said they did not turn off appliances as they had timers and clocks on them (would require resetting each time they turned them back on), or that they were difficult to reach. The reason given most commonly for not reducing showering times was simply that they like hot showers, or it was habit. Reasons given for not using a warmer blanket while sleeping rather than warming the whole room/house, or for dressing appropriately rather than cooling/warming the whole room/house, was the need to keep the house warm to reduce the chance of mould forming, to maintain the home temperature in line with WHO (1987) guidelines of 18ºC, and to keep the home comfortable for the baby. Other reasons were cost or that they can not be bothered. This information can provide useful clues of what is needed to help people act, such as automating some actions where possible or making actions mandatory, such as requiring homes to have water efficient shower heads.

3.4 Likelihood of adopting low to medium cost energy efficient behaviours

Next respondents were asked to indicate the likelihood of them adopting behaviours or actions in the next 12 months from a range of *low to medium cost* actions that have been identified as reducing greenhouse gas emissions produced by households. Not surprisingly fewer of the respondents were already taking action on the *low/medium cost* listed items compared to the *no/low cost* actions.

The most common actions already taken were: replacing single flush toilet with dual system; replacing the old fridge with a high Energy Star rated one; installing or topping-up ceiling insulation; installing a 5-Star energy saving instant gas, heat pump or solar water heater, and replacing the old washing machine with a more energy and water efficient one. Given that 42% of heat escapes through the roof and that heating and cooling consume the most amount of energy in a home (38%) installing or topping up insulation is one of the more cost-effective ways of reducing energy consumption in homes and saving money. Not surprisingly, with rebates available for installing insulation, over a third

of respondents (35%) had already done this. Similarly, water heating uses 25% of energy in homes but consumes the most greenhouse gas emissions and installing instantaneous gas or solar hot water heater is another cost-effective way of reducing both energy consumption and greenhouse gas emissions while saving money. Again, over a third (36.5%) had already taken measures to make heating water more energy efficient.

The *low/medium cost* actions respondents were *most likely* to take included: installing or topping-up ceiling insulation; having an energy audit completed, and replacing the old fridge with a high Energy Star rated one. The actions they were *most unlikely to take* were installing any of the following: a grey water system; a photovoltaic system; a HRV home ventilation system, and double glazing.

3.5 Reasons for not taking low to medium cost actions

The most common reasons for not acting on the various listed options were predominantly due to the cost of the item/s and the poor pay back on them. In terms of externally shading exposed western or eastern windows, respondents generally like the natural light and sun and did not want to close it out. For installing HRV home ventilation systems respondents felt that they were overpriced, not effective or that their house is not suitable due to a lack of roof space. Certainly, given the results of recent studies (for example Fitzgerald et al. 2011, and Boulic et al. 2010) it is not surprising there is some confusion about the benefits or effectiveness of HRV home ventilation systems.

3.6 Homestar™ Residential Rating Tool Use

The next part of the survey asked respondents questions about the new Homestar™ residential rating tool. Respondents were asked if they knew about the tool, and given that they were all attending a seminar about the tool it was not surprising that most of them had. When asked how they found out about the Homestar™ rating tool, 52% responded that they heard about it through a work related contact/building industry network, and 17.4% heard about it through the Green Building Council of NZ (the developers of the tool and host of the seminar respondents were attending).

Only half of them had used the rating tool and of those that had, they had completed the online self assessment (rather than using a HomeCoach™ or Homestar™ Assessor). In terms of their rating, 55.5% had a 2-Star (out of 10); 22% had a 6-Star, and 11% had a 4-Star and 5-Star, respectively. According to the Green Building Council of NZ, the average New Zealand house hovers between a two or three-star ranking, but with basic insulation can instantly be upgraded to a four or five (Radio NZ, 2011).

Of the respondents that had conducted the Homestar™ assessment, three quarters of them had not made any changes. The remaining 25% of those that assessed their home, only made three types of changes: added/topped up insulation in the ceiling, installed energy efficient compact fluorescent or LED lights, and draught seal around windows and doors. The cost was less then $300 for these changes. Of the 25% that made changes, two-thirds of them agreed that the changes had made a difference to their energy and gas bills by reducing it by $60 to $300 per annum. These respondents also felt that their homes were warmer in winter and that the house retained a comfortable temperature for longer, after heating/cooling was turned off. Only one respondent reassessed their home after making these improvements and reported that it increased the Star rating of the home.

3.7 Benefits for acting environmentally

It is recognised that many of the energy and water saving features in homes cost money so respondents were asked to rank from a list of financial and non-financial benefits what they considered to be the most important and that might motivate them to act.

Results from the two city respondent groups varied slightly for this question. Christchurch respondents' ranked comfortable home temperature as the most important followed by: healthy indoor air quality; reduced home running costs; increased property value; reduced environmental impact, and decreased obsolescence ranked last. Whereas Wellington respondents ranked reduced home running costs as most important followed by: comfortable home temperature; healthy indoor air quality; reduced environmental impact; increased property value, with decreased also obsolescence ranked last. Certainly it is the cost savings benefits that are reported most widely in the media in relation to acting in a more energy conserving way. Further, with so much media-attention to the need to combat climate change this has no doubt raised awareness amongst the public for the need to act in a more environmental sensitive way.

3.8 Barriers to incorporating sustainable features and suggestions to improve uptake

Respondents were asked to rank a list of potential barriers to the incorporation of sustainable features into homes. The results overall for both cities' respondents are outlined in Table 6, below:

Table 6: Barriers to incorporating sustainable features	
Rank	**Barriers**
1	High cost/low benefit of features; Lack of owner/occupier awareness
2	Unwillingness to pay additional cost
3	Poor access to information
4	Limited availability to new technology
5	Unreliable or unproven technology;
6	Lack of developer awareness
7	Difficulty getting local authority approval
8	Other

Wellington respondents ranked the first four options differently to their Christchurch counterparts. They felt that unwillingness to pay additional cost was the main barrier, followed: by high cost/low benefit of features; poor access to information, and lack of owner/occupier awareness. It does seem from the results to the last two questions that Wellington respondents are more cost focused than their Christchurch counterpart, that rank other options as more important than purely based on cost.

In terms of incentives to encourage the uptake of energy or water saving features in the design of new and retrofitted homes, respondents from each city ranked the listed options differently, again, as indicated in Table 7, below:

Table 7: Incentives to Encourage the Uptake of Sustainable Features		
Rank	**Christchurch Respondents**	**Wellington Respondents**
1	More rebates/subsidies	Better advertising; Mandatory energy efficiency reporting
2	Building code changes	More rebates/subsidies
3	Mandatory energy efficiency reporting	Availability of products
4	Building certification	Building certification
5	Changes to legislation	Building code changes; Changes to legislation
6	Better advertising	Other
7	Availability of products	
8	Other	

Results between respondent groups varied. The Christchurch respondents felt that more rebates and subsidies would have the strongest influence. This result is consistent with the feedback from the previous question, which found that unwillingness to pay additional cost is a primary barrier for incorporating sustainable features. The least important item for encouraging sustainable features in new homes was the availability of products. Building Code changes were ranked second. Certainly, from the literature review, Building Code changes have aided the improvement in the performance of new homes however such changes do little to help the performance of existing homes.

Wellington respondents felt that better information through advertising was most important to help increase both awareness and demand, and this was also consistent with the feedback on the previous question that there is a lack of owner/occupier awareness. Further, it is consistent with the NZEECS, 2007. Mandatory energy efficiency reporting was also considered very important as an incentive to encourage more sustainable behaviour in household choices. Certainly, the Australian Government has considered this important in their energy efficiency strategies and are introducing it for homes in 2012 (it was introduced for commercial buildings in 2010, under the *Building Energy Efficiency Disclosure Act 2010,* Department of Climate Change & Energy Efficiency, 2010).

3.9 Demographics

Lastly, demographic questions revealed that 56% of respondents came from the South Island Christchurch) and 44% from the North Island (Wellington), with 71% being male. Age of respondents were widely distributed 29% were

between 40-49 years of age, 25% between 30-39, and 21% were between 20-29 years of age. In terms of household income 61% earned between $100,000 and $200,000, 17% earned $30,000 - $60,000, and 13% earned between $60,000 and $100,000.

4. SUMMARY AND CONCLUSION

This paper outlines the results of a pilot survey of householders in 2011 to identify householders' lifestyle choices within homes that impact on energy use and their motivation to conserve energy. Barriers to energy efficiency in homes are larger homes and smaller households, initial costs, long payback periods for sustainable features, and a lack of credible information to make energy efficient choices. The same barriers were indicated by respondents to this survey, particularly those relating to cost and lack of consumer information about benefits and savings from incorporating energy efficient and water saving devices and features.

Given that water heating and heating and cooling of homes use the most energy and produce the most greenhouse gas emissions these areas should be focused on. The greater uptake of rebates for ceiling insulation and clean heating devices would aid in the fight to reduce greenhouse gas emissions. The introduction of the voluntary Homestar™ rating tool is seen as an important step towards empowering householders to act more sustainably, and it provides relevant and credible information to help householders make better environmental choices. If the NZ Government took a similar approach to the Australian Government by making it mandatory to provide energy, greenhouse and water performance information available to buyers and renters this would be a powerful tool to motivate change.

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