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Integrating Climate Change Mitigation And Adaptation Strategies for New Zealand's Built Environment

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Integrating Climate Change Mitigation and Adaptation Strategies for New Zealand's Built Environment

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Summary

The Earth's climate is changing, with the expected changes posing a serious challenge to the built environment. This includes our cities, our rural and coastal settlements, our homes and businesses, our infrastructure, and ultimately our health and safety. To date, the New Zealand Government's policy package on climate change is largely focussed on mitigation strategies, with minimal attention on how the built environment will need to adapt to future changes in climate.

What is required is a much better understanding of methods for integrating both mitigation and adaptation approaches to maximise synergies and minimise potential conflicts between interventions. In addition, integrated adaptation and mitigation approaches need to be viewed as long-term, continuous processes rather than single events. To address these issues, the Building Research Association of New Zealand (BRANZ Ltd) has been undertaking a two-year programme of research investigating flexible, integrated solutions to deliver:

- a carbon-neutral built environment, and
- an adapted built environment in an already altering climate.

The ultimate aim of this work programme is to design and build a carbon-neutral and climate-adapted building for the New Zealand context. This paper describes the research programme in more detail, showcases the results achieved to date, and further elaborates on the long-term aims of the programme.

1 Introduction

The Earth's climate is changing, with the expected changes posing a serious challenge to the built environment. This includes our cities, our rural and coastal settlements, our homes and businesses, our infrastructure, and ultimately our health and safety. Adapting to a warming climate is vital, but up until very recently buildings have not been considered at the forefront of the debate on climate change assessment and decision-making. Houses especially play a fundamental role in our lives, but any strong connection to the environment impacts beyond the home is rarely made. As a result, the New Zealand Government's policy package on climate change is largely focussed on mitigation strategies, with minimal attention on how the built environment will need to adapt to future changes in climate.

What is required is a much better understanding of methods for integrating both mitigation and adaptation approaches to maximise synergies and minimise potential conflicts between climate change policy decisions. In addition, integrated adaptation and mitigation approaches need to be viewed as long-term, continuous processes rather than single events. To address these issues, the Building Research Association of New Zealand (BRANZ Ltd) has been undertaking a two-year programme of research investigating flexible, integrated solutions to deliver:

- a carbon-neutral built environment, and
- an adapted built environment in an already altering climate

The ultimate aim of this work programme is to design and build a carbon-neutral and climate-adapted building for the New Zealand context.

1.1 The New Zealand context

New Zealand's built environment sector is wide ranging and includes a variety of government agencies, building and construction-related industries, organisations and institutions. The built element of the sector comprises both residential (houses, apartments, flats, terraced housing) and non-residential assets (industrial, commercial, service provision, e.g. hotels, hospitals, schools, churches, etc). Two of the more significant types of buildings are residential houses (around 1.4 million units) and office buildings (around 67,000 units). The capital value of the built environment stock accounts for approximately 9.5% of New Zealand's GDP (Page 2002).

The built environment and all it contains is integral to our survival on the planet: it accommodates and sustains individuals and families, economic activities, education and health services, and is a repository of the nation's cultural heritage. All of this is potentially under threat from the direct and indirect impacts of climate change. Research by Camilleri (2000) has identified three key direct risks for New Zealand's built environment: coastal and inland flooding, building overheating and tropical cyclones.

1.1.1 Coastal and inland flooding

Most of the impact due to flooding will be damage to energy/telecommunications infrastructure, goods and chattels, internal features (e.g. underfloor/wall insulation), internal plasterwork and refurbishments. Additionally, some properties may experience sewage intrusion (from sewer 'back-up'), corrosiveness of sea water (e.g. masonry damage) and run-off from agricultural land (e.g. fertilisers and soil minerals). Properties in flood-prone coastal or inland regions may also be subject to complete obliteration from a combination of storms and tidal surges enhanced by rising sea-levels.

1.1.2 Building overheating

High temperatures inside houses and offices will affect the comfort of occupants, especially those groups deemed to be vulnerable to extremes in temperature (the elderly, infirm and young children), especially when daytime work performance or night-time sleeping is affected. When high temperatures are coupled with high humidity (predicted for cities such as Auckland), the likelihood of mould proliferation, strongly linked to health problems, is also increased (Sanders and Phillipson 2003). Positive impacts include higher night-time winter temperatures and decreased winter energy consumption.

1.1.3 Tropical cyclones (extreme winds and driving rain)

The action of wind on buildings causes dynamic structural loading by pressure forces. Structural failure can range from removal of individual tiles or iron sheeting through to uplifting of entire roofs or walls. High wind speeds also have implications for the wind environment surrounding buildings, such as comfort and/or safety issues for pedestrians (Sanders and Phillipson 2003).

When a building is exposed to frequent driving rain, weathering generally occurs which can lead to higher maintenance requirements to ensure weathertightness over a building’s lifetime. More effective water management systems may have to be adapted for roofs, guttering and drainage to cope with predicted greater volumes of water to ensure damage to the building fabric is minimised.

1.2 Linking adaptation and mitigation strategies

Strategies for adaptation, whether current or future, do not (and should not) act in isolation. Government agencies and sector groups within the building and construction industry need to be aware that controlling carbon emissions is only one side of the climate change equation. New Zealand is a small emitter of GHG (in terms of total emissions per country) in comparison to the larger industrialised nations, and will be able to do little in its own right to halt global emissions. Therefore the focus and efforts in this country are increasingly likely to focus on adaptation, while maximising synergies with mitigation strategies. Indeed, it can be argued that adaptation and mitigation must be linked because despite efforts to stabilise greenhouse gas concentrations in the atmosphere at a relatively low level, climate change will not be altogether prevented. The impact of climate change phenomena cannot be altogether prevented (NZCCO 2004).

2 Research programme

To gain a much better understanding of methods to integrate both mitigation and adaptation approaches, BRANZ Ltd developed a two-year research programme exploring building solutions to deliver a carbon-neutral built environment and adapted built environment relevant to New Zealand’s anticipated climatic conditions. The proposed programme comprised of two stages: the first stage resulted in two separate, but related publications (prepared for two distinct audiences). The first was a formal guidance manual, which provides specific information on a range of built environment adaptation strategies for both government agencies and the building and construction industry. The second was a Calendar for 2005 entitled *Smart Building Tips for Climate Friendly Kiwis* aimed at informing the public about what they can do about climate change on a month-by-month basis.

The second stage of the research (ongoing) investigated what issues needed to be considered to develop a building brief for a mitigated AND adapted building (new, residential). At the time of writing this building brief was under development; the aim of the brief being to design, as far as practically possible, a 100% carbon-neutral and adapted house. Final stages of the research (from

April 2006) will include the development of the methodology to assess the building brief in terms of its actual performance. The ultimate end point of the programme is to build (i.e. determine what the brief means in terms of actual construction practice) the building, test it in terms of its performance, and encourage uptake into mainstream building practice.

2.1 Stage One

2.2.1 Guidance manual

The guidance manual entitled *Climate Change Adaptation: Guidance on Adapting New Zealand's Built Environment for the Impacts of Climate Change* provides information on the adaptation of the New Zealand built environment to the impacts of climate change. It is designed to help government agencies and the building and construction industry to: first, understand the key impacts that climate change will have on the built environment; and second, to begin planning and implementing integrated adaptation strategies to future-proof New Zealand's built assets and protect the communities of which they are a part.

Section One of the manual provides generic information about New Zealand's built environment, the climate change impacts likely to affect it, the concept of adaptation (and its relationship with mitigation) and provides reasons for taking action now. It also includes information about making adaptation work, such as linking adaptation with other agendas for change and taking into account regional climate variations.

Section Two provides specific adaptation strategies for the built environment in response to the three key predicted impacts of climate change (building overheating, flooding and tropical cyclones). This information is organised into three parts:

- Part A is targeted toward government agencies (central, regional and local authorities as major property and infrastructure owners and managers of the built environment)
- Part B at the building and construction industry (as the designers, developers, builders and renovators of the built environment)
- Part C provides international and national case studies of building-related adaptation initiatives.

Section Three provides the report's conclusions and recommendations for future work.

The manual is a companion document to the following New Zealand Climate Change Office of the Ministry for the Environment's publications (downloadable from: www.climatechange.govt.nz/resources/local-govt/guidance.html):

- *Climate Change Effects and Impacts Assessment* (May 2004)
- *Coastal Hazards and Climate Change* (May 2004)
- *Local Communities: Planning for Climate Change* (May 2004)

It also builds on a number of BRANZ publications (downloadable from www.branz.co.nz/branzltd/publications/pdfs/sr107.pdf), in particular:

- *Study Report 107 – Implications of Climate Change for the Construction Sector: Adaptation and Mitigation Strategies and Revised CCSI* (Camilleri 2001)

Space limitations prevent elucidating on the manual's contents in further detail. However, of particular interest is the provision of an indicative cost-benefit analysis for adapting houses, which examines payback times for building owners when they are faced with the question of whether or not to adapt their house to predicted climate impacts.

The analysis was carried out on a new 195 m^2 two-storey house with three climate change adaptation features added to the design:

- wind resistance: increased number of roof fasteners, strengthened roof and wall framing, strengthened windows and additional bracing in the wall linings
- flood adaptation: raised building platform, built 0.5 m above existing ground level, using imported fill material which is compacted. A 150 mm basecourse layer was placed on the compacted fill next to the concrete slab, as per normal practice
- passive solar measures: increased eaves width, double glazing, built-in window vents, and additional envelope insulation.

For the purposes of the analysis, climate change impacts were assumed to be at their most threatening in 30 years (c. 2030). The results are shown in the Table 1 below.

Table 1. Cost increases for a typical new house due to built-in climate change adaptation measures

Cost increases for a typical new house (1) due to built-in climate change mitigation measures						
Item	**Unit**	**Quantity**	**Unit rate**		**Cost increase $**	**Comments**
WIND DAMAGE ADAPTATION						
Timber framing						
Wall	m^3	0.141	640	$/$m^3$	90	Increase stud size in lower storey (2)
Roof	m^3	0.7	640	$/$m^3$	448	Increased truss sizes in roof (3)
Roof fasteners	number	180	3	ea	540	Additional fasteners required (4)
Aluminium windows	sqm	42.1	25	$/sqm	1,053	Heavier frame, better seals, glazing thickness may increase(5)
Linings Plasterboard	sqm	161	3	$/sqm	483	Increased use of Gib Braceline for wind bracing, $3/sqm
					2,614	
FLOODING ADAPTATION						
Slab sub-grade fill	m^3	160	22	$/ m^3	3,520	Increase ground floor sub-base level by 0.5 m (imported compacted fill)
INDOOR HEAT ADAPTATION						
Eaves extension	sqm	15.4	100	$/sqm	1,540	Increase eaves width lower story from 460/610 mm to 800 mm
Double glazing	sqm	42.1	80	$/sqm	3,368	Double glazing and tinted windows
Extra insulation walls	sqm	117	3	$/sqm	351	From R1.8 to R2.6 in walls
Extra insulation ceiling	sqm	147	3	$/sqm	441	From R2.2 to R4 in ceiling.
Vents in windows	sqm	42.1	20	$/sqm	842	Built-in secure vents in windows
					6,542	
			Total		**$12,676**	
		Total % cost increase			5.0	Assume house cost of $1,300/sqm = $253,500

(1) House is the Exemplar House (Willson 2002), two storeys, 195 sqm, concrete slab ground floor.

(2) Go from high to very high wind, in upper storey typically 100 x 40 studs to 100 x 50 studs @ 600 centres.

(3) Rafters typically go from 150 x 50 @ 900 centres to 200 x 50 @ 900 centres. Assume similar volume increase in truss construction.

(4) Increase from 3 to 5 fixings per purlin per 762 mm cover sheet, for 25% of the roof (namely the edges) i.e. extra 2.6 fasteners per m of purlin.

(5) Estimate by BRANZ window specialist. Small cost increase, probably 5 to 10%.

(6) Increase wind zone high to very high. Lower storey bracing required is increased by about 35BU/m in both wind directions.

Hence about 14.4 m * 35 BU=504 extra BU, either direction.

With standard 10 mm Gib have 75BU/m and Braceline 90 BU/m.

So we need 504/15 = 34 m of Braceline in place of ordinary Gib, i.e 28 sheets each way. BU= Bracing Unit.

Damage savings due to adaptation measures

Wind	Spend $2611 now to save $253500 in 30 years time (i.e. total loss of house).
Rate of return =	16.5% pa
Flood	Spend $3520 now to save $8,938 in year 30, 40, 50 and 60 (replacement of linings and wall insulation at 10 yr intervals).
Rate of return =	5.7%
Heat adaptation	Spend $1890 now (extra insulation and extra eaves only) to save $500 per yr after 30 yr on cooling energy and appliances.
Rate of return =	4.9% pa

(O’Connell and Hargreaves 2004).

From these results we can see that wind damage strengthening measures are well worth doing now, even though the extra capacity may not be required for another 30 years. Flood adaptation measures have a return of about 5.7%, which is a worthwhile after-tax return to the homeowner. The owner may also be charged lower flood insurance premiums than would otherwise be the case, and this benefit has not been included. The heat adaptation measures, with a rate of return of 4.9% after tax, are marginally worthwhile for the owner. Installation of extra ceiling insulation and double-glazed windows can be more economically installed nearer the time of assumed need (i.e. in 30 years time).

For more information, the manual can be downloaded (free) from the following weblink: www.branz.co.nz/branzltd/publications/pdfs/SR130.pdf

2.2.2 Calendar

The second publication to result from Stage One of the research programme was a calendar for the 2005 entitled *Smart Building Tips for Climate-Friendly Kiwis*. This calendar follows on from previously publically-available published material from BRANZ on climate change – the most relevant being *The Easy Guide to being a Climate-Friendly Kiwi* (a primarily carbon-calculator tool). The aim of both of these publications was to provide practical, easy-to-use information on how to both prepare for climate change and also to reduce greenhouse gas emissions. The readership level, and thus scope of the information provided in the Calendar, was similar to that of a moderately technical magazine. It was therefore distributed to ‘informed’ key clients and contacts within the building industry, including councils and central government agencies.

The climate change advice, both mitigatory and adaptive, was detailed month by month and concluded with an ‘additional resources’ page where readers could go for more information on the topics that interested them. Topics included:

- Climate change and you
- Lighting
- Appliances
- Water heating
- Keeping warm
- Flood protection
- Transportation
- Living on the coast
- Waste minimisation
- Tropical cyclones
- Building materials
- Keeping cool

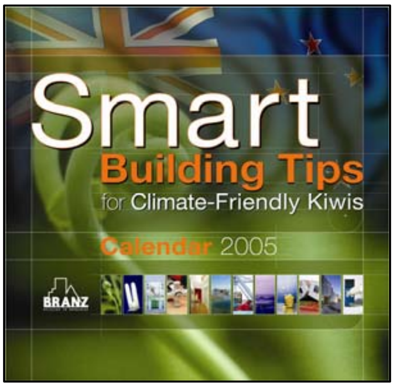

Figure 1. Front cover of the Climate Change Calendar 2005

The feedback received after distribution (December 2004) has been excellent, with many clients requesting more copies, as well as suggesting that another calendar be produced for the 2006 year.

2.3 Stage Two

As mentioned above, Stage Two of the research programme is still underway, with the development of the building brief in its early stages. The following paragraphs detail progress as of March 2005. First, it was decided to concentrate efforts on the new-build domestic market (i.e new houses), largely due to time and financial constraints, but also because of the challenging nature of the research problem and the likelihood of success. The scope was defined as providing practical, detailed design specifications and recommendations for houses in each of the three main urban regions in New Zealand (one from each climate zone[1] – see Figure 2): Auckland (in Zone 1), Wellington (in Zone 2) and Christchurch (in Zone 3).

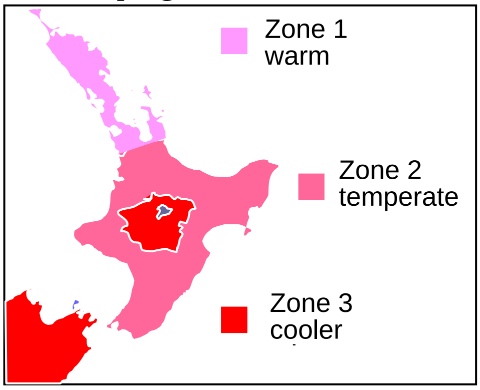

Figure 2. New Zealand's climate zones

Another key consideration in developing the design brief was determining what year the building specifications should be concerned with. It is expected that any built 'higher performance' home in New Zealand should last at least 150 years. Combining this with the uncertainties of climate change predictions, it seemed that a reasonable goal would be to develop specifications for a house for the year 2070. This means that the house should be adapted for a temperature increase of 1.9^{o}C (using a 1990 baseline), according to the latest research.

The next issue to consider was determining just what performance was desired, in terms of comfort and functionality, for a house area of about 200 m^2. In terms of comfort, the project team thought an achievable goal would be to require not more than 700 kWh per year for supplemental **space heating and space cooling** to maintain an internal temperature of not less than 16°C, and not more than 26°C for the lounge area, for each of the three climate zones year round. The figure of 700 kWh was chosen by building up the energy-efficient appliance loads and determining a reasonable

[1] New Zealand is divided into three climate zones for insulation requirement purposes under NZS 4218. Zone 1 covers the upper North Island, Zone 2 the rest of the North Island apart from the central plateau and Zone 3, the whole of the South Island and the central plateau of the North Island.

energy intensity, comparable with the internationally established ‘passive design’ houses (and accounting for the more extreme temperatures in the EU).

This model equates to about an energy intensity of 15 kWh/m2/year, which is a reasonable target for New Zealand. To achieve this target, the detailed design specifications are going to ensure that the elemental ‘R-values’ in the model house are such that comfortable temperatures will not be breached for more than 20 days in the wintertime (for more than six hours a day) or more than two continuous hours a day in the summertime. The energy requirements, internal temperature determination and overheating severity will be calculated using the ‘Energy + Software’ package, with the climate data adjusted to account for the expected increase in temperatures. Following this, a set of recommended heating and cooling appliances will be made, based on fuel use, efficiency, and carbon intensities. In terms of flooding and tropical cyclone-related specifications, these will also be regionally based for each of the three main centres for the predicted weather in 2070, but their specifics have yet to be established.

3 Conclusion

Climate change will bring about new ways of living in all sectors of New Zealand society. The climate system is changing, and will undergo further change, regardless of any sudden decline of greenhouse gas emissions or implementation of worldwide abatement policies under the Kyoto Protocol or other mitigation regimes. Adaptation is therefore a critical element of any climate change response. Building-related advice on climate change therefore needs to both mitigatory and adaptive in nature, to capture synergistic responses and to reduce compliance costs over time (as climate change impacts increase in intensity).

To increase our understanding of these issues, a two-stage research programme has been undertaken by the researchers at BRANZ Ltd. The broad aims of the programme have been to find integrated and flexible solutions to: a) deliver a carbon-neutral built environment: and b) deliver an adapted built environment in an already-altering climate.

Outputs to date – such as the guidance manual and the calendar – provide practical and relevant information on adaptation and mitigation strategies for buildings. The building brief, once completed, will provide a ‘template’ from which to begin future-proofing New Zealand’s building stock to the predicted impacts of climate change.

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