OCTOBER **2007**

National Value Case for Sustainable Housing Innovations

Making the case for the national benefit to be gained by transforming the New Zealand housing stock – both new and existing - to improve sustainability

Beacon

TOGETHER, CREATING TOMORROW'S HOMES

PUBLISHING DETAILS:

Published October 2007
by Beacon Pathway Ltd
PO Box 11 338
Auckland

AUTHORS

Allen & Clarke Policy and Regulatory Specialists
Infometrics
Eco$ense
Martin Jenkins
Beacon Pathway Limited

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

ACKNOWLEDGEMENTS

Much of the research forming the basis of this report has been undertaken by the researchers of Beacon Pathway Ltd. Beacon also acknowledges the significant contribution of researchers from BRANZ Ltd.

Photographs provided by Craig Robertson Photography, Chris Coad, David Killick & Deborah Dewhirst.

Graphic design by Sue Fern, Boffa Miskell.

Printed by Soar Print.

CONTENTS

CONTENTS 1
ABOUT BEACON PATHWAY 2
EXECUTIVE SUMMARY 3
1. INTRODUCTION 7
1.1 Purpose 7
1.2 Government Commitment 7
1.3 Scope 7
1.4 Definitions 8
1.5 High Standard of Sustainability 8
1.6 New Zealand's Unsustainable Housing Stock 9
1.7 Methodology 14
2. ANALYSIS OF EXAMPLE INNOVATIONS 16
2.1 Energy 18
2.1.1 Retrofit Insulation 18
2.1.2 Space Heating 19
2.1.3 Efficient Lighting 20
2.1.4 Water Heating 21
2.2 Water 23
2.2.1 Low Flow Devices for Water Efficiency 23
2.2.2 Water Metering 24
3. HIGH STANDARDS OF SUSTAINABILITY 26
3.1 Energy 26
3.2 Water 27
4. THE CASE FOR INTERVENTION 29
4.1 Retrofit Insulation 31
4.2 Space Heating 33
4.3 Compact Fluorescent Lighting 34
4.4 Water Heating 34
4.5 Water Efficiency Measures 35
4.6 Water Metering 36
4.7 Linkages 37
APPENDICES 41
REFERENCES 51

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

ABOUT BEACON PATHWAY

Beacon Pathway Limited (Beacon) is the vehicle chosen by a number of like-minded organisations that are working to find affordable, attractive ways to make New Zealand's homes more sustainable: warmer, healthier, cheaper to run and kinder to the environment. Beacon aims to bring about a significant improvement in the sustainability of the residential built environment in New Zealand through the provision of science based New Zealand research outputs.

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.

Beacon Pathway commenced its research programme with the construction of the Waitakere NOW Home® – a research home in Auckland designed to be affordable, healthy and more resource efficient than a standard new home. This home has been occupied by an ordinary family for 2 years and monitoring indicates that the research hypothesis is being validated.

Beacon has developed a second NOW Home® in Rotorua in collaboration with Housing New Zealand Corporation, and has undertaken research on a range of different sustainable building technologies, policy methods and market transformation initiatives aimed at increasing the sustainability of the residential built environment. Beacon is about to embark on a project that will see 100 NOW Homes® built across New Zealand.

Beacon has also undertaken significant research in the area of home retrofitting. Nine homes in Porirua have been retrofitted with a range of packages and are being monitored by Beacon as part of a research project to clearly identify both the actual cost-benefit of a range of sustainable retrofit options and what are the most effective retrofit packages which will deliver homes to a high standard of sustainability. A programme to see 1000 existing homes across New Zealand retrofitted with these packages is about to get underway.

Beacon's focus is on the homes of ordinary New Zealanders rather than any particular income or demographic group. If New Zealand is to make significant steps towards energy efficiency and sustainability, then retrofit programmes need to be targeted across the range of income groups and demographics.

Beacon has significant experience with working on collaborative projects and in pulling together multiple stakeholders. For example, Beacon has recently finished working in partnership with Consumers' Institute, URS New Zealand and a range of other partners to deliver the Smarter Homes website; an online information resource on sustainable building for the Ministry for the Environment.

More information on Beacon can be found at our websites: **www.beaconpathway.co.nz** and **www.nowhome.co.nz.**

EXECUTIVE SUMMARY

A strong value case exists at a national level to transform a significant proportion of the New Zealand housing stock to a High Standard of Sustainability with beneficial social, health, environmental and economic outcomes. The majority of the New Zealand housing stock performs poorly in terms of sustainability. Our homes are cold, damp and inefficient in energy and water use. Beacon has developed benchmarks for a High Standard of Sustainability defining the extent of change required, and assessed the implications for such a change, while keeping affordability as a key consideration.

- New Zealand homes are on average $6^{o}C$ below World Health Organization recommended minimum temperatures in winter;
- 45% of all New Zealand homes are mouldy;
- New Zealand has the second highest rate of asthma in the world and an excess winter mortality rate of 1600 not seen in other OECD countries;
- 300,000 New Zealand homes have an unflued gas heater;
- The air inside New Zealand homes can be more polluted than outdoor air; and cold damp homes pose serious health risks, particularly for the most vulnerable groups in the community who spend the most time at home (the young, elderly, infirm, and unemployed).

A High Standard of Sustainability is achievable in both new and existing homes. The Government needs to apply effort where it will best effect long term national-scale changes in the demand, uptake and supply of sustainable solutions that improve the quality and performance of new and existing housing.

This National Value Case focuses on how an improved housing stock can be valued across a range of Government priorities, demonstrating the national and economy-wide benefits of having housing stock at a higher standard of sustainability than currently.

Increasing the sustainability of New Zealand's housing stock will:

- improve New Zealanders' quality of life through healthier homes;
- reduce the demand from homes on reticulated energy;
- reduce total energy requirements;
- reduce carbon dioxide emissions and assist New Zealand in meeting our Kyoto commitments;
- reduce demand for reticulated water (and the associated energy required), with longer life for infrastructure and environmental benefits;
- improve management of stormwater and greywater to decrease negative impacts on the residential and natural environment, thereby making a more resilient water system;
- increase productivity and make more efficient use of New Zealand's resources; and
- improve the New Zealand housing stock in terms of resilience to global challenges such as climate change, resource availability, and population change.

A significant role exists for Government to drive the necessary upgrade of the existing housing stock to a higher standard of sustainability as well as substantially raise minimum standards in the Building Code for new houses. A range of simple interventions are examined here which demonstrate the significant difference that can be made to the sustainability of the housing stock, particularly when implemented in combination.

These proposed interventions provide examples of the compelling case for the kinds of interventions needed to achieve the Government's vision of being a sustainable nation, carbon neutral, and meeting our Kyoto commitments. Given the national priority on sustainable development, and the national-scale benefits that would accrue from an improved housing stock, there is a strong argument to be made for incentivising uptake. This assessment concludes that there is a strong case for both implementation of water efficiency technologies at a national level and for universal metering of domestic water supply.

There is a strong case for intervention around improvements in energy efficiency – currently the subject of a range of Government programmes in development by the Energy Efficiency and Conservation Authority (EECA). However the value case exists for a much higher standard of retrofit – for insulation, space and water heating – than is currently undertaken as part of EECA-supported voluntary programmes.

Programmes aiming to generate sustainability outcomes need to be both targeted differently and promote a much higher standard than is currently the case. The different triggers to incentivise such schemes need to be recognised (e.g. health, warmth, comfort, reduced noise) other than just financial savings.

The assessment also identifies that there are particular opportunities and value which are able to be unlocked by combining sustainability interventions, rather than retrofitting on a technology by technology basis, and from looking at energy, health, environment, and water efficiency as a combined package, rather than on an issue by issue basis.

Combining the five innovations that were rated as Medium Weak or better, and spreading installation costs over 20 years, would generate a direct private economic gain to households equivalent to 1% of GDP by 2017 or about $2 billion[1]. Non-monetary benefits of healthier and more comfortable homes, and environmental benefits, are additional.

Direct savings in household energy consumption amount to almost 22 PJ per year, or enough to power over 500,000 New Zealand homes for a year[2]. Most of the energy savings are in electricity use, implying a reduction in CO_2 emissions of 3600kt per year, the equivalent of $54 million in tradable emissions (at $15/tonne). Even allowing for take-back effects in the form of warmer and healthier homes and spending of household savings from energy on travel and other commodities, net economy-wide CO_2 savings of 1600kt are still produced. This will contribute to a reduction in carbon emissions in line with New Zealand's Kyoto commitments.

Direct water savings amount to 81 litres per person per day, or about 130 million m^3 per year.

Realisation of the benefits associated with the interventions identified in this paper requires homeowners, landlords and occupiers to make and implement decisions that will change how they build, insulate, heat and manage the consumption of water in houses they own. In some cases these decisions will involve relatively little cost apart from perhaps time and inconvenience. In other cases, decisions will involve what may be relatively large up-front costs for an individual benefit that will be realised over the long term, yet which may have large collective benefits on a national scale.

---

1 Note that the figure of $2 billion does not account for future inflation which will increase this figure. Also the actual measured increase in real private consumption is lower at 0.35% (or $106 per person per year), which is purely the overall resource use efficiency effect of households shifting expenditure from energy and water to other commodities.

2 Based on estimates by Beacon that the average New Zealand household uses 12,300kWh of energy per year if the home is to be heated to temperatures which meet minimum WHO standards.

The Government can create an environment conducive to more environmentally sustainable housing. It can:

- lead and communicate the case for change with stakeholders involved in all areas of the research, design, supply, construction, regulation, and use of the residential built environment;
- develop and implement appropriate policy frameworks and associated regulations to ensure that consumers face the full environmental and other costs and benefits of their decisions;
- provide assistance to households to retrofit their existing houses to a High Standard of Sustainability;
- effect change through its direct ownership of approximately 80,000 household units and related property maintenance and purchase decisions;
- regulate to mandate the installation or use of particular technologies;
- communicate and provide information to inform consumer choices and explain the case for change; and
- set performance levels to improve both owner-occupied and rental housing stock, e.g. through regulation of performance standards for houses at point of sale and at point of rental.

Options for Government to promote the achievement of a High Standard of Sustainability in New Zealand's housing stock include regulation and incentives to retrofit homes for high thermal performance (insulation), efficient space and water heating, lighting, water efficiency and healthy indoor environments (heating; insulation and ventilation measures), ensuring that these are delivered as a package rather than the current siloed approach by individual agencies; and setting minimum standards in the Building Code, which will substantially improve the sustainability of new housing stock.

Key areas of Government action to improve the sustainability of New Zealand homes are:

1. Amendments to the Building Code
    a. Include provisions for minimum requirements when retrofitting existing houses in the Building Code. The Code needs to consider the issue of poorly performing, sometimes poorly built existing buildings and provide provision for consequential action.
    b. Inclusion of a rating tool within the Building Code. Internationally the development of rating tools for the promotion and quantification of sustainable development is a prominent approach which needs to be taken up in the Building Code. The Home Energy Rating Scheme which is currently being developed by EECA should be included within the Code, and extended to a sustainability rating tool rather than solely energy.

2. Upgrade the current insulation retrofits being carried out with assistance from EECA to a High Standard of Sustainability.

   a. Expand the EECA EnergyWise Grants for low income households to include:

      - Best Standard of insulation;
      - energy efficient water heating;
      - energy efficient lighting;
      - an efficient heat source where required;
      - water efficiency; and
      - improvements in indoor environmental quality.

   b. Increase and simplify financial incentives for solar water heating.

   c. Provide interest free loans for homeowners to retrofit homes based on a High Standard of Sustainability with:

      - Best Standard of insulation;
      - energy efficient water heating;
      - energy efficient lighting;
      - an efficient heat source where required;
      - water efficiency; and
      - improvements in indoor environmental quality.

   d. Provide incentives through a housing supplement or interest free loans to landlords to upgrade rental housing stock to High Standard of Sustainability. Subsequently, in the medium term, Government should require landlords to have their properties certified. This could be as much from the health and safety aspect as from sustainability.

3. Ban unflued gas heaters.

4. Government leadership in Housing New Zealand Corporation and other Government managed residential housing, upgrading this to a High Standard of Sustainability over the next 5 years.

5. Build on the voluntary Home Energy Rating Scheme (HERS) being developed by the Energy Efficiency and Conservation Authority and implemented in December 2007 to:

   - a mandatory HERS at point of sale from December 2008;
   - a mandatory HERS at point of rental from December 2009; and
   - a mandatory Sustainability Rating at point of sale and rental from December 2010.

6. Additional regulatory review.

   a. Minimum standards in the Residential Tenancy Act for residential dwellings at point of rental.

   b. Urban water efficiency be integrated into the Ministry for the Environment's Water Programme of Action and any National Policy Statement developed under this.

1. INTRODUCTION

1.1 PURPOSE

This report provides an assessment of the National Value Case for bringing the majority of New Zealand's housing stock up to a High Standard of Sustainability. It sets out to explain the national benefit of doing this, and it provides analysis of a range of innovations related to the efficient and sustainable use of New Zealand's resources in housing. It provides Government with the opportunity to participate in interventions by providing the case for investment in sustainable housing and the removal of regulatory barriers.

1.2 GOVERNMENT COMMITMENT

The current Government has made firm steps and commitments in the direction of sustainability in the residential built environment and households. The Prime Minister's statement to Parliament in February 2007 was a strong signal of the Government's commitment, when she called for New Zealand to be the *first truly sustainable nation* and a *carbon neutral nation*. Current policy direction indicates that the Government has recognised the need to move towards more sustainable ways of living and building. However, the majority of New Zealand homes are still cold, damp, and energy inefficient. Significant changes are needed to bring them up to a High Standard of Sustainability.

For all families, young and old, we need houses that are substantially more resource efficient, healthy and comfortable, and we need to promote greater resource efficiency in housing, thereby reducing long term burdens on New Zealand in terms of infrastructure costs, environmental effects and climate change.

By providing supportive policies and regulations for sustainable housing, Government removes uncertainty for consumers and industry in demanding and supplying sustainable solutions for homes and neighbourhoods, and can provide stimulus for the implementation of effective solutions where long term individual and national benefits impose short term costs on households. Economic transformation is required to bring the housing stock to a High Standard of Sustainability, through incentivising and promoting effective sustainable housing innovations. Improving the sustainability performance of the New Zealand housing stock is likely to require Government intervention through a mix of instruments including policy interventions, economic incentives, monitoring and evaluation.

1.3 SCOPE

The *National Value Case for Sustainable Housing Innovations* was commissioned by Beacon Pathway Limited (Beacon) to quantitatively assess the national value of bringing the majority of New Zealand's housing stock up to Beacon's High Standard of Sustainability. To do this, a small range of innovations that could enhance the efficient and sustainable use of the country's resources in housing were analysed as examples of the possibilities.

Beacon has identified a large range of innovations in the areas of energy, water, indoor environmental quality, materials, and neighbourhood design. Quantitative evaluation was carried out on a selection of six energy and water saving innovations as examples of the possible benefits and costs of innovations for sustainable housing at a national level. This economic analysis was undertaken by Infometrics, who have carried out similar analyses for various Government departments, including recent analysis of the New Zealand Emissions Trading Scheme.

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

The National Value Case of the example innovations is evaluated with respect to four types of benefits: private economic benefits for households, environmental benefits, social and other private benefits, and national resource use efficiency. Different approaches are used for evaluating the different types of benefit, but the final assessment for each innovation is expressed as a set of weighted scores. Associated with this score is a complementary assessment of the scope for Government intervention. That is, some innovations have a strong National Value Case, but may face barriers to adoption by households. In such instances, Government intervention is appropriate.

This is not an exhaustive list of either the available innovations or the possible interventions to address them. To transform the New Zealand housing stock to a High Standard of Sustainability, a well researched range of interventions will be necessary, with such interventions used in combination rather than on their own.

1.4 DEFINITIONS

High Standard of Sustainability (HSS): Beacon's HSS defines the combination of factors that show a home is performing sustainably. Draft benchmarks have been established in the areas of energy and water (Easton, 2006). Checklists to address waste, indoor environmental quality (IEQ) and materials have also been established.

Housing Stock: term to describe all dwellings and homes across the country. Collectively dwellings can be considered as a national resource providing shelter, security and warmth to New Zealanders. The 'state' or performance of all homes has national implications, e.g. cold damp dwellings mean unwell occupants; inefficient energy use increases the carbon footprint of our homes.

Indoor Environment Quality (IEQ): this encompasses the aspects of the indoor environment which impact on the health and wellbeing of house occupants, and on the sustainability of a home. It includes aspects such as temperature, relative humidity, ventilation, noise and presence of pathogens and harmful chemicals in the air.

Retrofit: interventions made on a home to improve its performance.

1.5 HIGH STANDARD OF SUSTAINABILITY

The potential exists to transform a significant proportion of the New Zealand housing stock to a High Standard of Sustainability in terms of social, health, environmental and economic outcomes. The Government needs to apply effort where it will best effect long term national-scale changes in the demand, uptake and supply of sustainable technologies and solutions that improve the quality and performance of new and existing housing. Increasing the sustainability of New Zealand's housing stock will:

- improve New Zealanders' quality of life through healthier homes;
- reduce the demand from homes on reticulated energy;
- reduce total energy requirements;
- reduce carbon dioxide emissions and assist New Zealand in meeting our Kyoto commitments;
- reduce demand for reticulated water (and the associated energy required), with longer life for infrastructure and environmental benefits;
- improve management of stormwater and greywater to decrease negative impacts on the residential and natural environment, thereby making a more resilient water system;
- increased productivity and more efficient use of New Zealand's resources; and
- improve New Zealand housing stock in terms of resilience to global challenges such as climate change, resource availability, and population change.

Beacon has developed benchmark measures for energy and water consumption, waste, indoor environmental quality and materials used in house construction, which define Beacon's High Standard of Sustainability (Easton 2006). These measures represent benchmarks against which the sustainability of New Zealand homes can be measured, and have been developed with affordability as a significant consideration. These benchmarks are expected to be updated and refined over time as the research into the state of New Zealand's home performance continues. Beacon's High Standard of Sustainability defines the combination of factors that show a home is performing sustainably. The percentage reductions in energy and water use are attributable to the design and features of the home, and it is expected that occupier behaviour modification could see further significant improvements in the efficiency and healthiness of homes.

The benchmarks set represent:

- a 25% reduction in energy use in new homes and a 15% reduction in energy use in existing homes (with different benchmarks for new and existing homes in each of the Climate Zones in the Building Code);
- a 25% reduction in water use in both new and existing homes (benchmark of 180 litres per person per day);
- indoor temperatures which meet the World Health Organization minimum standards of 16°C in bedrooms and 18°C in living space;
- adequate ventilation without excessive draughts; mean relative humidity of 20-70%; mechanical ventilation of kitchen, bathroom and laundry; no unflued gas heaters or air conditioning; Environmental Choice certified paints and finishes;
- provision for kitchen waste minimisation, recyclables storage, no in-sink waste disposal unit, and construction or renovation in accordance with REBRI construction guidelines; and
- consideration of sustainability issues in the choice of materials used for construction or renovation of homes.

To assist in bringing the New Zealand stock to a High Standard of Sustainability, Beacon is undertaking a range of research initiatives including the NOW 100 programme to develop and test procedures for building sustainable homes with industry and local authorities. This will then pilot the application of Beacon's research learnings to 100 new homes in a range of locations around New Zealand. In addition the Retrofit 1000 programme aims to demonstrate successful retrofit methodology for achieving a High Standard of Sustainability in 1000 existing homes across New Zealand. These programmes will demonstrate the application of the High Standard of Sustainability in both new and existing homes across New Zealand.

1.6 NEW ZEALAND'S UNSUSTAINABLE HOUSING STOCK

Research conducted by Beacon and others shows that New Zealand's housing stock is generally poor quality with poor environmental performance. Our houses are unhealthy for many, and are large consumers of energy, water and materials, creating an increasing burden on the economy.

Upgrading the existing stock to higher levels of sustainability is critical:

- there are 1.6 million existing houses with only 25,000 new homes built each year;
- their condition and performance are critical as it is where most New Zealanders will live in the short and medium term future;
- existing housing stock represents considerable resource investments which should be optimised where possible; and
- for the significant reductions that can be made in greenhouse gas emissions from reduced energy use in homes and embodied energy in water use (both costs of energy and the production of greenhouse gases are inherent in water supply and disposal).

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

Direct burdens on the economy of poor performance of our housing stock include higher than necessary needs for health, police, and emergency services; energy demand; and carbon emissions relating to climate change. Indirect burdens include lost productivity and reduced educational achievement.

The performance of the economy is affected by growth and employment, which in turn are reliant on education, health and immigration. Poor performance of the housing stock can adversely affect health leading to lost time from education, employment and leisure. Sustainable housing can favourably affect health thus reducing these losses, and a positive reputation for quality housing can attract skilled immigrants.

For households, income and spending are measures for (micro-) economic well-being. Spending decisions involve a trade-off between leisure and consumption. Household investment in improving the sustainability of homes will be dependent on their ability to switch spending between leisure and consumption. The cost of housing represents a long term investment for most households. Additional investment to achieve a High Standard of Sustainability for the home is a complex decision influenced by motivation and perceived return on investment. The multiple benefits related to education, health and employment are currently not explicit in these household-level decisions. In addition, low income households are often not in a position to make such decisions despite the benefits.

INDOOR ENVIRONMENTAL QUALITY

Despite New Zealand's usually temperate climate, our houses are generally cold, damp and hard to heat in winter. There is a growing awareness that cold damp homes pose health risks, especially for particular groups in the community, mainly the very young, the elderly, and those with chronic health problems (Howden-Chapman et al, 2004). In addition, the types of heating used poses health concerns, in particular, air pollution caused by inefficient methods of solid fuel heating, and the release of combustion products from unflued gas heaters.

New Zealanders spend 75% - 90% of their time at home. The most vulnerable groups, namely infants, children, infirmed and elderly, spend the highest amounts of time at home. Common features of New Zealand homes found across all socioeconomic groups include (Phipps, 2007):

- New Zealand homes are on average 6°C below World Health Organization recommended minimum temperatures in winter;
- 45% of all New Zealand homes are mouldy;
- approximately 300,000 New Zealand homes have an unflued gas heater;
- the air inside New Zealand homes can be more polluted than outdoor air; and
- fungi and dustmites are common and trigger allergenic reactions and asthma, rates of which are increasing.

New Zealand has an excess winter mortality rate of around 1600[3]. This is not seen in other OECD countries, and our cold housing is thought to play a large role. New Zealand has the second highest rate of asthma in the world, with one in six adults and one in four children experiencing asthma symptoms (over 600,000 New Zealanders), conservatively estimated to cost New Zealand $825 million per year (Asthma and Respiratory Foundation of New Zealand 2007). Our damp cold homes are a significant contributor to asthma and bronchial diseases, therefore measures to decrease respiratory irritants and damp, cold homes are critical. Research shows evidence of health returns well in excess of the investment in housing improvements, and EECA have identified that health is a more persuasive driver for homeowners to upgrade their home than climate change or energy efficiency.

[3] The number of additional deaths occurring in winter compared to those occurring in non-winter months.

A significant proportion of New Zealand homes use unflued gas heaters as a major source of heating. This has many negative impacts. Unflued gas heaters are:

- unhealthy – generating excess moisture, carbon monoxide, nitrogen dioxide and other hazardous indoor air pollutants.
- inefficient – because they produce wet heat, it is harder for people to heat their homes as wet air is harder to heat than dry air.
- false economy – many people use unflued gas heaters in conjunction with a dehumidifier because of the significant moisture produced. Dehumidifiers are often poorly located and use significant energy.

Prior to 1977 there were no requirements nationally for insulation to be included in new house construction. Thus, about 65% of the current housing stock (about 900,000 homes) is estimated to have been built prior to any mandated requirement for insulation. Furthermore, many homes built since 1977 are known to still not meet these standards.

Since the mid 1990s an increasing number of energy efficiency retrofit programmes have been underway throughout the country, with Government assistance being available for low income homes. BRANZ data indicates that currently between 700,000 and 900,000 New Zealand homes are not insulated to 1977 standards (let alone new 2007 standards). These homes are cold and require large amounts of energy to raise temperatures to an adequate comfort level.

HOUSEHOLD ENERGY USE

Households directly consume 32.4% of energy (including transport energy) in New Zealand (EECA, 2007). If New Zealand is to fulfil our Kyoto commitments and move in the direction of carbon neutrality, household energy use will need to be reduced, become more efficient, or rely on alternative renewable energy sources. The Government has signalled its aspiration for New Zealand to be carbon neutral, and its recent climate change solutions set out targets for New Zealand to be carbon neutral in the energy sector by 2025, carbon neutral in the stationary energy sector by 2030, and by 2025, for 90% of New Zealand's electricity generation to be from renewable sources. These are substantial challenges, especially when factoring in estimates that electricity demand will increase 40% and energy-related greenhouse gases will increase by 35% under a business-as-usual scenario by 2030[4]. Transforming New Zealand homes to meet Beacon's High Standard of Sustainability can help deliver the Government's vision through a reduction in energy demand and increased use of renewable energy sources.

Energy use has a significant impact on the spending of families in New Zealand. Reducing household spending on energy will impact on:

- the amount that families have to spend on other commodities;
- the amount and price of energy available for business use, and hence the competitiveness of New Zealand's industry in the global market;
- the peaks in energy use from domestic consumption which result in increased cost / disruption to industry; and
- creation of greenhouse gases contributing to climate change.

4 http://www.climatechange.govt.nz/files/NZ-Climate-Change-Solutions.pdf

CONSIDERATIONS AROUND WATER USE

Water and energy efficiency are usually considered independently of each other. Yet, collection, storage, transport, treatment, use and disposal of water has significant associated energy costs, not currently considered in water planning. Decisions to, for example, build a new water supply dam (as is currently proposed in Wellington) instead of introducing measures to promote efficient use of water, will incur significant extra energy costs in construction, operation (e.g. pumping stations, pipe network), and the disposal of wastewater.

Hot water is a major energy use in households (approximately 30% of household energy consumption) and the majority of households do not have low flow devices. New hot water systems are often high pressure mains systems, which exacerbate the problem. Use of such innovations as low flow shower heads would have a significant positive benefit in terms of both water and energy efficiency.

There are good arguments for basic water efficiency measures (low flow devices, dual flush toilets) and rainwater harvesting to be used throughout the country, regardless of the security of water supply and energy implications. Abstraction of water always has an environmental impact which should be minimised. In addition the reticulation, maintenance and renewal of water infrastructure has a high cost to the ratepayer. These costs can be reduced if water efficiency measures are in place. Water efficiency and use of rainwater and greywater will also allow for growth without putting pressure on water supplies and systems. In some instances water efficiency would allow for surplus water to be reticulated to other surrounding areas where water sources may be depleted. Water use results in wastewater production, so water efficiency also results in a reduction in wastewater quantity and the requirement for wastewater treatment and disposal – with associated financial, health and environmental benefits. Considering the efficiency of water use by households and management of water at all levels with less reliance on reticulated systems will ensure wise use of our current resources and resilience in the face of climate change.

SUSTAINABLE HOMES ARE ACHIEVABLE

Beacon has been undertaking research into sustainability innovations in both new and retrofitted homes. In the Waitakere NOW Home® project, Beacon has demonstrated that a well designed, well insulated new home can easily use 30% less energy than a standard home. These improvements in design can be undertaken within an affordable context. Beacon's Waitakere NOW Home® was built for $220,000 (a low-medium price in the Auckland market). These sustainable, energy and water efficient homes contain only readily available technology and design methods, which could be adopted in any new home across New Zealand.

It has been demonstrated overseas (e.g. in most of Australia) that introduction of high minimum standards around energy and water efficiency has a very low additional cost to new homes. For example, the New South Wales Department of Planning identified a cost of $3878 for implementation of a 25% reduction in energy use for new homes when compared to a standard new home through mandatory application of the BASIX model (New South Wales Department of Infrastructure, Planning and Natural Resources 2004). Requirements have now been increased so that 80% of all new homes will have to meet a 40% energy savings target. Compliance with the energy targets is estimated to cost between AU$700 and $2,100 to implement (New South Wales Department of Planning 2006).

Retrofitting existing homes for sustainability can also be achieved relatively easily. Beacon is currently trialling a range of options in nine homes in Papakowhai, Wellington. These are standard 1960s/1970s homes, with the normal suite of energy, water, waste, and indoor environment issues (little insulation, high heating costs, use of inefficient electric hot water cylinders, unflued gas heaters, high moisture levels, under-heated homes, wasted water, and high domestic waste). Beacon has assembled a range of affordable retrofit options for these homes which will result in significant reductions in energy and water use, waste production and improvements in the indoor environment quality.

CURRENT INITIATIVES

Significant gains can be made from increasing the energy and water efficiency and indoor environmental quality in homes, but this needs to be undertaken with a view to upgrading homes to a high standard, not to "slightly better" standards. To date, much of the focus of retrofit measures has been on improving only the insulation of houses to reduce heat loss, improve indoor temperatures, and reduce the amount of heating required. The primary benefits of home insulation are:

- improved energy efficiency of home heating systems;
- reduced pollution from the energy sources; and
- the ability to better maintain comfortable indoor temperatures.

Research on the impact of retrofitting houses in New Zealand shows that, in almost all instances, programmes have been aimed at low income households and included a standard package of measures (ceiling insulation, basic under-floor foil and draught-proofing of doors). These measures generally achieved an average 0.5-1ºC temperature gain; insufficient to lift indoor temperatures to an acceptable level of comfort. As a result, over time much of the energy efficiency gains were taken back in increased energy use to increase the temperature and comfort levels of what were often under-heated homes.

Programmes aiming to generate energy efficiency need to promote a much higher standard of retrofit than is currently the case, and include different targets. HEEP[5] tells us that 36% of the energy consumed in households is used by 20% of the houses. Middle and high income households use more energy, and significant gains can be made from improvements in the insulation and heating method of these high energy using homes. Incentives need to also be targeted at high energy users where they will get the best energy efficiency gains.

Current programmes need to be radically overhauled to include maximum, rather than minimum, levels of insulation retrofits and also include a carbon neutral, energy efficient heating device such as a pellet burner or low emission log burner in parts of the country where they are needed. Only then will they result in both energy efficiency gains and the substantial indoor environment quality improvements needed.

[5] BRANZ (2006) HEEP Year 10 Report. The Household Energy End-use Project (HEEP) administered by BRANZ has surveyed energy consumption in New Zealand households since 1997.

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

1.7 METHODOLOGY

Sustainable housing is about reducing the adverse effects of housing on the environment while at the same time making houses more comfortable and healthy, and doing both in a nationally cost-effective manner. This means that evaluation is needed of what might happen in housing in an economy-wide context. This analysis set out to evaluate the value to the New Zealand economy of the national housing stock meeting the High Standard of Sustainability defined by Beacon. Essentially the National Value Case depends on the benefits to the nation exceeding the costs; that is, resources need to be used more efficiently in the consumption or production of housing services, or be allocated more efficiently between activities, and/or deliver social and environmental benefits in addition to economic benefits.

A preliminary qualitative assessment of a wide range of sustainable housing innovations was carried out based on research conducted by Beacon, and other documents (refer Appendix A) to rank the various innovations into three groups: strong, medium or weak National Value Case. Benefits were identified as well as possible reasons (barriers and/or externalities) why the innovations are not being pursued by private interests.

Six innovations were selected as examples for further analysis on the basis of two criteria:

- they were coded as having a strong National Value Case in the initial qualitative assessment
- sufficient information on which to base a robust cost-benefit analysis was easily available

Innovations were considered only in the areas of energy and water as there were no innovations in the areas of waste, indoor environment quality, materials (including embodied energy), and neighbourhood that were sufficiently well specified to be examined with cost-benefit analysis. Beacon is undertaking research to help bridge this data gap.

A detailed economic evaluation of the selected innovations was undertaken by Infometrics using both cost-benefit analysis and the Energy Substitution, Social Accounting Matrix (ESSAM) general equilibrium model.

The effect of innovations on *national efficiency of resource use* was calculated using the Energy Substitution, Social Accounting Matrix (ESSAM) general equilibrium model, in contrast to the traditional cost-benefit analysis undertaken to determine private economic benefits. The ESSAM model is a general equilibrium model of the New Zealand economy. It takes into account most of the key inter-dependencies in the economy, such as the flows of goods from one industry to another, plus the passing on of higher wage costs in one industry into prices and the costs of other industries. The change in private consumption is the measure of the welfare effect of changes in national resource efficiency. Separate model runs were used to look at the welfare effect of the cost of a given innovation (such as the cost of retrofit insulation) and the welfare effect of the benefit of the innovation (such as energy saving). The consequent benefit-cost ratio for the changes in private consumption provides the overall welfare measure for each innovation.

In order to allow benefits with different units of measurement to be combined, a weighting was assigned to each of the four types of benefit, and each innovation given a score that measures how well it contributes to each type of benefit. The weighted average score is an overall measure of the benefits of the particular innovation. The scores for each of the four different types of benefit were then plotted on an x-y axis, where the shaded area depicts the size of the total combined benefit rather than an overall score which could obscure scores in each of the specific benefit areas.

Benefits were classified into four types:

- Environmental (e.g. less pollution)
- Social and private non-economic benefits (e.g. warmer homes)
- Private economic benefits (e.g. lower household energy costs)
- National efficiency of resource use (e.g. less waste).

Four ways in which the *environment* may benefit were identified: fewer resources being used, more sustainable resources being used, resources being used more efficiently and less pollution from resource use. An innovation was graded yes/no against each of these and assigned a score of 3 if three of four benefits were relevant, with scores of 2, 1, and 0 applied thereafter.

Three types of *private non-economic and social benefits* were identified: more comfortable homes, better health, and better (more pleasant and safer) neighbourhood (these occur in addition to associated economic benefits such as less expenditure on health care). Each innovation was graded yes/no where it delivers, with a score in the range of 0-3.

Private economic benefit was measured by the internal rate of return (IRR) for each innovation, calculated over a twenty year period. The IRR measure takes into account other spending opportunities available to households and is less dependent on the current level of prices. Compared to the rates of return available on risk free term deposits, scores were awarded as follows:

IRR	Score
≥ 10%	3
≥ 5% & < 10%	2
≥ 0% & < 5%	1
< 0%	0

2. ANALYSIS OF EXAMPLE INNOVATIONS

Improving the sustainability of the New Zealand housing stock will require a variety of different mechanisms in all of the areas of energy, water, waste, materials and indoor environmental quality. To show the significant effect that even simple innovations can have, detailed analysis of six innovations was undertaken, using interventions on which there is well documented data. Beacon is not recommending the use of these specific interventions ahead of the wide range of possible interventions, but uses them to illustrate the variety of ways to reach a High Standard of Sustainability in New Zealand's housing stock, and the need for interventions to be used in combination.

The selected innovations are:

Energy

- Retrofit ceiling and floor insulation
- Space heating: heat pumps and pellet fires
- Energy efficient lighting using compact fluorescent lamps
- Water heating using gas, solar or heat pump systems

Water

- Low flow devices and appliances
- Water metering and pricing (potable water)

This section presents the results of the cost benefit analysis and general equilibrium modelling of the six example innovations, presenting the economic case and environmental and social (including non-economic) benefits of each.

All of the innovation assessments are based on national averages. There will almost always be innovations that have a weak or marginal National Value Case, but under particular circumstances – locations or household types – they could deliver strong gains.

Table 1 below shows the results of the different innovations. This is not a comparative analysis with the intention of picking one innovation over another but illustrates that no intervention on its own will bring a house up to a High Standard of Sustainability, and each contributes differently to the National Value Case for sustainable housing, with significant gains to be made at a national level from small innovations.

TABLE 1: ASSESSMENT OF SUSTAINABLE HOUSING INNOVATIONS

	Retrofit Insulation	Heat Pump	Pellet Burner	Compact Fluorescent Lamps	Hot Water Heat Pump	Hot Water Gas Instant	3 Water Measures	Water Metering	Total Δ Medium Weak or better
Private cost	$2482	$3000	$4700	negative	$3923	$425	$228	$200	
Private benefit	$253	$634	$634	very high	$350	$339	$91	$27	
Private benefit in energy savings per year	1267 kWh @ 20c	3172 kWh @ 20c	5287 kWh @ (20c-8c)		1749 kWh @ 20c	2665 kWh @ 20c v 2260 kwh @ 8.6c	70,014 l @ $1.30/ m³ + 130 kWh ele @ 20c & 29 kWh gas @ 8.6c	8% of 264,000 l @ 1.263/m³	
% Δ Private Consumption (net)	0.052**	0.045 (mean)		0.01	X	0.02	0.02	0.20	0.35%
% Δ Net CO_2	- 0.28**	- 2.12 (mean)		0.23	X	-1.91	-0.16	0.19	-4.05%
% Δ Energy	-7.9**	-17.7 (mean)		-2.7	X	-3.0	-1.2	-	-32.5%
% Δ Water							-27.0	-6.7	-33.7%
BENEFITS									
Private economic (%)	IRR=8.0	IRR=20.6	IRR=12.1	IRR=∞	IRR=6.3	IRR=79.8	IRR=52.7	IRR=11.9	
National resource efficiency (Benefit/Cost ratio)	B/C=1.1	B/C=1.5	B/C=1.2	B/C=10**	B/C=0.1	B/C=10**	B/C=10**	B/C=10.5	
Environmental	3 out of 4	2 out of 4	4 out of 4	3 out of 4	2 out of 4	3 out of 4	2 out of 4	2 out of 4	
Social & private non-economic	2 out of 3	2 out of 3	2 out of 3	1 out of 3	0 out of 3	1 out of 3	0 out of 3	0 out of 3	
OVERALL NATIONAL VALUE CASE	Medium weak	Medium strong	Medium strong	Strong	Weak	Strong	Medium strong	Medium strong	

* This is approximate.

** For new houses assume 50% of capital costs for retrofit, and 25,000 new dwellings per annum.

2.1 ENERGY

2.1.1 Retrofit Insulation

Six insulation scenarios were analysed, each a combination of retrofitting ceiling insulation and under-floor insulation. Weather differences mean that the economics of retrofit insulation will vary between different areas in New Zealand but a national scenario is presented here through weighting by population and energy use.

Retrofit insulation has a reasonable internal rate of return (private economic benefit /IRR) of 8% which makes it cost-effective from an energy-saving perspective. It performs well on environmental grounds by promoting more sustainable consumption and less pollution (such as less air pollution from coal-fired generation). It has positive health effects, as well as using recycled materials in the manufacture of some types of insulation. It scores 2 out of 3 for other private benefits by producing better health (separate to the economic benefits) and a more comfortable home. Overall though, its National Value Case ranks only *'medium weak'* as its total contribution to resource use efficiency is small. This is because of the opportunity cost of the additional capital that is tied up in the housing stock.

At a national level there is an increase in resources tied up in the housing stock which is a cost in resource efficiency. More investment in housing means less investment elsewhere. National gains in energy savings (energy resources that can be used elsewhere) are smaller than the cost of the extra capital tied up in housing.

A small net reduction of CO_2 of 0.6% is gained. The health benefits of warmer homes also contribute to national resource efficiency through an increase in labour productivity (fewer days off work) and savings in public health costs (less hospital admissions for respiratory conditions and less Government spending). There may also be other benefits such as the effect on children – less night coughing and respiratory inflammation, and fewer days absent from school, as well as gains in health and comfort from less noise.

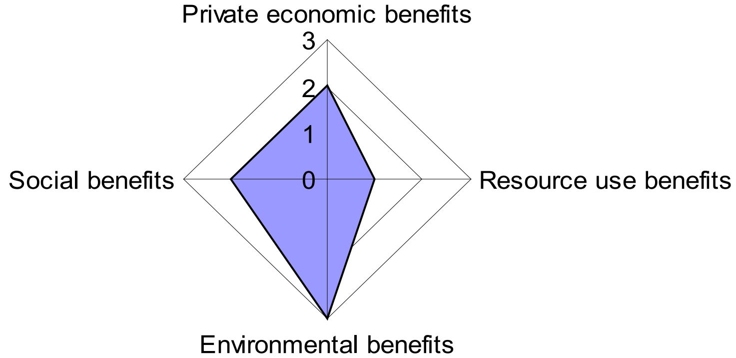

Figure 1: Benefits of Retrofit Insulation

If the only benefit from retrofit insulation is a saving in household energy consumption, it is unlikely to deliver an overall gain in national economic welfare. However, the health benefits it delivers results in an overall positive economic benefit. Hence the case for insulating homes is exactly that – healthy and more comfortable homes, not solely energy savings or CO_2 reductions (although insulation delivers both). Most of the economic benefit of healthy homes is captured more widely in the form of less spending on health, and greater worker productivity rather than direct economic savings. Because of the misalignment between private benefit (savings spread over long term as well as indirect and non-monetary) and private costs (up-front cost of installing of insulation), there is a case for Government intervention.

While an IRR of 8% is cost-effective from a purely energy-saving perspective, it is not much better than the current rate of return on bank term deposits, and while there will be locations and dwelling types with a higher IRR, it is likely that some form of inducement will be required to see the bulk of New Zealand's housing stock properly insulated.

2.1.2 Space Heating

Two options of efficient methods of space heating have been examined in detail: heat pumps and wood pellet burners. Both deliver the same amount of dollar savings relative to a standard electric heater, but their mechanisms are different. Heat pumps deliver their benefit by being much more thermally efficient than a regular heater, while pellet burners deliver their benefit by using a lower cost fuel, although they also deliver an efficiency gain if used in place of standard wood and coal burners.

	Cost (c/kWh)	Use Efficiency	Effective Cost (c/kWh)	Relative Saving	Cost (labour + materials)	IRR (20yrs)
Regular electric heater	18-21	100%	18-21			
Heat pump	18-21	220-300%	7-9	60%	$3000	20.6%
Pellet burner	6-8	75-92%	7-9[6]	60%	$4700	12.1%

Table 2: Space Heating Comparison

A pellet burner typically has about twice the output capacity (kW) of the average heat pump. From that perspective the IRR for the pellet burner is misleadingly low (12.1% compared to 20.6% for a heat pump), but it is based on a given amount of heating (kWh) being delivered through different fuel. Any consequential increase in the demand for heating is part of the take-back effect. If that occurs then a pellet burner has lower marginal costs.

Both space heating options have high private rates of return and good social and non-economic benefits. The only significant difference between the two is that pellet burners score higher in terms of environmental benefits. See Figures 2 and 3. Energy savings alone do not deliver national resource use benefits, and the inclusion of health benefits (50% of those obtained from insulation) enables both space heating options to secure a 'medium strong' rating.

Both efficient space heating options generate cost savings of about 60% when compared to standard electric heating. Heat pumps deliver this purely by an increase in efficiency, while the pellet burners rely on both gains in efficiency (when displacing open fires) and on the use of a lower cost fuel (when displacing electric heaters).

Heat pumps are assumed to have an average effective coefficient of performance of 2.5, while pellet burners are assumed to be 85% efficient. In contrast, open coal and wood fires have efficiencies of 10-14%. Inefficient gas heating (flued heaters) is about 65% efficient. Thus both save about 48% of home heating energy. Cost savings depend on relative fuel prices.

There are significant reductions in CO_2 emissions, especially in the pellet burner scenario. Both space heating options deliver a beneficial gain in national resource use efficiency through health savings, energy savings, welfare gains such as health benefits arising from the removal of unflued gas heating, and CO_2 reductions.

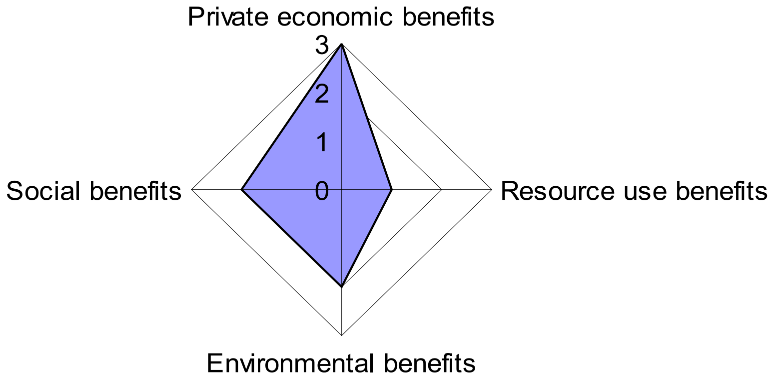

Figure 2: Benefits of Heat Pumps

6 Note that a pellet burner uses a small amount of electricity.

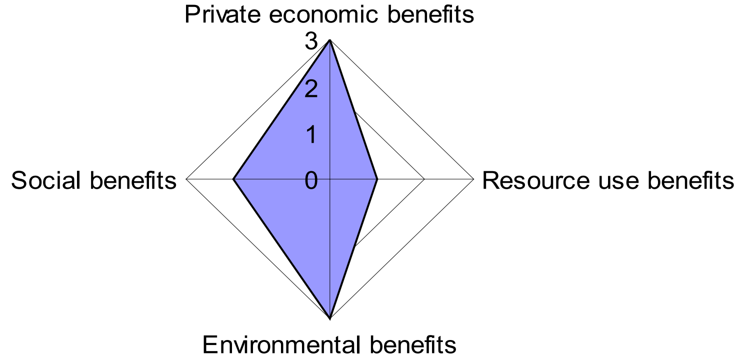

Figure 3: Benefits of Pellet Burners

2.1.3 Efficient Lighting

Lighting is estimated to account for nearly 9% of household energy consumption. Most of it is incandescent lighting which, if replaced with compact fluorescent lighting (CFL), would deliver savings of around 80%.

Estimates of the eventual use of CFL lighting in households range from 25% to 50%, due to unknown consumer behaviour and uncertain technical compatibilities. We assume a mid-point of 37.5%, and even given this low assumption, the amount of electricity currently used for household lighting could fall by 30%, resulting in a significant increase in national resource use efficiency.

The cost of CFL bulbs is about three times more than that of an incandescent bulb, although various subsidies can substantially reduce the cost to consumers. The longer life of CFL bulbs means that there is effectively no difference in capital costs relative to incandescent lighting. Hence the private consumption benefit-cost ratio (IRR) cannot be calculated, but is certainly high. Effectively this means that CFL presents a "free lunch". There is no significant opportunity cost; the IRR of CFL lighting approaches infinity and the payback period is zero. From a private economic perspective, CFL bulbs should be used wherever possible.

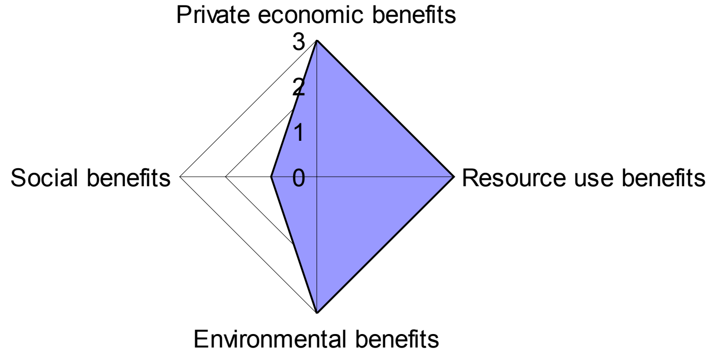

Figure 4: Benefits of CFL

Compact fluorescent lighting (CFL) shows a 'strong' rating. As illustrated in Figure 4, it scores a perfect 3 in three of the four benefit domains – resource use efficiency (more efficient light bulb), more sustainable consumption (fewer bulbs required over time), and less waste and pollution (less thermal generation). The only area where CFL performs poorly is with regard to social benefits. The private consumption benefit-cost ratio (national resource efficiency score) is set at 10 as CFL has essentially zero incremental cost relative to current incandescent lighting. For the same reason its IRR is infinite.

2.1.4 Water Heating

Three cost efficient options for water heating were identified by Beacon's research; solar water heating, a heat pump system, and instant gas heating, all considered relative to a traditional electric hot water cylinder (HWC) system. These were found to have energy savings of 83.5%. 65.6% and 15.2% respectively. However there are a number of caveats:

- the analysis assumes that the same amount of energy is required for water heating in all locations (temperature zones), although it does allow for the efficiency of heat pumps and solar heating to vary with location;
- gas is cheaper than electricity, so even though energy savings are only 15%, cost savings are over 60%;
- there is anecdotal evidence that instant gas systems generate a significant take-back effect in the form of longer showers. Thus maximum benefit from this innovation might depend on the simultaneous introduction of water metering.

Looking at the cost side, relative to an electric HWC the capital cost of a solar water heating system is around $5100, with a heat pump system at $3900, and an instant gas system at only $400. This assumes installation only when existing systems need replacing and that a property is already connected to a gas supply. The difference in capital costs leads to very different IRRs; 5.9%, 6.3% and 79.8% respectively, assuming an electricity price of 20c/kWh and a gas price of 8.6c/kWh.

Given the operational similarities between solar heating and heat pumps, and the low IRR of the former, national resource efficiency of only the heat pump option and the instant gas option were analysed.

The heat pump option presents an increase in the efficiency of household electricity use, while the instant gas option corresponds to a reduction in household electricity use, but an increase in gas use. Overall there is a reduction in energy use, and a reduction in costs as gas is cheaper than electricity. There may also be an additional reduction in the economy's total energy use through the displacement of relatively thermally inefficient gas-fired electricity generation with the direct use of gas. The upstream increase in efficiency from using gas directly rather than converting it to electricity is quite significant (as reflected in the consumer price difference between gas and electricity). Further evidence of this is apparent in the reduction in CO_2 emissions, which is greater in the gas scenario.

The cost premium for an instant gas system is low (about $400) relative to a traditional electric cylinder system, and relative to the value of the output produced. Thus from a resource use perspective, the case for instant gas systems is very strong. It may well justify Government assistance with regard to getting more dwellings connected to the gas reticulation network.

In contrast, heat pump systems, at an additional cost of around $3,900 over a standard electric system, are significantly dearer but produce about the same level of savings to the consumer as an instant gas system. From the perspective of national resource efficiency, there is no gain to replacing traditional electric systems with heat pump systems. The same argument applies to solar water heating[7].

7 Not considered here is the possibility of using a single heat pump for both hot water heating and space heating. The combination of economies of scale in capital costs and the health benefits that ensue from a warmer home may be sufficient to raise the private consumption benefit-cost ratio.

The two efficient water heating systems have markedly different national value scores, with instant gas having a *'strong'* rating, but heat pump systems scoring a *'weak'* rating. Instant gas has a very high IRR and, with incremental costs relative to a standard electric system too small to model, the benefit-cost ratio for resource use efficiency is at least ten. Environmental benefits are significant with an increase in resource-use efficiency, direct use of gas instead of for electricity generation, and less thermal generation. Gas systems also generate a private non-economic benefit in the form of greater flexibility of shower times as the supply of hot water is effectively unlimited (although not its flow rate). This feature perhaps also leads to a higher probability of take-back in the form of longer showers. To the consumer this is a benefit, but in terms of sustainability this should be offset against the estimated energy savings. Heat pump systems score reasonably well on environmental grounds, but their high cost reduces both the IRR and national efficiency of resource use.

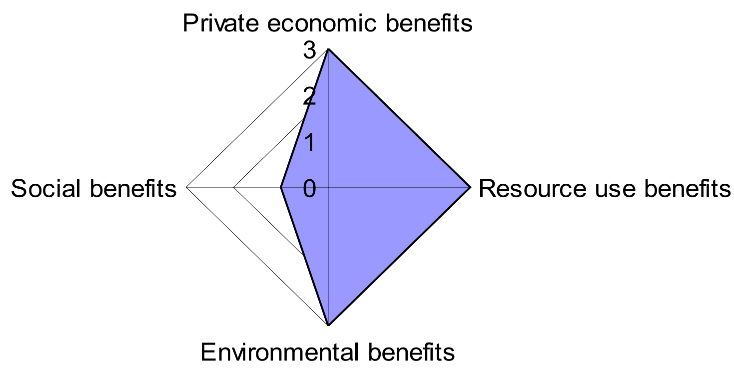

Figure 5: Benefits of Instant Gas Water Heating

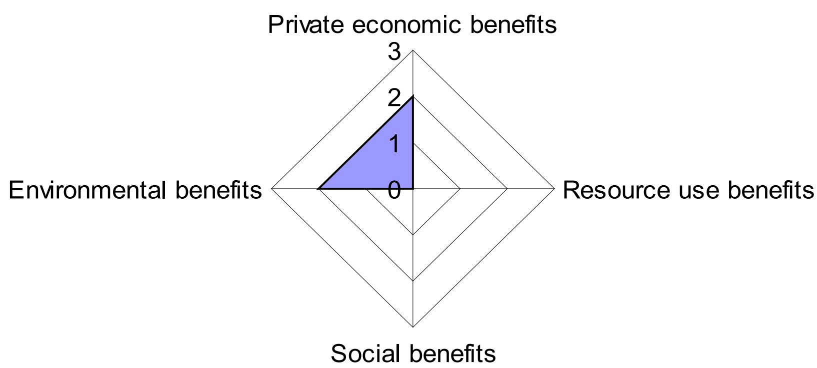

Figure 6: Benefits of Heat Pump Water Heating*

*Note re-arrangement of axes

2.2 WATER

2.2.1 Low Flow Devices for Water Efficiency

Three technical innovations that reduce water use were analysed, as outlined in Table 3.

Innovation	Saving	Explanation	Cost
Low flow shower heads	8.4%	Low saving due to due high proportion of low pressure systems and assumed take-back	$50 material and $118 labour
Dual flush toilets	54.5%	5 litres versus 11 litres per flush	No extra cost
Efficient washing machines	60%	60 litres per wash compared to 150 litres	$60 above standard machine

Table 3: Water Saving Innovations

The three measures combined reduce per person usage from 241 litres to 177 litres. Placing a value on these savings is not straightforward as many households do not pay directly for water. An estimated price of $1.30/$m^3$ was used in modelling with an average of 3 people per household.

The IRR for the three measures combined is 40%[8] – at least for those households with water meters or where they are otherwise compensated by water supply authorities for installation of these measures, such as by lower property rates. Such a high IRR also advances the argument for water metering.

Lower water use in showers also means lower energy use, with consequent savings in household electricity and gas use. These energy savings are worth approximately $30/year to a household, assuming prices of 20c/kWh for electricity and 10c/kWh for gas. This raises the overall IRR for the package of three water saving innovations to 52.7%.

The package of three innovations produces combined savings of 64 litres per person per day, (27% of consumption) or 96 million m^3 per annum. The cost of the three measures is estimated at $228, which is too small to model at a national level (less than 0.005%), so from a national resource use efficiency perspective, the water savings are virtually costless, with benefits from both water savings and energy savings.

Indirect benefits of lower water consumption are less discharge of wastewater, less pressure on water infrastructure and less waste flowing into natural waterways, but insufficient quantitative data prevented modelling such a benefit.

[8] Capital cost of $228 and water savings per household per annum of (241-177)*365*3 people per household, at $1.30/$m^3$.

The three water efficiency measures (low flow shower heads, dual flush toilets and water efficiency washing machines) are illustrated in Figure 7. The package has a very high private IRR as it produces both water savings and energy savings (with regard to low flow shower heads). Being almost costless it produces a private consumption benefit-cost ratio over 10 for national resource use efficiency. These attributes are sufficient to rate the package as *'medium strong'*. The lack of social benefits prevents a *'strong'* rating.

Water pricing (see Figure 8) delivers similar benefits and also secures a *'medium strong'* rating. This partly hinges on a relatively low cost for water meters which is possible if meters are introduced en masse. Individuals acting alone may face a higher cost. The take-up rate for both innovations would be increased under Government action.

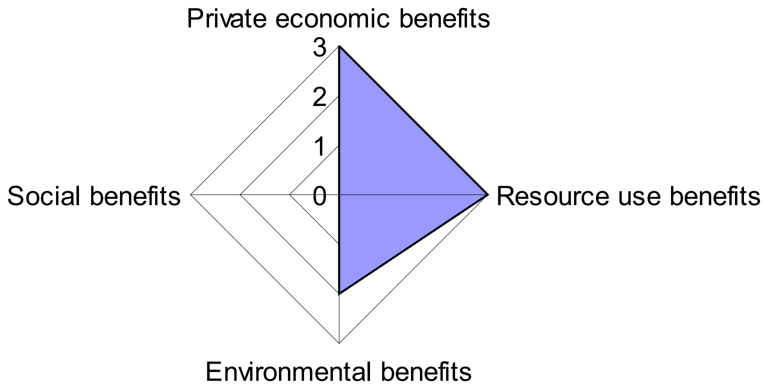

Figure 7: Benefits of Water Saving Innovations

2.2.2 Water Metering

The main reason for introducing water meters is to give a price signal to consumers, providing them with an incentive to reduce wastage, and ensure that decisions are made based on the true economic costs of water to the household. Charging for water use through property rates removes people from price signals and leads to excessive water consumption. In New Zealand, explicit charging for household water use is not widespread.

Based on the installation of water metering in Nelson in 1998, the cost of a water meter including installation is estimated at $200. The private economic benefit to a household depends on the extent to which their bill for water is offset by lower property rates[9].

Average water consumption is approximately 241 litres/person/day. For a typical household of three people, this implies 264 m^3/year. An analysis of data for Nelson City, adjusting for rainfall and population suggests that water consumption has fallen 8% per person since the introduction of water metering. For a three person household using around 264 m^3 per year, the IRR for a water meter costing $200 is reasonable at 11.9%.

Direct pricing of the provision of household water through metering is thought to lead to significant savings, with the incentive to save water depending on the price faced by the consumer. Direct pricing could also reduce present inefficiencies caused by over-investment in reticulated water supplies, caused by consumers not facing the true cost of such investment in their decisions about how much water to consume.

[9] This does not suggest current water supply systems be abandoned, but whether, when an existing system needs to be expanded or replaced, water metering might be a better option to reduce demand.

The cost of water meters is estimated at around $200 including installation. This is an increase in the capital intensity of housing but the cost in terms of lost private consumption is well below the benefit of more efficient water use. Indeed the private consumption benefit-cost ratio is around 10.5, a significant increase in national efficiency of resource use.

Comparing water meters with the package of three water saving measures, the former has a lower IRR, but a much higher national resource use efficiency effect. These two innovations demonstrate that private and public benefits can diverge quite markedly. Water metering presents the stronger case for Government intervention, although the gain to the consumer from the three water saving measures would be clearer – and thus more likely to be pursued – if water use is explicitly priced.

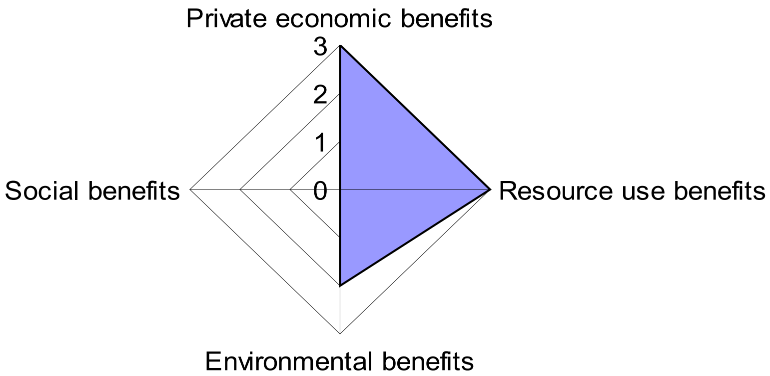

Figure 8: Benefits of Water Pricing

3. HIGH STANDARDS OF SUSTAINABILITY

Appendix A presents numerous examples of innovations which could potentially contribute to a High Standard of Sustainability in housing. Beacon's benchmarks for a High Standard of Sustainability provide a useful way to measure the change in sustainability induced by the selected innovations. Tables 4 and 5 summarise the results in terms of the energy and water savings produced by the example innovations

ENERGY*	kWh/hh/yr	% change	
Base Consumption	13524		
HSS Target	11204	17%	
Space heating	**Insulation**	**Heat Pump**	**Pellet Burner**
No insulation		21.9%	-6.4%
Ceiling insulation	4.6%	26.5%	-1.8%
Under-floor	3.7%	25.6%	-2.7%
Wall	3.6%	25.5%	-2.8%
Ceiling/floor	7.9%	29.8%	1.4%
Ceiling/floor/wall	10.7%	32.6%	4.3%
Water heating			
Cylinder wrap	1.0%	(5.1% of water heating energy)	
Solar water heating	22.9%	(83.5%)	
Heat pump hot water heating	18.0%	(65.6%)	
Gas instant	4.2%	(15.2%)	
Lighting (CFL)	**1.8%**	**(20% of lighting energy)**	
Appliances			
Fridge/freezer	2.4%	(25% of fridge/freezer energy)	

*** Weighted averages over three climate zones**

Table 4: Energy Savings

3.1 ENERGY

Insulation on its own is not sufficient to reduce household energy consumption to the High Standard of Sustainability target, but with the addition of a more efficient heat source such as a heat pump or pellet burner, the target is easily met. Indeed a heat pump on its own can deliver the target, although it is probably not the best option in terms of sustainability. These innovations are used as examples of the possible national value of sustainable housing improvements but also demonstrate the folly of using a single indicator such as energy savings as measure of sustainability.

Heat pumps are not efficient in colder climates and rely on electricity so are unable to be used if there is a power outage during winter. In addition, people use heat pumps for air conditioning in summer, increasing their electricity usage and CO_2 emissions, whereas a pellet burner or wood burner is carbon neutral. A pellet burner is less efficient than electricity and so produces negative energy savings relative to standard electric heating (shown in table 4 above). However, the lower cost of energy delivered via wood pellets (which are made largely from waste products rather than using electricity) means that pellet burners have a competitive IRR of about 12%.

In effect, the High Standard of Sustainability from using a pellet burner is not in lower household energy use, but in less resource use upstream from the household, reflected in the lower cost of fuel. That is, the production of pellets has a lower opportunity cost than the production of electricity. Furthermore, a pellet burner leads to a greater reduction in CO_2 emissions than a heat pump.

With regard to water heating, switching to either a heat pump or solar system produces a reduction in energy use that brings total household energy consumption within the High Standard of Sustainability target.

Gas instant water heating presents a similar situation to pellet burners. Because it is primarily fuel substitution, overall household energy consumption changes little and thus looks worse against the energy objective than solar or heat pump systems. Direct use of gas, however, is more thermally efficient than using it to generate electricity. It also means fewer CO_2 emissions per unit of delivered energy. Accordingly it is possible that instant gas water heating systems are just as sustainable a use of resources as heat pump and solar systems.

Other energy saving options such as more energy efficient appliances and lighting generate only small savings in total household energy use, but are significant in their own domains. Taken together they could make a worthwhile contribution to reducing domestic power costs.

3.2 WATER

The baseline for household water consumption is estimated to be 241 l/p/d. The High Standard of Sustainability target for household water consumption is 180 l/p/d, requiring a reduction in consumption of 25%. The package of three water consumption innovations; low flow shower heads, dual flush toilet cisterns and AAA washing machines, reduces water consumption by almost 27% and brings consumption within the High Standard of Sustainability target.

WATER	L/hh/d*	L/p/d**	L/hh/yr***	% change
Base Consumption	723	241	263,895	
HSS Target	540	180	197,100	25.3%
Package				
Washing machine			32,850	12.4%
Toilet			32,847	12.4%
Shower head			4,507	1.7%
			70,204	**26.6%**
2000 litre tank			153,866	58.3%
7500 litre tank			165,185	62.6%

*** Litres per household per day** **** Litres per person per day** ***** Litres per household per year**

Table 5: Water Savings

The High Standard of Sustainability target relates to use of water from a reticulated supply. Installing a rainwater tank produces no direct reduction in water consumption, but does produce a significant reduction in the use of reticulated water. Reducing consumption of water (or indeed energy) is not the main objective of the High Standard of Sustainability target. The real objective of a High Standard of Sustainability is to ensure that the nation's resources are used in an efficient manner – along their whole life cycle from extraction and production, through to final consumption and eventual disposal. Reducing water consumption per se is not the goal, but rather not wasting water, ensuring it is allocated efficiently across different users and that it is delivered to users in a resource efficient manner (which may mean through water tanks instead of reticulation). Reticulation of water and maintenance of water infrastructure has high costs to the ratepayer and water efficiency will reduce pressure on this infrastructure. However, there are also good arguments for a reduction in water use as abstraction of water always has environmental impacts, both from the view of reducing the water available for ecosystem services and also the disposal of wastewater after use by households. Water efficiency results in a reduction in wastewater quantity and the requirement for wastewater treatment and disposal – with associated financial, health and environmental benefits.

Household rainwater tanks do reduce water demand from reticulated systems (as does the package of water saving innovations) and in this sense meet Beacon's High Standard of Sustainability. As with pellet burners, however, there may be other effects external to the household sector that reinforce or detract from the sustainability of water use when sustainability is viewed from a broader perspective.

Improving the sustainability of the housing stock will require looking at wider effects and benefits than only energy and water use. The materials used in construction, the waste produced, and the quality of the indoor environment with the associated benefits for health and comfort of families and social and environmental benefits are significant, as noted in the analysis of the six individual innovations. Implementation of a combination of innovations to transform the sustainability of the New Zealand housing stock will have multiple benefits on a nationwide scale.

Beacon
TOGETHER, CREATING TOMORROW'S HOMES

4. THE CASE FOR INTERVENTION

The majority of New Zealand housing stock performs poorly in terms of sustainability. Our homes are cold, damp, unhealthy and inefficient in energy and water use. Beacon has developed a High Standard of Sustainability defining the extent of change required, based on an understanding of the quality of the existing housing stock. The potential exists to transform a significant proportion of the New Zealand housing stock to a High Standard of Sustainability with beneficial social, health, environmental and economic outcomes. Beacon research shows that a High Standard of Sustainability is achievable in both new and existing homes. The Government needs to apply effort where it will best effect long term national-scale changes in the demand, uptake and supply of sustainable solutions that improve the quality and performance of new and existing housing.

Transformation of the housing stock can be considered at a number of levels:

- physical transformation of the housing stock itself;
- economic transformation creating an economic environment that recognises the value of improving the performance of the housing stock; and
- market transformation creating demand from consumers and supply by industry for improvements in the housing stock.

Homes and neighbourhoods are critical for delivering sustainability. This National Value Case demonstrates, using six example innovations, how an improved housing stock delivers multiple benefits and can be valued across a range of Government departments, demonstrating the national and economy-wide benefits of having housing stock at a higher standard of sustainability than currently. A significant role exists for Government to drive the necessary upgrade of the housing stock to a High Standard of Sustainability. However, in order to achieve the significant changes necessary, a focus on stepwise change is needed. The Government's vision around being a sustainable nation, carbon neutrality, and meeting our Kyoto commitments will not be met without it.

EECA's current suite of retrofit programmes are small scale, do not result in significant changes in energy efficiency and do not address other aspects of sustainability. The necessary change in the housing stock will not be achieved without significant investment in new and expanded programmes, and without the necessary regulation to eliminate the most inefficient products and processes, and encourage the uptake of more efficient ones. Incentives and information are not enough.

Education programmes to date have focused around behaviour (turn off switches etc) and need to focus also on purchasing decisions, design and retrofitting of houses. This needs to include working with key industry groups (e.g. retailers, builders, designers). A different model of provision of incentives also needs to be considered with engagement of the health, insurance, and banking sectors and to a stronger degree with the electricity supply sector. Westpac Bank now offers incentives for energy efficiency retrofits to new mortgage holders; these programmes should be built upon and expanded across the sector. Electricity suppliers could provide for the capital cost of energy efficiency measures to be repaid through power bills, health insurers could offer lower premiums for insulated houses and heating methods which enable a healthy internal environment. In short, the Government needs to engage far more widely with the range of industry players who could assist in promoting sustainability outcomes for both public and business benefit.

Incentives offered by Government must be sufficiently attractive to change behaviour. This means those incentives which will significantly increase uptake in more efficient technologies and cover the range of different types of sustainability programmes, targeting the areas where biggest gains can be made for the level of investment and assisting those who can not afford such improvements. The Environment Canterbury Clean Heat programme has demonstrated what a well designed incentive programme can achieve. Incentives are targeted, with different incentives for different household and ownership types and are set at a level that encourages uptake. Nationally, the Electricity Commission's investment in Compact Fluorescent Lamps has achieved a high level of uptake and indicates the level of engagement required to succeed across consumers, power utilities and retailers.

Programmes aiming to generate sustainability outcomes need to be both targeted differently and promote a much higher standard than is currently the case. For example, HEEP tells us that 20% of households consume 36% of the energy – yet EECA insulation retrofit programmes mostly reach people who are low energy users already. In addition, BRANZ and Beacon research (as well as overseas research looking at similar programmes) tells us that with these programmes, significant take-back in comfort occurs because the level of insulation retrofit is so low that average temperatures in the home post-retrofit are still well below World Health Organization minimums – let alone a comfortable temperature, and while they achieve excellent health outcomes, the energy efficiency improvements are minimal. The different triggers to incentivise such schemes need to be recognised (e.g. health, warmth, comfort, reduced noise) other than just financial savings.

Realisation of the benefits associated with the interventions identified in this paper requires hundreds of thousands of homeowners, landlords and occupiers to make and implement decisions that will change how they build, insulate, heat and manage the consumption of water in houses they own. In some cases these decisions will involve relatively little cost apart from perhaps time and inconvenience. In other cases, decisions will involve what may be relatively large up-front costs for an individual benefit that will be realised over the long term, yet which may have large collective benefits on a national scale.

The Government can create an environment conducive to more environmentally sustainable housing. It can:

- lead and communicate the case for change with stakeholders involved in all areas of the research, design, supply, construction, regulation, and use of the residential built environment;
- develop and implement appropriate policy frameworks and associated regulations to ensure that consumers face the full environmental and other costs and benefits of their decisions;
- provide assistance to households to retrofit their existing houses to a High Standard of Sustainability;
- effect change through its direct ownership of approximately 80,000 household units and related property maintenance and purchase decisions;
- regulate to mandate the installation or use of particular technologies;
- communicate and provide information to inform consumer choices and explain the case for change; and
- set performance levels to improve both owner-occupied and rental housing stock, e.g. through regulation of performance standards for houses at point of sale and at point of rental.

In practice, successful policy and its implementation usually requires a mix of the above, rather than reliance on a single intervention. A policy approach that comprises a baseline of regulation, supported by non-regulatory Governmental initiatives and active private sector participation is likely to deliver the best outcome in terms of uptake of sustainable housing innovations.

The combined evidence of the low standard of sustainability in New Zealand's housing stock, along with evidence that a higher standard would improve national welfare, demonstrates the role for policy intervention with regards to sustainable housing. A number of issues are evident in the analysis:

- people's housing decisions seem to be at odds with their own best interests (e.g. they use expensive and inefficient heating options, do not insulate their houses adequately, and have poor health and high energy costs as a result).
- benefits and costs of the actions of individuals accrue to third parties and to New Zealand society in general (e.g. the impact of wastewater in the absence of direct water pricing, the impact on the environment from housing decisions, and the cost of carbon emissions from inefficient energy use).

A number of key factors may prevent people from acting in their own best interests. These include time, convenience, and short term comfort that may offset the adoption of more sustainable housing choices. For example, irrespective of cost, the inconvenience and disruption associated with house alterations will discourage the adoption of beneficial improvements.

Another major issue is the sunk cost of previous decisions and existing structures. Although there might be little difference in the price between more or less efficient appliances, the gains in efficiency are unlikely to be sufficient to encourage the early replacement of existing appliances by households.

People also make sub-optimal decisions due to a lack of awareness of the benefits of sustainable housing options. One would expect suppliers of genuinely beneficial products to be very willing to advertise the merits of such products. The area where there are incentives for sellers to be less forthcoming about housing quality is when it is the house itself that is being transacted. It is not in the financial interest of sellers or landlords to be forthcoming about shortcomings associated with the house. This is a situation where an information disclosure requirement such as a mandatory sustainability rating tool would improve purchase and renting decisions and provide house owners with the right incentives to invest adequately in maintaining/improving living conditions.

There are also concerns raised by the analysis regarding the externalities imposed on society in terms of carbon emissions (which will cost New Zealand under the Kyoto Protocol), environmental degradation and high costs in health care, and poor health of the population. The analysis of energy saving innovations in particular shows how individual actions are at odds with national interests. The analysis indicates that the benefits to individual households, via lower energy costs, are not sufficient to encourage most households to voluntarily undertake insulation retrofits. Yet when the national savings associated from improved health consequences are included, there is a compelling case for the promotion of retrofitting improved insulation in the existing housing stock. However the benefits of these gains do not go directly to the individual households, but rather are seen in lower national health costs and higher labour productivity. Individuals benefit from feeling healthier, but the main gains go to Government via significantly lower health costs and to businesses that have lower overheads due to fewer days lost due to sickness. This warrants policy intervention in the interest of the public good.

The case for intervention for each of the six sustainable housing innovations examined in this paper is outlined below. However, this is not an exhaustive list of the available innovations. To transform the New Zealand housing stock, a well researched range of interventions will be necessary that is wider than the examples used here. Programmes are needed that integrate the variety of different innovations required to achieve a High Standard of Sustainability in homes.

4.1 RETROFIT INSULATION

Homes built before 1977, when requirements for insulation were introduced, do not benefit from the same standards of thermal performance as those built today. Given that the majority of New Zealand's home were built prior to 1977 (and 2007), and many homes built after 1977 do not even meet the 1977 standards (Amitrano, Kirk and Page 2006), there are significant gains to be made from retrofitting insulation in existing homes.

Retrofit insulation is cost-effective from an energy-saving perspective. It performs well on environmental grounds and has positive health effects, as well as using recycled materials in the manufacture of some types of insulation. It produces better health and a more comfortable home. The health benefits of warmer homes increase labour productivity (fewer days off work) and create savings in public health costs (less hospital admissions). Its primary benefit is healthy and more comfortable homes, not energy savings or CO_2 reductions (although it delivers both). Most of the economic benefit of healthy homes is captured more widely in the form of less spending on health, and greater worker productivity.

Because of the misalignment between private benefit (over the long term as well as indirect and non-monetary) and private costs (up-front installation), there is a case for Government intervention. Analysis shows that it is likely that some form of inducement will be required to see the bulk of New Zealand's housing stock properly insulated.

In examining the case for public intervention, it is useful to consider why many homeowners do not take it upon themselves to retrofit insulation in their homes, given the amenity and economic advantages of doing so. Each of the following is significant, and a possible reason for public policy intervention:

- the economic benefits are longer term and are often outweighed by short term imperatives;
- many homeowners may be unaware of the potential benefits and the ease of retrofitting insulation; and
- one third of the population live in rented homes, and landlords may not see any economic or amenity benefits to themselves in retrofitting insulation.

At a general level the Emissions Trading Scheme will in effect introduce a carbon charge, covering one of the environmental costs of energy production, increasing the price of energy from non renewable sources and creating a stronger economic incentive for homeowners and occupiers to retrofit insulation in existing homes. There is an important role for Government to communicate the necessity and rationale for the change to households, and the actions and choices available to homeowners that they can make to offset the increased costs of energy. It will be important to link households in to their part in the Emissions Trading Scheme, and work with energy companies to provide incentives and assistance for retrofitting homes.

The Government should introduce high minimum standards for new homes and needs to consider the introduction of regulation requiring retrofitting of existing homes. It has been demonstrated overseas (e.g. in most of Australia) that introduction of high minimum standards around energy and water efficiency has a very low additional cost to new homes. For example, the New South Wales Department of Planning identified a cost of $3878 for implementation of a 25% reduction in energy use for new homes when compared to a standard new home through mandatory application of the BASIX model (New South Wales Department of Infrastructure, Planning and Natural Resources 2004).

The vast majority of homes which will be in use over the next 50 years have already been built (Amitrano et al, 2006) and most of the work in the coming century is likely to be on modifying existing buildings. The Building Code needs to consider this issue of poorly performing existing buildings and provide provision for consequential action. Such action might include, for example, a link with the EECA Home Energy Rating Scheme (HERS), requiring buildings to be assessed in terms of compliance with the current Building Code, or insulated to meet a minimum standard, at time of sale or at time of rental. This would enable buyers/renters to make an informed choice about occupying a building which is likely to be more expensive to operate and be less healthy and safe.

Government should introduce a rating scheme to convey the sustainability of homes. The provisions of such information might create additional demand for sustainable homes, and result in the value being factored into house prices and rents.

Different groups will require different interventions, and if the target population is segmented into two groups – owner occupiers and landlords, then the following mix of interventions are worth considering:

Owner occupiers – suspensory loans or subsidies to create a sharper and short term incentive for homeowners to retrofit insulation, and to enable low and medium income earners to adjust to increased energy costs; amend Section 112 of the Building Act to require retrofitting of ceiling insulation at the time renovations are carried out on existing buildings to the performance standard of the current Building Code. This is a practical means of requiring the retrofitting of existing homes at a time when the costs of doing so are likely to be lowest. A similar approach is taken to the installation of disabled access and fire safety features in commercial buildings.

Landlords – Government owns significant housing stock and so can undertake to retrofit insulation in all of the homes that it owns. In doing so, there are a number of benefits for Government – investment value as it raises the value of its housing stock; reduced costs of living for low income people and this takes pressure off welfare as well as health.

The rental property segment is the most challenging because owners will not necessarily reap the ongoing benefits of the improvements directly. To increase the sustainability of this market segment, Government is likely to need to play a key role. For non-Government landlords, tax benefits are already present and a subsidy exists for landlords whose tenants are community services card holders. Other options include:

- the inclusion of minimum baseline standards of sustainability through amendments to the Residential Tenancies Act 1986;
- setting minimum acceptable levels with the HERS scheme under development;
- requiring landlords to display the HERS rating (or a similar sustainability rating if developed) when advertising a property for rent;
- looking at opportunities to partially subsidise sustainability improvements to take into account the benefits that are passed onto the occupiers of the rental properties to kick-start improvement of this segment; and
- continuing to signal to industry changes in requirements and staircasing benchmarks for sustainability so that, as new technology is promulgated, we enhance our capability to improve the sustainability performance of homes.

4.2 SPACE HEATING

As part of the solution to the problem of New Zealand's cold, damp, unhealthy homes, Beacon suggests installation of a carbon neutral space heater in locations in New Zealand where required. Two options were analysed: heat pumps and wood pellet burners. Both deliver the same amount of dollar savings relative to a standard electric heater, but their mechanisms are different.

Both space heating options have high private economic benefit and good social and non-economic benefits. The only significant difference between the two is that pellet burners score higher in terms of environmental benefits. Both secured a 'medium strong' rating and generate cost savings of 60% when compared to standard electric heating. There are significant reductions in CO_2 emissions, especially in the pellet burner scenario. Both deliver a gain in national resource use efficiency through health savings, energy savings, welfare gains such as health benefits arising from the removal of unflued gas heating, and CO_2 reductions.

An argument that has been used in the past is that poorer households rely on unflued gas heating as otherwise they could not afford to heat their homes. Innovations such as efficient pellet burners are an affordable, healthier option for low income homes in terms of operating costs, although the up-front capital costs of installation may present a barrier for many households, requiring Government intervention to overcome.

Although heat pumps and pellet burners offer economic benefits to homeowners over the long term, when compared to alternative means of heating, the up-front costs of conversion may outweigh the longer term benefits. It is also possible that some homeowners are not aware of the benefits of converting to these more efficient forms of space heating. There is potentially a role for Government in providing financial or other assistance for homeowners, especially low to medium income earners to adjust to more efficient means of heating that might involve additional short term costs.

The Government should consider:

- providing suspensory loans or subsidies (possibly on an income targeted basis) specifically for the purposes of helping to meet or manage some of the short term costs of switching to more efficient forms of space heating;
- installing heat pumps and pellet burners in Housing New Zealand and other Government managed residential properties;
- regulating minimum efficiency levels for space heaters to eliminate inefficient appliances from the market; and
- regulating to require landlords to ensure homes are of a sufficient quality at the time of rental.

4.3 COMPACT FLUORESCENT LIGHTING

Replacement of incandescent bulbs with Compact Fluorescent Lighting (CFL) results in large benefits for homeowners and the nation in terms of resource use efficiency (more efficient light bulbs), more sustainable consumption (fewer bulbs required over time), and less waste and pollution (less thermal generation and greenhouse gases). Further, the costs of changing are very low, if incandescent bulbs are replaced with CFL when they expire. There is no significant opportunity cost, and from a private economic perspective, CFL bulbs should be used wherever possible. These bulbs are widely available and the benefits of switching to them are currently promoted to consumers by Government and industry.

Government should:

- legislate to restrict the supply or increase the cost to consumers of less energy efficient incandescent bulbs. Regulation to remove energy inefficient technology from the market could include fixing a date for the removal of incandescent light bulbs from the market (as has been announced in Australia and the UK), which would increase the speed of availability and lower the price of CFL lighting technologies.
- install energy efficient lighting in Housing New Zealand Corporation and other Government managed residential properties.

4.4 WATER HEATING

Two options for more energy efficient water heating were analysed: instant gas water heating and heat pump systems. Both are more efficient than alternative means of water heating.

The cost premium for an instant gas system is low (about $400) relative to a traditional electric cylinder system, and relative to the value of the output produced. From a resource use perspective, the case for instant gas systems is very strong, and may well justify Government assistance with regard to getting more dwellings connected to the gas reticulation network.

In contrast, heat pump systems, at an additional cost of around $3,900 over a standard electric system, are significantly dearer but produce about the same level of savings to the consumer as an instant gas system. Instant gas has a very high private economic return and environmental benefits are significant. Heat pump systems score reasonably well on environmental grounds, but their high cost reduces both the private economic benefits and national efficiency of resource use.

The relative up-front costs of investing in these more expensive systems for relatively small long term gains may continue to be a deterrent to their wider uptake. The incentives are relatively weak for existing homeowners to convert, unless their current means of water heating requires replacement.

Government could intervene in a number of ways to encourage and provide incentives for homeowners to switch to these more efficient means of space heating. As with other proposals, exposing homeowners to the full environmental costs of their energy consumption through the price on carbon resulting from the Emissions Trading Scheme will result in improved incentives for homeowners to switch to these more efficient forms of water heating. Associated with this is the need for Government to link citizens to the change and inform citizens of the reasons for change and to, either directly or indirectly (through partnerships with industry associations), educate citizens on their options and benefits that can be made from converting to more efficient methods of water heating. This would build on the current provision of product specific energy rating information and would ideally involve Government partnering with professional bodies, retailers, architects, builders and plumbers to provide this information to homeowners.

Government should consider:

- providing suspensory loans or subsidies (possibly on an income targeted basis) for the purposes of helping meet some of the short term costs of switching to more efficient forms of water heating;
- installing energy efficient means of water heating in Housing New Zealand Corporation and other Government managed residential properties;
- regulating for their use in all new houses through amendments to the performance measures in the Building Code and the compliance documents that underpin these;
- regulating for them to be installed in existing homes at the time alterations are made by amending Section 112 of the Building Act to require retrofitting of shower heads and toilets;
- regulating to remove energy inefficient technology from the market, for example, by putting in place minimum water heating standards to remove inefficient electric hot water cylinders from the market and promote greater uptake of efficient technologies.

4.5 WATER EFFICIENCY MEASURES

Water use by households accounts for about 45% of total reticulated supplies. There are good arguments for basic water efficiency measures to be used throughout the country, regardless of the security of water supply:

- water shortages in some areas
- abstraction of water always has environmental impacts which should be minimised;
- maintenance and renewal of water infrastructure has a high cost to the ratepayer, these costs can be reduced if water efficiency measures are in place;
- water efficiency allows for growth without putting pressure on water systems;
- water efficiency results in reduced wastewater and the requirement for wastewater treatment and disposal – with associated financial, health and environmental benefits, and less waste flowing into natural waterways.

The three water efficiency measures (low flow shower heads, dual flush toilets and water efficiency washing machines) have very high benefits in that they produce both water savings and energy savings, and the package is rated as ‘medium strong’ at a national level.

The package of innovations reduced water consumption by 27% or about 96 million m^3 per annum. From a national resource use efficiency perspective, the water savings are virtually costless, with benefits gained from both water savings and energy savings.

While the financial costs to homeowners of implementing the initiatives are very low, it is likely that a number of other factors including amenity concerns, finding the time to make or arrange for the switch and incomplete information on choices and the potential benefits of installing these features in new and existing homes are all barriers to their widespread take-up.

Government could intervene in a number of ways to encourage and provide incentives for homeowners to switch to these more efficient means of water heating. The take-up rate would be increased under Government action, especially if directed at the demand side.

Exposing homeowners to the full environmental costs of their water consumption through better pricing would result in improved incentives for homeowners to switch to such measures. As with other innovations, there is a role for Government in disseminating information to all citizens highlighting the value of water efficiency. The provision of specific product information can help in this, as might more general information and education campaigns, possibly in collaboration with professional bodies, retailers, architects and building associations.

Each of the following would complement improved price signals through mechanisms such as water metering or carbon charges:

- install water efficient measures in Housing New Zealand Corporation and other Government managed residential properties;
- regulate for their use in all new houses through amendments to the performance measures in the Building Code and the compliance documents that underpin these
- regulate for them to be installed in existing homes at the time alterations are made by amending Section 112 of the Building Act to require retrofitting of shower heads and toilets.

4.6 WATER METERING

The main reason for introducing water meters is to give a price signal to consumers, providing them with an incentive to reduce water wastage, and ensure that decisions are made based on the true costs of water. Charging for water use through property rates removes people from price signals and leads to excessive water consumption. Direct pricing of the provision of household water through metering is likely to lead to significant savings, and water metering presents a strong case for Government intervention to ensure the most efficient allocation of national resources.

Because the infrastructure costs of water supply are mainly met by local and regional government, charges for water supply are predominantly the concern of local and regional government. While most local authorities include the costs of water supply as a component of rates, only some require water metering whereby homeowners directly pay for their water in proportion to the volume of water that they use, creating an economic incentive for them to minimise their consumption.

From a national perspective, there is a case for central Government intervention if:

- the broader environmental or economic costs of water consumption are not being factored into the fees charged by local authorities; or
- there is the potential for scarcity of supply and the way that local authorities currently charge for the resource does not result in efficient allocation; or
- the way that local authorities currently charge for water does not result in adequate incentives for homeowners to appropriately manage their consumption of water.

There are few existing incentives for households to manage their water consumption. The most effective means of intervening are:

- by issuing a National Policy Statement under Section 45 of the Resource Management Act to state the objectives and policies to guide local authorities in the provision of water to homeowners; or
- by amending Section 19 of the Local Government Rating Act to require local authorities to directly recover the variable costs of water supply directly from homeowners.

Alternatively, Government could seek to facilitate a comprehensive approach across all local authorities to water charging. Through its leadership role, Government could encourage adoption of a more efficient approach to water charging in support of central and regional environmental objectives.

4.7 LINKAGES

Homes consist of a complex combination of systems (e.g. walls, roofs, floors, energy systems, plumbing, heating, ventilation), each of which provides a specific performance level for a home, and collectively they result in a certain level of comfort, resource use, and quality of life. There is a need to understand homes as a comprehensive system. The practical reality of designing, building and living in a dwelling involves balancing the performance of one system with the performance of another. The design, construction, operation and maintenance of a sustainable home requires more than the aggregation of a set of energy or water efficient products and systems. It is the combination of these things as well as the materials used and the indoor environmental quality, and the trade-offs between them which arise when considerations of affordability and future flexibility are applied.

Combining the five innovations that were rated as Medium Weak or better and spreading installation costs over 20 years, generates a direct private gain to households equivalent to 1% of GDP by 2017 or about $2 billion[10]. Non-monetary benefits of healthier and more comfortable homes, and environmental benefits, are additional. Direct savings in household energy consumption amount to almost 22 PJ per year or enough to power over 500,000 New Zealand homes for a year[11]. Most of the energy savings are in electricity use, implying a reduction in CO_2 emissions of 3600kt per year, the equivalent of $54 million in tradable emissions (at $15/tonne). Even allowing for take-back effects in the form of warmer and healthier homes and spending of household savings from energy on travel and other commodities, net economy-wide CO_2 savings of 1600kt are still produced. Direct water savings amount to 81 litres per person per day, or about 130 million m^3 per year.

[10] Note that the figure of $2 billion does not account for future inflation which will increase this figure, or that households will redirect some of this gain to spending on other commodities, so in terms of overall resource use efficiency there will be an increase in real private consumption of 0.35% or $106 per person per year.

[11] Based on estimates by Beacon that the average New Zealand household uses 12,300kWh per year if the home is to be heated to temperatures which meet minimum WHO standards.

Currently, many New Zealand homes are not operating as sustainable systems. They are cold, damp and inefficient. There is a significant role for Government to play in improving the sustainability of New Zealand's housing stock and the homes of our people. This will require recognition of the "joined up thinking" needed for sustainable building and renovation, and work across Government to achieve gains in health, energy efficiency, reduction in carbon emissions, increased labour productivity and quality of housing. This needs to involve:

- EECA retrofit programmes being aligned with the wider sustainable building context, and placing the EnergyWise Home Grants scheme within a framework that links to water efficiency and indoor environmental quality;
- developing the HERS tool within a wider sustainable building evaluation tool or star rating scheme for whole of house sustainability which would create additional demand for such homes;
- ensuring that Health programmes recognise the significance of housing quality;
- regulation of performance standards for houses at point of sale and point of rental;
- ensuring the range of sustainable building issues are addressed in the Building Code for both new and existing houses in the short not the long term.

Improving the sustainability of our housing stock presents the opportunity for a wide range of multiple gains if interventions are connected and appropriately targeted. Government needs to assist not just low income, but also middle income households in making their homes more sustainable. Government needs to acknowledge the unsustainability of New Zealand's housing stock and investigate the range of options to transform it. The innovations analysed for the purpose of this paper provide examples of the multiple benefits and overall national gains to be made in economic, environmental, social and health benefits for New Zealand, if the current unsustainability of New Zealand homes is addressed in a joined up way.

Key areas of Government action to improve the sustainability of New Zealand homes are:

1. Amendments to the Building Code
   a. Include provisions for minimum requirements when retrofitting existing houses in the Building Code. The Code needs to consider the issue of poorly performing, sometimes poorly built existing buildings and provide provision for consequential action.
   b. Inclusion of a rating tool within the Building Code. Internationally the development of rating tools for the promotion and quantification of sustainable development is a prominent approach which needs to be taken up in the Building Code. The Home Energy Rating Scheme which is currently being developed by EECA should be included within the Code, and extended to a sustainability rating tool rather than solely energy.
2. Upgrade the current insulation retrofits being carried out with assistance from EECA to a High Standard of Sustainability.
   a. Expand the EECA EnergyWise Grants for low income households to include:
      - Best Standard of insulation;
      - energy efficient water heating;
      - energy efficient lighting;
      - an efficient heat source where required;
      - water efficiency; and
      - improvements in indoor environmental quality.
   b. Increase and simplify financial incentives for solar water heating.

c. Provide interest free loans for homeowners to retrofit homes based on a High Standard of Sustainability with:
   - Best Standard of insulation;
   - energy efficient water heating;
   - energy efficient lighting;
   - an efficient heat source where required;
   - water efficiency; and
   - improvements in indoor environmental quality.

d. Provide incentives through a housing supplement or interest free loans to landlords to upgrade rental housing stock to High Standard of Sustainability. Subsequently, in the medium term, Government should require landlords to have their properties certified. This could be as much from the health and safety aspect as from sustainability.

3. Ban unflued gas heaters.
4. Government leadership in Housing New Zealand Corporation and other Government managed residential housing, upgrading this to a High Standard of Sustainability over the next 5 years.
5. Build on the voluntary Home Energy Rating Scheme (HERS) being developed by the Energy Efficiency and Conservation Authority and implemented in December 2007 to:
   - a mandatory HERS at point of sale from December 2008;
   - a mandatory HERS at point of rental from December 2009; and
   - a mandatory Sustainability Rating at point of sale and rental from December 2010.
6. Additional regulatory review.

   a. Minimum standards in the Residential Tenancy Act for residential dwellings at point of rental.

   b. Urban water efficiency be integrated into the Ministry for the Environment's Water Programme of Action and any National Policy Statement developed under this.

APPENDIX A: SUSTAINABLE HOUSING INNOVATIONS

Likely National Value Case for existing housing and new housing	
A	Strong
B	Medium
C	Weak
E	Existing housing
N	New housing

		INITIATIVE	PRIVATE BENEFITS	FISCAL BENEFITS	RESOURCE USE EFFICIENCY	ENVIRONMENTAL BENEFITS	EXTERNALITIES AND BARRIERS	OTHER
E	N	ENERGY						
A		Retrofit ceiling insulation (up to the current 2007 Code.	More comfortable home. Better health. Energy cost savings. 1/3 of household energy is for space heating. Take-back for comfort occurs because current retrofits are inadequate.	Lower (or redirected) health expenditure. Less absenteeism in the national workforce which is thus more productive	Less investment in large energy generation. Fewer work days lost through illness.	Lower greenhouse gas (GHG) emissions from less thermal generation, and perhaps lower PM10s. Use of waste materials in insulation.	Credit constraints. High discount rate. Insufficient information. Inability to capture sufficient benefits. Lack of roof cavity.	≈1m homes built before 1979 and 1.6m before 2007. Crown owns ≈70,000 units, most retrofitted to 1978 standards. Need retrofitting to at least 1992 Code levels, if not 2007.
B		Retrofit floors and walls						Is the floor suspended or is it a slab on the ground?
C	A	Double glazing	Less noise and improved amenity. Less condensation and dampness.					Limited benefit without insulation.
A	A	Space heating: heat pumps and pellet fires.	Log burners (and pellet burners if have a battery) raise resilience to power cuts. More comfort.			Lower (GHG) & particulate emissions. Reuse sawdust waste.		Limited benefit without insulation. Take-back – greater comfort, lower energy savings.
C	B	Solar, heat pump, wetback, water heating	Energy cost savings. Solar hot and wetbacks increase resilience to power cuts. But long payback period.		Less investment in large energy generation. Reduction in GHG emissions.	Less thermal generation at margin.	High capital cost.	1/3 of household energy is for water heating.
A	A	Instant gas water heating	As above		Direct use of gas. No cylinder	As above. Could lower GHG emissions.		

		INITIATIVE	PRIVATE BENEFITS	FISCAL BENEFITS	RESOURCE USE EFFICIENCY	ENVIRONMENTAL BENEFITS	EXTERNALITIES AND BARRIERS	OTHER
C	B	Energy efficient appliances	Energy cost savings			Lower ozone depletion as some appliances made in China still have CFCs as the refrigerant.		Accelerated replacement probably not economic
A	A	Energy efficient lighting using Compact Fluorescent Lamps	Energy cost savings			Lower thermal generation.		LED technology is developing rapidly. Halogen lights are not an energy efficient lighting option and interfere with ceiling insulation
B	B	Energy efficient lighting using LED lights						
	B	Passive solar design – Eaves (new buildings are often missing these)	Energy cost savings. More comfortable indoor environment. Better weather tightness		Less investment in large energy generation	Lower thermal generation.	Some District Plans – smaller sites and height in relation to boundary controls mean new houses are often built without eaves.	In hotter climates, lack of eaves leads to air conditioning being installed.
	B	Passive solar design – thermal mass	Energy cost savings. More comfortable indoor environment. Easy to maintain.		Less investment in large energy generation.	Lower thermal generation.	Sloping sections	Slab of insulated concrete to absorb heat and release heat overnight.
	B	Passive solar design - minimise glazing on southern (and western to some extent) facade	Energy cost savings. More comfortable indoor environment. Walls are cheaper than windows.		Less investment in large energy generation.	Lower thermal generation.	Urban design issues in some instances e.g. where street frontage is to the south; some consumer resistance if south facing views.	Glazing too evenly spread around the house. Maximise northward glazing and minimise south facing glazing. West facing glazing can cause over-heating due to the low angle of western sunlight.
		WATER						
C	B	Rainwater capture	Lower water fees or rates	Less local government spending on new water supply, stormwater transport, treatment and disposal.	Less use of reticulated water	Less damming of waterways & less stress on aquifers. Less damage & contamination from stormwater discharge to streams & coast, but possible negative effect if discharges are more concentrated.	Many householders do not directly face price of reticulated water. Health regulations may conflict.	Need to segment by rainfall zone and whether metered already (Auckland, Tauranga, Nelson).

		INITIATIVE	PRIVATE BENEFITS	FISCAL BENEFITS	RESOURCE USE EFFICIENCY	ENVIRONMENTAL BENEFITS	EXTERNALITIES AND BARRIERS	OTHER
A	A	Water use: low flow devices	Less energy use with low flow devices on hot taps & with low flow shower heads	As above.	Less water use from technical efficiency.	Less wastewater discharge to receiving environments. Less damming of waterways & less stress on aquifers.		Could be marked comfort trade-off, but not for toilets.
A	A	Water metering, (potable and waste)	Financial impact could be +ve or –ve, depending on the way fees are set.	As above. Better leak detection.	Less water use from price signal		Introduce a price signal. Perceived social issue for low income households with a large number of occupants.	Anecdotal evidence of strong effect.
C	C	Collection of greywater.	Lower water fees or rates	Less spending on local govt wastewater transport, treatment and disposal.	Less use of reticulated water.	Less waste into waterways.	Householders not directly face price of wastewater removal. Probably viable only in dry or un-reticulated areas or where constraints on wastewater disposal exist.	Chemical build-up in garden? Synergy with rainwater capture if in dry area and/or high watering of gardens.
A	A	No in-sink waste disposal unit	Power savings. Disbenefit of more waste handling with more composting.	As above	Less water use	Less waste into waterways		
		WASTE						
B	B	Composting of green waste vs landfills	Lower charges for rubbish collection	Less local government spending on land-fills and cost of collection and transport of waste.	Less energy use transporting waste.	Fewer landfills. Fewer emissions (local air and greenhouse gas) from transporting waste.	Some councils have user charges, but many in general rates.	Possible loss of electricity generation. Larger regional landfills have better env. stds but more waste is moved, e.g. Whangarei & Akld refuse to Waikato.
C	B	Space for recyclables storage	Lower charges for rubbish collection.	Less local government spending on land-fills.	Waste returning back into the consumption stream.	Fewer landfills.		Particularly an issue for apartment and medium density housing developments.
		BUILDING MATERIALS						
C	B	New homes made of sustainable materials. Also apply to renovations to older homes.	Health benefits from use of materials with low Volatile Organic Compounds.		Less resource use to make the materials.	Less hazardous waste input to the environment.	Building Act issues in some cases.	Only apply to verified/certified materials based on cleaner production components and minimisation of hazardous inputs.

		INITIATIVE	PRIVATE BENEFITS	FISCAL BENEFITS	RESOURCE USE EFFICIENCY	ENVIRONMENTAL BENEFITS	EXTERNALITIES AND BARRIERS	OTHER
C	B	Reduce construction waste going to landfills	Prefabrication may lower costs as does use of standard material sizes.	Less local government spending on land-fills.	Less energy use from transporting waste. Less embodied energy in materials going to landfill.	Fewer emissions from transporting waste and embodied energy in materials	Waste disposal may not be priced below the true social cost.	The NOW Homes® produced 2.5 tonnes instead of average 4 tonnes for a new home – largely as a result of design using standard material sizes.
		INDOOR ENVIRONMENT						
C	B	Ventilation: active mechanical in wet areas	More comfortable home. Lower maintenance. Better health. Energy cost savings.	Lower (or redirected) health expenditure	Fewer work days lost through illness.		As for retrofit insulation	Synergy with insulation, but double glazing could raise humidity
	B	House orientation	Warmer home. Less cost to heat. Better amenity of living space.		Lower energy use	Lower energy use	Needs to be considered at the individual house & subdivision design level – developer resistance.	In Australia there is a regulatory requirement for East-West subdivision layout cf North-South.
	A	Passive vents	More comfortable home. Better health. Lower maintenance.	Lower (or redirected) health expenditure	Fewer work days lost through illness			Passive vents reduce mould growth and poor indoor air quality.
B		Removal of unflued gas heaters	More comfortable home. Better health. Lower maintenance.	Lower (or redirected) health expenditure.	Fewer work days lost through illness.		Perception that is a low cost form of heating and thus favoured by low income households.	CEA research indicates pellet burners have the lowest running cost of any heating method.

	INITIATIVE	PRIVATE BENEFITS	FISCAL BENEFITS	RESOURCE USE EFFICIENCY	ENVIRONMENTAL BENEFITS	EXTERNALITIES AND BARRIERS	OTHER
	NEIGHBOURHOOD						
Outside scope	Access to public transport	Cheaper transport	Possible reduction in expenditure on new road capacity, but more on road maintenance	Less fuel use. Net roading expenditure unclear	Lower CO_2 emissions.	Requires urban density and dominant travel routes.	Very dependent on frequency, reliability and comfort.
Outside scope	Siting of dwellings in relation to one another	More privacy. More community spaces. Lower crime.	Less policing	Less policing?		Cost of land	Refer *The Value Case for Urban Design (MfE).*
C	Multi-purpose dwellings & functional flexibility	Disbenefit from sub-optimal floor plan if try to build whole house for both domestic and commercial use.		Less use of building materials.	Less use of building materials.	Future needs difficult to predict – how much flexibility to build in.	Apartments overseas are often designed so that walls are easy to move, to accommodate changing needs.
Outside scope	Higher density land use	More affordable house prices. Disbenefit from more crowding.	Councils gain through more efficient use of infrastructure e.g. public transport	More efficient use of land.	Less pressure from expansion of cities on natural resources unless intensive housing pushed into natural areas.	¼ acre section and suburban dream	Only appropriate where services exist. Higher density land use in sparsely populated areas is not efficient. Good design is essential.

APPENDIX B: METHODOLOGY

Infometrics carried out the quantitative analysis of the National Value Case and notes that the analysis in their report is not the final word on High Standard of Sustainability innovations for sustainable homes. In particular, the following caveats should be noted:

1. Relative prices change over time, so benefit-cost ratios can change and hence too the National Value Case for an innovation.
2. Even if prices are constant over time, they may differ across regions or across suppliers, or with economies of scale. Again this can affect the National Value Case.
3. Some innovations will be worth pursuing in particular circumstances (such as regions or household types) even if their National Value Case is doubtful. We look only at national average effects.
4. The weights that we have applied to each of the four benefit types; household economic benefits, environmental benefits, social and other private benefits, and national resource use efficiency, are merely our assessment of plausible values. We stress that these have not been derived from any community consultation or surveying. They need to be carefully validated.
5. Where possible the analysis takes into account economies of scale and the efficiencies of doing multiple installations rather than one-off installations, for innovations that relate to broadly the same area. However, possible savings from combining, say, ceiling insulation with the installation of low flow shower heads have not been considered.
6. While the evaluation of national resource use efficiency effects allows for upstream effects such as the mix of electricity generation at the margin, the energy needed to pump reticulated water over long distances, the differences in using gas directly versus using electricity generated from gas, and so on, it is implicitly assumed that the prices of all of these goods and services reflect the true opportunity costs of the resources involved. This may not always be true. For example we include a price on CO_2 emissions, but we cannot claim that it is the correct price.
7. While our conclusions about the National Value Case for any given innovation are expected to be reasonably robust, major changes in relative prices or in the weights for the various types of benefits could change the results. Sensitivity analysis is recommended following a discussion about priorities.

Four potential types of innovation were identified:

- Those that generate a net improvement in economic efficiency which goes directly to households. In this case the role of public policy would be small (perhaps confined to education and information) as private incentives will be aligned with achieving the goal.
- Those that generate a net improvement in economic efficiency but where externalities exist that hamper their introduction. In this case the role of public policy would be critical, but the justification for the required policy changes is straightforward.
- Those that generate an improvement in the quality and sustainability of the housing stock but at a net economic cost (or where it is difficult to quantify the intangible benefits). In this instance there is potentially a role for policy if one can provide strong arguments that the environment or social improvements (such as health gains) justify the economic costs of the policy.
- Those that generate an improvement in the quality and sustainability of the housing stock that is not sufficient to justify a policy response. The economic cost required to implement the initiative does not justify the perceived benefits. These are initiatives that should not be pursued.

Four sources of environmental innovation associated with sustainable housing were identified as set out in the table below.

$\Delta R / H$	Change in total resource intensity of housing	e.g. re-use of waste materials or use of standard material sizes.
$\Delta R_i / R$	Change in mix of resources used	e.g. more use of insulation and less use of energy, or using tanks for water supply.
$\Delta R_{wi} / R_i$	New technology for use of a given resource	e.g. a more efficient hot water cylinder.
$\Delta E_{wi} / R_{wi}$	Emissions / waste control technology	e.g. lower particulate emissions from a wood burner.

Table 6: Main Sources of Environmental Innovation

A preliminary assessment of a wide range of sustainable housing innovations was carried out in qualitative terms based on research conducted by Beacon, and other documents (refer Appendix A) to rank the various innovations into three groups: strong, medium or weak National Value Case. Benefits were identified as well as possible reasons (barriers and/or externalities) why the innovations are not being pursued by private interests.

Six sustainable housing innovations were selected for further analysis on the basis of two criteria:

- they were coded as having a strong National Value Case in the initial qualitative assessment
- sufficient information on which to base a robust cost-benefit analysis was easily available

Innovations were considered only the areas of energy and water as there were no innovations in the areas of waste, indoor environment and neighbourhood that were sufficiently well specified to be examined with cost-benefit analysis.

A detailed economic evaluation of the selected sub-group of innovations was then undertaken by Infometrics using the equation below. Following Bruvoll and Medin (2000), the equation presents a breakdown of economic output in terms of the impact on the environment through resource use and emissions of waste.[12]

(1)

$$E = \sum_{w} \sum_{i} \sum_{j} \frac{E_{wij}}{R_{wij}} \cdot \frac{R_{wij}}{R_j} \cdot \frac{R_j}{R_j} \cdot \frac{R_j}{Y_j} \cdot \frac{Y_j}{Y} \cdot \frac{Y}{P} \cdot P$$

- E is a measure of entropy which could be waste, emissions from the combustion of energy, pollution, harm to the environment, harm to species, ecosystems and so on;
- R is a measure of resource use, this could be the consumption of energy, the utilisation of raw materials, land use and so on;
- Y is consumption or production;
- P is a measure of population or households;
- w is the technology specific resource use method, for example with energy use it could be the combustion method;
- i is the resource type, e.g. oil, building materials.
- j is the industry or sector, e.g. farming or energy.

Benefits were classified into four types:

- Environmental (e.g. less pollution)
- Social and private non-economic benefits (e.g. warmer homes)
- Private economic benefits (e.g. lower household energy costs)
- National efficiency of resource use (e.g. less waste).

[12] This model has also been used by Infometrics in a report to the Ministry of Economic Development for assessing the economic development potential of environmental technologies

In order to allow benefits with different units of measurement to be combined, a weighting was assigned to each of the four types of benefit, and each innovation given a score that measures how well it contributes to each type of benefit. The weighted average score is an overall measure of the benefits of the particular innovation. Weights were assigned as follows:

- Environmental (20%)
- Private non-economic benefits and social benefits (20%)
- Private economic benefits (30%)
- National efficiency of resource use (30%).[13]

The effect of innovations on national efficiency of resource use was calculated using the ESSAM general equilibrium model in contrast to the traditional cost-benefit analysis undertaken to determine private economic benefits. The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It takes into account most of the key inter-dependencies in the economy, such as the flows of goods from one industry to another, plus the passing on of higher wage costs in one industry into prices and thence the costs of other industries.

The change in private consumption is the measure of the welfare effect of changes in national resource efficiency. Separate model runs were used to look at the welfare effect of the cost of a given innovation (such as the cost of retrofit insulation) and the welfare effect of the benefit of the innovation (such as energy saving). The consequent benefit-cost ratio for the changes in private consumption provides the overall welfare measure for each innovation in terms of its effect on national efficiency of resource use.

The scores for each of the four different types of benefit were then plotted on an x-y axis, where the shaded area depicts the size of the total combined benefit rather than an overall score which could obscure scores in each of the specific benefit areas.

ENVIRONMENTAL BENEFITS

Four ways in which the environment may benefit were identified:

- fewer resources being used,
- more sustainable resources being used,
- being used more efficiently and
- less pollution from resource use.

Innovations were graded yes/no (1/0) against these four types of environmental benefit according to where they deliver, and a score assigned of 3 if three or four benefits are relevant, with scores of 2, 1 and 0 applied linearly thereafter.

PRIVATE NON-ECONOMIC BENEFITS AND SOCIAL BENEFITS

Three types of social and private non-economic benefits were identified:

- More comfortable homes
- Better health
- Better (more pleasant and safer) neighbourhood

These are benefits that occur in addition to any associated economic benefits such as less expenditure on health care, which are captured elsewhere. Innovations were graded yes/no (1/0) according to where they deliver, and the score for private non-economic and social benefits lies in the range 0-3.

[13] Although the weights are considered plausible, we cannot claim that they reflect the community's marginal benefit preferences.

PRIVATE ECONOMIC BENEFIT

Private economic benefit was measured by the internal rate of return (IRR) for each innovation, calculated over a twenty year period. Against the background of rates of return available on risk free term deposits, scores were awarded as follows:

IRR	Score
≥ 10%	3
≥ 5% & < 10%	2
≥ 0% & < 5%	1
< 0%	0

NATIONAL EFFICIENCY OF RESOURCE USE

Indirect effects correspond to the increase in economic welfare generated by the flow-on effects of an innovation, in the form of a more efficient use of the nation's resources. This includes both productive efficiency (the amount of output obtainable from a given quantity of inputs) and allocative efficiency (when the value that consumers place on a good or service equals the cost of the resources used in its production).

With regard to sustainable housing innovations, consider the following example:

An innovation that replaces energy with more use of insulation in dwellings might have the direct effect of reducing household expenditure on energy. If insulation requires fewer of the nation's resources to deliver a given output – a warm home – than heating it to the same temperature, there is national gain in productive efficiency. If a warmer home also leads to better health and thus less demand for tax-funded health services, a reduction in taxation would be possible. That is, a rise in allocative efficiency.

Such indirect effects are not easily evaluated by consideration of the innovation alone. Consumer behaviour and inter-industry linkages in the wider economy need to be taken into account. For this purpose an economy-wide model is appropriate. The ESSAM general equilibrium model of the New Zealand economy was used to calculate the economy-wide, resource use effects of sustainable housing innovations.

It is important to understand the difference between standard cost-benefit analysis and general equilibrium analysis. In the latter we are not comparing the actual cost of an innovation with the benefits to private consumption; rather we are comparing the cost of the innovation in terms of private consumption foregone, with the benefit to private consumption.

ESSAM MODEL

The effect of innovations on national resource use efficiency was calculated using the ESSAM general equilibrium model in contrast to the traditional cost-benefit analysis undertaken to determine private economic benefits. The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It takes into account most of the key inter-dependencies in the economy, such as the flows of goods from one industry to another, plus the passing on of higher wage costs in one industry into prices and thence the costs of other industries.

Some of the model's features are:

- Forty-nine industry groups.
- Substitution between inputs into production - labour, capital, materials, energy.
- Substitution between four energy types: coal, oil, gas and electricity.
- Substitution between goods and services consumed by households.
- Social accounting matrix (SAM) for tracking financial flows between households, government, business and the rest of the world.

The change in private consumption is the measure of the welfare effect of changes in national resource efficiency. Separate model runs are used to look at the welfare effect of the cost of a given innovation (such as the cost of retrofit insulation) and the welfare effect of the benefit of the innovation (such as energy saving). The consequent benefit-cost ratio for the changes in private consumption provides the overall welfare measure for any given innovation. This benefit-cost ratio is not discounted.

It is important to understand the difference between standard cost-benefit analysis, and general equilibrium analysis. In the latter we are not comparing the actual cost of an innovation with the benefits to private consumption; rather we are comparing the cost of the innovation in terms of private consumption foregone, with the benefit to private consumption.

Clearly, the private consumption benefit-cost ratio will be higher, the lower the opportunity cost of an innovation. In this sense it is intuitively similar to traditional cost-benefit analysis. The key difference is that a general equilibrium model takes into account indirect effects and feedback effects that could either enhance or offset the benefits that accrue to a single private household.

WEIGHTED SCORE

The score for each of the four benefit types is then multiplied by its weight, and aggregated. With the top score being 3 in all categories and the weights adding to unity, the aggregate score – the National Value Case – lies in the range 0-3. An overall qualitative rating for an innovation is produced by the model using the following mapping:

Aggregate Score	Aggregate Benefit
< 1.0	No benefit
≥ 1.0 & < 1.5	Weak
≥ 1.5 & < 2.0	Medium weak
≥ 2.0 & < 2.5	Medium strong
≥ 2.5	Strong

REFERENCES

Amitrano, L., Kirk, N. and Page, I. (2006). *Market Segmentation of New Zealand's Housing Stock*. Report PR106 prepared for Beacon Pathway Limited.

Asthma and Respiratory Foundation of New Zealand (accessed 19/09/2007). http://www.asthmanz.co.nz/in_new_zealand.php.

Bruvoll, A and H. Medin (2000): *Factoring the Environmental Kuznets Curve: Evidence from Norway,* Statistics Norway, Discussion Paper No 275.

Easton, L. (2006). PR109: *Defining the Benchmarks for Beacon's High Standard of Sustainability*, Interim Report to November 2006 Board Meeting.

Easton L., D. Mean, C. Trenouth, D. Fullbrook and P. Arnold (2006): *Local Council Sustainable Building Barriers and Incentives – Auckland City Case Study*. Report PR 200 for Beacon Pathway Limited.

Energy Efficiency and Conservation Authority (2007). Accessed 19/09/2007. http://www.eeca.govt.nz.

Howden-Chapman, P., A. Matheson, J. Crane, H. Viggers, M. Cunningham, T. Blakely, D. O'Dea[1], C. Cunningham, A. Woodward, K. Saville-Smith, M. Baker, Nick Waipara, M. Kennedy & G. Davie (2004): *Retrofitting houses with insulation to reduce health inequalities: a community-based randomised trial*. Paper presented at Second WHO Conference on Housing and Health, Vilnius, Lithuania, October.

Infometrics (2004): *Analysis of New Zealand's Trade in Environmental Goods and Services*.

Infometrics, Eco$ense, and Martin Jenkins (2007). *Sustainable Homes National Value Case*. Report prepared for Beacon Pathway Limited.

McChesney, I and Amitrano, L. (2006). *Sustainability Options for Retrofitting New Zealand Houses – Energy*. Report TE106 for Beacon Pathway Limited.

New South Wales Department of Infrastructure, Planning and Natural Resources (2004). *Summary of Cost Benefit Study for BASIX*.

New South Wales Department of Planning (2006). *BASIX Fact Sheet: BASIX Energy Target*.

Phipps, R. (2007). *Indoor Environment Quality*. Report TE220 for Beacon Pathway Limited.

World Health Organization (1987). *Health Impact of Low Indoor Temperatures*. Copenhagen, WHO Regional Office for Europe (Document ICP/RUD 003/m01).

BEACON'S VISION

Creating homes and neighbourhoods that work well into the future and don't cost the Earth

BEACON'S GOALS

Beacon has two key goals:

- To help bring 90% of New Zealand homes to a high standard of sustainability by 2012 and;
- To ensure that every new or redeveloped subdivision or neighbourhood, from 2008 onwards, is created with reference to a nationally recognised sustainability framework.

BEACON'S SHAREHOLDERS

Our shareholders are organisations with a considerable stake in the quality of the residential sector. The founding shareholders – Building Research, Fletcher Building, Scion and Waitakere City Council – were joined by New Zealand Steel in June 2005.

Shareholder contributions are matched, dollar for dollar, by funding from the Foundation for Research, Science & Technology (FRST).

FOUNDATION FOR RESEARCH SCIENCE & TECHNOLOGY Tūāpapa Rangahau Pūtaiao

Waitakere City Council Te Taiao o Waitakere

NEW ZEALAND STEEL

SCION

FletcherBuilding

BUILDING RESEARCH INVESTING FOR NEW ZEALAND'S CONSTRUCTION FUTURE

Beacon

TOGETHER, CREATING TOMORROW'S HOMES

CONTACT US:

Beacon Pathway Ltd
PO Box 11 338 Auckland
0508 Beacon
www.beaconpathway.co.nz
www.nowhome.co.nz
www.homesmarts.org.nz

PRINTED ON 9LIVES FSC MIXED SOURCE CERTIFIED, 55% RECYCLED, 45% FSC CERTIFIED PULP.