STUDY REPORT

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Housing life cycle and sustainability

Part One

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Preface

This is the first of two reports prepared during research into the life cycle of the housing stock and the opportunities for introducing sustainable features such as insulation and water saving devices into existing houses during major maintenance.

Acknowledgments

This work was funded by the Building Research Levy.

Note

This report is intended for designers, housing researchers, and officials interested in the retrofit potential of the housing stock to achieve improved sustainability performance of the stock.

BRANZ Study Report SR 214

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Abstract

This report is part one of a two part investigation into the opportunity and economics of introducing sustainable features into the existing housing stock. The report is in three main parts. First, an analysis of the types of renovation and maintenance carried out now on the housing stock. Second, a model of the numbers requiring major maintenance allowing for losses through demolition. Third, the cost benefits of various types of retrofit, and the trade-off between demolition/ replacement and renovation. There is some consented work already being carried out on the stock which is major renovation and component replacement. However the maintenance model developed in this report suggests that these numbers will need to rise significantly in order to retain the housing services presently provided by the housing stock. Major renovation is an opportune time to retrofit efficiency measures into existing houses and thereby improve the sustainability of the stock. The cost benefits of many of these retrofits are identified in the report.

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1. SUMMARY

This report investigates the life cycles of New Zealand housing and how sustainability features can be incorporated during the buildings life.

Many houses undergo significant changes to their form during their life span, involving external additions, internal alterations and changes in use of internal space. There are approximately 33,000 residential alterations/ additions consents in a typical year, ignoring minor consents below $5,000 in value, and over a 10 year period this affects about 20% of the housing stock. As well, other work is done without a building consent, consisting of minor repairs, replacements, decoration and small scale renovation. This projects aims to identify the types of work done on the stock and to assess the opportunities for incorporating sustainability features into dwellings.

What sorts of sustainability features could be incorporated? The obviously measures are installation of bulk insulation (roof, walls and under-floor), double glazing, efficient heating appliances, water efficiency measures, solar water heaters, cylinder and pipe wraps, and household waste handling facilities. The best time to install then is when related or adjacent work is being done as part of the maintenance cycle or at a time of major renovations.

The main findings are:

- The most common consented work carried out on houses is additions, in particular garages, decks, bedrooms, bathrooms, en-suites, and relocations of kitchen and laundry. The maintenance model developed in this report assumes that houses of the 1940s-60s era now require major renovation at a rate of about 35,000 per year. As yet there is no evidence that this volume of work is appearing in alterations / addition consents.
- Housing demolitions are estimated at about 2,600 per year at present and are likely to rise to about 4,000 per year within 10 years. Only half of demolitions are related to physical failure, the rest being re-development of the site for higher housing density, or a single house rebuild to a higher level of amenity.
- The net benefits for various retrofit sustainability measures vary greatly, with the most cost effective being simple low cost measures such as lagging, wraps, low flow shower heads, draughtproofing and efficient lights. The more expensive retrofits such as ceiling insulation (where none or little exist), and floor insulation retrofits are also very cost effective in all regions. Wall insulation retrofitting and double glazing are cost effective outside Auckland.
- Is it better to demolish and rebuild to current code requirements, or to retrofit efficiency measures and undertake major renovation to prolong the life of a house? It was found renovation to extend the life of an existing house for another 30 years before replacement is the preferred option in terms of life cycle costs.

2. INTRODUCTION

This report is part one of a two part investigation into the opportunity and economics of introducing sustainable features into the existing housing stock. The report is in three main parts:

- Analysis of the types of renovation and maintenance carried out now on the housing stock.
- A model of the numbers requiring major maintenance allowing for losses through demolition.
- The cost benefits of various types of retrofit, and the trade-off between demolition/ replacement and renovation.

Further work, to be reported later as part two, is intended on how builders and designers understand retrofit and the practical issues of installation. Also further development of the cost benefit model is intended, which will incorporate more regional data.

The next section is a brief literature review relating to the housing stock and types of sustainable retrofit.

3. LITERATURE REVIEW

3.1 Renovation types, and the housing stock condition

There is no published analysis of the types of work done on renovating or adding to the existing housing. However, surveys have been undertaken of alterations and additions (A&A) work which are reported later.

The main source for data on the physical condition of housing in New Zealand is the BRANZ House Condition Survey. Three surveys have been carried out, in 1994, 1999 and 2004. Each survey is restricted to approximately 600 houses in the three main regions, Auckland, Wellington and Canterbury. The last survey (Clark et al 2005) found that the amount of outstanding maintenance had decreased from the previous survey, from about $4,900 in 1994 to $3,700 in 2004, for the repair of the more serious defects. These amounts are less than the $3,000 expenditure per household on property maintenance, alterations and additions as reported by Statistics New Zealand in their 2007 Household Economic Survey. This suggests the stock is being under-maintained.

3.2 Maintenance cycles and renovation versus demolition

BRANZ has published a number of maintenance guides, which recommend maintenance periods for various components (Smith 2006).

Sartori et al (2008) developed a model of new construction, renovation and demolition for the Norwegian dwelling stock. It is demographic model with the main aim of predicting material and energy demands. Rather than dwelling numbers the main quantum is dwelling floor area. The exogenous inputs include population, persons per dwellings, and floor area per dwelling, all with 3 scenarios. The demolition input uses a normal distribution life profile and has three scenarios of average life 75, 100 and 125 years, with a standard derivation of 0.25 times the average life. For the 100 year mean the result is that 90% of the stock is demolished between 65 years and 135 years. Renovation has a similar distribution with major renovation (that which considerably improves a dwelling’s energy performance) occurring in three scenarios (every 30, 40 or 50 years), and with a 0.25 times mean standard derivation. The model results in demolitions of about 4,000 per year, out of a stock of 2 million dwellings, and is a similar demolition rate to estimates for New Zealand, discussed next.

Demolitions remove houses from the stock and in order to assess opportunities for sustainable retrofits it is important to allow for loss through demolition. As well, demolition models of the housing stock have similarities with maintenance models of the stock and are often adapted for use in maintenance planning.

Lowe R (2004) reports on demolitions in the UK housing stock. During the 1960s there was a need to replace large areas of "squalor housing" consisting of housing in very poor physical condition which were deemed to be unrepairable. However since then demolition rates have been 10 times lower, and repair and maintenance has become the norm. Usually physical deterioration is not the primary cause of demolition, and the main reasons include:

- Declines in local and regional economic bases (e.g. coal mining towns).
- Replacement of low density housing with high density, i.e. demolitions caused mainly by economic factors.
- Transport infrastructure (road, rail air) expansion requiring demolition of otherwise sound dwellings, and the increased traffic, and associated pollution, has caused the progressive decay and abandonment of remaining dwellings in the vicinity of the new traffic routes.

Van der Flier (2006) reports on demolition by the Dutch Housing Association. He finds demolition is influenced by 3 factors, physical, functional, and economic. Physical is the physical decay and deterioration of the building. Functional means the building no long provides the required housing services, i.e. too large or small, changed family types, and life styles. Economic factors include the better use of land that is currently used by buildings. Housing associations with rental stock often actively manage the stock including sales, new construction and demolition. The landlord may have social and budget priorities that affect demolition decisions. Similar associations with similar type of stock appear to have quite different demolition rates and reasons for this are not known but the report suggestions there is some irrational behaviour by some managers. Apart from the associations there are several large private landlords (20% of rentals) and these private owners are less likely to demolish than the large associations. The Dutch demolition rate of about 0.2% of the stock per year is among the highest in Europe, (e.g. UK 0.08%pa, France 0.1%pa, Germany 0.1%pa).

Kohler et al (2007) describes housing renovation in the German perspective. They have a focus on preservation of the existing stock for sustainability reasons (economic, social and cultural). The report states the composition (all building types) and long-term behaviour is not well known, nor has much work been done of building demand into the future. Older stock (pre- 1920s) is more is durable than younger stock in part because the "modern movement" in architecture planned for life times of new buildings to decrease, to allow introduction of new materials and more flexibility for modern industrial processes and commercial use. In terms of sustainability longer life is preferred, but the situation is complicated in Europe due to declining populations in some countries. This is now causing problems in terms of maintenance workloads and/or demolition replacements. Institutional arrangements and scenarios relating to demography and pension obligations have to be considered to avoid dramatic losses of economic, social and cultural capital in the coming decades.

Work by Johnson (1994) uses housing survival tables to estimate the demolition rates of the New Zealand housing stock. His model is based on derived life tables for each cohort of the housing stock. The life tables give the probability of demolition at each year of life and there are different tables for each age cohort (in 5 year age bands). The expansion rate of the stock (i.e. the volume of new dwellings) affects the life tables for each age cohort, i.e. in times of higher new house construction the rate of demolitions increases. He concludes about 50% of dwellings has been lost from each cohort by the age of between 90 and 130 years, depending on the expansion rate of the stock. The distribution of losses follows a bell curve skewed to the left. For the 5 years to the 2006 census his model (90 years average life) gives about 8,000 demolition replacements per year. This number appears to be somewhat high when compared to the simple models discussed later, which give around 2,000 demolition replacements per year over the same period.

Later work by Johnson (1997) argues that the life can be extended up to 210 years if extensive rehabilitation is carried out in the 75th year. It is unclear if the 75th year was chosen as being the optimal time to extend the life but it approximately corresponds with the life of some roof and wall claddings.

3.3 Sustainable retrofits

Various reports on assessing the energy and other environmental impacts of housing in New Zealand have been done. These include Baird and Chan (1983), Wright and Baines (1986), Buchanan and Honey (1992), Mithraratne (2001), Vale and Mithraratne (2001), Johnstone (2001). Most of these are from the view-point of potential gains in sustainability performance that can be incorporated into new housing.

3.3.1 Beacon Pathway work on retrofit.

Potential retrofit technologies for housing were identified in a Beacon report (Nebel et al, 2005). A quite wide range of technologies were examined, including appliances, decoration, electricity generation, windows, indoor climate, lighting, safety, sanitation, structure, supporting technologies and waste. Approximately 102 technologies were identified and score against Beacon criteria by a panel of experts. The criteria were affordability, community desirability, future proof, investment potential, landscape, performance, health and resource use.

The most favoured technologies were; bulk insulation, rainwater harvesting, permeable pavers, air-air heat exchangers, passive cooling, wood-pellet burners, efficient appliances, solar water, efficient lights and double glazing. In general proven technologies scored the highest.

Options for retrofitting were examined by McChesney and Phillips (2006). The work concentrated on insulation and the findings were:

- There are indoor temperature gains in almost all cases of retrofit and the amount of gain depends on how much of the previous energy input is used. Insulation on its own is often not enough to lift temperatures to a sufficient level and provision of an efficient heating appliance, as well as the insulation retrofit, provides a better outcome.
- There are significant health benefits arising from retrofit for the most deprived groups in the community.
- Energy savings average about 12-20% in the first year but in subsequent years there appears to be some “take-back” in increased comfort levels. Cost benefit analysis indicated that low flow shower heads, water efficient washers, and floor and ceiling insulation is cost effective in all areas of New Zealand.

- Rain water tanks are also cost effective in Auckland and are likely to become so elsewhere if metered water charging is widely introduced.
- Replacement of existing single glazed windows with double glazing was found to be economic outside the Auckland climate zone, assuming reuse of the existing frame and electric space conditioning. Removal and replacement of wall linings and installation of insulation was economic for all climate zones, assuming electric space heating.
- Insulation retrofit and replacement of claddings were found to be uneconomic, for current energy prices used at the time.

Another Beacon report is on the market segmentation of the housing stock, (Amitrano et al, 2006). The three key areas for improvement are energy efficiency, water efficiency and internal environmental quality. For the rental sector it is suggested that landlords be required to display the soon to be developed HERS rating when advertising a property. It is also suggested that local government be encouraged to reduce barriers to installing rain water tanks and grey water systems. It is noted that life stages are an opportunity to include sustainability and these segments are family with children (need to have adequate temperatures in winter), teenage children (higher energy and water use), and retirement (retrofit near retirement to lower costs in retirement and provide amenity features for the elderly).

The two main insulation categories are pre and post-1979 houses, corresponding to the introduction of mandatory insulation. These are further sub-divided into owner occupied and rentals. The shares for the 4 groups are; owner-occupied pre-1979 43%, post-1979 owner-occupied 25%, pre-1979 rentals 20% and post-1979 rentals 12%.

McChestney, Cox-Smith and Armitrano (2008) provide a comprehensive evaluation of thermal insulation in NZ houses for Beacon Pathway Ltd. The report covers technical and policy aspects, and provides recommendations for achieving a high standard of insulation in new build and retrofit. Among the recommendations are:

- Improve the data on the insulation status of the current stock via an early roll-out of HERS, and in the medium term consider expanding the BRANZ House Condition Survey (next survey due in 2010) to more regions.
- Product research is required to verify the claims of some new insulation products. Solutions for retrofit of walls and floors are also required.
- Provide consumer advice on optimising whole house energy performance including cost effectiveness advice for various measures for both new housing and retrofit.
- Aspire to “best practice” through promotion of better than code insulation via the rating scale of HERS.

Other Beacon projects have looked at water use conservation and efficiency. An early report is on water saving technologies, Heine (2006). It finds that major gains are possible with existing technologies, including front-loaded washers, dual flush toilets, and garden watering. There is discussion on tap and shower fittings, local grey water systems, toilet cisterns, rain harvesting, and stormwater control. Cost savings are difficult to estimate due to the opaque nature of water charging, but the report notes other researchers have made estimates including hot water energy savings and cost savings from delays in infrastructure expansion due to water supply and wastewater savings.

Another report looks at potential legislation and policy measures to increase the use of rainwater tanks, (Lawton et al, 2007). The focus was on tanks for non-potable use only, and the purpose is for water collection rather than stormwater attenuation.

Savings of approximately 45% of total household demand are possible. The approach suggested was for a combination of methods including regional water authorities encouraging or requiring the provision of rain tanks in the District Plans, via the RMA or the LGA, and TAs Practice Notes Guidelines and Engineering Standards.

Further work on policy is in a later Beacon report, (Lawton et al, 2008), and finds that while education of consumer is essential, it is not enough and that regulation and pricing is required to achieve significant water savings.

3.3.2 BRANZ work on retrofit

A number of BRANZ reports have considered climate change impacts on the housing stock. Camilleri (2000) used NIWA climate change scenarios, and noted increased cooling loads, higher electricity prices, increased flooding risks and tropical cyclones, and higher insurance premiums. O'Connell and Hargreaves (2004) updated the impact using more recent NIWA climate scenarios, including some specific adaptations (for wind, flooding and temperature rise) and an approximate cost benefit analysis of adaptations in a typical new house. Bengtsson et al (2007) considered temperature rises, driving rain, wind, bush fire and sea level rises on the existing housing stock and estimated the national costs and benefits for adapting those houses at risk. It noted that insulation space conditioning benefits are maximised with early retrofit and if retrofit is delay over the next 25 years the benefits reduce due to warmer temperatures. The analysis considered summer cooling and well as winter heating.

3.3.3 Other work on retrofit

There have been a number of papers in the European context of regulation for improved energy performance of new and renovated buildings since 2000. In the UK a Government White Paper (DTI 2003) requires 60% reduction in the CO_2 emissions from all energy uses in the whole housing stock by 2050. Lowe (2007) calculates that new housing is currently achieving 40 to 50% reductions compared to the stock average due to improved envelope insulation, window improvements and heating appliance efficiency gains, and that further improvements in these will achieve the 60% target. For the existing stock the measures are generally high cost – "such measures are unlikely to be economic unless applied toward the end of life of each subsystem." The measures include efficiency boilers, super-glazing, external wall insulation, and localised or district combined heat and power plants.

The comparison of renovation with demolition and re-build has been addressed by some authors. In Australia an actual office building renovation was compared with a similar new office (Tucker, Treloar, 1994). Embodied energy only was considered, and the two projects had very similar intensities at about 8.3 GJ/sqm of gross floor area.

A comprehensive case study comparing new housing with renovated housing was undertaken in Holland (Itard, Klunder, 2007). Four scenarios were examined, ordinary maintenance, moderate upgrade (insulation), transformation (change of floor plan), and demolition/ re-build. Environmental impacts measured included energy, material and water use, demolition waste, and LCA environmental impacts (e.g. water, land and sediment toxicity, etc). The most favourable outcomes were from transformation. The embodied energy was about 20% of the total energy use over a 50 year life.

4. CURRENT ALTERATIONS/ ADDITIONS WORK

The main source of data on what work is currently being carried out on existing New Zealand housing is the building consent series for alterations and additions (A&A). A building consent is required for work that has health or safety implications (i.e. structural, plumbing, recladding, fireplaces, etc) and Statistics New Zealand (SNZ) collect and publish information on all consents over $5,000 in value. The descriptors they use for type of work are not very informative (namely alterations/additions, re-site home, garages, carports, conservatories, outbuildings i.e. sheds workshops and sleep-outs). See the appendix for recent data for this series, summarised in Figure 1. Interesting results from the A&A consents includes:

- Most residential A&A involves work done to stand-alone houses.
- House alterations/ additions have an average value of $47,100 per consent. This includes a mix of new additions and alterations to the existing house.
- The value distribution of all consents is shown in Figure 2 and indicates that about 45% of A&A work, by value, is for jobs over $99,000 in value each. There are about 2,600 A&A consents per year over $99,000 in value, with an average of about $226,000 each. These large consents are believed to include major renovation of the existing structure, as well as some new additions.
- The number of re-sited houses per year is about 2,200 at an average consent value of about $38,000. I.e. $38,000 is spent on the foundations in the new site, plus renovation work to the relocated house. This includes both existing houses and new transportable houses erected in a builder's yard.

Figure 1 Types of residential alterations/ additions work

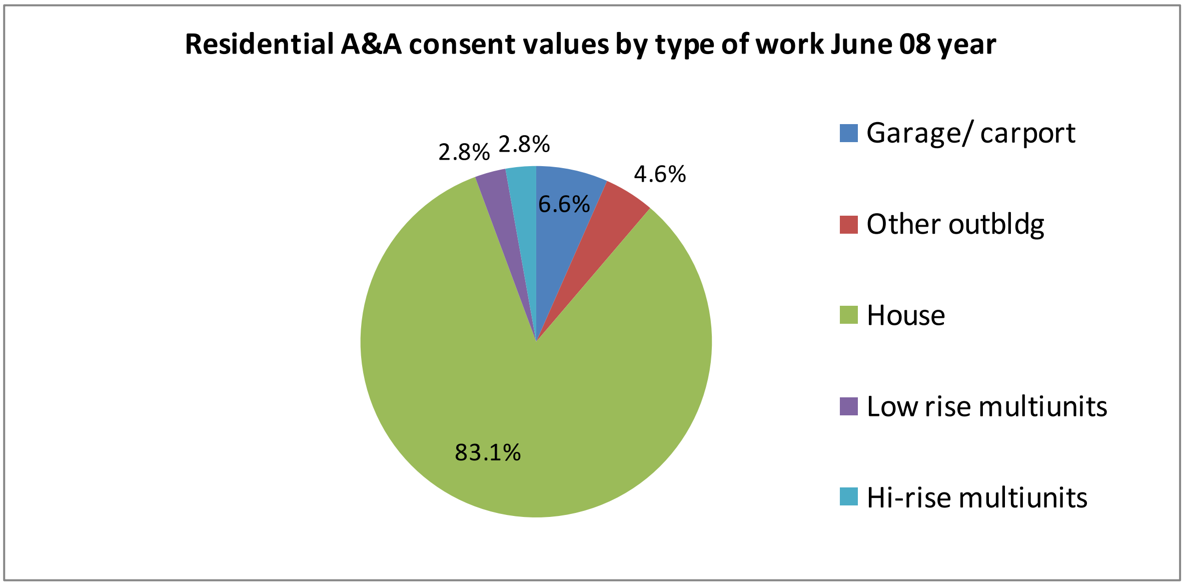


Figure 2 Residential A&A consents by value.

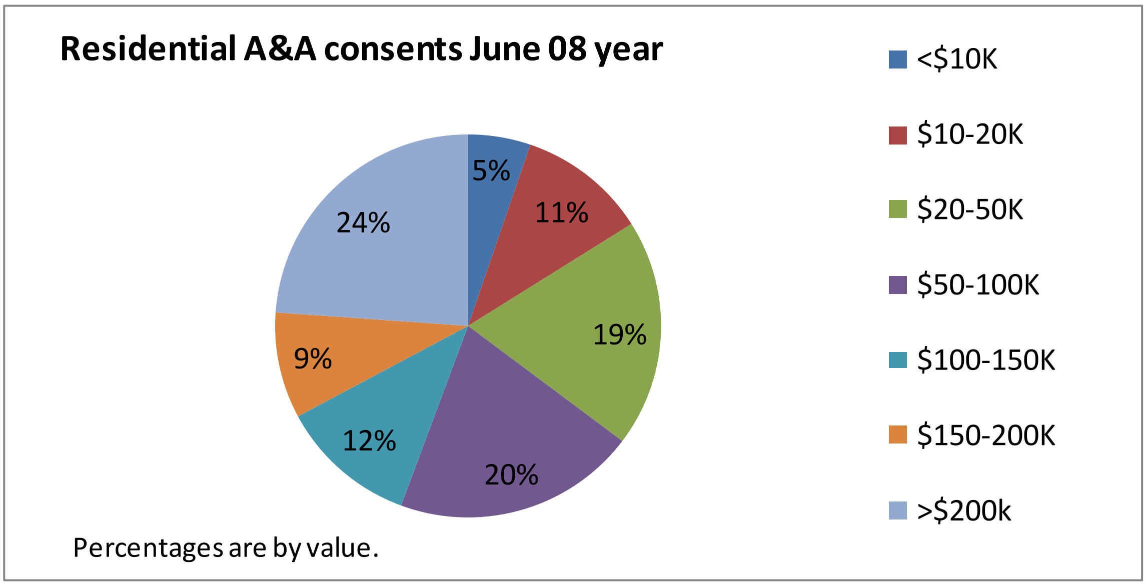
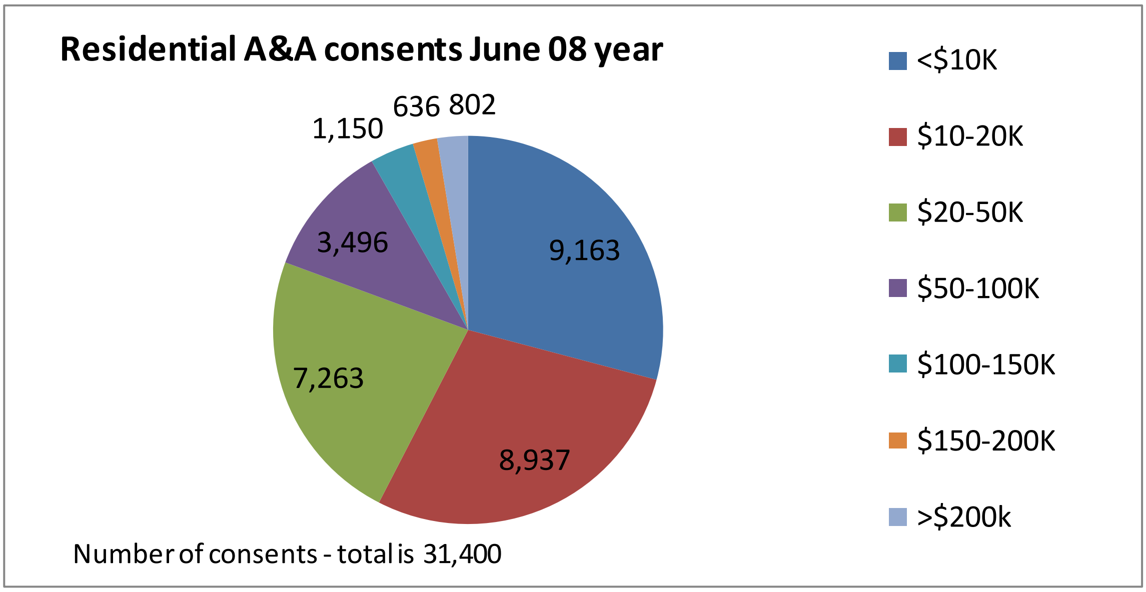


Figure 3 Residential A&A consents by number



To obtain more detailed information on alterations and additions work three additional sources were used:

- BRANZ Materials Survey
- Whats-On database
- House Condition Survey

The first two use the consent series to identify types of work and to identify builders for survey relating to particular consents.

4.1.1 BRANZ Materials Survey

The BRANZ survey is a postal survey to builders in which a particular building is identified from building consent lists published by territorial authority (TA). A variety of questions are asked in the survey about the type of work and also the materials used. See the appendix for a recent survey form. Approximately 400 responses are received per year.

The most common additions are garages, bathrooms and bedrooms, see Figure 4. However when the larger projects are examined, garages drop-out and the large consents have bedrooms, family rooms and bathrooms as the largest expenditure areas of additions and alterations.

The survey also asks about efficiency and conservation measures installed with A&A work see Table 1. It shows that about 35% of all A&A consents involve new or replacement cisterns and these are dual flush to conserve water. Efficient lights, heat pumps and low flow shower heads are also quite common in A&A work. Solar water heaters and built-in window vents have a low incidence in consented A&A work. Many of the measures are more likely to appear in new housing and the table shows this. Solar panels and heat pumps were particularly high in new housing, at 11% and 37% respectively of all new houses.

Figure 4 A&A work by type- BRANZ survey

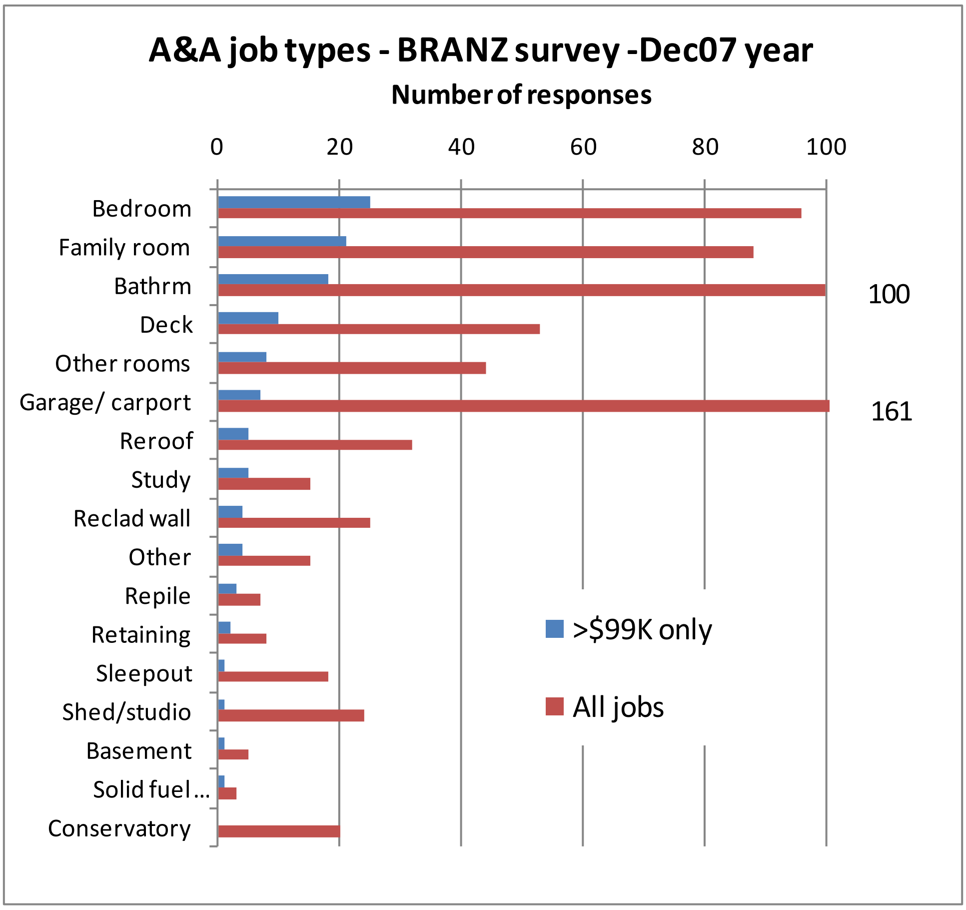


Table 1 Efficiency and conservation measures included with A&A work

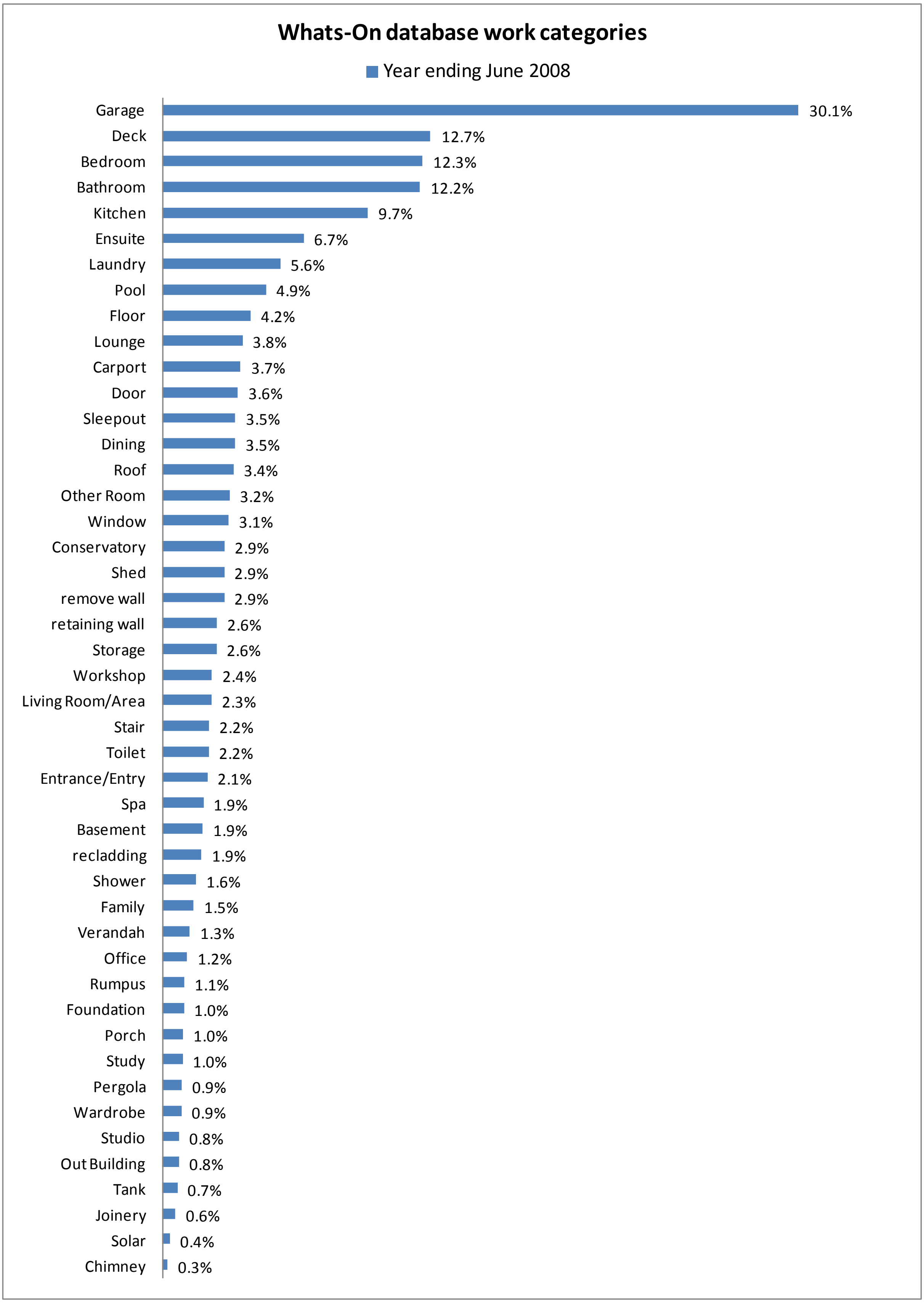
Efficiency/ conservation measures in residential A&A and new dwellings 18 months ending March 2009.							
	Solar panels	Dual flush cisterns	Energy eff lights	Heat Pump	Low flow shower heads	Window vents (sliding.)	None
	Percentage incidence						
A&A to dwellings	3	35	16	14	12	2	39
New housing	11	78	28	37	19	9	3
Source:BRANZ Materials Survey, sample size A&A 356 responses, new housing 1686 responses.							

4.1.2 Whats-On database

The second source of A&A work types, the Whats-On database, is similarly based on TA consent lists. Unlike SNZ, the Whats-On people enter the complete description of work on the consent application into their database. In most cases these are 10 to 20 words long and include all the work, rather than the limited categories in Figure 1 that SNZ provides. The work types are shown in Figure 5.

The Whats-On descriptions identify work areas which are either an addition or alteration to the existing room type or component. The most common room/component types were garages, decks, bedrooms, bathrooms, kitchens, ensuite, laundry and pools. Garages are new buildings (they require an A&A consent), decks and bedrooms are generally additions, bathrooms and en-suite are generally new facilities created by change of use of existing floor space, while the kitchen work is either relocation to new space or enlargement at the current location, involving wall removal and some new space. Approximately 3% of A&A involved windows, probably window replacements.

Figure 5 Whats-On database A&A work categories



The bars in Figure 5 add up to more than 100% because a consent may have more than one work category. The BRANZ Materials survey and the Whats-On data are in fairly close agreement in the incidence of work; see Figure 6 and Figure 7.

Figure 6 BRANZ survey compared to Whats-On - major A&A items

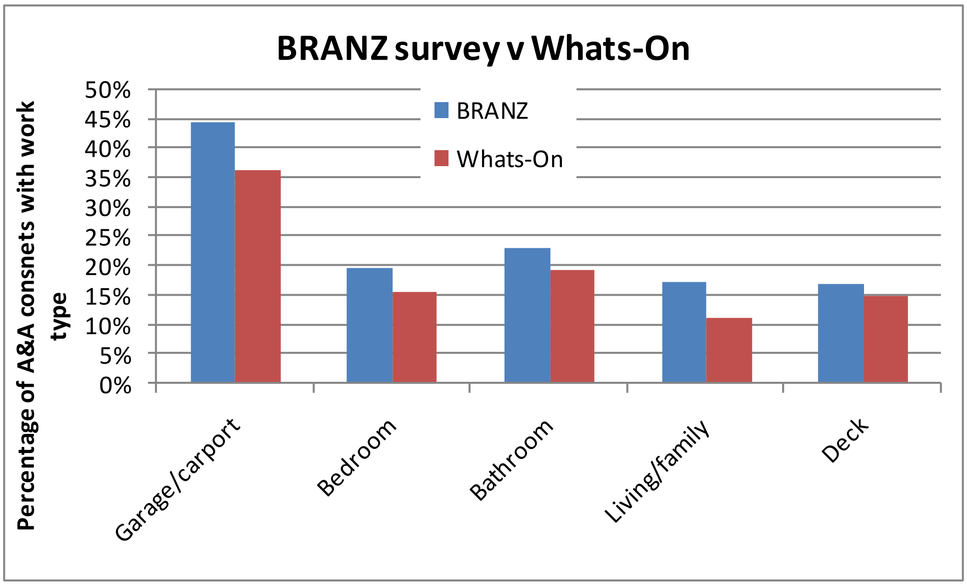
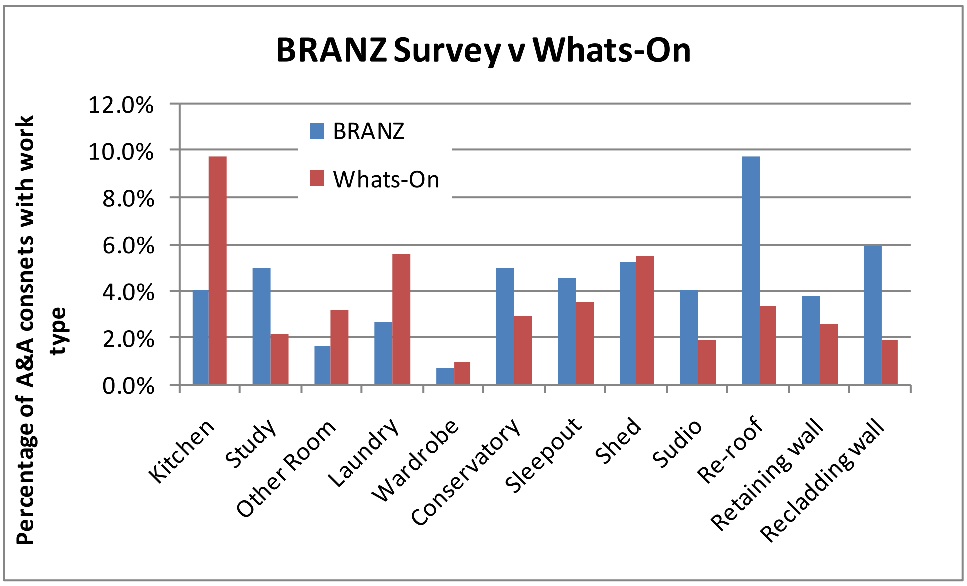


Figure 7 BRANZ Survey compared to Whats-ON data – minor A&A items



The major differences between the BRANZ survey and Whats-On are re-roofs and wall recladding. In the BRANZ survey probably some respondents have tick the recladding boxes for new additions, not understanding these categories are only for cladding replacement on existing parts of the house. In general the Whats-On data should be more accurate because it is a larger sample.

4.1.3 House Condition Survey 2005 – maintenance done by owners

This survey (Clark et al 2006) carried out by BRANZ covers 565 houses in the Auckland, Wellington and Canterbury regions. It is primarily a survey to establish the condition of the housing stock, and approximately 30 components are inspected and their condition recorded, for each house. Owners were also asked about their understanding of maintenance and what maintenance had been carried out in the previous 12 months, see Table 2. The table indicates that the most likely maintenance is painting, with up to 29% of owners having painted some part of their home over the 12 month period.

Table 2 Maintenance work on the housing stock – 2005 HCS

Components worked-on over 12 months 2005 House Condition Survey				
	Percentage of houses			
	Paint	Repair	Replace	None
Roof	9	9	6	76
External walls	27	4	4	65
Windows	17	7	7	70
Spouting	4	5	11	79
Exterior doors	14	4	4	79
Piles	1	0	2	97
Kitchen fittings	11	4	8	78
Kitchen linings	18	5	8	68
Bathroom fittings	11	5	15	70
Bathroom linings	20	5	12	63
Bedroom linings	0	0	0	0
Living room linings	29	4	6	61
Other linings	10	6	9	75
Sample size 565 houses, from Auckland, Wellington and Canterbury regions.				

The respondents indicated that some repairs had been done in the period, with roof, windows and linings the most likely components. The replacement of bathroom fittings and linings is quite high at 15% and 12%, suggesting that owners are renovating the bathroom every 7 to 8 years. The replacement of the roof and external walls is 6% and 4% respectively, which coincidentally is the same as found for the BRANZ A&A survey. However, the materials survey was for A&A consented work only, i.e. 4% of all A&A includes total wall recladding, while the HCS is saying that 4% of all existing houses have some replacement of damaged wall claddings. The surveys are measuring total replacement (A&A survey) versus some repairs and replacement (HCS).

The HCS is also useful for assessing the likelihood that various components need replacing. For example, the condition of the wall cladding, roof cladding, windows and linings was recorded, see the appendix. This data indicates that generally the 1930's cohort of houses were in the worst physical condition and are more likely to need replacement of these components than other age groups.

5. LIFE CYCLE OF HOUSING

In this section we cover the topics:

- What are the characteristics of the stock (e.g., age profile, housing type, etc) that may affect retrofit feasibility?
- What is the typical life of New Zealand dwellings and how many demolitions are there?
- Maintenance/ retrofit life cycle model.

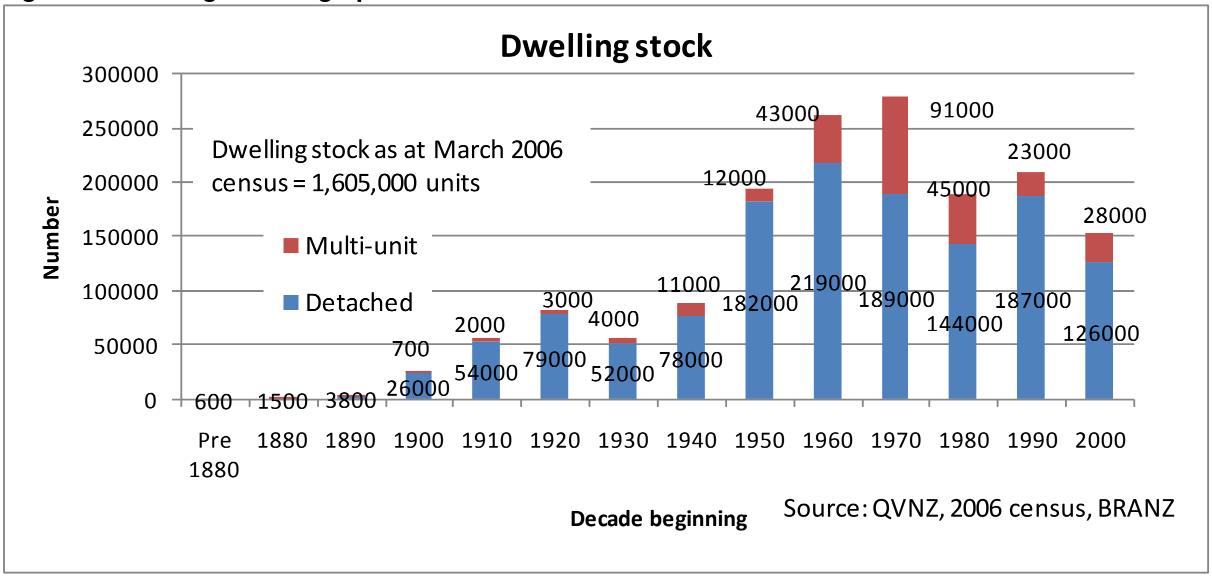
5.1 Housing stock characteristics

Data is required on the characteristics of the housing stock as it affects the ability to retrofit for sustainability. The characteristics have been examined in reports for Beacon e.g. Storey et al (2005), Kirk (2006), Page (2008) which aimed to quantify house numbers by mainly age groups with a similar house style and form.

The age profile, as at the last census is shown in Figure 8. The peak numbers are in the decade starting 1970, with approximately 280,000 dwelling units remaining from that decade. The multi-units in the 1960's to the 1980's are mainly semi-detached and row single storey units, with similar materials to stand-alone houses of the period. In the 1990s onward the multi-units tended more toward multi-storey terrace housing and medium to high rise apartments.

BRANZ uses housing type categories in its publication "Maintaining your Home", Smith (2006). The categories are: Villa(1880s-1910s), Bungalow (1920s-1930's), Art Deco (late 1920s- 1930s), State house period (1930s-1960s), 1970s style, 1980s style, 1990s style. The publication has photos showing typical houses of each era. In general this classification follows the age profiles and they are useful categories because owners can identify with the different styles.

Figure 8 Dwelling stock age profile



A Beacon project (Page 2008) uses similar categories to those used by Smith. The numbers from the Beacon work are in Table 3. The individual component characteristics determine what can sensibly be retrofitted. The lower part of Table 3 scores the components for feasibility / ease of retrofit, based on an assessment of the characteristics of components in the Beacon report. The scoring is on a 0 to 2 scale, and the more favourable the particular component characteristic in the age group, the higher the score. For example, large sub-floor clearances in the 1940's to 1960's house, compared to other ages groups, gives these cohorts a high score for ability to retrofit floor insulation and install polythene ground cover sheeting. Each component is given an equal weight (e.g. floor insulation is weighted equally with ceiling retrofit insulation, and chimney space for efficient heaters.) The component score are added and the higher total scores indicate which typologies are the better ones to retrofit. These are the Villas, the 1940s to 1960's mass housing, and the 1920-35 Bungalows.

The components scored are under-floor space for retrofitting insulation, roof space clearances for installing insulation, existing chimneys for retrofitting efficient solid fuel burners, condition of the windows indicating likely replacement in the next few years with double glazing, likely replacement of the old water cylinders with a solar panel system, the amount of existing ceiling insulation which determines the worth of installing more, and wall cladding condition indicting the likelihood of replacement and hence the ability to install wall insulation. Existing sustainability measures such as water tanks, double glazing and under-floor insulation, heat pumps and solar panels, are not shown. At the time of the HCS 2004 the incidence of these was very low, and if individual house conditions are favourable the potential for these measures is large.

Table 3 Existing housing numbers by typology

House numbers by typology

Number of dwelling units to March 2006.

Dwelling unit numbers (000s) (1)

Decade start	Villas	Bungalow 1920-36	Art Deco 1925-40	Mass housing 40s-60s	Multi units 1960-70s	Mass housing 1970-78	Housing 1978-80s	Multi units 1980-90s	Housing 1990-96	Housing post 96	Multi units 2000s	Total
pre-1900	6											6
1900	26											26
1910	54											54
1920		71	8									79
1930		42	10									52
1940				78								78
1950				182								182
1960				219	43							262
1970					91	151	38					279
1980							144	45				189
1990								23	112	75		209
2000										126	28	155
Total	86	113	18	479	133	151	182	68	112	201	28	1572
Pre 1960s multi-unit numbers =												34
Component characteristics (2) Total all dwelling units (000) at 2006 =												1606
0= Unfavourable, 1= Moderate 2 =Favourable												
Sub-floor clearance	0	0	0	2	1	1	1	1	0	0	0	
Roof space	2	2	0	1	1	0	1	1	1	1	1	
Chimney space	2	2	1	1	0	0	0	0	0	0	0	
Window condtn	1	1	2	2	1	1	0	0	0	0	0	
HW Cylinder age	0	0	0	2	1	1	0	0	0	0	0	
Existing insulation	1	1	1	2	1	2	1	1	1	0	0	
Wall cladding condtn	1	1	2	1	0	0	0	0	0	0	0	
Total (3)	7	7	6	11	5	5	3	3	2	1	1	

(1) The numbers are based on Figure 1 age cohort numbers, from QVNZ data including a breakdown into multi-units and detached housing.
(2) Each decade is scored on a 3 point scale for the favourability or otherwise of retrofit of the component. See text.
(3) The higher the more favourable the decade is for retrofit. Each component is equally weighted, i.e scores are added.

5.2 Typical life spans of NZ houses

The life span of housing is the period over which a house provides accommodation services appropriate for the current and potential resident households. The span is determined by structural, user specific and economic factors. The average age of the NZ housing stock is about 40 years and we do not know the life span of the various age cohorts with any accuracy. Often the structural life is longer than the economic life. Johnstone (2001) defines the economic life as the period to when the market value of the property including demolition and site clearing is less than the value of alternative uses of the property. A survey of owners exploring the reasons for demolition, (reported later), finds that site redevelopment is a major reasons for demolition. In many other cases the existing structure has some weaknesses which are repairable, but the house is not providing the level of amenity required. Hence the owner makes the decision it is easier and/or cheaper for the house to be demolished rather than relocated. In less than half the responses the physical decay was the prime reason for demolition.

What is the current rate of demolition and why are houses demolished? Answers to these question help in assessing the life span of NZ houses. The amount of official data on demolitions is limited even though a building consent is required when demolition is undertaken. The reasons for this include:

- Demolitions are often combined with the replacement work in a single consent and the demolition work description on the consent application is often omitted or not recorded by Statistics NZ.
- Consents below $5,000 are not recorded and some demolition only contracts are for less than this amount.
- Statistic NZ consent data has only 194 dwelling demolitions for the 9 years ending December 2007, and this is believed to be a small fraction of all demolitions in that period.

One model for calculating demolitions is shown in Table 4. It is based on the dwelling census counts and the number of new dwelling consents between the censuses. The table indicates the average number of demolitions in recent years was about 2,000 per year. The model is based on the relationship:

Stock (t) = Stock (t-5) + Consents (5 years) – Demolitions (5 years).

Rearranging the equation we get:

Demolitions (over 5 years) = Stock (t-5) – Stock (t) + Consents (5 years).

Where t = years, so that, for example, Stock(t-5) is the dwelling stock number at the 2001 census and Stock(t) is the stock number at the 2006 census.

Consents are new dwelling consents over the 5 year period between censuses. A six month lag is allowed between consent issue and completed dwelling, so in the example we count all new dwelling consents for the 5 years ending September 2005.

For some inter-census periods the apparent number of demolitions is negative. This arises when there is an increase in temporary dwellings (e.g. farm workers accommodation) between sequential censuses, and conversion of large houses into multi-units (and not consented).

Table 4 Demolition model for all NZ using census counts and consents.

New dwelling demographic model							
			Updated Aug08				
Census year	**76**	**81**	**86**	**91**	**96**	**01**	**06**
Occupied Private Dwellings (1)	923,200	1,005,489	1,088,598	1,177,662	1,276,332	1,359,843	1,471,746
Unoccupied dwellings (1)	84,600	97,116	107,532	122,712	113,388	147,435	159,273
All Private Dwellings	1,007,800	1,102,605	1,196,130	1,300,374	1,389,720	1,507,278	1,631,019
Unocc dwell as % of stock	8.4	8.8	9.0	9.4	8.2	9.8	9.8
Dwelling consents (5 years) (2)	157875	108922	96911	103597	98541	115919	135143
Cancellations %	4.0%	2.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Dwelling consents (5 years) (2b)	151560	106744	95942	102561	97556	114760	133792
Average consents per year			19188	20512	19511	22952	26758
Demolitions per year (3)		2388	483	-337	1642	-560	2010
		Demolition average per year 1976 to 2006 =				938	
Usually Resident Population (1)	3,088,700	3,132,800	3,262,397	3373926	3618303	3737277	4,027,947
Population growth %pa		0.28	0.81	0.67	1.41	0.65	1.51
Persons per Occupied Dwelling	3.346	3.116	2.997	2.865	2.835	2.748	2.737

(1) Source: Statistics New Zealand. Occupied includes mobile homes, motor camp accomodation & rough shelters(eg garages).
(2) Number of consents for the five years to the September preceding the census. Assume varied cancellations
(3) Derived from the proceding rows: Demolitions (t) = (Stock(t-5) - Stock(t) + Consents(5 years))/5. -ve demos implies some more garage/ shed accomodation, & conversions from houses to multi-units.

This same model was used at a territorial authority (TA) level and the details are in the Appendix. The main result, adding the TAs together, was the rate of demolitions was about 2,200 per year, which is similar to the NZ total above.

Looking ahead in the period to 2016 we believe a reasonable assumption is that demolitions will average about 2,500 per year for the next 5 to 10 years and this number has been used in the next section, where percent losses per age cohort are calculated from survey data.

5.3 Maintenance cycles

The components of a house require different maintenance cycles, depending on the condition and materials used in the house. The most common item is painting of surfaces, particularly the exterior in order to protect against deterioration caused by rain and sun. Major components such as roof and wall claddings, windows and foundations will need repair or replacement from time to time. These major replacements are an opportunity to install measures that will improve the sustainable performance of the house. For example, replacement of wall claddings can enable insulation to be placed. Re-piling work may be an opportunity to install under-floor insulation. Windows replacement should be with double glazed windows. Also at the time of replacement of major appliances such as heaters or hot water cylinders, efficient solid fuel burners or heat pumps, and solar water panels should be considered. The renovation of the bathroom and laundry areas may be the time to consider installation of rain water collection for servicing these areas.

These components have different life spans and it is unlikely replacement or renovation of these areas would be required simultaneously. However, assume that wall claddings are replaced/or undergo major repair, on a 40 year cycle and that this is also the occasion for installing the sustainable measures just mentioned. What numbers of sustainability retrofits are required now, and into the future?

The maintenance model is in Table 5 and is for major maintenance that includes work that considerably alters a dwelling's sustainable performance. It is assumed that this type of renovation takes place at 40 year intervals but 30 and 50 year period are also provided in the model. While a maintenance distribution could be used for each age cohort, it was decided to simply assume that all members of a cohort are renovated at either 30, 40 or 50 years. Hence the numbers of houses to undergo major maintenance at any time in the future are derived by adding the numbers built in the years that are multiples of 30 to 50 years previously, and subtracting demolitions since that time.

This is a simplification since not all houses in a particular age cohort will be maintained at exact 30 to 50 year intervals, but this simplification will not greatly affect the maintenance numbers in any future period. Some houses will have major maintenance at periods less than average and others at longer periods. All this model is doing is calculating approximate maintenance numbers, assuming that on average houses need major maintenance at period approximating to between 30 to 50 years.

The model in Table 5 allows for demolition removals from the stock, currently at a rate of about 2,500 per year and rising to 3,900 per year after 2010. The derivation of demolition numbers is described in the appendix.

Table 5 House maintenance numbers

Maintenance model															
	Normal distribution - average house life 110 years.														
Decade start	**pre1900**	**1900**	**1910**	**1920**	**1930**	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
Current stock #	14649	26817	56071	81569	55961	89647	194301	261835	279359	189249	209346	226356			
Maintenance numbers ignoring demolitions												Number of renovations per decade			
30 yr maintenance cycle												425077	479767	553959	651433
40 yr maintenance cycle												343404	349969	305713	459718
50 yr maintenance cycle												221118	317906	360927	245210
Demolitions													Total		
Decade start 2000	2079	5199	7016	6150	2318	1853	1790	960	358	75	22	0	25741		
Decade start 2010	2079	5926	9114	9104	3911	3564	3924	2398	1020	242	83	17	39302		
Decade start 2020	1824	5926	10387	11826	5789	6013	7547	5257	2548	690	268	61	56312		
Decade start 2030	1404	5199	10387	13478	7520	8902	12734	10109	5585	1724	763	198	76601		
Maintenance numbers allowing for demolitions										Number of renovations per decade (allow for demos)					
											Decade start	2000	2010	2020	2030
											30yr cycle	415849	464417	536719	626360
											40yr cycle	336294	342959	293084	435834
											50yr cycle	214128	306394	346553	235966

The demolition numbers for each cohort are obtained for each future decade and subtracted from current stock numbers to give the cohort numbers in future years and hence the maintenance numbers. Two scenarios are assumed for demolition, first a normal distribution with a standard derivation of 0.25 times the average life of 110 years. Second a Weibull distribution which is skewed to the left slightly (i.e. defective houses drop out quickly) and an average life of 90 years. These demolition scenarios are described further in the appendix. The results of the maintenance model are shown at the bottom of the table and in Figure 9 and Figure 10.

Figure 9 House numbers for major maintenance – 110 years average life

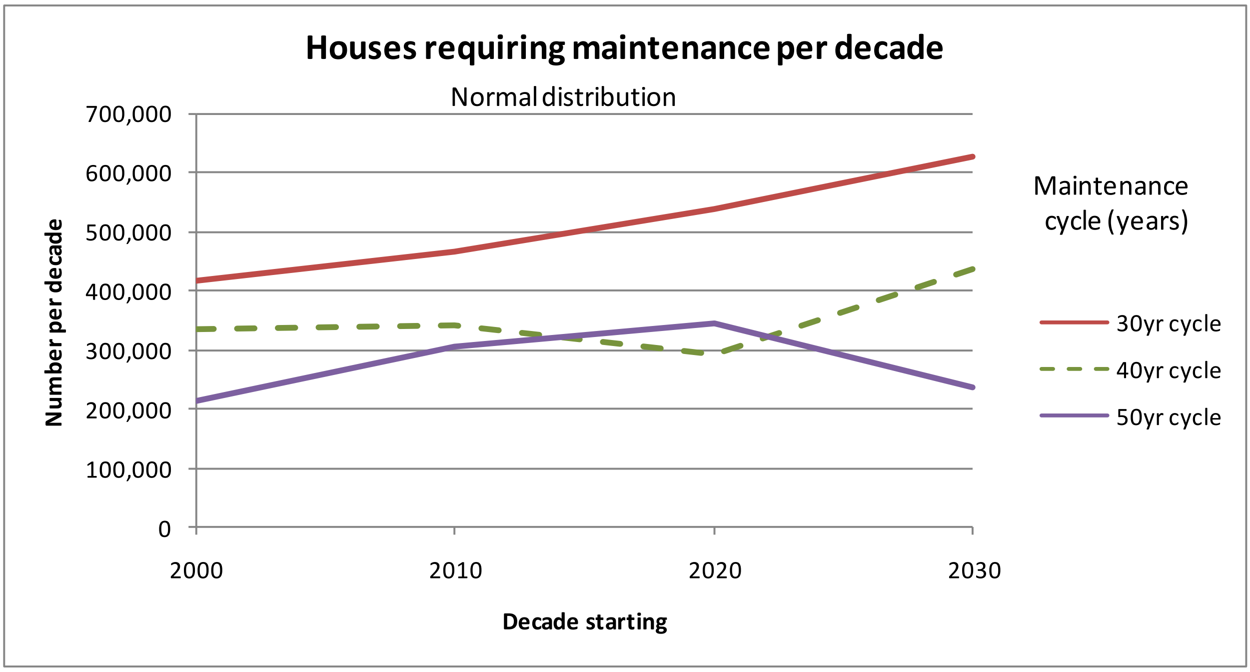


Figure 10 House numbers for major maintenance – 90 years average life

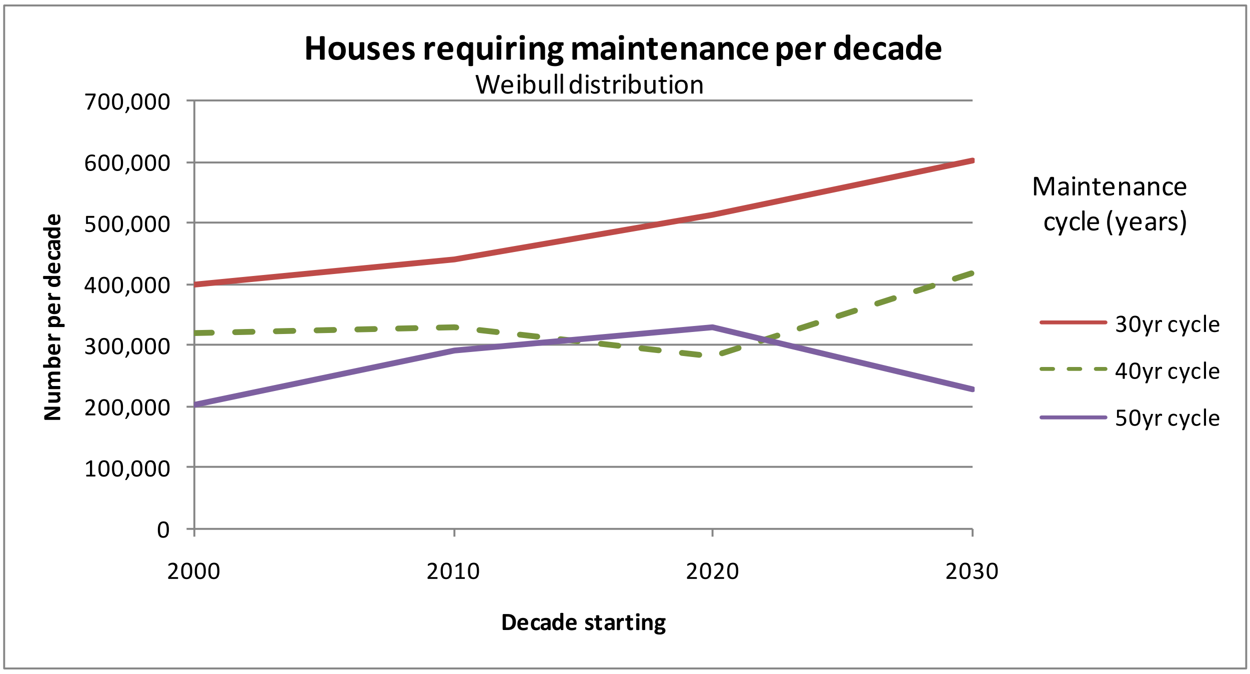


Figure 10 has the future maintenance numbers, assuming a Weibull demolition distribution (and a 90 year average life). The numbers are slightly lower than for the demolition normal distribution (and 110 years life) but not greatly.

The main changes occur with the assumption for the maintenance period. With a 40 to 50 year maintenance cycle the number of houses for major maintenance are about 30,000 per year over the next 10 years, whereas if we assume 30 years maintenance cycle the number of houses is about 45,000 per year over the next 10 years.

What house components are involved in major maintenance? This depends somewhat on the materials used in individual houses. Some major maintenance/ renovation items are:

- Timber/ weatherboard replacement
- Stucco/ fibre sheet replacement
- Brick veneer re-pointing/ some replacements.
- Sheet metal roofing replacement
- Windows replacement
- Foundation/ sub-floor repairs
- Substantial relining
- Some framing and flooring repairs/ replacement.
- Electrical re-wiring
- Hot water cylinder replacement.
- Chimney repairs or demolition.

Replacement of wall claddings or linings provides an opportunity to install insulation. Roof replacement enables insulation to be fitted in skillion roofs and other roof types where roof space access is limited. Window replacement should be with double glazed windows. Foundation repair is an opportunity to install timber floor insulation and a polythene sheet to reduce ground moisture transfer. Re-wiring results in safer cabling, and also communication cabling at the same time. Hot water cylinder replacement is an opportunity to install solar panels and a solar water cylinder. The undertaking of chimney repairs is best combined with installation of an efficient solid fuel heater.

The next section considers the economics of a number of retrofit measures.

6. RETROFIT COST- BENEFITS

The range of potential retrofit items in housing include:

Space conditioning

- Ceiling insulation, including skillion roofs.
- Wall insulation accessed either externally or internally,
- Timber floor sub-floor insulation
- Double glazing
- Secondary fitted glazing
- Efficient heaters (solid fuel, pellets, heat pumps, etc)
- Draught proofing

Water efficiency

- Solar panels
- Efficient shower heads
- Tap flow economisers
- Dual flush cisterns
- Pipe and hot water cylinder wraps

Other

- Ground polythene sheet cover
- Kitchen and bathroom extractor fans
- Efficient light bulbs

The benefit cost ratio for some of these measures are in Figure 11 and Figure 12. The benefits are the energy and/or water savings, discounted over a 30 year period, using a discount rate of 5%pa. The costs are the initial costs of the measure plus any replacement costs, discounted back to the present.

The charts indicate most measures are cost effective (i.e. the BCR is above 1.0) in most locations. The analysis period of 30 years is an estimate of the life of a renovated house. In the national perspective it is worth upgrading the stock for most of these retrofit measures. However, the economics may be somewhat different from the perspective of individual owners. Assume an owner undertakes the retrofit and resides in the house for 10 years, so that the savings are counted over only 10 years. Then some of the measures become uneconomic, from the owners point of view. Wall insulation retrofit, double glazing and solar water heating are uneconomic in all areas. Topping up thin existing ceiling insulation, and timber floor insulation are both uneconomic in Auckland. All other measures listed remain economic.

This ignore any improved sale price of a renovated house, and quite small gains in sale price due to efficiency measures will cover some of the initial costs. For example, in Auckland the ceiling insulation top-up and the floor insulation retrofit costs, less 10 years of energy savings, leaves a deficit of about $1,400 for a typical house. This can be recovered if the re-sale price 10 years ahead is $2,400 larger than it would have been without the retrofit. It is quite feasible this type of margin is achievable for these two measures alone. For retrofitted double glazing the resale premium needs to be an additional $5,400, which also appears to be achievable. In cooler areas the required margin is lower.

Figure 11 Benefit cost ratios for major retrofit items

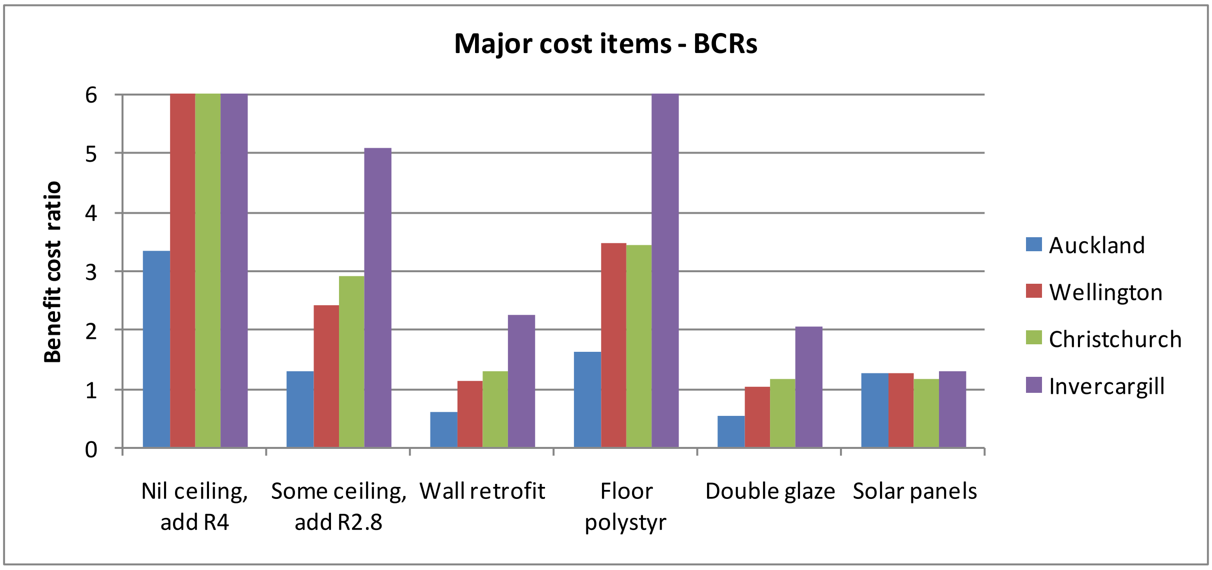
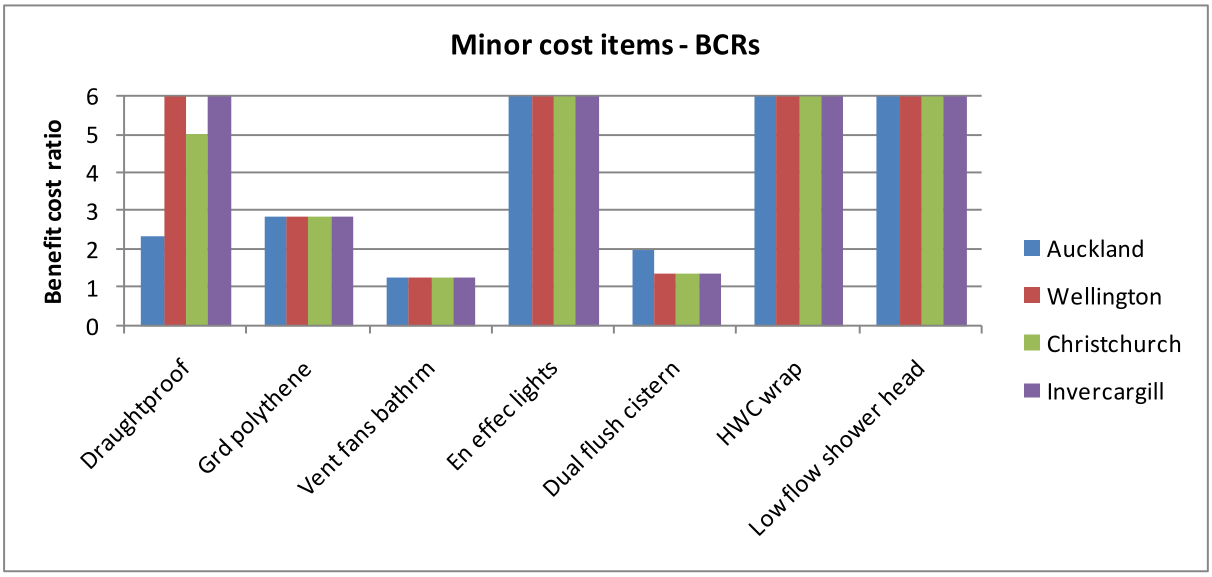


Figure 12 Benefit cost ratios for minor retrofit items



7. DEMOLISH/ REBUILD OR RENOVATE?

This section briefly examines the life cycle costs of demolition and rebuild to a high standard of sustainability, versus undertaking insulation upgrades and major renovation which extends the life of the house. The results for 2 options of demolition and rebuild (now and in 10 years), versus major upgrade for another 30 years of life before replacement are shown in Table 6. Fuller details of the options are in the appendix.

Table 6 Life cycle costs of demolish/ rebuild versus renovation

Demolish or renovate ? Life cycle costs $ (1).	Auckland	Wellington	Christchurch	Dunedin
Option 1 Demolish and rebuild with optimal orientation/ passive solar, major renovation at year 30 and year 60.	201,315	201,627	203,643	200,347
Option 2 Major renovation now for another 30 years life, then demolish/ rebuild, with major renovations at year 60.	133,308	138,031	139,886	142,039
Option 3 Do nothing now, Demolish & rebuild (opt orientation/ passive solar) in 10 years. Major renovation at year 40 & 70.	146,636	153,152	156,952	158,810
(1) Cost are discounted over 90 years and include demolition, rebuild, renovation, painting, and space heating energy costs	Discount rate= 5%		ıergy price escal = 1%	

The main result from Table 6 is that renovation and upgrade to extend the life of an existing house for another 30 years before replacement is the preferred option in terms of life cycle costs.

8. CONCLUSIONS

- Currently renovation work that is consented is about $1.2 billion per year, including additions, and is approximately one third the value of new dwellings. About 1,400 A&A consents per year are over $150,000 in value and it is likely most of these include significant upgrade of the existing dwelling as well as additions work.
- Examinations of consent descriptions indicate about 3% of consents (900 houses) involve re-roofing and windows replacement, 2% (600 houses) are wall re-cladding and about 1% (300 houses) of consents include re-piling and/or foundation repairs, per year. Examination of the house condition survey data indicates a significant percentage of houses in the 1930s to 1960s age groups require major repairs/ replacement of wall and window components. This work provides opportunities for insulation retrofit.
- House demolitions were about 2,600 per year and are expected to rise to about 3,900 per year next decade. A survey of builders involved in demolition indicates that about half of demolitions are due to physical decay and the rest due to site re-development with multi-units or a single house replacement with improved amenities.
- The major housing cohort that is now requiring major renovation are the 1940s to 60s houses, which number about 480,000 houses. These, and possibly the 1970s era houses (150,000 units) are the main target group for sustainable retrofit packages.
- Ceiling, wall and floor retrofits with insulation are cost effective for most pre 1978 houses, in most locations. Double glazing retrofit is economic outside the Auckland climate zone.
- Extending the life of a house through major renovation with insulation upgrades is the preferred approach, rather than demolition replacement, in terms of life cycle costs.

9. FURTHER WORK

It is proposed to undertake the following work in part two of this project:

- Investigate the cost benefits of retrofit in more detail, based on actual studies of retrofit being undertaken by Beacon, and others.
- Extension of the cost-benefit model beyond 4 regions, including local energy savings and costs of various retrofit measures.
- Survey builders of major projects on what retrofit measures they incorporate into the existing houses, and provide data to them of the potential cost benefits of retrofit.
- Extend the demolition / rebuild, versus renovate cost analysis to include embodied energy and CO_2 emissions comparisons. Allow for higher future efficiency measures.

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11. APPENDIX

This appendix consists of the following data:

- Statistic NZ alterations and additions consents.
- BRANZ Materials Survey form for alterations and additions.
- BRANZ House Condition Survey
- The TAs demolition model.
- The reasons for demolition survey form.
- Analysis of recycled demolition material.
- Demolitions in the future.
- Demolition replacement versus retrofits and renovation extending the house life.

11.1 SNZ alterations and additions consent data

Table 7 shows alterations and additions building consents (over $5,000) by type of work categories used by SNZ. Most of the work is alterations (e.g. moving walls, replacing windows or claddings, re-piling, etc) and additions to existing houses. There is a small amount of A&A to flats/ apartment which includes weather-tightness repairs, hence the quite high average values in Auckland and Wellington. Average expenditure on re-sited dwellings, and out-buildings, is quite high, at$30-40,000 each consent.

Solid fuel heater installation requires consent but most of these are below $5,000 each and are omitted from the SNZ database. Similarly most conservatories cost less than $5,000 each and hence few appear in the table. Out-buildings are mainly workshops, sleep-outs, studios and general storage areas. Permanent accommodation out-buildings, such as granny flats, are classified as normal houses and are included in the statistics as new dwellings.

Table 7 A&A consents excluding alterations/ additions in the main house.

Alteration and addition building consents Year ending December 2008									
	Number of consents		Re-sited			Conserv-	Out-		
	House A&A	Flat A&A	houses	Garages	Carports	atory	buildings	Misc	Total
Northland Region	749	0	176	261	51	0	196	0	1,433
Auckland Region	3,926	43	207	388	67	0	286	0	4,917
Waikato Region	1,812	5	419	825	98	0	318	1	3,478
Bay of Plenty Region	1,282	5	153	331	39	0	155	0	1,965
Gisborne Region	274	1	40	71	8	0	25	0	419
Hawke's Bay Region	834	1	107	182	39	0	71	0	1,234
Taranaki Region	623	2	76	257	23	0	97	0	1,078
Manawatu-Wanganui	1,210	1	181	414	44	1	226	0	2,077
Wellington Region	2,705	32	149	398	59	0	163	1	3,507
West Coast Region	515	0	21	94	14	0	37	0	681
Canterbury Region	2,656	4	208	617	49	0	301	0	3,835
Otago Region	1,559	5	64	301	29	0	131	0	2,089
Southland Region	724	0	53	191	8	0	47	0	1,023
Tasman Region	305	0	28	48	12	0	58	0	451
Nelson Region	335	2	8	33	5	0	16	0	399
Marlborough Region	302	1	30	94	13	0	41	0	481
Area Outside Region	1	0	0	1	0	0	0	0	2
Total New Zealand	19,812	102	1,920	4,506	558	1	2,168	2	29,069
	Average value per consent $								
			Re-sited			Conserv-	Out-		
	House A&A	Flat A&A	houses	Garages	Carports	atory	buildings	Misc	Total
Northland Region	52,689		40,669	21,557	22,269		54,256		44,674
Auckland Region	85,192	726,140	49,586	24,272	20,985		46,306		81,354
Waikato Region	49,224	78,318	37,052	20,305	13,620		36,889	10,000	38,798
Bay of Plenty Region	49,380	56,800	37,004	18,280	11,576		29,959		40,914
Gisborne Region	33,697	19,000	37,325	18,844	7,250		26,224		30,541
Hawke's Bay Region	45,638	30,000	41,738	14,952	9,565		30,815		38,769
Taranaki Region	37,571	70,000	39,676	17,836	10,361		28,357		31,665
Manawatu-Wanganui	31,859	98,000	32,078	17,503	10,267	14,000	24,718		27,805
Wellington Region	53,619	574,603	35,726	22,070	14,480		37,539	5,600	52,613
West Coast Region	15,760		35,571	16,593	11,214		29,716		17,151
Canterbury Region	39,874	36,500	45,658	17,757	14,066		35,875		35,982
Otago Region	34,387	24,749	38,317	19,623	10,539		29,994		31,751
Southland Region	25,598		36,478	19,975	11,763		21,399		24,811
Tasman Region	40,857		37,408	35,694	11,100		28,442		37,705
Nelson Region	31,072	27,000	52,725	22,533	6,600		32,289		30,521
Marlborough Region	43,700	6,000	37,133	19,103	13,085		34,697		36,810
Area Outside Region	10,000			45,000					27,500
Total New Zealand	50,624	499,055	39,544	19,764	14,132	14,000	35,965	7,800	44,884

11.2 BRANZ Materials survey form for alterations and additions

ALTERATIONS AND ADDITIONS TO A DWELLING

Please give this form to the builder or designer to fill out for the building consent listed over the page

Value Contract value of work (incl sub-trades) $ .... incl GST.

Additions

	tick	Ground floor: Floor area Sq metres	Timber or concrete floor ? (circle one)	1st/ 2nd floor level: Floor area Sq metres	Timber or concrete floor ? (circle one)
Bedroom		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Bathroom		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Family/ living/dining		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Study		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Other room (state)		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Conservatory		______ sqm	Timb / Conc	______ sqm	Timb / Conc
Deck		______ sqm	Timb / Conc	sqm	Timb / Conc

Separate Structure

	tick	Sq metres	Timber or concrete
Garage/ carport		______ sqm	Timb / Conc
Sleepout		______ sqm	Timb / Conc
Shed/ studio		______ sqm	Timb / Conc

Other Work

	tick	Sq metres		tick	Sq metres
Re-roof		______ sqm	Basement conversion		______ sqm
Retaining wall		______ sqm	Repiling		______ sqm
Recladding ext wall		______ sqm	Solid fuel heater / fire		
			Other (state)		

Wall Framing (tick appropriate box)

Radiata ☐ Steel ☐ Douglas fir ☐ Concrete block ☐ Other ☐ (state) ....

Was the wall framing precut ? Yes / No (circle one)

Gross wall area of new work .... Sq metres of new walls, include doors/ windows.

Timber treatment (for framing) Please tick one or more

Untreated kiln dry ☐ Untreated Wet ☐ H1.2 ☐ T1.2 (orange) ☐ H3.1 ☐

Floor joists

	Solid timber	Posistrut	Hybeam	Steel	Twinaplate	Origin I beam	Laminated veneer lumber	Other (state)	Hyne (I beam)
Tick one or more	☐	☐	☐	☐	☐	☐	☐	☐	☐
Joist depth	......mm	......mm	......mm	......mm	......mm	......mm	......mm	......mm	......mm

Insulation in additions

Tick one or more	R-value	Pink Batts	Bradford Gold	Premier Fibreglass	Blown FG Rockwool	Greenstuf (polyester)	Other Polyester	Wool	Other state)
Wall Insulation	R -	☐	☐	☐	☐	☐	☐	☐	☐
Ceiling Insulation	R -	☐	☐	☐	☐	☐	☐	☐	☐

	R-value	Expol Warmfeet	Polystyrene Under slab	Cosy Floor	Sisalation Foil	Ribraft Floor	Other (state)
Floor Insulation	R -	☐	☐	☐	☐	☐	☐ ....

Insulation Installer (name) *Please tick* .... Builder ☐ Other, please specify ☐ ....

Noise Control

Have you installed noise control products? **(circle one) Yes / No**

If so then what type? (Tick one or more boxes)

Pink Batts Silencer ☐ Gib Noiseline ☐ Other Gib Products ☐ Bradford Gold ☐ Pink Batts ☐ Double Glazing ☐ Other Specify ☐

Building wraps (tick one or more)

Roof wrap: Flamestop ☐ Thermakraft ☐ Bitumac ☐ Greencap ☐ Pauloid ☐ Black Paper ☐ Other (state) ☐ Diflex 130 ☐

Wall wrap: Flamestop ☐ Tyvek ☐ Thermakraft coverup ☐ Framegard II ☐ Greenwrap ☐ Fastwrap ☐ Black Paper ☐ Other(state) ☐ Diflex 130 ☐

Wall cladding on additions (if applicable)

Type .... eg Fibre cement, cedar, radiata weatherboard, clay brick, stucco, etc.

If Fibre Cement cladding is used, who is the Manufacturer? (tick one or more) Hardies ☐ BGC ☐ CSR ☐ PRIMA ☐ Other ☐ Eterpan ☐

Fibre Cement Product was used as (Circle one or more) Applied texture finish sheet, Flat sheet, FC plank, FC weatherboard/Linea

If solid plaster, what backing? (circle one if solid plaster) Fibre Cement, Plywood, Paper, Triple S, Block/Brick, Metal Lathe

Roof cladding on additions (if applicable)

Type .... eg: metal tiles, prepainted corrugated, concrete tiles, butyl, etc.

Decking material on addition (if applicable) (circle one or more)

Deck surface material (please tick): Radiata ☐ Hardwood ☐ Butyl ☐ Tiles ☐ Pour-on ☐ Other ☐

Deck substrate (please tick): Plywood sheet ☐ Fibre cement sheet ☐ Concrete ☐ Timber joists ☐

Wet wall linings (Tick one or more in each row)

	Formica Aquapanel	Seratone	Villaboard	Hardies Hardiglaze	Standard GIB	GIB Aqualine	Other	(state)
Bathroom	☐	☐	☐	☐	☐	☐	☐	....
Laundry	☐	☐	☐	☐	☐	☐	☐	....

Is fibre cement sheet flooring underlay used in the bathroom or laundry ? Yes/ No (circle one)

Energy efficiency Tick if any of the following are being installed:

Double glazing ☐ Solar water heaters ☐ Dual flush toilets ☐ Efficient lights ☐ Energy Heat pump ☐ Low flow showers ☐ Sliding air vents built into window frame ☐

Thank You. Please fold this form, and freepost it in the return envelope. Jun-08

11.3 House Condition Survey

This survey, undertaken by BRANZ, was done in 1994, 1999, and 2004. A wide variety of data on the physical condition, and other aspects of the house, is recorded. Condition is recorded on a 1 to 5 scale with 1= Serious defects affecting health and safety and 5 = excellent, as new condition. Some results for walls, windows and linings condition are shown in the tables below, from the 2004 survey.

Table 8 Wall condition – 2004 HCS

Combined Regions		Wall Cladding Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	1	0	1	0.2%	0.0%
1900	0	1	4	9	3	17	3.0%	5.9%
1910	0	2	5	9	4	20	3.5%	10.0%
1920	0	4	14	22	9	49	8.7%	8.2%
1930	0	8	4	9	5	26	4.6%	30.8%
1940	0	2	9	12	4	27	4.8%	7.4%
1950	0	6	12	42	8	68	12.1%	8.8%
1960	0	2	20	63	17	102	18.1%	2.0%
1970	1	4	16	43	20	84	14.9%	6.0%
1980	0	2	16	35	11	64	11.3%	3.1%
1990	0	3	11	26	26	66	11.7%	4.5%
2000	1	1	0	4	30	36	6.4%	5.6%
mixed	0	1	1	2	0	4	0.7%	25.0%
Total	2	36	112	277	137	564	100.0%	6.7%
% condition	0.4%	6.4%	19.9%	49.1%	24.3%	100.0%		
Ave cond						3.91		
Auckland Region		Wall Cladding Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	#DIV/0!
1900	0	0	3	6	3	12	4.0%	0.0%
1910	0	1	3	8	2	14	4.6%	7.1%
1920	0	2	7	15	3	27	8.9%	7.4%
1930	0	1	1	6	0	8	2.6%	12.5%
1940	0	0	5	6	3	14	4.6%	0.0%
1950	0	2	3	26	3	34	11.2%	5.9%
1960	0	1	9	34	7	51	16.8%	2.0%
1970	0	3	10	26	11	50	16.5%	6.0%
1980	0	1	8	20	5	34	11.2%	2.9%
1990	0	1	10	11	12	34	11.2%	2.9%
2000	0	0	0	2	20	22	7.3%	0.0%
mixed	0	1	1	1	0	3	1.0%	33.3%
Total	0	13	60	161	69	303	100.0%	4.3%
% condition	0.0%	4.3%	19.8%	53.1%	22.8%	100.0%		
Ave cond						3.94		
Wellington Region		Wall Cladding Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	1	0	1	0.9%	0.0%
1900	0	0	1	3	0	4	3.6%	0.0%
1910	0	1	1	1	2	5	4.5%	20.0%
1920	0	0	4	5	4	13	11.7%	0.0%
1930	0	1	2	3	4	10	9.0%	10.0%
1940	0	1	1	1	1	4	3.6%	25.0%
1950	0	2	3	5	4	14	12.6%	14.3%
1960	0	1	5	8	8	22	19.8%	4.5%
1970	0	1	3	4	3	11	9.9%	9.1%
1980	0	1	6	1	4	12	10.8%	8.3%
1990	0	2	0	5	3	10	9.0%	20.0%
2000	1	1	0	1	1	4	3.6%	50.0%
mixed	0	0	0	1	0	1	0.9%	0.0%
Total	1	11	26	39	34	111	100.0%	10.8%
% condition	0.9%	9.9%	23.4%	35.1%	30.6%	100.0%		
Ave cond						3.85		
Christchurch Region		Wall Cladding Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	#DIV/0!
1900	0	1	0	0	0	1	0.7%	100.0%
1910	0	0	1	0	0	1	0.7%	0.0%
1920	0	2	3	2	2	9	6.0%	22.2%
1930	0	6	1	0	1	8	5.3%	75.0%
1940	0	1	3	5	0	9	6.0%	11.1%
1950	0	2	6	11	1	20	13.3%	10.0%
1960	0	0	6	21	2	29	19.3%	0.0%
1970	1	0	3	13	6	23	15.3%	4.3%
1980	0	0	2	14	2	18	12.0%	0.0%
1990	0	0	1	10	11	22	14.7%	0.0%
2000	0	0	0	1	9	10	6.7%	0.0%
mixed	0	0	0	0	0	0	0.0%	#DIV/0!
Total	1	12	26	77	34	150	100.0%	8.7%
% condition	0.7%	8.0%	17.3%	51.3%	22.7%	100.0%		
Ave cond						3.87		

About 10% of houses in Wellington and Canterbury region have poor or serious wall cladding condition (Score 1 or 2). Many of these are in the 1930s to 1950s cohorts. Replacement of claddings is an opportunity to install wall insulation.

Table 9 Window condition - 2004 HCS.

Combined Regions	Window Condition							
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	1	0	0	1	0.2%	0.0%
1900	0	5	4	3	5	17	3.0%	29.4%
1910	0	4	7	5	4	20	3.5%	20.0%
1920	0	10	17	19	3	49	8.7%	20.4%
1930	0	8	6	12	0	26	4.6%	30.8%
1940	0	7	8	9	3	27	4.8%	25.9%
1950	1	10	23	29	5	68	12.1%	16.2%
1960	0	11	18	59	14	102	18.1%	10.8%
1970	0	4	21	49	10	84	14.9%	4.8%
1980	0	3	8	40	13	64	11.3%	4.7%
1990	0	0	4	28	34	66	11.7%	0.0%
2000	0	0	0	2	34	36	6.4%	0.0%
mixed	0	0	0	4	0	4	0.7%	0.0%
Total	1	62	117	259	125	564	100.0%	11.2%
% condition	0.2%	11.0%	20.7%	45.9%	22.2%	100.0%		
Ave cond						3.79		

Auckland Region	Window Condition							
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	#DIV/0!
1900	0	3	3	1	5	12	4.0%	25.0%
1910	0	1	5	5	3	14	4.6%	7.1%
1920	0	7	7	10	3	27	8.9%	25.9%
1930	0	1	2	5	0	8	2.6%	12.5%
1940	0	3	5	3	3	14	4.6%	21.4%
1950	1	6	9	16	2	34	11.2%	20.6%
1960	0	6	10	28	7	51	16.8%	11.8%
1970	0	2	12	30	6	50	16.5%	4.0%
1980	0	2	5	20	7	34	11.2%	5.9%
1990	0	0	0	16	18	34	11.2%	0.0%
2000	0	0	0	1	21	22	7.3%	0.0%
mixed	0	0	0	3	0	3	1.0%	0.0%
Total	1	31	58	138	75	303	100.0%	10.6%
% condition	0.3%	10.2%	19.1%	45.5%	24.8%	100.0%		
Ave cond						3.84		

Wellington Region	Window Condition							
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	1	0	0	1	0.9%	0.0%
1900	0	1	1	2	0	4	3.6%	25.0%
1910	0	3	1	0	1	5	4.5%	60.0%
1920	0	1	5	7	0	13	11.7%	7.7%
1930	0	2	3	5	0	10	9.0%	20.0%
1940	0	2	2	0	0	4	3.6%	50.0%
1950	0	3	6	3	2	14	12.6%	21.4%
1960	0	3	2	13	4	22	19.8%	13.6%
1970	0	2	2	4	3	11	9.9%	18.2%
1980	0	1	3	5	3	12	10.8%	8.3%
1990	0	0	2	3	5	10	9.0%	0.0%
2000	0	0	0	1	3	4	3.6%	0.0%
mixed	0	0	0	1	0	1	0.9%	0.0%
Total	0	18	28	44	21	111	100.0%	16.2%
% condition	0.0%	16.2%	25.2%	39.6%	18.9%	100.0%		
Ave cond						3.61		

Christchurch Region	Window Condition							
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	#DIV/0!
1900	0	1	0	0	0	1	0.7%	100.0%
1910	0	0	1	0	0	1	0.7%	0.0%
1920	0	2	5	2	0	9	6.0%	22.2%
1930	0	5	1	2	0	8	5.3%	62.5%
1940	0	2	1	6	0	9	6.0%	22.2%
1950	0	1	8	10	1	20	13.3%	5.0%
1960	0	2	6	18	3	29	19.3%	6.9%
1970	0	0	7	15	1	23	15.3%	0.0%
1980	0	0	0	15	3	18	12.0%	0.0%
1990	0	0	2	9	11	22	14.7%	0.0%
2000	0	0	0	0	10	10	6.7%	0.0%
mixed	0	0	0	0	0	0	0.0%	#DIV/0!
Total	0	13	31	77	29	150	100.0%	8.7%
% condition	0.0%	8.7%	20.7%	51.3%	19.3%	100.0%		
Ave cond						3.81		

Wellington region has the highest proportion (16%) of houses with poor/ serious condition windows. Before 1960 there is a quite high incidence of poor windows in all regions and age groups and these are candidates for double glazed replacements.

Table 10 Linings condition – 2004 HCS

Combined Regions		Other room(s) linings Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	1	0	0	1	0.2%	0.0%
1900	0	0	4	8	5	17	3.0%	0.0%
1910	0	1	0	9	9	19	3.4%	5.3%
1920	0	1	12	25	11	49	8.7%	2.0%
1930	0	4	6	12	4	26	4.6%	15.4%
1940	0	0	11	11	5	27	4.8%	0.0%
1950	0	4	17	36	10	67	11.9%	6.0%
1960	0	6	23	53	20	102	18.1%	5.9%
1970	0	3	17	47	17	84	14.9%	3.6%
1980	0	1	12	30	21	64	11.4%	1.6%
1990	0	0	9	26	31	66	11.7%	0.0%
2000	0	1	0	4	31	36	6.4%	2.8%
mixed	0	0	2	2	0	4	0.7%	0.0%
Total	0	21	114	263	164	562	100.0%	3.7%
% condition	0.0%	3.7%	20.3%	46.8%	29.2%	100.0%		
Ave cond						4.01		

Auckland Region		Other room(s) linings Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	0.0%
1900	0	0	2	7	3	12	4.0%	0.0%
1910	0	0	0	8	5	13	4.3%	0.0%
1920	0	0	4	19	4	27	8.9%	0.0%
1930	0	2	0	6	0	8	2.6%	25.0%
1940	0	0	3	7	4	14	4.6%	0.0%
1950	0	3	6	21	4	34	11.3%	8.8%
1960	0	4	7	35	5	51	16.9%	7.8%
1970	0	3	8	33	6	50	16.6%	6.0%
1980	0	1	8	18	7	34	11.3%	2.9%
1990	0	0	5	16	13	34	11.3%	0.0%
2000	0	0	0	3	19	22	7.3%	0.0%
mixed	0	0	2	1	0	3	1.0%	0.0%
Total	0	13	45	174	70	302	100.0%	4.3%
% condition	0.0%	4.3%	14.9%	57.6%	23.2%	100.0%		
Ave cond						4.00		

Wellington Region		Other room(s) linings Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	1	0	0	1	0.9%	0.0%
1900	0	0	1	1	2	4	3.6%	0.0%
1910	0	1	0	0	4	5	4.5%	20.0%
1920	0	1	3	3	6	13	11.8%	7.7%
1930	0	0	1	5	4	10	9.1%	0.0%
1940	0	0	1	3	0	4	3.6%	0.0%
1950	0	0	3	4	6	13	11.8%	0.0%
1960	0	0	4	5	13	22	20.0%	0.0%
1970	0	0	2	3	6	11	10.0%	0.0%
1980	0	0	1	1	10	12	10.9%	0.0%
1990	0	0	2	1	7	10	9.1%	0.0%
2000	0	1	0	1	2	4	3.6%	25.0%
mixed	0	0	0	1	0	1	0.9%	0.0%
Total	0	3	19	28	60	110	100.0%	2.7%
% condition	0.0%	2.7%	17.3%	25.5%	54.5%	100.0%		
Ave cond						4.32		

Christchurch Region		Other room(s) linings Condition						
Decade built	1	2	3	4	5	Total	% decade	% of 1 & 2
1890	0	0	0	0	0	0	0.0%	0.0%
1900	0	0	1	0	0	1	0.7%	0.0%
1910	0	0	0	1	0	1	0.7%	0.0%
1920	0	0	5	3	1	9	6.0%	0.0%
1930	0	2	5	1	0	8	5.3%	25.0%
1940	0	0	7	1	1	9	6.0%	0.0%
1950	0	1	8	11	0	20	13.3%	5.0%
1960	0	2	12	13	2	29	19.3%	6.9%
1970	0	0	7	11	5	23	15.3%	0.0%
1980	0	0	3	11	4	18	12.0%	0.0%
1990	0	0	2	9	11	22	14.7%	0.0%
2000	0	0	0	0	10	10	6.7%	0.0%
mixed	0	0	0	0	0	0	0.0%	0.0%
Total	0	5	50	61	34	150	100.0%	3.3%
% condition	0.0%	3.3%	33.3%	40.7%	22.7%	100.0%		
Ave cond						3.83		

The lining condition is poor for a significant percentage of 1930s houses. To a lesser extent the 1950s and 1960s cohorts also have poor condition. Relining is an opportunity for retrofitting wall insulation.

These tables show that many houses in the 1930 to 1969 age group require wall component repair or replacements and this provides an ideal opportunity to install insulation in the wall which is otherwise the most difficult part of the house envelope to retrofit.

11.4 Territorial authorities demolitions model

This model is based on the same method as used for the national model in section 5.2.

For some TAs the demolition numbers are negative and this is thought to arise when there is a trend over the inter-census period for more people to be living in garages, and mobile homes, and when houses are converted to multi-units without a building consent. Make-shift dwellings in garages, sheds and mobile homes/ caravans are picked up as occupied dwellings at census time but these dwellings do not appear as residential building consents.

Large (>1.5% over 5 years) and small (<0.5%) rates of demolition are marked in red and green shading, respectively. The TAs with low demolition rates usually has low unoccupied rates, and some TAs with high demolition rates also have high unoccupied rates. This is the pattern expected if we assume that the causal relationship is low unoccupied rates result in low demolition rates. However, the correlation is not very close as shown in the scatter diagram for TAs, in Figure 13. An alternative scenario that high demolition rates result in low unoccupied rates is not supported by the tables.

If the TAs with negative demolitions are ignored the total for all NZ is about 11,000 over the 5 year period, or about 2,200 per year, which is slightly larger than obtained for the national model in Table 4.

Table 11 Demolitions by TA

Derived demolitions by territorial authority.

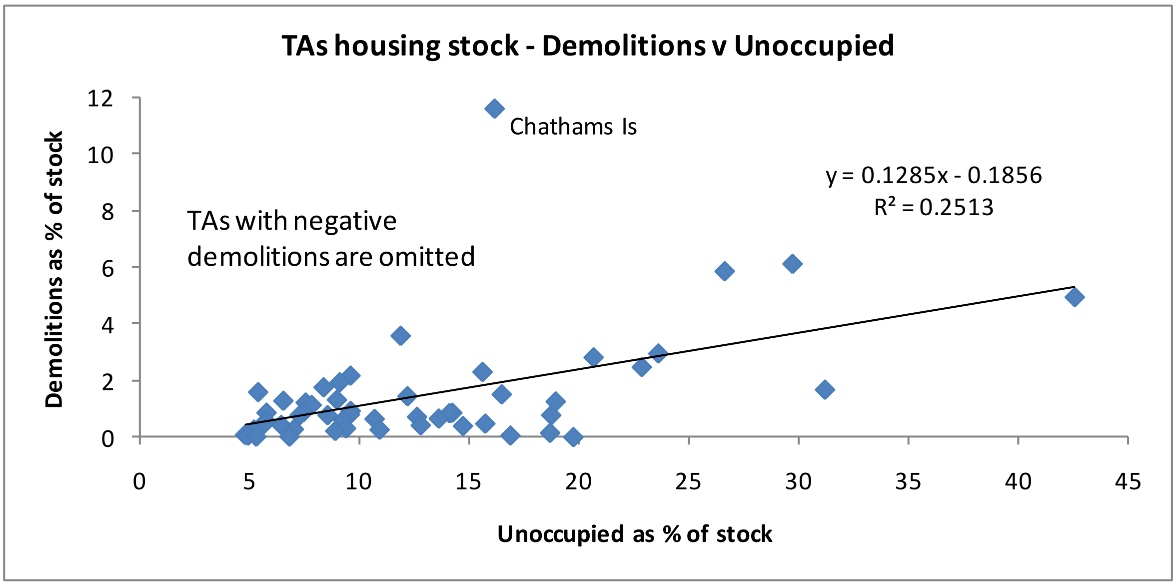
	Building Consents	2006 census			2001 census		Implied demolitions		Comment
	Dwelling units (incl granny flats)	Occupied	Unocc	Unocc as	Occupied	Unocc	2006		(possible reasons for negative demolitions)
	Oct00 to Sep05	PrivDwell		% of total	PPDwell		5 years	%	
Far North District	1976	20,478	4,722	19	19,560	3,852	188	0.8	
Whangarei District	3055	28,035	4,053	13	25,506	3,744	217	0.7	
Kaipara District	731	6,996	2,316	25	6,546	1,944	-91	-1.1	Large upturn in mobile homes accomodation
Rodney District	5688	33,348	5,757	15	28,533	5,025	141	0.4	
North Shore City	6487	72,657	3,993	5	66,465	3,903	205	0.3	
Waitakere City	6140	62,271	3,597	5	56,037	3,615	-76	-0.1	Large upturn in garage accomodation
Auckland City	18192	145,014	13,260	8	132,126	10,503	2,547	1.8	
Manukau City	11221	94,950	4,569	5	83,592	4,533	-173	-0.2	Large upturn in garage accomodation
Papakura District	1311	14,907	795	5	13,515	834	-42	-0.3	
Franklin District	2609	20,379	1,959	9	17,670	1,842	-217	-1.1	Large upturn in garage accomodation
Thames-Coromandel D	2323	11,382	10,917	49	10,860	8,853	-263	-1.3	Large upturn in mobile homes accomodation
Hauraki District	443	6,747	903	12	6,294	891	-22	-0.3	
Waikato District	1522	15,096	1,413	9	13,479	1,629	121	0.8	
Matamata-Piako D	592	11,394	699	6	10,773	831	103	0.9	
Hamilton City	4828	46,095	2,586	5	41,313	2,559	19	0.0	
Waipa District	1559	15,768	900	5	14,361	996	248	1.6	
Otorohanga District	167	3,081	570	16	2,973	594	83	2.3	
South Waikato District	142	8,163	993	11	8,091	843	-80	-0.9	
Waitomo District	113	3,438	726	17	3,378	669	-4	-0.1	
Taupo District	1714	12,312	5,583	31	11,610	4,851	280	1.7	
Western Bay of Plenty	1634	15,687	2,577	14	14,043	2,379	-208	-1.3	Temporary farm worker accomodation (sheds)
Tauranga District	6177	40,494	4,287	10	35,316	3,609	321	0.8	
Rotorua District	1246	23,577	2,892	11	22,557	2,739	73	0.3	
Whakatane District	635	11,889	1,341	10	11,469	1,041	-85	-0.7	Temporary farm worker accomodation (sheds)
Kawerau District	14	2,421	219	8	2,340	252	-34	-1.3	Large upturn in garage accomodation
Opotiki District	154	3,243	798	20	3,210	678	1	0.0	
Gisborne District	517	15,660	1,599	9	15,405	1,443	106	0.6	
Wairoa District	51	3,132	816	21	3,132	879	114	2.8	
Hastings District	1638	25,419	1,920	7	24,084	1,695	78	0.3	
Napier City	1168	21,660	1,323	6	20,787	1,158	130	0.6	
Central Hawke's Bay D	290	4,962	681	12	4,734	543	-76	-1.4	Temporary farm worker accomodation (sheds)
New Plymouth District	1305	26,745	1,959	7	25,503	1,908	12	0.0	
Stratford District	106	3,411	342	9	3,315	405	73	2.0	
South Taranaki District	236	10,197	1,083	10	10,134	1,158	248	2.2	
Ruapehu District	185	4,950	1,797	27	5,028	1,944	410	5.9	
Wanganui District	434	17,049	1,449	8	16,692	1,584	212	1.2	
Rangitikei District	120	5,694	768	12	5,634	945	237	3.6	
Manawatu District	519	10,488	1,026	9	10,017	1,005	27	0.2	
Palmerston North City	1692	27,732	1,662	6	26,268	1,569	135	0.5	
Tararua District	158	6,786	813	11	6,663	828	50	0.7	
Horowhenua District	684	11,988	2,181	15	11,481	1,866	-138	-1.0	Large upturn in mobile homes accomodation
Kapiti Coast District	2220	19,311	3,045	14	17,394	2,880	138	0.7	
Porirua City	657	15,516	804	5	14,868	807	12	0.1	
Upper Hutt City	815	14,214	705	5	13,185	837	-82	-0.6	Large upturn in garage accomodation
Lower Hutt City	807	35,646	1,797	5	34,584	2,091	39	0.1	
Wellington City	5677	68,706	4,086	6	62,475	4,551	-89	-0.1	?
Masterton District	520	8,985	1,248	12	8,667	1,191	145	1.5	
Carterton District	236	2,787	357	11	2,634	273	-1	0.0	Temporary farm worker accomodation (sheds)
South Wairarapa D	296	3,678	1,047	22	3,486	876	-67	-1.5	
					Ignore negative demos total =		6,713		

Demolitions by TA (continued)

Derived demolitions by territorial authority (continued).

	Building Consents	2006 census			2001 census		Implied demolitions		Comment
	Dwelling units (incl granny flats) Oct00 to Sep05	Occupied PPDwell	Unocc	Unocc as % of total	Occupied PPDwell	Unocc	2006 5 years	%	
Tasman District	2143	17,271	2,535	13	15,744	1,998	79	0.4	
Nelson City	1389	17,190	1,185	6	16,125	939	78	0.5	
Marlborough District	1851	16,839	3,420	17	15,318	3,105	15	0.1	
Kaikoura District	199	1,446	447	24	1,344	402	52	3.0	
Buller District	260	4,179	825	16	3,960	858	74	1.5	
Grey District	240	5,187	852	14	4,968	882	51	0.9	
Westland District	280	3,405	636	16	3,135	645	19	0.5	
Hurunui District	583	4,272	1,266	23	3,900	1,182	127	2.5	
Waimakariri District	2208	15,918	930	6	13,602	855	-183	-1.3	Large upturn in garage accomodation
Christchurch City	10130	134,721	9,438	7	122,754	7,578	1,706	1.3	
Banks Peninsula D	354				3,294	1,755			Banks Peninsula joined with Chrstchurch
Selwyn District	2387	11,568	1,200	9	9,333	1,083	35	0.3	
Ashburton District	813	10,923	1,161	10	10,164	1,215	108	0.9	
Timaru District	735	17,601	1,440	8	16,986	1,551	231	1.2	
Mackenzie District	292	1,530	1,134	43	1,485	1,011	124	5.0	
Waimate District	114	2,982	495	14	2,889	504	30	0.9	
Chatham Islands D	8	249	48	16	252	75	38	11.6	
Waitaki District	366	8,589	1,749	17	8,331	1,632	-9	-0.1	
Central Otago District	895	6,825	1,911	22	5,919	1,893	-29	-0.4	Temporary farm worker accomodation (sheds)
Queenstown-Lakes D	3334	9,087	3,843	30	6,789	3,435	628	6.1	
Dunedin City	1560	44,808	3,612	7	43,644	3,645	429	0.9	
Clutha District	260	6,618	1,521	19	6,621	1,272	14	0.2	
Southland District	611	10,911	2,550	19	10,755	2,262	167	1.3	
Gore District	137	4,863	480	9	4,833	444	71	1.3	
Invercargill City	629	20,025	1,575	7	19,641	1,500	170	0.8	
Area Outside TAs	0	225	75	25	264	60	24	7.4	
Total New Zealand	132782	1,471,743	159,273	10	1,359,843	147,435	9,044	0.6	
	check	1,471,770	159,261	check	1,359,837	147,426	9,014		
			1,631,031			Ignore negative demos total =	4,270		
						Ignore negative demos NZ total =	10,983		

Figure 13 Demolitions versus Unoccupied dwellings – TA scatter chart



11.5 Demolitions survey form

Housing Demolitions Survey

Could you please fill out this survey for the building that was demolished at the address given over the page.

1. Approximately how old was the demolished building? ....years

2. How large was the demolished building? .... square metres

3. What was put in its place? ....

4. Why was the existing house demolished? (Circle as many as applicable)
   A. Physical deterioration of the existing structure beyond repair
   B. Change of use from housing to commercial or industrial use
   C. A change in use to multi-unit housing. How many new units were installed? .....
   D. Fire damage
   E. Storm/ flood damage
   F. Other ....(state)

5. Were any of the demolition materials recycled? Yes/No

   What materials were recycled? ....

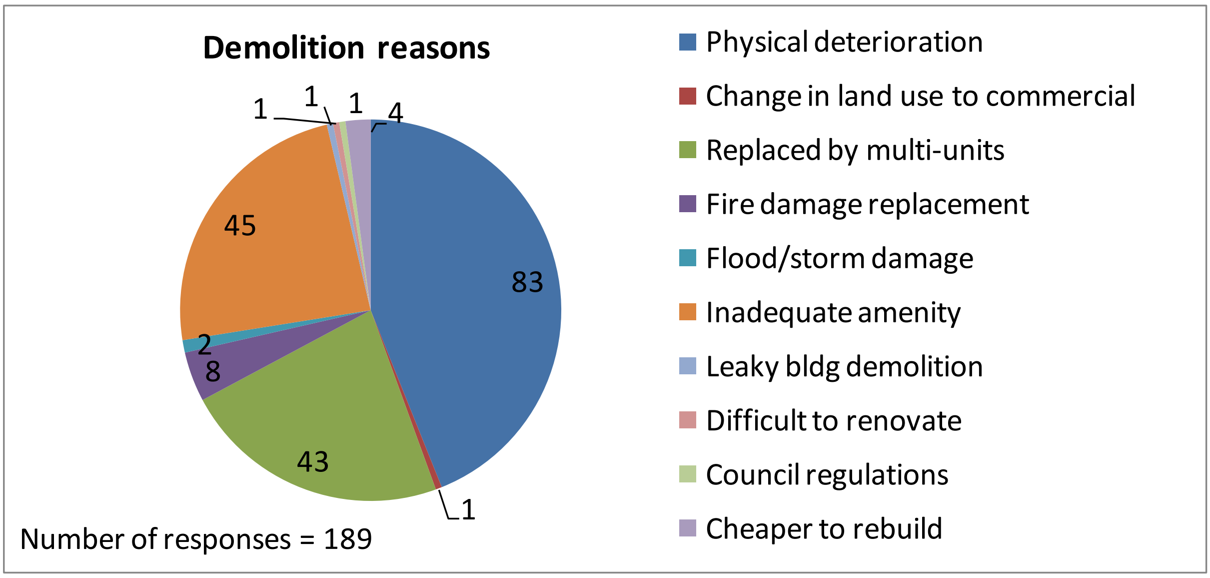
Thank you. Please indicate your preferred reward over page and place this survey in the enclosed reply paid envelope.

11.5.1 Survey of reasons for demolition

A survey of builders and owners was undertaken by BRANZ to ascertain the reasons for demolition, and ages of the demolished houses. Demolition was identified from the "Whats-On" dataset where the consent is for a new dwelling and the work descriptor includes the words "demolition replacement" or similar wording. The survey questions related to the particular consent only, and not builders general experience of demolitions.

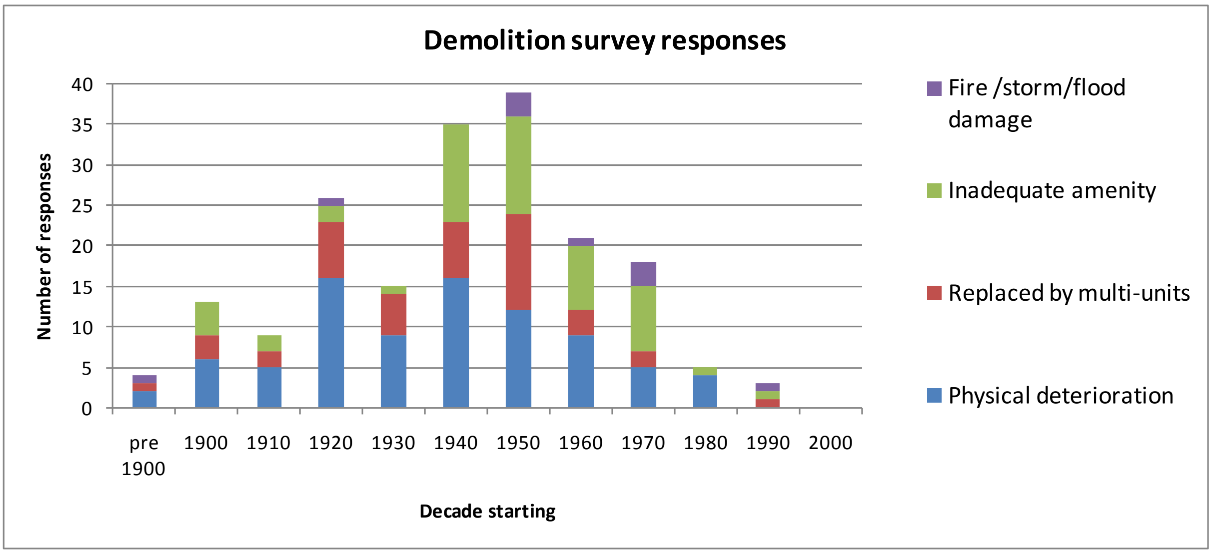
The respondents were asked about the reasons for demolition and the results are in Figure 14. The major reason given is physical deterioration, at about 44% of all reasons given. Redevelopment of the land for multi-units is also a significant cause of demolition amounting to about 22% of responses. The third major reason "Inadequate amenity" is that owners wanted a bigger or better designed house, or it was difficult to renovate and/or council requirements caused renovation problems. These respondents found it easier and cheaper to demolish and rebuild on the same site. It is likely these owners enjoy the location, and wish to remain at the same address, but have a wish to significantly upgrade their accommodation. About 48 of the responses were for this third group, representing about 27% of the reasons given. This suggests a sizable amount of demolition is due to functional reasons rather than physical deterioration or site redevelopment. The remaining 7% of reasons are for fire, storm or leaky building damage. See the appendix for the survey form.

Figure 14 Reasons for house demolition



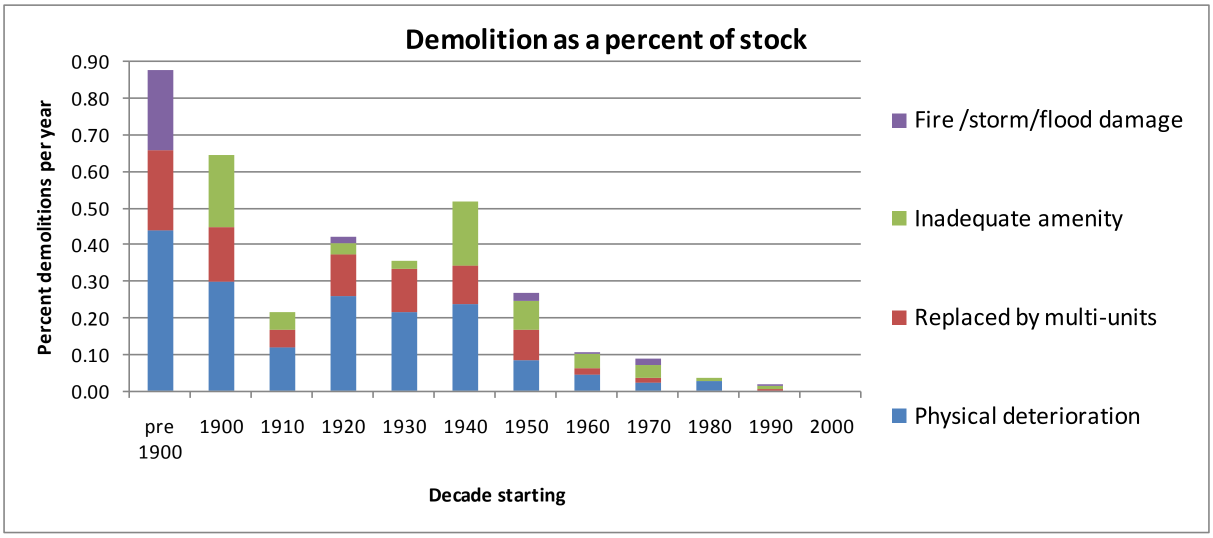
The demolitions were sorted by age group and reasons for demolition, shown in Figure 15. The single responses for "Difficult to renovate", "Cheaper to rebuild", and "Council regulations" have been included in "Inadequate amenity". The highest number of demolitions was found in the 1940s and 1950s house groups.

Figure 15 All demolitions by age group – BRANZ survey results



The above are unadjusted survey results and a slightly different pattern emerges when total demolitions are expressed as a percentage of the housing stock, see Figure 16. In this chart the number of demolitions in each age group have been scaled up to a total of 2,500 per year and then expressed as a percentage of the stock numbers in each age group. Figure 16 indicates that before 1910 and the 1940s groups have the highest percentage loss from its stock. Percentage losses due to physical deterioration increase with age, except for the 1910s cohort. Inadequate amenity percentage losses were high in the 1900s and 1940s cohorts. Multi-unit replacements account for approximately 0.1% of losses per year in all groups earlier than 1960.

Figure 16 All demolitions by age group as percentage of stock numbers

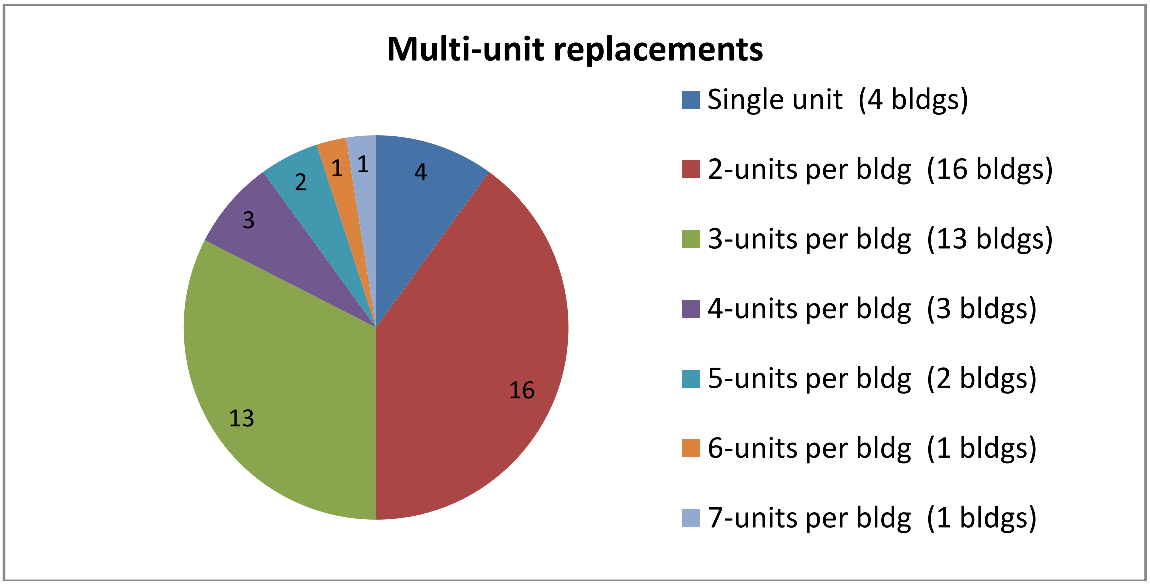


The survey did not explore in depth why houses were demolished rather than relocated (for the “Replaced by multi-units” and the “Inadequate amenity” categories). However comments on the reasons for demolition give clues as to non-relocation such as; too expensive to renovate, unable to physically relocate, too old to move, unable to restore due to poorly maintained house, and poor design hence easier to redesign/rebuild. It is concluded about half of the houses were demolished for economic and functional reasons, rather than physical deterioration or fire/ storm damage.

Other data collected from the survey included multi-unit replacements and recycling of materials, as follows.

The survey found that about 22% of the demolitions were due to multi-unit residential replacements. The most common replacements were 2-unit and 3-unit buildings, see Figure 17. There were four projects where initially only a single unit was built, with more to follow later.

Figure 17 Replacements for demolished dwellings



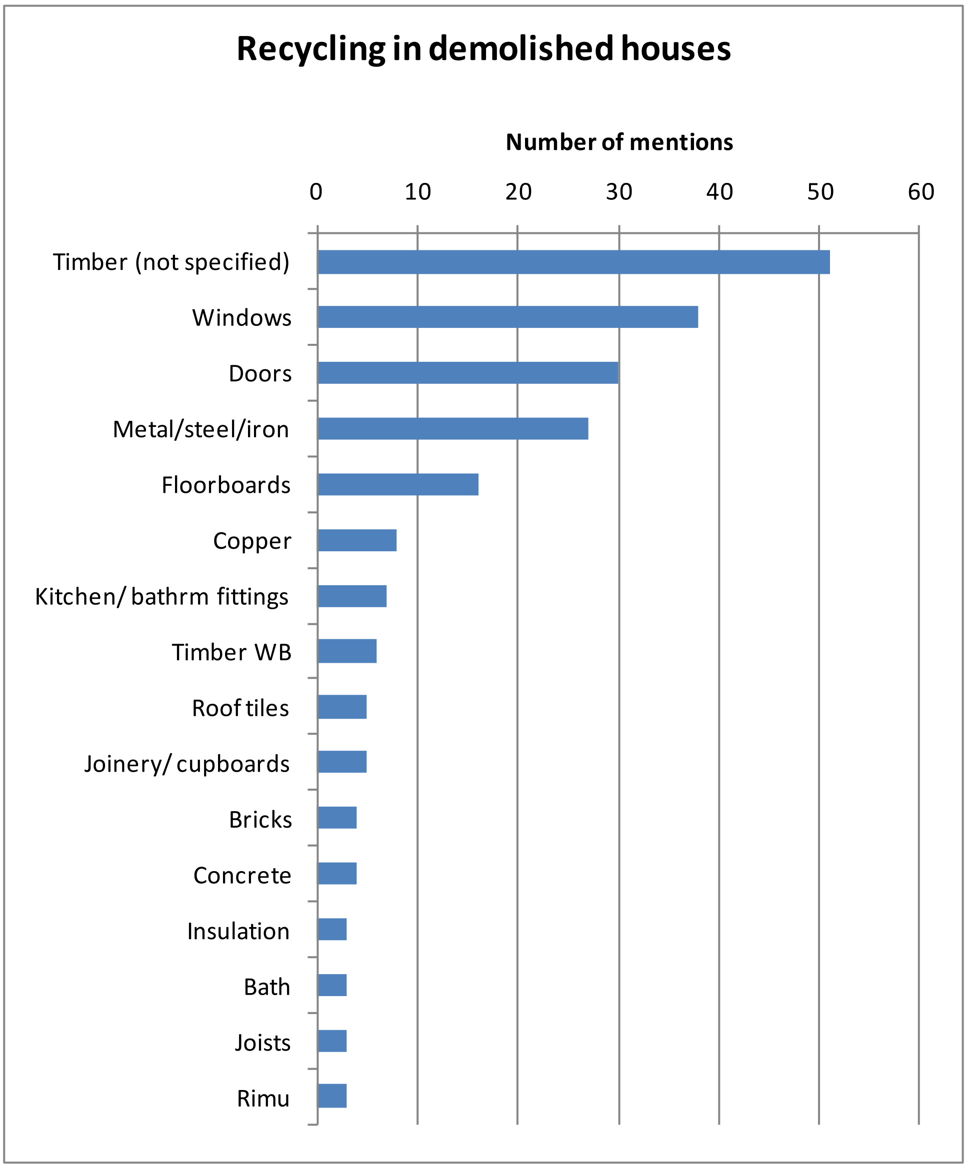
Recycling occurred in approximately 69% of the demolished houses. The other 31% specifically stated they did not recycle. The most common materials recycled were timber (unspecified), windows, doors, metal, and floor-boards. Further details of the materials that were recycled are in Figure 18.

The main conclusion from the survey is that there are a variety of reasons for demolition and that site redevelopment either for single or multi-units is a major reason at 49% of responses. Relocation of the existing house was not considered in these cases and the reason would appear to be that it was not cost effective.

11.6 Material recycled in demolished houses.

The responses from the demolition survey for recycled materials are shown in Figure 18.

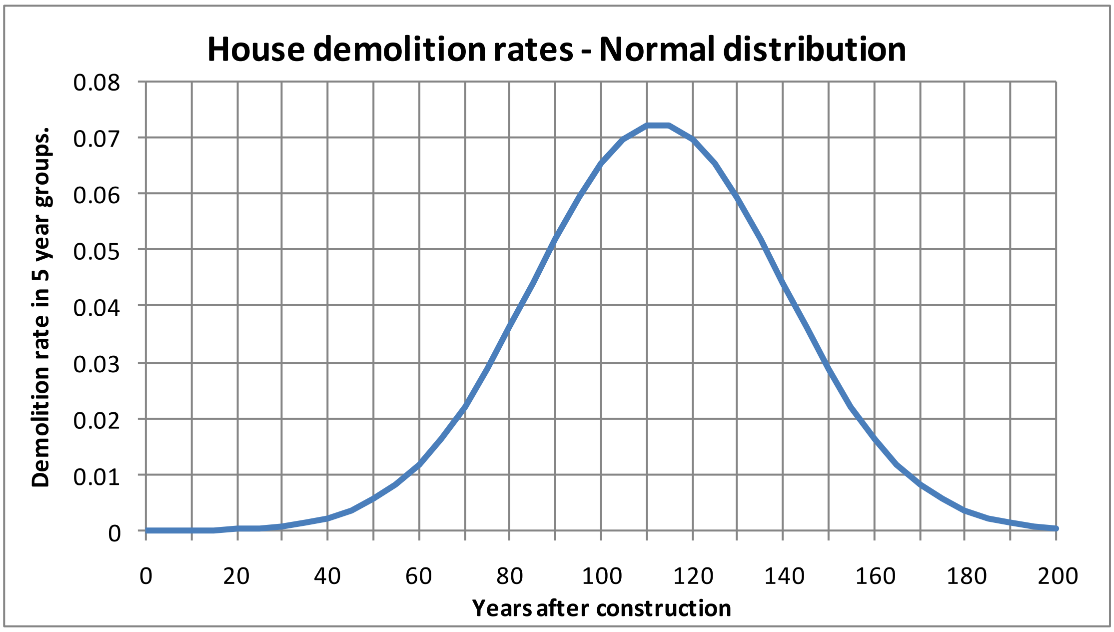
Figure 18 Recycling of demolition materials.



11.7 Demolitions in the future

To calculate the maintenance numbers in future years the housing demolition rate needs to be considered. A simplified model of demolitions is presented which assumes that houses built in each decade have an average life of 110 years and the demolition rate can be represented by a normal distribution with a standard deviation of 0.25 times the average life. The derived demolition rate by age of house is in Figure 19. This distribution, when applied to the original house numbers in each decade gives a current demolition rate of about 2,800 per year on average for the 2000 decade. This is in line with the forecast in Table 4, which had 2,200 per year in the 5 years to 2006, and allows for an increase in demolitions for the second half of the decade.

Figure 19 Demolitions rates – normal distribution

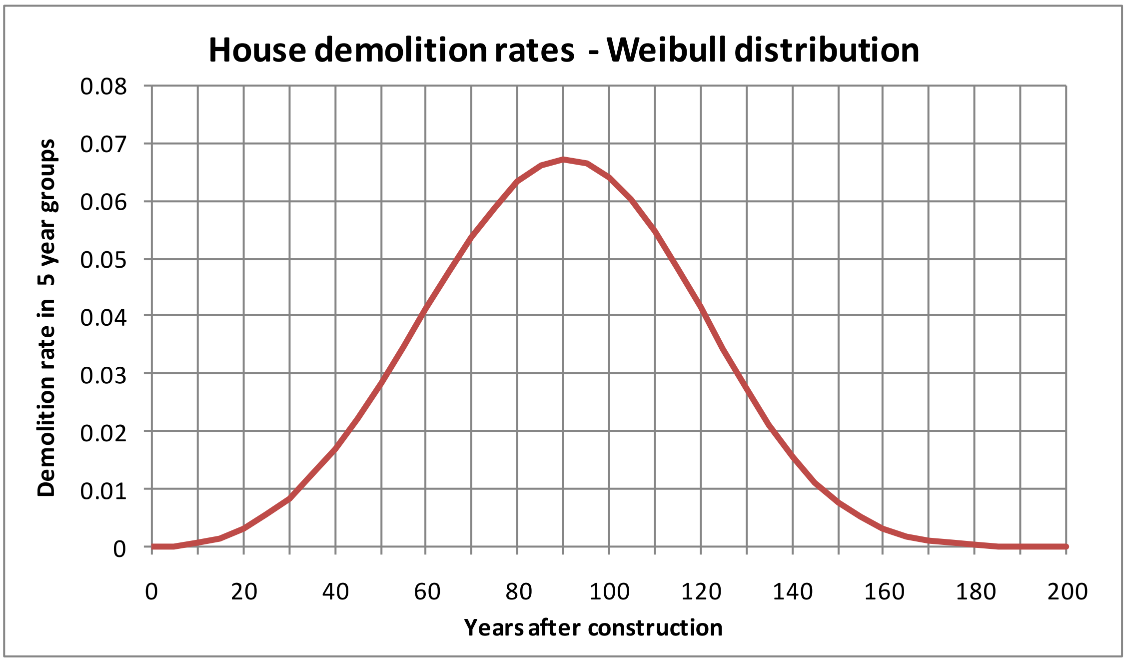


An alternative distribution is shown in Figure 20, a Weibull distribution which allows for some skew to the left, i.e. defective houses fail early and the failure rate decreases over time as they fall out of the population. The average life in this distribution is 90 years and gives an average of 7,800 demolitions per year in the decade starting 2000. It allows for a significant proportion of demolitions after 20 years, hence the quite high current demolition rate produced by this distribution. It produces demolition numbers in line with the Johnstone forecasts, mentioned in the literature review.

There are a number of simplifications in these modelling including the assumption of the same loss-rate distribution for all age groups which is probably somewhat unrealistic. Due to the lack of accurate data on the current rate of demolitions it is difficult to know which method gives the correct number. We know from the survey of builders on reasons for demolitions, see section 11.5.1, that less than half are due to physical deterioration, and that the majority are due to site redevelopment either for multi-units, or because the owner is replacing the existing house for functional and amenity reasons. So in periods of high new dwelling construction the demolition rate would tend to be quite high compared to normal or low levels of new starts.

It was decided to use the 110 year average life normal distribution model which has demolitions averaging about 2,600 per year this decade, 3,900 per year in the decade to 2020, and 5,600 per year in the following decade, see Table 5.

Figure 20 Demolitions rates – Weibull distribution



11.8 Demolition/ rebuild versus renovation life cycle costs.

This section compares the three scenarios below from a life cycle point of view. The re-built or renovated house is to be of HSS standard (clause H1). Life of the new re-built house is 90 years. The comparison is between 3 options:

1. Demolish & re-build, then minor renovation (replace 20% weatherboards, HWC, entire roof) at year 30 and year 60
2. Major Renovation, demolish & re-build at year 30, then minor renovation (replace 20% weatherboards, HWC, entire roof) again at year 60 more years
3. Do nothing now, Demolish and rebuild in 10 years, then minor renovation (replace 20% weatherboards, HWC, entire roof) at year 40 and 70.

11.8.1 Method

- The house specification was from the NZIV 1983 national modal house.
- The Present Worth method is utilised to work out future costs to present day values. The total of these costs is the life cycle cost.
- The program ALF 3.1 (Annual loss factor) was utilised to calculate space heating kHw (kilo watt hours per year).
- $/sqm rates were utilised from Rawlinsons 2008. GST is excluded and rates are for a new build.

- If there was a range in the costs, the midpoint was utilised. Example from Rawlinsons page 26: In Auckland, a new 1-storey house 100-200 sqm with pine/cedar weatherboards is between $1650-$1850 per sqm. We use $1750 per sqm rate.
- Wall insulation was installed from the inside of the house by removing interior walls as opposed to insulating from the outside by removing weatherboards and exterior walls. This worked out to be the more economical option.

The demolished then re-built house details as follows (Option 1 and Option 3):

- Concrete slab foundation
- Aluminium double glazed windows
- Radiata weatherboard wall cladding
- Addition of timber framed steel flue chimney
- ALF calculated north-west orientation on house side B facing sun to be most energy efficient and it was assumed this orientation is feasible for all rebuilt houses.

The Major renovated house has the following upgraded features (Option 2):

- Under floor polystyrene insulation to HSS
- other floor work (refer to excel spread sheet)
- Aluminium double glazed windows
- Re-clad 20% of all radiata walls
- Insulated walls to HSS
- Other wall work (refer to excel spread sheet)
- Re-roof
- Insulate ceiling to HSS
- All interior and exterior repainted
- Hot water cylinder replaced
- Draught proof air leaks
- Electrical work including 50% more lights and power outlets
- ALF calculated south orientation on house side B facing sun to be 2^{nd} worst most energy efficient and this orientation was assumed for all existing houses.

Assumptions

- 4 occupants per house based on 2 single rooms, 1 double bedroom
- About 20% of weatherboards are to be replaced after each 30 year period
- 100% of roof is to be replaced after each 30 year period
- HWC to be replaced after each 30 year period
- Re-paint 15 years after rebuild, and then in 10 year intervals
- All other work listed in major renovated house upgraded features (apart from insulation, floor work, other wall work, and chimney) is to be replaced after 30 years.
- House will be heated in the morning and evening (7am-9am, 5pm-11pm) at 18 degrees Celsius.

11.8.2 Results

The tables below of New Zealand's main cities show the option to undertake a major upgrade now (Option 2) to be the most economically cost effective (over 90 years with discount rate 5%, 1% pa energy price escalation rate after general inflation). The decision to demolish now then rebuild (Option 1) shows the highest present value cost.

An intermediate cost outcome (Option 3) is to do nothing for 10 years, then demolish and re-build.

Over the main cities, the difference between Option 1 and Option 2 is between $58,000 to $68,000, and the difference between Option 2 and Option 3 range between $13,000 to $17,000. The main difference between Option 2 and Option 3 are the higher space-heating running costs.

Table 12 Auckland – Demolish v Renovate

AUCKLAND. Demolish versus Renovation - Life cycle costs - Present Value	
Option 1 Demolish and rebuild with optimal orientation/ passive solar, minor renovation at year 30 and year 60.	**Present Value**
Demolition	6,326
Rebuild	166,925
Painting 15 yrs then 10yrs intervals	18,830
Minor renovate(20%WB, roof,HWC)	2,313
Space conditioning energy 90 yrs	6,921
	201,315
Option 2 Major renovation now for another 30 years life, then demolish/ rebuild, with minor renovations at year 60.	
Major renovation	50,796
painting @ 10 yrs	15,283
Demolition	1,464
Rebuild @ 30 yrs	38,623
Painting 15 yrs then 10yrs int	19,484
Minor renovate @ 60yrs(20%WB, roof,HWC)	435
Space conditioning energy 90 yrs	7,224
	133,308
Option 3 Do nothing now, Demolish and rebuild (opt orientation/ passive solar) in 10 years. Minor renovation at year 40 and 70.	
Demolition	3,884
Rebuild	102,477
Painting 15 yrs then 10yrs intervals	26,835
Minor renovate(20%WB, roof,HWC)	1,420
Space conditioning energy 90 yrs	12,019
	146,636

Table 13 Wellington – Demolish v Renovate

WELLINGTON. Demolish versus Renovation - Life cycle costs - Present Value	
Option 1 Demolish and rebuild with optimal orientation/ passive solar, minor renovation at year 30 and year 60.	**Present Value**
Demolition	6,271
Rebuild	159,958
Painting 15 yrs then 10yrs intervals	18,469
Minor renovate(20%WB, roof,HWC)	2,275
Space conditioning energy 90 yrs	14,655
	201,627
Option 2 Major renovation now for another 30 years life, then demolish/ rebuild, with minor renovations at year 60.	
Major renovation	50,198
painting @ 10 yrs	14,990
Demolition	1,451
Rebuild @ 30 yrs	37,011
Painting 15 yrs then 10yrs int	19,110
Minor renovate @ 60yrs(20%WB, roof,HWC)	427
Space conditioning energy 90 yrs	14,844
	138,031
Option 3 Do nothing now, Demolish and rebuild (opt orientation/ passive solar) in 10 years. Minor renovation at year 40 and 70.	
Demolition	3,850
Rebuild	98,200
Painting 15 yrs then 10yrs intervals	26,321
Minor renovate(20%WB, roof,HWC)	1,397
Space conditioning energy 90 yrs	23,385
	153,152

Table 14 Christchurch – Demolish v Renovate

CHRISTCHURCH. Demolish versus Renovation - Life cycle costs - Present Value	
Option 1 Demolish and rebuild with optimal orientation/ passive solar, minor renovation at year 30 and year 60.	**Present Value**
Demolition	6,271
Rebuild	159,958
Painting 15 yrs then 10yrs intervals	18,469
Minor renovate(20%WB, roof,HWC)	2,244
Space conditioning energy 90 yrs	16,702
	203,643
Option 2 Major renovation now for another 30 years life, then demolish/ rebuild, with minor renovations at year 60.	
Major renovation	49,882
painting @ 10 yrs	14,990
Demolition	1,451
Rebuild @ 30 yrs	37,011
Painting 15 yrs then 10yrs int	19,110
Minor renovate @ 60yrs(20%WB, roof,HWC)	422
Space conditioning energy 90 yrs	17,020
	139,886
Option 3 Do nothing now, Demolish and rebuild (opt orientation/ passive solar) in 10 years. Minor renovation at year 40 and 70.	
Demolition	3,850
Rebuild	98,200
Painting 15 yrs then 10yrs intervals	26,321
Minor renovate(20%WB, roof,HWC)	1,377
Space conditioning energy 90 yrs	27,204
	156,952

Table 15 Dunedin – Demolish v Renovate

DUNEDIN. Demolish versus Renovation - Life cycle costs - Present Value	
Option 1 Demolish and rebuild with optimal orientation/ passive solar, minor renovation at year 30 and year 60.	**Present Value**
Demolition	6,271
Rebuild	152,990
Painting 15 yrs then 10yrs intervals	18,469
Minor renovate(20%WB, roof,HWC)	2,233
Space conditioning energy 90 yrs	20,384
	200,347
Option 2 Major renovation now for another 30 years life, then demolish/ rebuild, with minor renovations at year 60.	
Major renovation	49,906
painting @ 10 yrs	14,990
Demolition	1,451
Rebuild @ 30 yrs	35,398
Painting 15 yrs then 10yrs int	19,110
Minor renovate @ 60yrs(20%WB, roof,HWC)	420
Space conditioning energy 90 yrs	20,763
	142,039
Option 3 Do nothing now, Demolish and rebuild (opt orientation/ passive solar) in 10 years. Minor renovation at year 40 and 70.	
Demolition	3,850
Rebuild	93,923
Painting 15 yrs then 10yrs intervals	26,321
Minor renovate(20%WB, roof,HWC)	1,371
Space conditioning energy 90 yrs	33,345
	158,810

11.8.3 Data sources for life cycle costing

Building cost rates: 2008 Rawlinsons New Zealand Construction Handbook.

House specifications: NZIV The National Modal House Plan, Specification and Schedule of Quantities 1983.

Space heating electricity Rates: www. meridianenergy.co.nz/ YourHome/Pricing+plans/#pricingrates. Standard Anytime rates applied. Otago Net Area rate used for Dunedin.

Insulation from interior method: www.gib.co.nz/Your-Home/Your-Renovation/Your-Renovation-Book/Bring-your-home-into-the-21st-century.asp?PageID=6263&ID=2&CatID=2157&Level=2&CatID2=4110

Draught proof windows/doors: http://www.cea.co.nz/retail-shop/#V-Seal. Assume uniform price.