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Doing Better in Residential Dwellings: Going Beyond the Code in Energy and Accessibility Performance

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Integrated Report

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EXECUTIVE SUMMARY

This report brings together findings from four research reports concerned with how we can go beyond the current New Zealand Building Code (NZBC) to construct better performing dwellings. Residential buildings in New Zealand can 'do better' than code in one of two ways:

- First, consumers can demand and the building industry can deliver new-build and renovated dwellings that exceed the standards set out in the NZBC.
- Second, consumers can demand and the building industry can deliver new-build and renovated dwellings with dimensions of performance that are not specified within the NZBC.

The Building Act 2004 and NZBC are intended to provide a flexible framework focused on what buildings need to do, rather than how they are to be designed and built. A focus on performance was originally aimed at giving the industry the flexibility to push regulatory boundaries. This research argues that the potential for doing better than the code has largely been unfulfilled. The research presents two case studies of research-based tools developed to improve residential building performance beyond the code. Those case studies concern energy consumption related to thermal performance and the functionality of residential buildings broadly associated with the concept of accessibility. In both areas there is significant value to be generated by performance improvement. Furthermore, both areas have seen a long history of unmet consumer demand.

The research explored whether research-based solutions for 'beyond code' dwelling performance have been incorporated into or exceeded by the building code minimums. It also considered whether research-based solutions have been recognised and promoted by the building industry or demanded by consumers in either new residential builds or renovations. Finally, the research examined the determinants of take-up or non-take-up of the performance levels that research shows are achievable.

This document starts with the integrated report setting out the key findings from this research. Following on are the three reports, on which the integrated report is based:

- An overview of the NZBC identifying the requirements and performance required around energy efficiency/thermal performance and accessibility (Annex A).
- An analysis of the way in which beyond code performance standards have been integrated into householder or industry decision tools and guidelines (Annex B).
- A review of both domestic and international research about the dynamics of building industry take-up of innovation and available product, materials and design solutions (Annex C).

Further analysis of the accessibility and energy-related New Zealand research confirms the findings and interpretation in those reports. Annex D provides a selected list of research based material. Annex E provides an annotated bibliography of selected material.

The overall findings are:

i. Energy and thermal performance is included in building legislation and is associated with standards in the NZBC.
ii. Dwelling accessibility and functionality are very limited in the NZBC and are entirely excluded from application to private residential dwellings despite evidence suggesting that accessibility and dwelling functionality improvement is crucial to ageing societies, ageing in place policies and positive ageing policy. It is problematic when performance is not specified in the NZBC, since the minimum is effectively zero. It is therefore crucial to reflect these other areas of performance in building legislation including the NZBC in order to get industry take-up.
iii. Where a dimension of performance is not recognised or is poorly specified in building legislation, there is poor research investment into, and research activity around, net benefits, appropriate measurement, and technical/product solutions.
iv. Lack of recognition of a dimension of building performance, under-investment in research, and low industry take-up may establish a vicious cycle where lack of research is cited as a reason not to incorporate requirements into legislation.
v. Low take-up of innovation in the building industry inhibits performance enhancing solutions from crossing the chasm from early adoption to widespread market take-up.
vi. Research is an important element in improving residential dwelling performance. However, the claim that limited take-up of performance enhancement is primarily a failure in research-based knowledge transfer is overstated. There already exists a body of New Zealand research which would help the industry to push boundaries. The review of research undertaken for this project has not uncovered research-based solutions for exceeding the minimum aspects of thermal performance and access, standards or measurement unknown by either the industry, advisors to the industry such as BRANZ or even consumers. On the contrary, there are a range of research-based accreditation tools which, while in the public arena, are largely ignored by industry.
vii. Both New Zealand and international research into take-up of building performance enhancing solutions consistently show that a concerted and multi-pronged approach is necessary in order to achieve outcomes that exceed minimum performance requirements. Relevant research is necessary, but also essential are combining a regulatory framework, industry incentives, consumer education and accreditation as well as industry development, all backed by sufficient investment
viii. The view that the industry is “set in its ways” and cannot be innovative is false. To improve take-up, net benefits need to be demonstrated and solutions should be “plug and play”.

This research suggests three areas of further research to encourage doing better than the NZBC. These are around: the establishment of net benefits of adopting a higher performance standard; identification of and solutions to particular barriers to transformation; and the development of plug and play solutions. These research themes can be applied to any area of building performance. They are, however, particularly necessary for accessibility and functionality where the legislation fails to incorporate performance requirements.

In addition, there needs to be strategic research into the nature and operation of building legislation. The dynamics of what is and is not included in building legislation merit research into the: institutional and procedural aspects of NZBC review and specification; conditions that prompt certain performance dimensions to be recognised in legislation related to building performance; and, the extent to which current building legislation is adequate in the context of housing needs in an ageing society.

1. INTRODUCTION

This report integrates key findings from three reports completed for the Doing Better research funded through the BRANZ levy and includes further analysis of energy-related research completed in June 2017. The research has been focused on how the building industry can go beyond the current New Zealand Building Code (NZBC) to construct better performing dwellings with reference to two dimensions of performance: energy consumption related to thermal performance and the functionality of residential buildings broadly associated with the concept of accessibility.

The research was structured around a number of key questions:

i. To what extent do research-based solutions from research completed over the past two decades demonstrate 'beyond code' dwelling performances could be achieved?
ii. To what extent have the performance(s) indicated in those research based solutions been incorporated into or exceeded by the building code minimums?
iii. To what extent have those research-based solutions been recognised and promoted by the building industry or demanded by consumers in either new residential builds or renovations?
iv. What are the determinants of take-up or non-take-up of the performance levels that research shows are achievable?

The three reports have been released to date. Those are respectively:

- An overview of the New Zealand building code (NZBC) identifying the requirements and performance required around energy efficiency/thermal performance and accessibility (Annex A).
- An analysis of the way in which beyond code performance standards had been integrated into householder or industry decision tools and guidelines (Annex B).
- A review of both domestic and international research about the dynamics of building industry take-up of innovation and available product, materials and design solutions (Annex C).

Further analysis of the accessibility and energy-related New Zealand research confirms the findings and interpretation in those reports. Annex D provides a selected list of research based material. Annex E provides an annotated bibliography of selected material.

Collectively those analyses and reports identify a series of critical findings which are highlighted in this final, integrated report. In summary, those are:

i. Building legislation in New Zealand has always been characterised by the variability in the attention given to different elements of building systems or building performance. That tendency is also found in the explicitly performance-based 2004 Building Act, its later amendments and the NZBC. Energy and thermal performance is included in building legislation and is associated with standards in the NZBC. However, dwelling accessibility and functionality are very limited in the NZBC and are entirely excluded from application to private residential dwellings despite evidence suggesting that accessibility and dwelling functionality improvement is crucial to ageing societies, ageing in place policies and positive ageing policy.

The dynamics of inclusion and exclusion merit research into the:

- institutional and procedural aspects of NZBC review and specification;
- conditions that prompt certain performance dimensions to be recognised in legislation related to building performance; and,
- extent to which current building legislation will remain adequate in the context of housing needs in an ageing society.

ii. If the building industry is to take-up performance enhancing solutions in any particular dimension, building legislation must recognise that dimension of performance as important.

iii. Where a dimension of performance is not recognised or is poorly specified in building legislation, there is poor research investment into, and research activity around, net benefits, appropriate measurement, and technical/product solutions.

iv. Lack of recognition of a dimension of building performance, under-investment in research, and low industry take-up establish vicious cycles. A lack of research and research-based measurement and solutions is cited by officials as a basis for not incorporating requirements into the legislative and regulatory framework.[1] This, however, is debatable and is commented on in the conclusion.

v. In the context of building industry innovation, low take-up inhibits performance enhancing solutions from crossing the chasm from early adoption to more widespread market take-up.

vi. Research is an important element in improving residential dwelling performance. However, the often implicit view that limited take-up of performance enhancement is primarily a failure in research-based knowledge transfer is almost entirely overstated. Moreover, both New Zealand and international research into take-up of building performance enhancing solutions consistently shows that a concerted and multi-pronged approach is required. That approach requires a robust investment pathway into relevant research and combining regulatory, industry incentives, consumer education and accreditation as well as industry development.

Beyond those key conclusions this report provides a structured and integrated summary of the whole programme framing and findings:

- Section 2 sets out what is meant by going beyond the minimum of the code and doing better.
- Section 3 presents two case studies of research-based tools developed to improve residential building performance beyond the code. Those case studies concern energy/thermal related and accessibility related residential building performance.
- Section 4 summarises a review of international research examining factors affecting the take-up of research-based innovations to improve residential building performance.
- Section 5 comments on the research platform relevant to energy/thermal performance in residential dwellings and accessibility respectively.

[1] Personal communications by both officials and disability advocates. See also https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/#jumpto-development-of-the-building-code

- Section 6 highlights the key findings of this programme and identifies ways forward in research that could illuminate pathways to improve the performance standards of New Zealand's residential buildings.

2. WHAT IS MEANT BY 'BEYOND THE CODE'

The discourse around 'doing better', 'exceeding the minimum' and 'going beyond' the code in the residential building industry is persistently couched in terms of exceeding the minimum performance standards set out in the NZBC. This assumes that critical dimensions of performance are those incorporated into the NZBC as it applies to New Zealand's residential buildings. This section shows that this is not the case. Consequently, going 'beyond the code' needs to be recognised as more expansive than simply the recalibration or even re-specification of existing performance standards. In short, residential buildings in New Zealand can 'do better' than code in one of two ways:

- First, consumers can demand and the building industry can deliver dwellings, new-build and through consented and non-consented renovations, that exceed the standards set out in the code.
- Second, consumers can demand and the building industry can deliver dwellings with dimensions of performance which are not specified within the NZBC for new-build and through consented and non-consented renovations.

Notably, Section 18 of the Building Act 2004 requires that "building work [is] not required to achieve performance criteria additional to or more restrictive than building code", except as expressly provided for in any other act. For example, disabled access and facilities beyond those established in the NZBC could be required by other legislation. Alterations to existing buildings, under Section 112, are required to only continue in compliance with the relevant provision of the NZBC except for "means of escape from fire" and "access and facilities for persons with disabilities (if this is a requirement in terms of Section 118)". Section 118 deals solely with buildings "to which members of the public are to be admitted,"

The introduction of a performance-based regulatory system through the 1992 and then 2004 Building Acts, and subsequent amendments and associated regulations including the NZBC, was intended to provide a flexible framework focused on what buildings needed to do, rather than how they were to be designed and built. This review focused on doing better in private dwellings in relation to access in general and specifically to personal services facilities, and energy efficiency. The NZBC clause groups that relate to those dimensions of performance are: D1, G1 and H1.

The sub-clauses related to D1 are set out in Infobox 1. NZBC H1 relates to energy/thermal performance. These performance statements are set out in Infobox 2. G1 deals with Personal Hygiene, but as can been seen in Infobox 1, these requirements are excluded by D1 from application in private housing. Issues that are in G1 around personal hygiene are included in LifeMark accreditation and we include those dimensions in the discussion by referring to both accessibility and functionality in relation to residential dwellings.

Infobox 1 – D Access NZBC – Does not Apply to Private Houses or Private Apartments

OBJECTIVE
D1.1 The objective of this provision is:
(a) Safeguard people from injury during movement into, within and out of b*uildings*,
(b) Safeguard people from injury resulting from the movement of vehicles into, within and out of *building*s, and
(c) Ensure that *people with disabilities* are able to enter and carry out normal activities and functions within *building*s.

FUNCTIONAL REQUIREMENT
D1.2.1 *Building*s shall be provided with reasonable and adequate access to enable safe and easy movement of people.
D1.2.2 Where a *building* is provided with loading or parking spaces, they shall be constructed to permit safe and easy unloading and movement of vehicles, and to avoid conflict between vehicles and pedestrians.

PERFORMANCE
D1.3.1 *Access routes* shall enable people to:
(a) Safely and easily approach the main entrance of *building*s from the apron or *construction* edge of a *building*,
(b) Enter *building*s,
(c) Move into spaces within *building*s by such means as corridors, doors, stairs, ramps and lifts,
(d) Manoeuvre and park cars, and
(e) Manoeuvre and park delivery vehicles required to use the loading space.
D1.3.2 At least one *access route* shall have features to enable *people with disabilities* to:
(a) Approach the *building* from the street boundary or, where required to be provided, the *building* car park,
(b) Have access to the internal space served by the principal access, and
(c) Have access to and within those spaces where they may be expected to work or visit, or which contain facilities for personal hygiene as required by Clause G1 “Personal Hygiene”.

Infobox 2 – H1 Energy Efficiency NZBC

OBJECTIVE

H1.1 The objective of this provision is to facilitate efficient use of energy.

Objective H1.1 applies only when the energy is sourced from a *network utility operator* or a depletable energy resource.

FUNCTIONAL REQUIREMENT

H1.2 *Buildings* must be *constructed* to achieve an *adequate* degree of energy efficiency when that energy is used for—

(a) modifying temperature, modifying humidity, providing ventilation, or doing all or any of those things; or
(b) providing hot water to *sanitary fixtures* or *sanitary appliances*, or both; or
(c) providing artificial lighting

Requirement H1.2(a) does not apply to *assembly service buildings, industrial buildings, outbuildings,* or *ancillary buildings.*

Requirement H1.2(c) applies only to c*ommercial buildings* and *communal non-residential buildings* whose floor area is greater than 300 m^2.

PERFORMANCE

H1.3.1 The *building* envelope enclosing spaces where the temperature or humidity (or both) are modified must be constructed to—

(a) provide *adequate thermal resistance*; and
(b) limit uncontrollable airflow.

H1.3.2E *Buildings* must be constructed to ensure that their *building performance index* does not exceed 1.55.

Performance H1.3.2E applies only to *housing*.

H1.3.3 Account must be taken of physical conditions likely to affect energy performance of *buildings*, including—

(a) the thermal mass of *building elements*; and
(b) the building orientation and shape; and
(c) the airtightness of the building envelope; and
(d) the heat gains from services, processes and occupants; and
(e) the local climate; and
(f) heat gains from solar radiation.

H1.3.4 Systems for the heating, storage, or distribution of hot water to and from *sanitary fixtures* or s*anitary appliances* must, having regard to the energy source used,—

(a) limit the energy lost in the heating process; and
(b) be constructed to limit heat losses from storage vessels and from distribution systems; and
(c) be constructed to facilitate the efficient use of hot water.

Performance H1.3.4(b) does not apply to individual storage vessels that are greater than 700 litres in capacity.

Performance H1.3.4(c) applies only to *housing.*

H1.3.5 Artificial lighting fixtures must—

(a) be located and sized to limit energy use, consistent with the *intended use* of space; and
(b) be fitted with a means to enable light intensities to be reduced, consistent with reduced activity in the space.

Performance H1.3.5 does not apply to lighting provided solely to meet the requirements in clause F6.

H1.3.6 *HVAC systems* must be located, *constructed*, and installed to—

(a) limit energy use, consistent with the *intended use* of space; and
(b) enable them to be maintained to ensure their use of energy remains limited, consistent with the *intended use* of space.

Performance H1.3.6 applies only to *commercial buildings*.

3. BEYOND CODE RESEARCH-BASED RESIDENTIAL BUILDING SOLUTIONS

Two areas where research directed at dwelling performance improvement has been transformed into tools intended to allow the building industry to do better were examined. The first set of tools relates to energy performance and is an example of pushing beyond performance requirements already subject to statutory minimums. The second tool, which deals with accessibility and functionality in new built homes, is an example where the current legislation not only does not require minimum performance, but it actively excludes residential homes from accessibility requirements that are mandated for the non-residential building stock.

These two areas were examined because they represent areas where it has been argued that there is significant value to be generated by performance improvement. In both areas there has been a long history of unmet consumer demand. Finally, these two areas of dwelling performance are handled quite differently within the code.

3.1 Energy performance

There have been a number of tools, guidelines and specifications aiming to encourage consumers to demand, and the industry to supply, dwellings that do better than the prevailing energy performance standards of the building code. Three of those were selected for examination:

i. PAS 4244:2004 is a guidance tool and a tool to demonstrate compliance. It provides prescriptive specifications for "code compliant", "better" and "best" insulation levels in houses.
ii. Homestar is a rating tool that aims to improve the performance and reduce the environmental impact of new and existing homes. Typical new homes built to minimum code standard will achieve 3 - 4 under Homestar v3. A 6 Homestar home will exceed the minimum requirements of NZBC Clause H1 (Energy Efficiency). That home will use significantly less energy as well as water (not covered in H1), and will have less moisture or condensation issues, making it healthier to live in and more affordable to run. The latest (v4) Homestar, effective from 25 July 2017, although allocating 60 (out of 120) points for "Energy, Comfort and Health" has a maximum of 13 points for the building thermal envelope.[2]
iii. High Standard of Sustainability (HSS), developed by Beacon Pathway, sets benchmarks in five key performance areas, based on a whole-of-house approach. The benchmark performance areas are energy, water, indoor environment quality, waste and materials. Energy levels are set above minimum code requirements. The other benchmark performance areas - water, indoor environment quality, waste and materials - are outside the current code.

All tools are voluntary and are targeted to home owners and the residential building industry. Homestar is also suitable for tenants and is used by some tenant advocates to help them

[2] https://www.nzgbc.org.nz/Category?Action=View&Category_id=305

assess the performance of the dwelling[3]. The tools have educational and informational roles, aiming to increase public demand for better than code features, and encourage builders, designers and developers to produce better performing dwellings. Of the three tools, Homestar is supported by a dedicated organisation with market presence, employed staff and professional accreditation which enables it to actively promote Homestar.

The research chain for these tools are not always easily discernible. PAS 4244 was based on various research projects on energy efficiency and thermal comfort. That research was used as one input into the development of the standard. Homestar and the HSS represent the phenomenon of accumulated, taken-for-granted research-based information. That is, the research base is not always directly referenced subsequent to the initial development of tools.

The extent of take-up of the tools is not clear. There is little or no data available on how they are being used, levels of uptake and impacts on improving dwelling performance, although a 2015 BRANZ study provides a benchmarking base for new standalone housing for the 2012 year.[4] When this research is repeated, it will provide data on housing compliance with the NZBC, but the sample size may not be sufficient to provide information on the use of specialist tools such as Homestar™. Research and uptake data that have been sourced are presented in the second report, *Doing Better: A review of beyond New Zealand Building Code research and traction through residential building accessibility and energy efficiency tools.* That report is attached as Annex B. The impact of these tools on the code appears to have been negligible. Except for changes following a Government decision to increase the minimum thermal performance of housing which used PAS 4244 as a starting point, there has been no further change in the code that can be directly attributed to the tools reviewed.

3.2 Accessibility and functionality

The NZBC clause D1and G1 requires buildings with public access to provide access and facilities for disabled people and access to personal hygiene facilities. These requirements relating to access do not apply to residential buildings. There remains a persistent resistance to any appropriate specification of accessibility and functionality performance dimensions in building legislation. New Zealand has been slow to respond to the international movement towards lifetime/universal design of housing, despite strong lobbying for lifetime design in residential housing for over two decades, in particular from disability advocates.[5] The 2012 report commissioned by MBIE and the Office of Disability was prompted precisely by that concern.[6] The nature of evidence and attempts to promote the inclusion of accessibility and functionality performance are set out in *Doing Better: A review of beyond New Zealand Building Code research and traction through residential building accessibility and energy efficiency tools.* That report is attached as Annex B.

LifeMark is the only accessible housing accreditation in New Zealand. It is based on the view that it is more cost effective and less disruptive for households to design in accessible

[3] https://www.nzgbc.org.nz/Category?Action=View&Category_id=107

[4] Roman Jaques (2015) Measuring our sustainability progress: Benchmarking New Zealand's new detached residential housing stock. BRANZ Study Report SR 342

[5] See Annex B, and Scotts, Saville-Smith and James, 2007 for a review of international trends in accessible housing.

[6] Saville-Smith, K., and Saville, 2012.

features at the planning stage, rather than retrofit them later in response to residents' needs. Like Homestar and HSS it is a voluntary standard and is designed to inform both the supply and demand ends of the value chain.

Compared with the research investment made into residential energy performance, the research investment into accessible dwellings has been and remains tiny (see Section 5). There is considerable reliance on overseas research to demonstrate efficacy and impact. However, the application of international research to the New Zealand context is problematic because the characteristics of New Zealand houses are significantly different from housing stocks overseas. New Zealand and overseas research that has been used to demonstrate need and to build a value case for accessible housing is presented in the second report, *Doing Better: A review of beyond New Zealand Building Code research and traction through residential building accessibility and energy efficiency tools.*

LifeMark uses a variety of promotional pathways. Nevertheless, uptake has been modest and considerably below the 8,000 accessible homes needed every year for 10 years to make up the deficiency in high standard lifetime homes. See Annex B *Doing Better: A review of beyond New Zealand Building Code research and traction through residential building accessibility and energy efficiency tools* for an extensive discussion of take-up.

LifeMark is an example of innovation within a system where housing innovation is fragmented and unsupported by coherent policy and planning frameworks. LifeMark goes beyond the very limited focus of the current code in three fundamental ways. First, LifeMark promotes accessible features in residential buildings. While accessibility of public buildings is necessary, those regulations do nothing to address the problems of poorly functioning residential dwellings. Second, the tool highlights that people of all ages and abilities can benefit from lifetime design; it is not only for those with a disability. Third, by taking the NZ Standard Specification 4121 as a minimum baseline, LifeMark goes beyond those requirements to put in place best practice standards for accessible buildings.

4. RESEARCH REVIEW ON FACTORS AFFECTING TAKE-UP

The review of international research focused on the factors affecting the take-up of research-based innovations that would allow the building industry to take dwellings beyond the minimum building performance as set out in the relevant code.

In the context of dwelling accessibility and functionality, the most recent New Zealand review into the conditions that prompt take up of better than regulated dwelling performance by the building industry and consumers was commissioned in 2012 by the Ministry of Business, Innovation and Employment (MBIE) in partnership with the Office for Disability Issues. *Getting Accessible Housing: Practical Approaches to Encouraging Industry Take-up and Meeting Need* [7] focused on identifying the different levers that could be used to improve the supply of life-time design housing through an analysis of relevant international research. It examined research on universal design, life-time design and the accessibility and

[7] Saville-Smith and Saville, 2012.

functionality of dwellings. It also reviewed research related to the conditions which prompted take-up of low energy and energy efficiency solutions within the building industry.

The 2012 review, *Getting Accessible Housing: Practical Approaches to Encouraging Industry Take-up and Meeting Need*, found that where innovations were taken-up and widely delivered by the building industry:

i. The innovation does not require significant reworking of the existing industry relationships, designs, or labour processes. That is, they tend to be 'plug and play' products.
ii. The adoption of new materials or products tends to be driven through manufacturers and product suppliers.
iii. Some innovative products, such as heat pumps and downlighting, are promoted by both direct marketing to householders and housing sector suppliers as well as to builders and developers.
iv. The new products, processes or materials that have limited impact on building consent requirements and tend to be more attractive to the industry than systems that require consenting.
v. Innovations that generate low or no hump costs for builders and developers are more likely to be adopted as are innovations that are perceived to be easily accommodated within pricing structures prevailing in the market.[8]

Innovations that are widely taken up have crossed the chasm between 'early adopters' and the 'early majority'. Jumping the chasm involves two dynamics. The first is the demonstration of practicality. The second dynamic is social proof or informational social influence. That is, later adopters take up innovations as an emulation of previous adopters. Under those conditions, the take-up of new products, materials and designs become effectively self-propelling.

The 2012 review identified the levers that successfully shifted innovation and performance enhancements from early adopters to an early majority and set off self-generating diffusion. In the realms of accessible housing, energy and thermal performance, the review found that the research identified five broad sets of levers:

- regulatory and government controlled instruments;
- investment, subsidies, taxation and other economic and market-based instruments;
- accreditation;
- planning and procurement;
- capability development, information provision and demonstration.

The 2012 review noted that research on the efficacy of different levers, or sets of levers, show the importance of using multiple levers for change. Furthermore, the array of effective levers includes but is not restricted to regulation. With regard to promoting willingness and ability to deliver accessible housing, the international reviews show that successful delivery of

[8] Hump costs are the initial investments in new plant, skills, re-design of labour processes, or other changes need to implement new processes. There may also be 'double running' costs when the introduction of new processes or techniques or systems requires both the old and new systems to operate in parallel for a period of time.

accessible housing is one aspect of a wider societal commitment to universal design and accessibility.

To avoid unnecessary duplication with the 2012 review, our approach was to review research subsequent to 2012, and consider the extent to which that later research diverges, elaborates or simply restates the findings of previous research. The literature search scope and method are outlined in the report *Taking-up of Research-based Solutions to Do Better Building: International Research Review* (Annex C). In all, 16 papers published since 2013 were reviewed. The systematic review analysis of those papers is included in the annotated bibliography in Annex E.

This review of more recent literature reiterates and reinforces the idea that that innovation and take-up happen where it is easy and inexpensive for the industry to incorporate into existing practice, where it has limited impact on consenting requirements and where there is direct marketing to householders.

To encourage the building industry to take-up innovation with performance benefits, the research identified the importance of:

- Development of professional capability.
- Technology and design research and development.
- Ability to use innovation to differentiate from competitors.
- Clear value cases around the rewards and benefits of take-up.
- Innovative collaboration in design, development and marketing among stakeholders, including regulators, designers, providers and consumers.

The 2012 report's conclusions about the most effective levers for a transformational approach are supported by the recent literature reviewed. In particular, that literature places a strong emphasis on the efficacy of a package of instruments for transformation, tailored to institutional, market and cultural conditions and with a set of unifying goals. There is also support for legislation and regulation as a fundamental component to drive change. Voluntary standards and informational levers are considered to be important, but insufficient and often ineffective on their own.

5. THE RESEARCH PLATFORM

Annex E provides an annotated bibliography of the research reviewed in the course of this programme. That bibliography includes:

- Abstracts of energy-related and accessibility performance related research in New Zealand supported by the National Library and a search of the BRANZ indexes as well as VUW's indexing of theses.
- Summaries of results of systematic review and analysis of accessibility research.
- Summaries of results of systematic review and analysis research into take-up.

The energy/thermal performance research and other relevant research was primarily accessed by way of two New Zealand focused databases, both supported by the National Library of New Zealand. The first was NZResearch which collects research papers and related sources from universities, polytechnics and research organisations (including BRANZ). Index New Zealand (INNZ) is accessed through the National Library of New Zealand website. It

contains abstracts and article descriptions from about 1,000 New Zealand newspapers and periodicals from the 1950s to the present day. Not all New Zealand research is cited in those databases – notably where no formal publication resulted or where the work is still in progress. Neither database includes "confidential" or "private" research documents, such as University theses, held in libraries but for which permission has not been obtained (or has been withheld) to make them publicly available.

Accessibility related research both international and national was accessed by way of institutional publication searches in New Zealand research organisations and funders, grey literature references found through Google, Researchgate, and Scholar engines, and international journal search engines. As previously noted, accessibility research and research regarding industry take-up built on the extensive work reported in a 2012 review and did not 're-review' the research included in that review. There were sixteen primary research papers that extended those found in the 2012 review *Getting Accessible Housing: Practical Approaches to Encouraging Industry Take-up and Meeting Need* Most of that literature focused on what might be broadly referred to as sustainable housing. Within that literature, twelve papers focused solely on or included energy efficiency. Eight papers included other sustainability aspects of dwelling performance in addition to energy efficiency, such as water efficiency, indoor environmental quality, building durability and resilience to natural hazards and climate change, carbon footprint, materials toxicity and dwelling size. Further sustainability aspects considered wider environmental impacts of residential development, such as lot size, dwelling density, walkability, and land impacts. Only four articles were concerned with universal design or accessibility.

Table 1 gives the simple count of items returned from the overall NZResearch database for New Zealand Building Code and energy efficiency after non-relevant items had been removed (search words or phrases are underlined). Similar analysis was not required for accessible design, as out of the 222 items found: 213 were not relevant; 1 examined life cycle analysis; two were concerned with issues of fire egress from commercial buildings; while just 6 related to the provision of accessible design in buildings. Table 1 shows that for the search term New Zealand Building Code just under half (47%) of the items came from the University of Canterbury, with the University of Auckland (15%), BRANZ (13%) and Unitec (7%) accounting for another 35%. The remainder came from other universities. The search findings for energy efficiency were more equitable, with the universities of Auckland (19%), Canterbury (16%), Waikato (13%) and Massey (12%) along with the Energy Efficiency and Conservation Authority (EECA) (12%) each providing very similar proportions.

Search term:	New Zealand Building Code		Energy Efficiency	
Source	**%**	**Count**	**%**	**Count**
Canterbury	47%	76	16%	94
Auckland	15%	25	19%	111
BRANZ	13%	21	4%	25
Unitec	7%	12		
Waikato	3%	5	13%	72
EECA			12%	68
Massey			12%	69
Other sources				
Other Universities	14%	23	23%	132
TOTAL	100%	162	100%	571

Table 1: NZResearch Results for New Zealand Building Code and Energy Efficiency– Sources

Search term:	New Zealand Building Code		Energy Efficiency	
Topic	**%**	**Count**	**%**	**Count**
Structure (inc seismic)	38%	50	6%	4
Fire	25%	33	3%	2
Other clauses	13%	17		
Other issues	20%	27	7%	5
Energy Efficiency	4%	5	85%	61
Accessibility	1%	1		
TOTAL	100%	133	100%	72
NZBC related		82%		13%

Table 2: NZResearch Results for New Zealand Building Code And Energy Efficiency – Topics

Of the 162 items counted in Table 1 for New Zealand Building Code, 133 or 82% of these are relevant to this research. In the case of energy efficiency, just 72 out of 571, or 13% are relevant. Three topics - structure, fire and other issues - together accounted for the remaining 15% of the items. For New Zealand Building Code the most popular topics identified were structures (including seismic issues) and fire which together accounted for 63% of the items. Relevant energy efficiency accounted for just 5 items or 4% of the total, and accessibility just a single item. Table 3 shows a significant investment concentrated on BRANZ and its publications.

Organisation/Type	Industry Magazine	Masters	Paper	Journal	Report	TOTAL
BRANZ	7				8	15
Unitec		2	2	2	1	7
Otago		2	1			3
Other University		2	2		2	6
Other					2	2
TOTAL	7	6	5	2	13	33

Table 3: Energy Efficiency Publications by Originating Organisation and Paper Type

Of the thirty-three bibliographic items related to energy efficiency, the vast majority were traditional research reports. Only seven were magazine articles. This contrasts with bibliographic references to accessibility. As Table 4 shows the vast majority of references around accessibility were magazine articles and almost a third of those were published by non-research or sectoral organisations.

Organisation/Type	Industry Magazine	Book	Masters	Journal	Report	**TOTAL**
BRANZ	13		1		3	17
Other/sectoral	8					8
Waikato				1		1
TOTAL	21		1	1	- 4	26

Table 4: Domestic Building Accessibility Publications by Originating Organisation And Type

A total of 26 publications were identified as dealing with issues of accessibility in domestic buildings (i.e. non-commercial building). Five (19%) were from research databases in NZResearch.org.nz while 21 (81%) came from the more general articles in INNZ. This is almost the exactly opposite of the energy efficiency articles, suggesting a greater non-research interest in domestic building accessibility. Table 4 shows that, as with energy

efficiency, BRANZ was the largest source of publications on domestic building accessibility. Only a single master's thesis was identified, in this case from the University of Waikato.

As Figure 1 and Figure 2 show, there is very limited research focus on issues of accessibility relative to energy efficiency. Even when a broad definition of accessibility is taken to include papers with a variety of topics and fire respectively, there are more than four times the number of relevant papers in relation to energy efficiency.

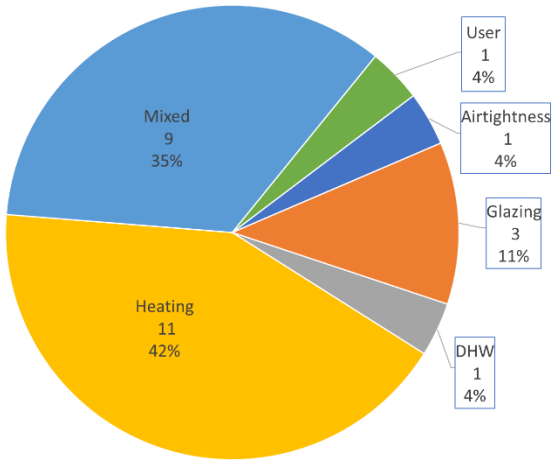


Figure 1: Energy Efficiency Research (Total = 26)

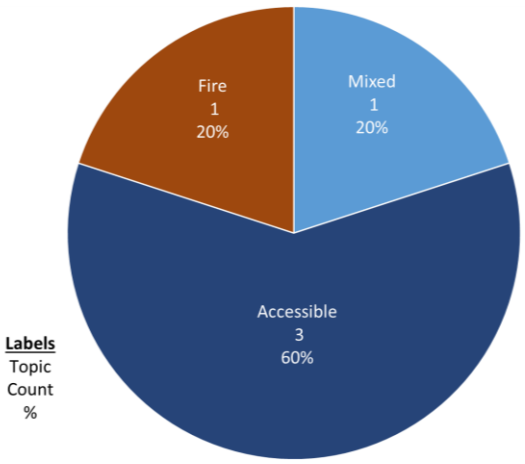


Figure 2: Accessibility Research (Total = 5)

In relation to the searches in the New Zealand research bibliographies, the following conclusions can be drawn:

- **A limited set of sources**: Both NZResearch and IndexNZ show BRANZ to be a major source of relevant research, with reports freely available and supported by publication of articles in BUILD magazine, or in the case of accessibility a specialist book.
- **Uneven interest in the performance dimensions**: Research topics relevant to the NZBC in the NZResearch database were related to fire and earthquake. Energy efficiency was not represented among the most prevalent research topics.
- **Limited coverage of thesis research:** Of the 7 relevant master's theses found, 1 considered accessibility for Maori aging-in-place, 1 improving glazing efficiency and 5 were concerned with space conditioning or thermal comfort.

Those findings suggest that there is not an untapped reservoir of research which could be used to leverage or source research-based solutions that would support the building industry to go past the minimums set out in the NZBC.

The systematic review and review of accreditation tools largely confirms those findings. It is notable that dedicated websites operated by accreditation providers or research providers and funders are an important access point to research related to broader issues of sustainability and accessibility respectively. It is notable that both energy efficiency and sustainability have attracted research funding through multi-year funding from the BRANZ Levy (internal and external), the Health Research Council, the Public Good Science Fund, and government agencies including EECA and MBIE's building and housing sections. Examples include the

Household Energy End-Use Programme (HEEP), the Healthy Housing Programme, the Beacon Consortium, and Sustainable Cities. By way of contrast, there has been minor investment in usually short-run, narrowly defined research around accessibility funded by the now defunct Centre for Housing Research Aotearoa New Zealand (CHRANZ), Ministry of Social Development, and the BRANZ Levy. Access to that research tends to be by way of websites operated by commissioning agencies or the research provider. Some of that research is now not easily accessible because of organisational change.

6. CONCLUSIONS AND WAYS FORWARD

The notion of going beyond the code as a meritorious venture embeds a variety of assumptions and ideas. The first is that while the NZBC is seen by regulatory agents as setting a minimum performance standard, there are opportunities and good reasons to exceed those minimum standards. Indeed, by focusing on performance and releasing the industry from prescriptions of how to build, it was hoped that the legislation would allow the industry to push beyond the minimum regulatory requirements around building performance and, by the industry choosing to do better, lead to the minimums in the code being increased. The second, is that there is a substantial research base which has not yet infiltrated the industry and which, if unlocked, would prompt the industry's 'performance stretch'.

From a review of research down to Masters level undertaken in New Zealand relating to exceeding the minimum aspects of thermal performance and access, this research has not uncovered research-based solutions, standards or measurement unknown by either the industry, advisors to the industry such as BRANZ or even consumers. On the contrary, there are a range of research-based accreditation tools which, while in the public arena, are largely ignored by industry. This is despite evidence that there is consumer demand for performance not required under regulation. This inability to get a response to desire performance from the building industry is clearly an experience for those commissioning dwellings among those seeking universal design.[9]

The report undertaken in this research programme entitled *Taking-Up of Research-Based Solutions to Do Better Building – International Research Review* and attached as Annex C shows that success in driving performance improvement has required a multiplicity of approaches. Legislative support is, however critical. Internationally opportunities for "doing better" have often been supported by incentives ("carrot") while minimum requirements have been enforced by legislation ("stick").[10] While the minimum is mandatory, improvements in (for example) energy efficiency can be encouraged through access to lower interest loans, special tariffs or even just official recognition of doing better – this later approach has been used in Canberra where the energy performance based on a standardised analysis must be made available as part of all housing transactions, whether for renting or selling. In other cases, a "ratchet" approach is used – incentives are offered to "do better", until the large

[9] Saville-Smith, Fraser and Saville-Smith, 2016

[10] A review of these types of approaches for both accessible dwellings and for improved energy performance in the residential and non-residential sectors can be found in Saville-Smith and Saville, 2012.

majority of the market is doing better and this becomes the new minimum requirement within the legislation.

Most importantly, this research calls into question the adequacy of New Zealand's building legislation itself. While in energy/thermal performance the legislation and the associated NZBC recognises that dimension and sets performance standards for it, this is not the case for the accessibility and functionality of dwellings. The 'model' of going beyond the minimum becomes extremely problematic where the minimum is zero and the performance dimension itself is fragmented, inadequately specified and the legislation excludes that performance from application to residential buildings.

What the unevenness of the NZBC in handling energy/thermal performance relative to performance around accessibility does show is that having dimensions of residential building performance recognised in building legislation and regulation is crucial both to wide scale building industry take-up of performance enhancing solutions and research investment. Research investment into and research activity around net benefits, appropriate measurement or, and technical/product solutions around specific dimensions of performance is low where there is no legislative imperative to address performance. Low take-up inhibits performance enhancing solutions from crossing the chasm from early adoption to more widespread market take-up. Research under-investment and low take-up establish vicious cycles in which a lack of research is cited as the basis for not incorporating requirements into the legislative and regulatory framework.

In consequence, it is clear that research is an important element in improving residential dwelling performance. However, the often implicit view that limited take-up of performance enhancement is primarily a failure in research-based knowledge transfer is almost entirely overstated. Both New Zealand and international research into take-up of performance enhancing solutions consistently shows that a concerted and multi-pronged approach is required. That approach requires both a robust investment pathway into relevant research and combines regulatory, industry incentives, consumer education and accreditation as well as industry development.

The research contained in Annexes B-E and summarised here shows that reliance on non-regulatory mechanisms generates poor take-up. This is certainly the case for HomeStar and LifeMark. Moreover, there are a series of undesirable activities on the part of the industry. Those include:

- '**Wash' problems** – that is, the industry making claims to sustainability, accessibility, age-friendliness and so forth where there is little verification or the alleged standards used do not move significantly beyond the minimum.
- **Problems of premium pricing** – that is, the tendency for performance or amenities to be tied to significant increases in price beyond the cost of design or delivery.
- **Poor responsiveness** to consumer demand on the supply-side.
- **Lack of acceptable and accepted solutions** which exacerbate the impact of low skill in the industry and anxieties and inconsistencies in the regulatory regime.
- **Low levels of engagement** of the Government in its procurement regimes and commissioning of housing.

The problems of 'wash' and 'premium pricing' are clear evidence that the industry is aware of consumer demand and are choosing to manage that demand by appear to be responsive to

it or by seeking additional rewards for response. The latter occurs even where the costs of meeting those demands would be marginal and in come cases without direct costs.

There has also been a view that low take-up is due to an inherent and widespread inertia in the building industry manifest in a hesitancy to adopt new designs, practices, materials and products. That view, however, sits uneasily with the succession of building typologies which have emerged in the market over time. Nor does it sit easily with the building industry's adoption of a changing array of products and materials such as heat pumps, sheet cladding, and downlights. Nor can the tendency be attributed to a lack of clarity around the pathways to better performance. Both in the domain of energy and thermal performance and in accessible housing there are well-specified, research based accreditation tools.

What are the conditions that have prompted pushing beyond minimum code requirements in the past? For example, in the energy clauses significant lifting of statutory requirements as well as raised expectations and delivery have been observed. The conditions that have driven that forward may be listed as follows:

- Recognition in the Building Act and the code and the setting of minimums.
- An in-government champion for energy efficiency (EECA) that has:
  - Instigated significant public and industry promotion.
  - Provided incentives for take-up of solutions.
  - Promoted code change.
- A broad base of research with:
  - Cost-benefits studies across a range of outcomes from fiscal benefits to social and health benefits.
  - Technical studies to support the measurement and verification of performances.
  - Resource use studies.
- Agreed measures which allow focus on the performance standard.
- Plug and play products and design solutions.
- Industry and government investment in and promotion of accreditation tools.

Overall, although there is a limited range of research regarding the efficacy of particular levers or sets of levers, experiential evidence combined with research evidence suggests that the delivery of improved performance is contingent on:

- A multi-layered approach to supporting innovation that includes a range of co-ordinated instruments and tools including an actively implemented regulatory framework.
- Attention needs to be given to the building industry capability but also enabling those commissioning buildings and using dwellings.
- The implementation of policies and instruments that interact in a complementary way with other instruments both within the building and construction sector but also other sectors, particularly housing, health, disability, income support and tax sectors.

In relation to research leveraging change, what is clear is that while technical elements of research around performance are needed, particularly in relation to net benefits and 'plug and play' solutions, there is a need to recognise and remedy areas of persistent under investment in performance related research. Research into the research solutions that get traction in industry suggest that research investment needs to be persistent and intensive. While a significant number of programmes have focused on energy efficiency in New Zealand over the last two decades, this is not the case around accessibility. That under-investment needs to

be remedied. Most importantly, in relation to the accessibility and functionality of New Zealand dwellings, there needs to be three foci:

i. Research into the net benefits of accessible dwellings.
ii. Research into identifying the particular barriers to transformation that would provide the best, most immediate and most certain returns on industry change.
iii. Developing research-based 'plug-and-play' solutions easily taken up by industry with appeal to householders, and easily articulated by householders.

Of course, those research sets – net benefits, particular barriers to transformation and the development of plug and play solutions – can be applied to any area of building performance. They are, however, particularly necessary for accessibility and functionality where the legislation fails to incorporate performance requirements into the standards required for residential stock despite our ageing society, a policy commitment to ageing in place, considerable fiscal pressure on home modifications funding, and the fact that most people with disability live, work and play in the community.

In addition, there needs to be strategic research into the nature and operation of building legislation. The dynamics of what is and is not included in building legislation merit research into the:

- institutional and procedural aspects of NZBC review and specification;
- conditions that prompt certain performance dimensions to be recognised in legislation related to building performance; and,
- extent to which current building legislation is adequate in the context of housing needs in an ageing society.

ANNEX A: REPORT 'DOING BETTER – GOING BEYOND THE MINIMUM: INTERIM AND PRELIMINARY REPORT'

Doing Better – Going Beyond the Minimum

Interim and Preliminary Report

LR0508

February 2017

Kay Saville-Smith (CRESA), Nigel Isaacs (VUW) and Bev James (PP&R)

Introduction

New Zealand has regulated building standards and minimum expected performance of materials and buildings since 1932 when the Buildings Regulations Committee and Standards New Zealand were established. The current regime for the regulation of building standards, amenities and performance was introduced in the 2004 Building Act, its 2013 amendments and its associated regulations including the Building Code. The current Building Act follows the approach established in 1991. That is, an approach centred on performance and setting out minimum performance standards supported by the New Zealand Building Code codified in a handbook, Acceptable Solutions and Verification Methods. The most recent handbook of the Code was released 14 February 2014. The performance standards in that handbook are mandatory. Acceptable Solutions and Verification Methods are not. They are merely guidance and exemplars of routes to, and methods of demonstrating, that code compliance has been achieved.

The introduction of a performance-based regulatory system was intended to provide a flexible framework that would provide the building industry, ranging across designers, developers, product manufacturers and suppliers, opportunities to innovate and develop products, processes and systems that would increase the ease of build, decrease costs, and deliver buildings more able to meet the needs of a diversifying population. In short, a regulatory framework that focused on what buildings needed to do, rather than how they were to be designed and built.

By focusing on performance and releasing the industry from prescriptions of how to build, it was also hoped that the legislation would allow the industry to use designs, products and develop systems and specifications that would push beyond the minimum set out in the regulatory requirements around building performance: that the code would set out performance minimums but the industry would choose to deliver, and consumers would demand, buildings that would exceed those minimums; and, by the industry choosing to do better, the minimums in the code could be increased. The anticipation of innovation, increased productivity and stock diversification respectively have largely been disappointed. So too has optimism that regulatory performance requirements would be exceeded by the building industry.

The Research into Doing Better

The past two decades have seen a wide range of research into different aspects of improved building performance, including energy efficiency, environmental impact, lifetime design, improvements in house condition and performance that have positive health impacts, and reduced resource consumption. Much of that research offers solutions and improvements to dwelling performance beyond the current levels of performance required by the NZBC. Some of those solutions have been demonstrated to offer significant individual as well as public benefits at relatively little impact on construction costs. Nevertheless, anecdotal and other research evidence suggests that opportunities to improve dwelling performance beyond the code by using such research-based solutions and products are not being taken up by the industry or demanded by consumers. This raises questions around the effectiveness and currency of the research solutions, their communication to consumers, consumer decision

criteria and influences when considering their spend on a new build or renovation, and how consumers and industry source information to inform decision-making, as well as the dynamics around limited take-up. To address those broad questions, the research explores three dimensions of research-based innovation to improve dwelling performance:

- To what extent are the research-based findings, completed over the past two decades that could lead to 'beyond code' dwelling performance, still current or superseded by other research-based solutions?
- To what extent have those research-based solutions been recognised and promoted by the building industry or demanded by consumers? What has their impact been on the new build and renovations market?
- What have been the determinants of take-up or non- take up of these research-based solutions?

By addressing those questions, this research is designed to meet broader objectives to:

- Identify ways in which researchers can better target and promote research-based solutions that allow the industry and home owners to improve the performance of dwellings beyond the NZBC baseline.
- Identify industry and consumer barriers to take-up of research-based solutions.
- Identify the range of key performance and cost metrics as well as processes critical to take-up of research based solutions.

This report provides a preliminary note highlighting key aspects and dynamics emerging from the review to date. It does not detail the substantive material but focuses on the framing of the idea of 'beyond the code', identifying tools that have had some success in going to market and encouraging the industry and consumers to 'do better', and the conditions that encourage take-up of products, systems and designs that 'do better' including increasing the performance requirements embedded in regulation.

Doing Better – What is Beyond the Code?

Residential building in New Zealand can 'do better' than code in one of two ways:

- Firstly, the building industry can deliver dwellings that exceed the standards set out in the NZBC.
- Second, the building industry can deliver performance which is not specified within the NZBC.

This review has focused on three domains related to private dwellings: access, services and facilities, and energy efficiency. Those are NZBC clauses D, G and H. In relation to G, the focus is on G1 related to Personal Hygiene. The specification and application of these vary in the current NZBC 2014.

In relation to D1 Access, the specification of objectives and function are clear (Infobox1). Those objectives and the performance requirements in the NZBC associated with them are, under the Act, applied exclusive of private houses and private apartments. The Act explicitly places accessibility, in a contemporary and accepted, sense outside the needs of people with some functional compromise as well as outside the domestic sphere. There is a similar exclusion from the performance requirements in the Code in relation to personal hygiene. Private dwellings are **not** required to meet the performance requirement in G1.3.4 that "personal hygiene facilities provided for *people with disabilities* shall be *accessible*."

Infobox 1 – D Access NZBC – Does not Apply to Private Houses or Private Apartments

OBJECTIVE
D1.1 The objective of this provision is:
(a) Safeguard people from injury during movement into, within and out of b*uilding*s,
(b) Safeguard people from injury resulting from the movement of vehicles into, within and out of *building*s, and
(c) Ensure that *people with disabilities* are able to enter and carry out normal activities and functions within *building*s.

FUNCTIONAL REQUIREMENT
D1.2.1 *Building*s shall be provided with reasonable and adequate access to enable safe and easy movement of people.
D1.2.2 Where a *building* is provided with loading or parking spaces, they shall be constructed to permit safe and easy unloading and movement of vehicles, and to avoid conflict between vehicles and pedestrians.

PERFORMANCE
D1.3.1 *Access routes* shall enable people to:
(a) Safely and easily approach the main entrance of *building*s from the apron or *construction* edge of a *building*,
(b) Enter *building*s,
(c) Move into spaces within *building*s by such means as corridors, doors, stairs, ramps and lifts,
(d) Manoeuvre and park cars, and
(e) Manoeuvre and park delivery vehicles required to use the loading space.
D1.3.2 At least one *access route*

While there are distinctions in the other clauses between private and non-private dwellings as well as between dwellings and other buildings, both G and H embrace clear specification and provide performance standards attached to private dwellings, although not always for all their users. Under those conditions, 'doing better' or going beyond the code for G and H tends to fall within the category of extending the existing performance standards. Doing better and going beyond the code in D means both a decision to apply the code to residential buildings **and** developing and applying a set of performance standards.

Tools Taking Industry and Dwellings Beyond Code

There is no doubt that some dwellings are built beyond code in these and other areas of performance. All dwellings with, for instance, a level entry shower or widened doorways or extended turning circles in the kitchen may be considered beyond code. Similarly, as Albrecht Stoecklein's work shows, there is a smattering of dwellings in New Zealand that have consciously sought to become zero energy dwellings.[1] These are, in essence, bespoke dwellings. While these may present opportunities to test innovations and the performance impacts of designs, plant, products and systems, the evidence suggests that these bespoke dwellings do

[1] Albrecht Stoecklein, Yuan Zhao, Lauren Christie and Lisa Skumatz (2005) The value of low energy technologies for occupant and landlord. BRANZ Conference Paper CP112.

not have a significant impact on innovation take-up. In short, they may be beyond the code, but they are unlikely to provide a route for mass adoption within the industry.

Both here and overseas, driving dwelling performance higher than minimum regulated requirements in the general new built housing stock has been pursued through the development of accreditation, performance and verification tools. These tools typically are directed at:

- Providing the building industry with pathways, standards and measures to do better, often on a progressive basis.
- Verifying beyond minimum performance.
- Generating recognition among consumers of better than minimum performance and, where there is no minimum such as in relation to accessibility and personal hygiene functionality of all people irrespective of life stage and capacity, defining performance standards.

In the New Zealand context, four tools have emerged as accreditation tools and 'standard setters': Homestar, the Beacon High Standard of Sustainability (Beacon HSS), WELS, and LifeMark (Infobox 2). Most are supported by training and or verification processes. There are also tools such as ALF that were used to help the industry to calculate the Annual Loss Factor for thermal heat loss in designing dwellings. The latter, as ALF eventually became in relation to H1 Energy, can become the accepted method for demonstrating a regulated performance standard as well as performance beyond the code.

Not all these tools are mutually exclusive. For example, there is a significant interface between the Beacon HSS and Homestar. Overlaps arise out of institutional interlocks (centred on BRANZ and EECA) as well as the sharing of a base of research from which both draw. They do not entirely overlap, however, and the expectations of performance promulgated in the Beacon HSS differs from Homestar in both scope and standards.

Infobox 2 – Key Accreditation Tools
Homestar - www.homestar.org.nz Deals with health and comfort –insulation, accessibility, moisture management, water use minimisation, waste management, use of site, security, safety etc
Beacon High Standard of Sustainability (HSS) - http://www.beaconpathway.co.nz/further-research/article/beacons_hss_high_standard_of_sustainability – a tool to help homeowners understand the performance of their homes. The HSS sets benchmarks for 5 key performance areas energy, water, indoor environment quality, waste and materials.
WELS - http://www.mfe.govt.nz/fresh-water/tools-and-guidelines/water-efficiency-labelling-scheme "The WELS applies to six product classes: clothes washing machines; dishwashers; lavatories; showers; taps; and urinals." – 2008 proposal was to include low flow showerheads in NZBC. See http://www.scoop.co.nz/stories/PA0810/S00187.htm
Lifemark - http://www.lifemark.co.nz/ "Lifemark™ rated homes are designed to be usable and safe for people of all ages and stages. They are easy to live in – for a lifetime."

Market Traction and Research

None of these tools has a great deal of market traction. Although both LifeMark and Homestar have some prominence, they struggle to generate mass innovation in the new-build stock. The market impact is characterised by:

- 'Wash' problems – that is, the industry making claims to sustainability, accessibility, age-friendliness and so forth where there is little verification or the alleged standards used do not move significantly beyond the minimum.

- Problems of premium pricing – that is, the tendency for performance or amenities to be tied to significant increases in price beyond the cost of design or delivery.
- Poor responsiveness to consumer demand on the supply-side.
- Lack of acceptable and accepted solutions which exacerbate the impact of low skill in the industry and anxieties and inconsistencies in the regulatory regime.
- A lack of non-regulatory levers in the supply side or the demand-side to prompt take-up, either within the building sector or ratcheting through other sectors.
- Low levels of engagement of the government in its procurement regimes and commissioning of housing.

A desire to avoid cost driving is often used by the industry as an explanation for not going beyond the code. There are also arguments around the lack of research demonstrating:

i. The practicality of beyond code solutions including the delivery of desired performance.
ii. The cost-effectiveness of beyond code solutions in relation to benefits to the consumer; and
iii. The impacts on build prices.

Those arguments are difficult to sustain. Arguably there could be improvements in the comprehensiveness of the research base underpinning the current range of accreditation tools. However, even where research has provided robust data on each of those issues, there has not necessarily been take-up of the tools or the solutions. Nor have the standards they suggest been incorporated into the NZBC, although in the past H1 has shown significant shifts in the NZBC performance requirements that has been clearly aligned to research such as the Household Energy End-Use Project.

Conditions that Lead to Doing Better

This raises questions around the conditions that have prompted pushing beyond minimum code requirements both through ratcheting up the regulatory minimums and by widespread adoption of beyond code performance.

In that regard, it is clear that it is in the energy clauses that significant lifting of statutory requirements as well as raised expectations and delivery have been observed. The conditions that have driven that forward may be listed as follows:

- Recognition in the Building Act and the Code and the setting of minimums.
- An in-government champion for energy efficiency (EECA) that has:
  - Instigated significant public and industry promotion.
  - Provided incentives for take-up of solutions.
  - Promoted Code change.
- A broad base of research with:
  - Cost-benefits studies across a range of outcomes from fiscal benefits to social and health benefits.
  - Technical studies to support the measurement and verification of performances.
  - Resource use studies.
- Agreed measures which allow the performance standard to be focused on.
- Plug and play products and design solutions.
- Industry and government investment in accreditation tools.

Other aspects of performance have been less advantaged in getting traction. Notably much of the traction around Homestar has been gained through leveraging off the energy efficiency route. LifeMark has gained traction because of initial joint investment by central government and CCS-Disability Action. There is also a raft of research and demographic analysis that identifies the benefits of accessible housing within the general stock. Doing better in that space, however, continues to be inhibited by the exclusion in law of private dwellings from parts of G and D aspects of accessibility. There is, consequently, no minimum to leverage off. While LifeMark provides a clear specification of measures and standards, there is no central government commitment to those in relation to its own procurement, nor is there industry or public promotion from the centre. Research shows, considerable variability around awareness and provision within the industry as well as the consistency of local authorities in dealing with aspects of universal design and accessibility that may appear to compromise other aspects of building performance.

Those conclusions need to be treated with care. Further analysis is being undertaken and these comments should be treated as preliminary and interim. What those conclusions suggest, however, is that it is not deficiencies in research or its communication that is at the heart of doing better. A robust evidential base through good and comprehensive research is important, but it is not sufficient. There are, however, opportunities for research to be more nimble and engage at points when key players are more likely to have both a desire and an opportunity to do better. Those points will be discussed at more length in the final report.

ANNEX B: REPORT 'DOING BETTER – A REVIEW OF BEYOND NEW ZEALAND BUILDING CODE RESEARCH AND TRACTION THROUGH RESIDENTIAL BUILDING ACCESSIBILITY AND ENERGY EFFICIENCY TOOLS'

Doing Better

A review of beyond New Zealand Building Code research and traction through residential building accessibility and energy efficiency tools

LR0508

April 2017

Bev James (PP&R), Nigel Isaacs (VUW), Nina Saville-Smith and Kay Saville-Smith (CRESA)

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

Residential building in New Zealand can 'do better' than the minimum performance standards set out in its building regulation. There is a research base which demonstrates that there is value in surpassing code in the areas of energy efficiency and accessibility. Second, the building industry has tools to deliver improved performance over that which is required by statute as a minimum.

This report presents examples of how research directed at dwelling performance improvement has been transformed into tools which were intended to allow the building industry to do better. This transformation of research into industry guidelines and accreditation tools might be expected to provide a pathway from research to industry transformation. The first set of tools relates to energy performance and is an example of pushing beyond performance requirements already subject to statutory minimums. The second tool, which deals with accessibility and functionality in new built homes, is an example where the current legislation not only does not require minimum performance, but it actively excludes residential homes from accessibility requirements that are mandated for the non-residential building stock.

These two areas were proposed because they both represent areas in which significant value is has been argued to be generated by performance improvement. Similarly, they both are areas in which there has been a long history of unmet consumer demand. Finally, these two aspects of dwelling performance are handled quite differently within the New Zealand Building Code. The parameters of each within the New Zealand Building Code and the requirements and performance required around energy efficiency and accessibility.[1]

This report is structured as follows:

- Section 2 provides a brief overview of the research, its legislative context and the systematic review template methodology used.
- Section 3 describes the research findings on three tools/innovations designed to improve energy performance.
- Section 4 overviews the LifeMark accreditation tool and looks at accessibility as a measure of doing better.
- Section 5 provides some concluding comments.

2. DOING BETTER FOR HOMES

New Zealand's current regime for the regulation of building standards, amenities and performance was introduced in the 2004 Building Act, its 2013 amendments and its associated regulations including the Building Code. The current Building Act is centred on performance standards and is supported by the New Zealand Building Code, Acceptable Solutions and Verification Methods. The Code sets out mandatory

[1] Saville-Smith, Isaacs, and James, 2017.

standards while the Acceptable Solutions and Verification Methods provide non-mandatory methods of achieving or demonstrating code compliance.

By focusing on performance rather than prescriptions of how to build, the current regulatory framework was envisaged as one that would allow designs and products to push beyond performance minimums. It was hoped that the building industry would choose to deliver, and consumers would demand, buildings that would exceed those minimums. Anticipation of innovation, increased productivity and stock diversification has been disappointed.[2]

This research explores three dimensions of research-based innovation associated with going beyond the minimum and doing better. Those are the:

- Extent to which research-based findings completed over the past two decades could lead to 'beyond code' dwelling performance and are still current or superseded.
- Extent to which those research-based solutions have been recognised and promoted by the building industry or demanded by consumers in both new build and renovations.
- Determinants of take-up or non-take-up of those research-based solutions.

This report overviews the findings emerging from the following research activities:

- Definition and description of building industry accreditation tools that offer solutions and improvements to dwelling performance beyond the current levels of performance required by the NZBC.
- For each accreditation tool, evidence of business case development and market take-up, both in relation to consumer demand and industry supply.

This approach is taken for three reasons. First, it allows us to dig-back into the research that has been associated with attempts to improve energy and accessibility performance. Second, it allows us to examine the extent to which transformation from research into industry tools has prompted or not prompted take-up. Third, it provides an opportunity to reflect on the interface between the New Zealand Building Code and the research. All of those issues will be addressed in the integrated report which triangulates this analysis with analyses arising from other components of this research programme.

A systematic review template was developed to interrogate research and commentary related to the selected accreditation tools and other tools and standards (Appendix A). This template was developed to provide an input into the integrated analysis and a systematic capture of narrative, where it existed, in relation to:

- Owning and promulgating body
- Objectives and associated standards from initial version to current version

[2] Building and Construction Sector Productivity Taskforce, 2009; Burke, 2010; Buxton, 1998; Campagnac, 1998; Fairweather, 2009

- Associated business case, rationale and evidential base cited by promulgating body.
- Promotion and implementation pathway including:
  - Self-accreditation or independent audit processes
  - Training
  - Industry access – free or by subscription or pay as you go
  - Householder access – free or by subscription or pay as you go
- Evidence of industry take-up
- Evidence of consumer demand
- Evidence of impact on NZBC.

To locate relevant literature on each of the tools, key agency websites, including EECA, Lifemark, Beacon Pathway, Homestar and BRANZ were searched.

3. ENERGY PERFORMANCE

There have been a considerable number of tools, guidelines and specification claiming to allow consumers demand and the industry to supply dwellings that do better than the prevailing standards of the building code. Three have been selected for this report:

- PAS 4244:2004
- Homestar
- High Standard of Sustainability (HSS).

These are detailed in in sections 3.1, 3.2 and 3.3 below. It should be noted that Homestar and BEACON Pathway's High Standard of Sustainability (HSS) are quite different from PAS 4244:2004 in their targeting, positioning within the value-chain and in relation to the dwelling itself. The former are accreditation tools targeting both the industry and consumers. The latter might be better defined as a guidance tool and a tool to demonstrate compliance. The former are whole house-systems directed, the latter is directed to allowing specifiers to select insulation levels and explore window options.

3.1 PAS 4244:2004[3]

This was prepared to "*provide guidance on the selection of insulation levels and window options to improve the energy efficiency of houses beyond the minimum required by the New Zealand Building Code*."[4] PAS 4244 provides prescriptive specifications for "**code compliant**", "**better**" and "**best**" insulation levels in houses. The performance achieved by these specifications could be achieved by a range of alternative prescriptive specifications. The insulation levels chosen for PAS 4244

[3] Nigel Isaacs was a member of the Standards NZ committee which developed PAS 4244. Unreferenced material provided in that section is based on the committee papers.

[4] Standards New Zealand, 2004, p. 5.

were selected based on the insulation products then currently available and in common NZ use.[5]

Prepared by a Standards New Zealand committee it was prompted by a goal to provide an option to do better than the minimum NZBC thermal performance. The mechanism of a PAS (Publicly Available Specification) was used because a PAS is an ISO (International Standards Organisation) recognised category for documents. While those are not national standards, they are produced by a national standards body. In New Zealand that is Standards New Zealand (SNZ). The process used to develop a PAS is similar to that used to develop a National Standard and this process meets the requirements of the Standards Act 1988. It was believed that this approach would provide industry credibility and foster take-up.

Target groups

PAS 4244 was seen as a way to encourage house builders (client, designer, architect or builder) to build to a level of thermal performance higher than the then current NZBC requirements.

Development of the tool

PAS 4244 had its origins in the interests of the energy sector, building researchers and, subsequently, elements within the building sector. Quantifying the relative importance of thermal insulation and thermal mass in creating comfortable and energy efficiency household thermal environments was a concern of the New Zealand Energy Research and Development Committee which awarded a contract in 1974 to the Building Research Association of New Zealand (Inc) to explore issues of thermal mass in housing.[6] In 1994 the Cement and Concrete Association of New Zealand (CCANZ) commissioned a thermal simulation research study to further explore the importance of thermal insulation. This concluded "correctly used, increased mass in housing has the potential to offer energy and thermal comfort benefits."[7] A further report was commissioned from BRANZ which came to similar conclusions.[8] CCANZ commissioned further analysis from VUW for the publication of "Designing Comfortable Homes." That document was first published in 2001[9] with a revised edition published in 2010.[10]

In developing the Designing Comfortable Homes, particular attention was given to the diversity of climate conditions experienced in New Zealand. In addition, it was recognised that there was considerable debate around the issue of comfort. Consequently, the research explored the appropriate levels of thermal insulation, glazing and thermal mass based on:

- Three cities (Auckland, Wellington and Christchurch)

[5] Standards New Zealand, 2004, p. 4.
[6] Leslie, 1976.
[7] Isaacs and Donn, 1994, p. 37.
[8] Stoecklein and Pollard, 1998.
[9] Donn and Thomas, 2001.
[10] Donn and Thomas, 2010.

- Three levels of glazing (low, medium & high areas)
- Three variations of mass (low, medium and high)
- Three variations of insulation (code compliance, good practice and best practice)
- A variety of thermal comfort and energy measures:
  - thermal comfort (hours above 26 ^{o}C or hot, 16 – 26 ^{o}C or comfortable and under 16 ^{o}C or cold)
  - heating energy required (24 hours a day heating or 7 am to 11 pm heating)
  - heating sizing for only 7 am to 11 pm heating.

As Standards NZ had been put on a user-pays funding model, it was necessary to seek funds from external agencies. Ultimately funding was provided by EECA, Tasman Insulation, Metro Glass and Glasstech. The research was undertaken at VUW with some technical assistance provided by BRANZ.

The existence of a promotional document for one industry (concrete) led to interest in developing a guidance document suitable for wider use. One author of "Designing Comfortable Homes" moved in 2001 from CCANZ to Standards New Zealand, and in their new role saw a market opportunity to develop the code/better/best concept into a broader document covering different construction types. They convened a meeting in November 2001 bringing in a range of specialists, and developed a plan for a new publication (PAS 4244) by mid-2002. At the time, it was recognised that this proposal represented a maturity within the building sector to recognise that compliance with the NZBC was not "good" design.

PAS 4244 used the same approach as for Designing Comfortable Homes (3 levels of glazing, mass and insulation for the 3 cities). A wide range of the house construction industry, including suppliers, consultants and builders commented on the various drafts of the PAS. The mass industry was not entirely in agreement with the proposed document due to a perception as to the way in which concrete walls (notably hollow concrete block) were treated. This was resolved following discussions with the committee and the PAS was cleared for release in 2003.

The responsible committee had representatives from: Building Industry Authority; Building Research Association of New Zealand Inc.; Employers and Manufacturers' Association; Energy Efficiency and Conservation Authority; Glass Association of New Zealand and the Royal Society of New Zealand. Although these included the authors of "Designing Comfortable Homes", the committee showed the traditionally wide Standards NZ approach to membership.

The development of PAS 4244 had the:

- active support of EECA, the Government agency responsible for the promotion of energy efficiency);
- support of BIA (Building Industry Authority), the government agency responsible for the development and maintenance of the NZBC;
- active interest of SNZ (Standards NZ) as the agency who would benefit from the "sale" of the PAS – although in this case the print run was fully paid for by advertising and the other agencies and businesses;

- active support of major insulation and glazing industries who sold specific products which could be used to meet the generic requirements of the PAS (and as major players while investing partially for the good of the nation and their industry could expect to receive a major share of any increased demand).

Promotion pathways and evidence of take-up

The availability of PAS 4244 supported the proposal for the next (2006) revision of NZS4218.[11] The 2006 paper supporting the revision noted the thermal insulation requirements of PAS4244 'better' provided about 30% improvement on NZS4218:1996, through requiring additional roof, wall and floor insulation and improved glazing. The "better" requirements were comparable to the then Australian 5 star requirements but by no means at the level for a "Zero" or "low heating energy" house. These additional requirements were shown to be cost-effective using the conventional NZBC economic analysis in both warm and cool locations. It was noted that by meeting non-energy (e.g. health due to warmer, dryer indoor environment) or environmental (e.g. reduced electricity demand leading to reduced need for new generation) needs higher levels of thermal performance might be required. PAS 4244 did not deal with high thermal mass construction (concrete, brick, earth) but the supporting analysis showed comparable thermal performance. One consequence of this was the incorporation of high mass tables in the 31 October 2007 edition of the Verification Method H1/VM1 and then in NZS4218:2009.

PAS 4244 has been used to provide guidance on doing better in BRANZ publications, including the construction of more sustainable urban house in Hamilton[12] and guidance for increasing levels of thermal insulation[13]. Beacon Pathway offer compliance with the "Best Practice" recommendations of PAS 4244 as part of a package to increase the rating of an existing house[14]. Although PAS 4244 was not used to define the levels of thermal insulation in the Beacon Pathway NOW house, it formed part of the conceptual development.[15] There is no data available most likely due to the complexity and cost of monitoring the use of the voluntary tool.

The research base

The development of PAS4244 followed a conventional process for standards developments. A draft was developed (in this case based on NZS4218:1996 and "Designing Comfortable Homes"); submitted to the SNZ committee for committee discussion and comment; additional research undertaken and incorporated in the draft; a final committee draft agreed and sent out for public comment; comments collated provided to the committee; agreed changes incorporated and the final document approved by the SNZ Council under the Standards Act. The research built on that undertaken for "Designing Comfortable Homes". Although the thermal simulation

[11] Isaacs and Donn, 2006.

[12] Jaques and Mardon, 'Passive *Design* Strategies'.

[13] Elkink, 'Retrofitting Roof *Insulation'*.

[14] http://www.beaconpathway.co.nz/existing-homes/article/what_a_whole_of_house_renovation_might_look_like

[15] Bayne, Jaques, Lane and Allison, 2015.

programmes have improved in their algorithms and interfaces, the key change which had started to impact by this time was the increasing speed of desktop computers with the consequential increase in the speed of generation of alternative scenarios.

3.2 Homestar

Homestar rating tool aims to improve the performance and reduce the environmental impact of new and existing homes through:

- Establishing a common language and standard of measurement for efficient, comfortable, healthy homes;
- Raising awareness of the benefits of green homes for homeowners and tenants and the construction industry;
- Creating a value proposition for investment into the attributes that improve the performance of homes, by providing recognition with a star rating;
- Reduce the environmental impact of New Zealand homes; and
- Provide advice enabling the building and construction industry to produce targeted solutions.

Typical new homes built to minimum Building Code standard will achieve 3 - 4 Homestar. A 6 Homestar home will use significantly less energy and water, and will have less moisture or condensation issues, making it healthier to live in and more affordable to run. Table 3.1 briefly compares NZBC requirements with the 6 Homestar recommendations.

Table 3.1 Homestar Recommendations Compared to NZBC[16]

Feature	NZBC Clause H1 Acceptable Solution	6 Homestar
Ceiling Insulation	R 2.9 (NI), R 3.3 (SI)	R 3.6
Wall insulation	R 1.9 (NI), R 2.0 (SI)	R 2.8
Concrete slab	R 1.3	Raft / pod with slab edge insulation, R 2.2
Windows	R 0.26	Thermally broken double glazing, R 0.31
Ventilation	Total opening window area of 5% of floor area	Dedicated extraction in kitchen and bathrooms
Water efficiency	Not required	WELS 3 star shower WELS 4 star toilets WELS 4 star taps

By achieving 6 Homestar, a house design will exceed the minimum requirements of Clause H1 (Energy Efficiency), of the Building Code. The Homestar Certified Tool can be used to check compliance by automatically calculating the Building Performance Index.

Principles and design

The Homestar tool uses a 10 point rating system, similar to comparable overseas tools. A rating of 1 Homestar means it needs significant work, and 10 Homestar indicates international best practice. Most existing New Zealand homes only achieve a

[16] Table adapted from NZGBC, n.d.

2-3 Homestar rating. A new home built only to Building Code would achieve 3-4 Homestar:

- 3 stars or above In the Whole House Thermal credit the dwelling must achieve at least 7.6 out of 15 points. If this is not achieved a maximum rating of 2 stars is available.
- 5 stars or above the mandatory minimum for 3 stars must be achieved. In the Moisture Control credit the dwelling must achieve at least 3 out of 4.5 points In the Whole House Thermal credit the dwelling must achieve at least 10 out of 15 points.
- 6 stars or above the mandatory minimum for 3 and 5 stars must be achieved. In the Internal Potable Water Use credit the dwelling must have dual flush toilets with a maximum 6/3 L/flush) and showers must have a flow of 9L/min or less.
- 7 stars or above the mandatory minimum for 3, 5 and 6 stars must be achieved. In the Whole House Thermal credit the dwelling must achieve at least 11.3 out of 15 points.

There's no one way to achieve a Homestar rating – although houses have to score a mandatory minimum number of points in energy, health and comfort, there are many options in other areas. For example, some people might opt for photo-voltaic panels for solar energy; others may want to score high for good waste practice.

Target groups

The Homestar tool allows tenants and homeowners to assess the health, warmth, sustainability and efficiency of their homes, and those looking to build to make design choices that will maximise the health, sustainability and efficiency of their homes. Through creating a measurable, consistent and reliable (trustworthy) rating, the tool is intended to increase public demand and encourage developers to build better homes.

Development of the tool

In 2008, the New Zealand Business Council for Sustainable Development (NZBCSD) published a two-year study "Better Performing Homes for New Zealanders". It found that if homes were warmer, drier and more water and energy efficient, New Zealand would:

- Achieve 50 fewer hospital stays per day due to respiratory problems (saving $54 million/yr).
- Cut sick days by 180,000 per year (creating a productivity gain of $17 million per year).
- Cut household power bills by $475 million each year.
- Stop houses wasting enough water to fill 9200 Olympic swimming pools per year.

In early 2009, NZBCSD gained industry-wide support for the National Housing Upgrade Action Plan, which identified the need for a single rating tool or framework. This tool would help homeowners understand their home's performance in terms of energy and water use, indoor air quality and internal moisture, and make informed decisions about possible improvements within a household budget. This proposal was presented at the Prime Minister's Job Summit in March 2009, by Jonathan Ling, CEO of Fletcher Building. The Government agreed to support an industry-developed

residential rating tool. Many government organisations were involved in early support, including: Ministry of Economic Development (MED); Energy Efficiency Conservation Authority (EECA); Ministry for the Environment (MfE); and Department of Building and Housing (DBH). EECA, DBH and MfE subsequently went on to provide government financial support.

Launched in 2010, Homestar was developed by the New Zealand Green Building Council (NZGBC), BRANZ and Beacon Pathway, after extensive consultation with experts and organisations across industry and government. Homestar is based on successful international rating tools and adapted for New Zealand's conditions, in consultation with a Technical Advisory Group (TAG) made up of industry experts from across the building industry value chain. In addition to the Government organisations listed above, the TAG included representation from: Building Industry Federation (BIF); Certified Builders Association (CBA); Concrete and Cement Association (CCANZ); Designers Institute of New Zealand (DINZ); Hobsonville Land Company Ltd; Institute of Professional Engineers New Zealand (IPENZ); National Association of Steel-Framed Housing (NASH); New Zealand Building Subcontractors Federation (NZBSF); New Zealand Institute of Architects (NZIA); NZ Wood; Registered Master Builders; and Federation Right House.

The Homestar research base is often mentioned in Homestar promotional material, but there seems to be little of this research background that is explicitly available. Much of the comfort and health value data is likely to be connected to BRANZ's HEEP research and the various research undertaken by the Healthy Housing Research Programme led by the Wellington School of Medicine.[17]

Promotion Pathways

Although Homestar does not certify products or materials, it rewards the use of third-party certification, both NZ[18] e.g. Environmental Choice NZ, and international e.g. GreenTag, GreenRate, Good Environmental Choice Australia, Forest Stewardship Council. The industry considers this sufficiently important to include Homestar references in their advertising e.g." Within the Homestar tool, GIB® can contribute to achieving points in the following areas …"[19]

Promotions also include an annual home owner survey run annually since 2012. The 2014 survey found 91% of New Zealanders rate good sun and 90% good insulation as 'important' or 'very important' when choosing a new home – far outweighing other factors [20.] At the business level, for example, Metlifecare view the competitive advantage of achieving a 6 Homestar Design rating for 17 apartments as worthy of a press release.[21] The Homestar website lists 14 homes[22] which have been Homestar

[17] Isaacs et.al., 2010; Telfar Barnard et.al., 2011; Howden-Chapman et.al., 2011; Howden-Chapman, Crane, Chapman and Fougere, 2011.

[18] See for example: http://www.nzgbc.org.nz/Category?Action=View&Category_id=252

[19] See for example: https://www.gib.co.nz/design/sustainability/homestar/

[20] Green Living Magazine, 2015.

[21] Metlife Achieves Homestar Milestone, 2015.

[22] See http://www.homestar.org.nz/success-stories

certified but there appears to be no data on the total number of houses which have made use of the tool.

Auckland Council's Special Housing Areas (SHAs) have a "6 Homestar Policy", which requires house performance beyond that of the NZBC in the specified areas.[23] However, this intervention will have minimal impact on house performance. There seems little evidence that the SHAs in Auckland are generating significant numbers of dwellings on the ground. According to current, public monitoring reports some 1,342 dwellings had been completed in only 25 of the 154 SHAs within three years up to 30 June 2016.[24]

3.3 High Standard of Sustainability (HSS)

The Beacon Pathway[25] "HSS High Standard of Sustainability®"[26] tool (HSS) was intended to help homeowners and the industry understand:

- The performance of homes;
- How their actions and habits can affect the homes performance; and
- How the environmental footprint of homes might be reduced.

That understanding is supported by a set of achievable benchmarks.

Principles and design

What constitutes a sustainable home by providing a set of benchmarks that define what a "high standard of sustainability in the home is," whilst remaining relatively achievable for a mass market. The HSS sets benchmarks in five key performance areas, based on a whole-of-house approach (Figure 3.1).

Where the benchmark forms part of the NZBC (notably energy) the levels are set above minimum code requirements, but a level below that which would be required for a non-heating energy house based on the capital versus running cost trade-off. For example, based on the requirements of the NZBC, the HSS energy benchmark represented a 35% reduction in energy use in new homes. A separate benchmark was developed for existing homes, which for energy represented a 25% reduction in energy use.

The other four benchmarks (Water; Indoor Environment Quality; Waste; and Materials) are outside the current NZBC, although water was considered as part of the code development. The benchmark levels were developed in a process analogous to that used for the NZBC, but using a wider range of issues than primarily financial payback for selection (or rejection). These included:

- impact on sustainability
- low cost for retrofitting

[23] Auckland Council Special Housing Areas – Frequently Asked Questions; "Homestar in Auckland Special Housing Areas" https://www.nzgbc.org.nz/Category?Action=View&Category_id=200

[24] Ministry of Business, Innovation and Employment, 2016.

[25] See http://www.beaconpathway.co.nz/ for more information.

[26] See http://www.beaconpathway.co.nz/further-research/article/beacons_hss_high_standard_of_sustainability

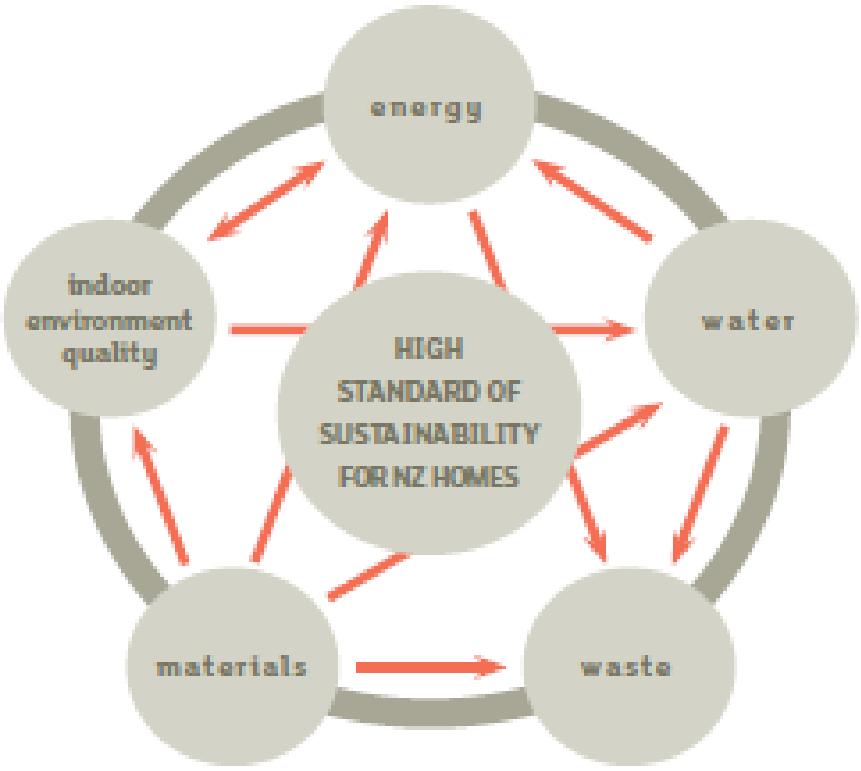
- payback period under 10 years; or
- for new development, can be undertaken at no or minimal extra cost.

Sustainability, in HSS, is considered under five headings,[27]which are in turn underpinned by issues of affordability and future flexibility:

1. Energy use (insulation, heating, hot water, appliances etc.)
2. Water use (low flow shower heads, dual flush toilets, urban rainwater tanks)
3. Indoor Environment quality (temperature, humidity, ventilation)
4. Waste (construction, compost, recycling etc.)

Materials (durable, low-maintenance, reused or easily reusable, renewable or sustainably sources, and promote good health e Although developed on theoretical calculations, the benchmarks were validated by empirical data such as HEEP[28] and the monitoring data generated by demonstration Beacon Pathway NOW Home®.

Figure 3.1: HSS Key Performance Areas



Target groups

The HSS is directed to house owners and builders. By creating a measurable, consistent, reliable and achievable rating, the HSS is intended to increase public demand and encourage developers to build and renovate better homes with lower environmental impacts.

[27] http://www.beaconpathway.co.nz/further-research/article/beacons_hss_high_standard_of_sustainability

[28] Isaacs et.al., 2010.

Development of the tool

Beacon Pathway Ltd started as a Foundation for Research, Science and Technology (now MBIE Science and Innovation) consortium in July 2004 with $6.75 million funding, matched by consortium members, and ended 30 June 2010. Beacon Pathway Ltd was incorporated in 2004 with shareholders BRANZ Inc, Waitakere City Council, Forest Research Institute and Fletcher Building. It was closed in 2011.[29] In 2010 the research was passed over to Beacon Pathway Incorporated with activities aimed at "Transforming New Zealand's homes and neighbourhoods to be high performing, adaptable, resilient and affordable through demonstration projects, robust research and a collaborative approach to creating change." As well as four individual members, four organisational members signed the incorporation application (New Zealand Steel Ltd, CRESA, EECA and Insulpro Manufacturing and Certified Builders Association).[30]

Beacon Pathway's key goal was for the majority of New Zealand homes (90 percent) to achieve a high standard of sustainability by 2012 whether existing or new build. As far as the Beacon Pathway reports take-up, take-up has been minimal despite the slimming down of the HSS into the HomeStar.

In defining this goal, they developed an extensive research base leading to benchmarks for energy and water consumption and checklists for waste, indoor environment quality and materials used in house construction which defines the high standard of sustainability. It was driven by:

- New industry and local authority interests.
- A platform of existing research and tools which BRANZ was particularly keen to integrate. Those included the BRANZ **Green Homes tool** [31] which was developed in the 1990s and included thermal efficiency, appliance efficiency, sustainable materials, recyclable material storage, water economy, site selection, compost system, spatial efficiency, climate change readiness, moisture management, smoke detection, hazardous material storage, and design excellence. A variant for existing homes, the "**Existing Homes**" tool dealt with: GHGs, sustainable materials, waste, water consumption, indoor environment, and indoor air quality, while the "**Renovation"** tool dealt with: household energy consumption, sustainable materials, waste, water consumption, safety, and climate change.[32]
- Emerging concerns with the costs of resource shortages across scale for homes and cities and the implication of the built environment in exacerbating those.

[29] Company number 1488596
http://www.companiesoffice.govt.nz/companies/app/ui/pages/companies/1488596
[30] Society number: 2541300 http://www.societies.govt.nz
[31] Jaques, 2004.
[32] Burgess, 2011, p. 13.

The research base

The HSS started as a set of benchmarks around which a research programme was developed to establish the achievability of the benchmarks and associated value cases. Extensive underpinning research has been published and made freely available through the Beacon Pathway website. As well as using existing research, two NOW Homes® were designed, built and monitored - Waitakere was completed in 2005 and Rotorua in 2006.[33] Nine "middle-income" homes in Papakowhai, Porirua were retrofitted with different packages of interventions in 2007.[34]

There is probably no other environmental performance tool with such a freely available research base. The importance of the ambitious Beacon Pathway leadership, its staff and funders should not be underestimated. The drive to ensure the tool was developed with a consortium and researchers dedicated to practical but ambitious solutions, while the active involvement with industry, national and local government ensured opportunities for its use were encouraged.

Beacon Pathway continues to present at industry, local government and other relevant events. The HSS contributed to a Beacon Pathway, BRANZ and the New Zealand Green Building Council joint venture to develop the Homestar™ assessment tool. The HSS continues to be available through the Beacon Pathway web site and it use is discussed in the Auckland City Council design guidance. There is no clear evidence of HSS take-up in relation to new builds or renovations.

3.4 Summary

Of the three tools considered in this section, Homestar is the most professionally and actively promoted, as it has a dedicated organisation with market presence, employed staff and professional accreditation. This professionalization is also the case for the other NZ Green Building Council assessment tools. Homestar is:

- Supported by BEACON Pathway's HSS
- Has strong links into industry including product and material suppliers, designers and architects, as well as central and local government
- Is used as a marketing tool by local government and industry.

The research chain is not always discernible. Homestar and the HSS represent the phenomenon of accumulated, taken-for-granted research-based information. That is, the research base is not always directly referenced subsequent to the initial development of tools directed to promote action by different actors across the value chain. Finally, the extent of take-up is not clear. Except for changes following a Government decision to increase the minimum thermal performance of housing which used PAS 4244 as a starting point, there has been no further change in the NZBC.

[33] Easton, Karlik Neale, and Jaques, 2010.

[34] Easton, 2007.

4. ACCESSIBILITY AND FUNCTIONALITY

The Building Code requires buildings with public access to have access and facilities for disabled people. These requirements relating to access do not apply to residential buildings. Requirements on access to non-residential buildings are sketchy and implicit in them is a notion of an able-bodied, ideal adult without any compromise associated with sensory, size, mobility or other characteristics. Thus, Clause D1.3.2 of the Code states that at least one access route shall have features to enable people with disabilities to:

a) Approach the building from the street boundary or, where required to be provided, the building car park,
b) Have access to the internal space served by the principal access, and
c) Have access to and within those spaces where they may be expected to work or visit, or which contain facilities for personal hygiene as required by Clause G1 "Personal Hygiene".

The NZ Standard Specification 4121 sets out the performance specifications required to meet the Code for non-residential buildings. For non-residential buildings it states that the design of buildings, facilities within buildings, driveways, car parks, passages and any associated landscaping and accessways should be suitable for use by people with disabilities.[35] In the non-residential building context, the Standard states that design shall be carried out using the principles of approachability, accessibility and usability. Minimum provisions and minimum dimensions for floor space and door openings are specified in the standard. The Standard covers:

- Accessible routes
- Car parks
- Footpaths, ramps and landings
- Entrances, corridors, doorways and doors
- Stairs
- Lifts
- Toilet and shower facilities
- Public facilities
- Places of assembly, entertainment and recreation
- Accessible outdoor public areas
- Accessible accommodation.

The Standard explicitly excludes private residential buildings.

4.1 Accessibility in International Jurisdictions

New Zealand has been slow to respond to the international movement towards lifetime/universal design of housing. The aim of lifetime/universal design is to better prepare for an ageing population and better support people with disabilities, while ensuring that housing suits all ages, from young families to older people. The international interest in lifetime or universal design has been driven by the

[35] NZ 4141:2001, Clause 1.1.1.

demographic ageing of most industrial societies, increasing prevalence of disability (in part due to the demographic transition and also due to increased longevity of those with a disability), and the human rights movement centred on the inclusion and participation of people with disabilities.[36] These trends have positioned accessible housing as a key way of improving living environments and reducing exclusion of the elderly and disabled.

Many international jurisdictions recognise that accessibility requirements for homes reflect:

- The inherent needs and functionality changes of individuals over the life course.
- Structural ageing as well as disability prevalence rates make planning housing stock that is functional and accessible for all increasingly important.
- The housing stock's long life and the considerable sunk investment associated with the built environment and the consequent importance of the stock's functionality over its life course.
- The housing stock is used by many people, not simply the residents.

All those considerations have seen a movement away from the special disabled housing orientation that was evident in the immediate post-war period. In addition, the societal benefits of lifetime design have been shown to be significant. They include public expenditure savings on reduced hospitalisation from accidents in the home such as falls, reduced expenditure on retrofitting home modifications, reduced requirement for in-home care and delayed entry to publicly funded aged residential care.[37]

Popular movements promoting lifetime design have been accompanied by the development of mandatory standards for residential housing in the United Kingdom, European countries, Australia and Japan.[38] But regulations have not emerged in New Zealand and governmental response has been slow, despite strong lobbying for lifetime design in residential housing for over two decades, in particular from disability advocates.

4.2 A Tool for Doing Better in New Zealand

LifeMark is the only accessible housing accreditation in New Zealand. Like Homestar and HSS it is designed to inform both the supply and demand ends of the value chain. LifeMark is a voluntary standard specifically developed for residential buildings. This accreditation tool enables the building industry, home owners, sellers and landlords to build accessible homes and consequently show the high accessibility standard of their dwellings.[39] LifeMark is based on the view that it is more cost effective and less disruptive for households to design in accessible features at the planning stage, rather than retrofit them years later in response to residents' needs.

[36] Scotts, Saville-Smith, and James, 2007.

[37] E.g. see Bridge, Phibbs, Kendig, Mathews and Cooper, 2008.

[38] Saville-Smith and Saville, 2012; Scotts, Saville-Smith and James, 2007.

[39] LifeMark Design Standards Handbook.

LifeMark principles and design standards[40]

The key principles of LifeMark are:

- Usability: design features meet the needs of different ages and abilities over time, without the need for major adaptation of the dwelling in future.
- Adaptability: design features can be easily adapted to the changing needs of residents.
- Accessibility; occupants and visitors of all ages and abilities can access the dwelling independently, safely and easily.
- Safety: design features are proven to prevent injuries such as slips and falls.
- Lifetime Value: features can be easily incorporated into the early stages of design and construction with marginal cost effects.

LifeMark standards set out specifications for building residential dwellings that are safe, accessible and liveable throughout the life cycle. Those standards are very detailed, but broadly cover seven areas:

- Accessing the dwelling
- Getting around
- Fittings and fixtures
- Bedrooms
- Dwelling facilities
- Bathrooms
- Multi-storey access

Table 4.1 provides more detail about the accessible features under each area.

Table 4.1: Summary of LifeMark Accessibility Features

Area	Requirements
Accessing the dwelling	• Car parking space allows for passengers to fully open all doors and move easily around the vehicle • Pathways allow for safe and easy access to the dwelling entrance • Occupants can safely and easily enter and exit a dwelling
Getting around	• Internal doors and corridors facilitate comfortable and unimpeded movement
Fittings and fixtures	• Light switches are at easy to reach heights for all occupants • Power points are at easy to reach heights and away from corners • Window controls and sills are at a height that allows them to be easily opened from a sitting or standing position • Door hardware allows occupants to easily and independently open and close doors • Tap fixtures can be easily and independently operated by all occupants

[40] K. Saville-Smith was a member of advisory council considering the substance and scope of LifeMark.

	• Installation of approved smoke alarm with visual and audio cues
Bedrooms	• Space provides for easy movement around the bed and bedrooms
Dwelling facilities	• Laundry space supports ease of movement and use of appliances and storage space • Kitchen space supports ease of movement between fixed benches and use of appliances and storage space
Bathrooms	• The entry living level has a toilet • The dwelling has a shower that can be easily and independently used by all occupants and visitors
Multi-storey access	• There is provision for a platform lift/stair lift in multi-level dwellings • Stairway are designed to reduce the risk of injury

A LifeMark approved home can achieve 3-, 4-, or 5- star certification. The entry level standard, 3 stars, means that the dwelling meets mandatory LifeMark standards for quality design and is fully adaptable in the future at a minimal cost. The 4-star standard means that a high percentage of LifeMark standards are built in, and the dwelling can be adapted further if required. Homes awarded a 5 star LifeMark are fully accessible now, with virtually all requirements in place.

The LifeMark design standards were revised in August 2016.[41] The revision increased the number of design standards from 60 to 80. The number of mandatory standards for a 3 Star rating was reduced. New minimum standards for a 5 Star rating were introduced. Those design changes reflect the increased density of new developments and technological changes.

Target groups and accreditation

The main target groups for LifeMark can be divided into four broad areas:[42]

- The building industry, including architects and designers, builders and developers.
- Private individuals wishing to buy or build their home.
- Entities providing housing, such as retirement village operators, rest home operators, community housing providers, councils, Housing New Zealand and landlords.
- Health professionals such as occupational therapists.

Anyone can access the 'useful tips' web page for designing an accessible house, the interactive Guide for Homeowners, and download the LifeMark Design Standards Handbook from the LifeMark website. The useful tips page is a quick summary of LifeMark features. The Guide provides more detail, including pictures and plans showing how accessible features can be designed into a home. The Handbook

[41] LifeMark Design Standards Overview.

[42] LifeMark Design Standards Handbook.

provides a detailed specification of the design standards for each of the seven areas described above and lists the standards required for a 3-star, 4-star or 5-star rating.

Householders and builders cannot self-accredit, although there is a facility on the LifeMark website for individuals to self-assess their dwelling through Homescore. While this assessment covers only 20 percent of the LifeMark standards, it provides a quick way of assessing the extent to which the features of the dwelling potentially meet some of those standards. Homescore is in the form of an online checklist covering:

- The pathway to the front door
- The entrance area and front door
- Bathroom location, features and space
- The toilet
- The kitchen design and space
- Bedrooms
- Laundry
- Various fittings such as tapware, light switches and power points.

Applicants pay a fee for accreditation. Plans for the new-built home can be submitted to LifeMark for a formal assessment. Upon completion of the build and submission of a producer statement a final rating is given and a certificate showing the star rating is issued.

4.3 Development of the tool

The development of the LifeMark tool reflected a number of critical engagements and institutional developments. These can be summarised as follows:[43]

- CCS Disability Action (CCS) lobbied Government for accessible housing over many years, including lobbying around the review of the Building Act, which resulted in the 2004 Act. This review did not result in accessibility provisions for residential housing.
- The 2011 Relationship Agreement between the Government and the Maori Party, which sought lifetime design principles and standards to be included in Housing New Zealand new builds, or housing directly leased by Housing New Zealand.[44]
- In 2012 the Human Rights Commission report on disabled people and the built environment recommended extending NZS 4121:2001 to residential housing.[45]

Having struggled over years to get any commitment from Government for regulatory reform, CCS turned to focus on ways that it could work on influencing the market to invest in and deliver accessible housing.[46] Disability Action established Lifetime

[43] Saville-Smith and Saville, 2012; Innovation to improve future, 2012; Human Rights Commission 2012.

[44] Of course, Housing New Zealand stock is a very small proportion of New Zealand's housing stock, about 11.5 percent. Statistics New Zealand, 2014.

[45] Human Rights Commission, 2012.

[46] Innovation to improve future, 2012.

Design Ltd in 2006 and released the LifeMark Design Standards in 2012. Lifetime Design Ltd is a registered charity with a board and a small number of employed staff.

While this initiative initially attracted supplementary funding from Government, it relies on sponsorship and revenue from its accreditation process, and CCS Disability Action remains the leading organisational supporter and funder of LifeMark.

4.4 Promotion pathways and evidence of take-up

LifeMark uses a variety of pathways to promote LifeMark. Its website, http://www.LifeMark.co.nz , is the major platform for dissemination of information about the tool. Also extensively used are social media, including Twitter, Facebook, Pinterest, Houzz, and YouTube.

LifeMark uses champions to widen market influence and encourage take-up of the tool. These champions include accredited partners, product partners and community stakeholders. Accredited partners are building industry companies and developers that build LifeMark homes. They include:

- National franchise building companies.
- Stand-alone building companies.
- Architects and designers.
- Retirement villages and rest home providers.

Product partners provide products that meet universal design standards. The product partners cover windows, kitchen fittings and systems, bathroom fitting, building systems, paint, lifts and smoke alarms.

LifeMark's community stakeholders consist of councils and community housing providers that build LifeMark homes. Age Concern, the advocacy and service provider for older people is also a community stakeholder. Currently there are 23 community stakeholders.

Through their promotion and use of universal design, the accredited partners, product partners and community stakeholders show in real-life situations how LifeMark can be successful. The applicability of LifeMark is also demonstrated through case studies on the LifeMark website.[47] Case studies include private homes, community housing provider dwellings, cohousing, rest homes, retirement village independent living units, and a property investor with accessible homes in his rental portfolio.

LifeMark is also promoted through Lifetime Design Ltd's support of two interior design course that deliver modules on universal design at the Ara Institute Canterbury and UCOL, Palmerston North.[48]

In 2016 there were over 1,500 homes with a LifeMark certificate.[49] In the 12 month period to January 2017, 600 new LifeMark accredited homes were built.[50] Geoff Penrose, general manager of LifeMark has commented that 8,000 accessible homes

[47] See: http://www.LifeMark.co.nz/case-studies/cs-category/homes
[48] See: http://us12.campaign-archive1.com/?u=92d7d9384cfa871fb97ac24bf&id=aa1e4b7b40
[49] http://www.radionz.co.nz/national/programmes/nz-society/audio/20164448/LifeMark
[50] http://www.radionz.co.nz/national/programmes/nz-society/audio/20164448/LifeMark

were needed every year for 10 years to make up the deficiency in high standard lifetime homes.[51] Another estimate, from Prefab New Zealand, is that 140,000 lifetime design homes are needed, with a forecast of an undersupply of 240,000 homes, by 2039.[52]

4.5 Research Base

Compared with the research investment made into residential energy performance, the research investment into accessible dwellings has and remains tiny. There is considerable reliance on overseas research. The application of international research to the New Zealand context is problematic for several reasons. The characteristics of New Zealand houses are significantly different from housing stocks overseas. Compared to the United Kingdom, North America and even Australia, New Zealand is more likely to build detached villas and less likely to build multi-units and apartments. There is a preponderance of timber-framing in New Zealand's residential stock, single-level housing and light-weight materials. In addition, the value-chain, the structure of building costs and planning regimes show significant differences compared to other jurisdictions.

Despite differences between jurisdictions, research overseas and the limited research in New Zealand has focused on four issues:

i. The extent and barriers to take-up of universal design by the building industry. The latest New Zealand research within that general rubric is CRESA's 2015/16 research funded by the Building Research Levy.[53]
ii. The impacts of universal design on building costs.
iii. The impact of home accessibility and functionality on independence and dependence, in particular the likely movement of individuals from community settings to residential care.
iv. The private and public benefits and costs of residential building modification and associated value cases.

In Australia, there has also been an industry-researcher engagement[54] and the development of evidence reports based on systematic review methodology, around particular built and product solutions, including ramps, lifts, lighting, grab rails, and coating for tiled floors.[55] Industry-researcher engagement has not been so evident in New Zealand although it is recommended by Prefab New Zealand in relation to universal bathroom pods and in Saville-Smith and Saville. [56]

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[51] Far too few new homes suit elderly people – lobby group *Radio New Zealand*, 4 August 2016. http://www.radionz.co.nz/news/national/310151/far-too-few-new-homes-suit-elderly-people-lobby-group

[52] Bell, 2015.

[53] Saville-Smith, Fraser and Saville-Smith, 2016.

[54] For example, in relation to accessible bathrooms. See Demirbilek, Bridge, Mintzes, and Sweatman, 2015.

[55] See: Home Modifications Information Clearinghouse Research Publications Evidence Based Practice Reviews https://www.homemods.info/resources/hminfo-research-publications/evidence

[56] Bell, 2015; Saville-Smith and Saville, 2012.

In New Zealand, three reports detailing research on housing, ageing and disability noted that the provision of care services in the home, critical to achieving the policy of ageing in place, needs homes that function well.[57] Those reports demonstrate that if the home performs poorly or is unsafe, or the resident cannot move around easily, then their care and health needs increase, necessitating a move to residential care. This research also noted that most overseas estimates of the increase in cost to build in adaptable features are between one and five percent of total construction costs. Information gaps in understanding the value case for accessible housing in New Zealand were identified:

- The relative costs and benefits of adaptable housing compared to providing higher levels of home-based support services or higher levels of care.
- The relative costs of accessible housing design compared to subsequent modifications to meet accessibility needs and dwelling functionality for mobility impaired people.

Using construction cost data for both new-builds with accessible features, and retrofit, Page and Curtis[58] established that universal design features add about 0.5 percent to the costs for a new-built single storey house. They concluded that it is cost-effective to install universal design features in new builds, rather than retrofit, estimating that retrofitting would cost approximately 3-7 percent of the average house cost, based on estimated sales data. Those calculations excluded exterior changes such as the addition of a ramp and covering the house entrance. Those changes would increase retrofit costs. While noting data limitations, Page and Curtis suggest that if the provision of universal design features contributed to a 10 percent reduction in falls, this could result in an annual cost saving of $27 million a year. Accessible features allow people to stay in their homes for longer and would thus reduce the cost of institutional care (approx. $35,000 per year/per person). Their analysis of future savings, based on Rashbrooke (see below), indicated that by 2039, cost savings from installing universal design features in the construction of new homes, compared to retrofitting in future, amount to approximately $390 million in present value.

Saville-Smith and Saville cited overseas and New Zealand research showing lifetime housing reduces in-home support costs, reduces the cost of home modifications, increases safety, reduces injury associated costs and reduces the likelihood of residential care.[59] This included a study by the Joseph Rowntree Foundation suggesting the cost of home help could be reduced by up to 20 percent in accessible dwellings. The authors also cited New Zealand research suggesting that the incidence of falls among older people can be reduced between 14-41 percent by widening paths, improving lighting and providing non-slip surfaces within a dwelling and in the yard. Improved accessibility for disabled people also reduces injury risk to in-home carers.

[57] Saville-Smith, James, Warren and Coleman, 2009; Saville-Smith, James, Fraser, Ryan and Travaglia, 2007; Scotts, Saville-Smith and James, 2007.
[58] Page and Curtis, 2011.
[59] Saville-Smith and Saville, 2012.

Earlier analysis by Rashbrooke for the Ministry of Social Development compared universal design features being incorporated into new housing, to the need to retrofit accessible features in future. That analysis used disability sector data and statistics to develop a value case. Rashbrooke calculated the marginal cost of LifeMark approved features on a new build, and then compared that to three scenarios: adapting existing buildings, costs of moving, and the relative costs of in-house services and connectivity. [60] The report concluded that it is cheaper to include universal features, rather than retrofit them later. The analysis estimated that adapting lifetime design, based only on disability sector data, would result in potential savings to the economy of $20-40 million per year, if 33 percent of new builds took up LifeMark standards. Rashbrooke estimated an additional 3,500 universal design homes would be needed annually for the next 20 years. At that time, the number represented about 15 percent of new builds per year. It should be noted that a NZIER review of Rashbrooke's work considered that the net benefits to the individual and economy-wide were lower than those estimated by Rashbrooke. NZIER's review appears to be based on an assumption that not all people with moderate-severe disabilities need a modified home, which is contrary to considerable evidence.[61] NZIER did, however, also conclude that there would be an economic case for LifeMark, finding that, with a 33 percent take-up of LifeMark at $2,000 per new house, there would be a break-even situation if only 40 percent of those with moderate-severe disabilities needed to retrofit in future.

Recent research by He Kainga Oranga / Housing and Health Research Programme at the University of Otago tested the safety benefits of low-cost home modifications such as hand rails, grab rails, outside lighting, edging for outside steps and slip-resistant surfaces on outside areas such as porches and decks. [62] That research found a strong association between home injury hazards and actual injuries. Following the home modifications intervention, the study found a 26 percent reduction in the rate of injuries caused by falls at home per year. Cost-benefit analysis showed a reduction in the costs of home fall injuries of 33 percent. The social benefits of the injuries prevented were estimated to be at least six times the cost of the intervention. The researchers estimated that for older people the benefit-cost ratio could be at least doubled.

4.6 Summary

Currently the Building Code requirements relating to access do not apply to residential buildings. Consequently, there is no mandatory requirement or incentive for builders to construct accessible housing, or for consumers to demand it.

LifeMark is the only accessible housing accreditation in New Zealand. This voluntary standard was specifically developed for residential buildings by CCS Disability Action, which has promoted accessible, lifetime design housing for over two decades. LifeMark was developed because there was no government leadership, nor building

[60] Rashbrooke, 2009.

[61] Carnemolla and Bridge, 2014; Saville-Smith and Saville, 2012.

[62] Keall, et.al., 2015; Keall, et.al., 2017.

regulation as a basis for generating consumer demand and encouraging building industry production of accessible housing. Having struggled to make progress on lobbying for accessibility regulations, CC Disability Action turned to working directly with the building industry and housing providers to achieve its goals.

Given the lack of a regulatory framework and government leadership, LifeMark has used multiple ways of promoting the tool in the market, and achieved some success in raising awareness of the benefits of accessible housing, as well as increasing the number of new-built lifetime design homes. LifeMark is an example of innovation within a system where housing innovation is fragmented and unsupported by coherent policy and planning frameworks . Previous work shows that poor regulatory framing and incoherent central and local government policy is unlikely to inspire industry take-up.[63] within which the industry works and which are set by public bodies. Despite its innovation, LifeMark's reliance on voluntary uptake suggests that the benefits of lifetime design housing may be limited to those who can afford it, or who are lucky enough to have a landlord committed to accessible housing stock. Lifetime/universal housing is not narrowly targeted to specialised disabled housing. It is aimed at ensuring suitable and functional housing for all ages and abilities. It is focused on the cost-effectiveness of designing in accessible features, rather than spending to retrofit later in response to residents' changing needs. The extent of unmet need and demonstrated value of universal design in housing have been established. The three New Zealand research reports previously mentioned have demonstrated value and unmet need around dwelling accessibility and functionality. There has also been a review of need in this area which notes the importance of a coherent policy, incentive and regulatory framing at central government level to encourage take-up.[64] Research into the housing stock and housing futures in 2009 also notes the divergence between housing need and building industry ability or willingness to meet that need.[65]

As an accessible housing accreditation model, LifeMark goes beyond the very limited focus of the current Building Code, which only sets out requirements for buildings with public access to have access and facilities for disabled people. LifeMark goes beyond the Code in three fundamental ways. First, LifeMark promotes accessible features in residential buildings, where people live and spend the most time. While accessibility of public buildings is necessary, those regulations do nothing to address the problems of poorly functioning residential dwellings. Second, the tool highlights that people of all ages and abilities can benefit from lifetime design; it is not only for those with a disability. Third, by taking the NZ Standard Specification 4121 as a minimum baseline, LifeMark goes beyond those requirements, to put in place best practice standards for accessible buildings.

[63] Saville-Smith and Saville, 2012.
[64] Saville-Smith and Saville-Smith, 2012.
[65] Saville-Smith *et al*., 2009.

5. SOME REFLECTIONS

The most obvious and yet the most important point that comes out of this review is the diversity of drivers which have generated tools to do better in the residential housing space. LifeMark was driven out of frustration around the NZBC's accessibility provisions, both in relation to their scope and their measurement. By contrast, the energy performance tools were driven, implicitly at least, by the idea that through tools that take the industry and consumers beyond the minimum the NZBC might raise the minimums incorporated within the code. The HSS, like LifeMark, has also been concerned to widen the scope of building standards. An extended narrative of the institutional landscape and stakeholder dynamics in those two sectors and how those have interacted with the development of building codes is beyond the scope of this research. Such a study appears to be a fruitful opportunity in the future and some further preliminary commentary on this will be made in the integrated report arising from this research. In the meantime, it can be noted, in all cases, research is embedded in the tools but shows a very different nature. For LifeMark and to a lesser extent the HSS, the research has been directed to establishing that meeting the standards set out in the tools are achievable and can be done with minimal cost. All the tools have had some research directed to establishing societal value cases. Some have been concerned to establish through research methods for measuring compliance. Notably, embeddedness in the NZBC has, it seems, another impact on research. It is clear that where the NZBC has detailed specification and measures within a domain, this can drive significant research investment. Research investment in universal design and LifeMark has been low despite considerable demands that proponents of universal design demonstrate the value case to government. That pattern may also be a manifestation of the constituencies that have shaped building standards as well as research fields. LifeMark has not been situated in a stream of research funding either in the past or currently. Nor has it had significant government agencies promoting either research or influencing the NZBC.

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APPENDIX A SYSTEMATIC REVIEW TEMPLATE ACCREDITATION INSTRUMENTS

Instrument Name:

What is the purpose of the instrument?		
What are the key aspects of dwelling performance the instrument addresses?		
Current Instrument Performance Standards		
NZBC clause		
Who owns/runs/promulgates instrument?		
Date when instrument was established?		
Number and dates of revisions of instrument	❑1 0 ❑2 1 Date revised: ❑3 2 Date revised: ❑4 3 Date revised: ❑5 4 + Date revised:	
What changes were made to objectives and standards? Describe each change	Revision 1	
	Revision 2	
	Revision 3	
	Revision 4	
	Revision 5	
Target groups	❑1 building industry – designer/architects ❑2 building industry – builders/developers ❑3 Building industry – other (Specify) ❑4 Owner occupiers ❑5 Tenants ❑6 Landlords	

	❑7 Other – (Specify)				
How does industry access the instrument?	Website ❑1 Yes ❑2 No Website:	Free? ❑1 Yes ❑2 No	Subscription? ❑1 Yes ❑2 No	Pay as you go? ❑1 Yes ❑2 No	Other? Describe
How does householder access the instrument?	Website ❑1 Yes ❑2 No Website:	Free? ❑1 Yes ❑2 No	Subscription? ❑1 Yes ❑2 No	Pay as you go? ❑1 Yes ❑2 No	Other? Describe
Accreditation process Householders	Self-accreditation? ❑1 Yes (who) ❑2 No Is Self-accreditation ❑1 Free ❑2 Paid	Independent accreditation? ❑1 Yes (who) ❑2 No Is Independent accreditation ❑1 Free ❑2 Paid			
Accreditation process Industry	Self-accreditation? ❑1 Yes ❑2 No Is Self-accreditation ❑1 Free ❑2 Paid	Independent accreditation? ❑1 Yes ❑2 No Is Independent accreditation ❑1 Free ❑2 Paid			
Describe accreditation process [How much paid, what happens, e.g. site visit or plans, was a checklist used – attach link]					
What training / guidance is provided for the industry? [Webinar, courses, downloadable info etc.]					
What training / guidance is provided for					

consumers/householders? [Webinar, courses, downloadable info etc.]		
Who provides training/guidance for the industry?		
Who provides training/guidance for consumers/householders?		
Key messages used to promote instrument		
Main methods/channels for instrument promotion		
Evidence of household consumer demand		
Evidence of take-up by householders		
Evidence of barriers to householders take-up		
Evidence of industry take-up		
Evidence of barriers to industry take-up		
Evidence of impact on Building Code		
Is a business case developed?	❑$_1$ Yes ❑$_2$ No	Who is business case aimed at? ❑$_1$ Householder ❑$_2$ industry ❑$_3$ Other (specify)
Key points of business case		
Research evidence base for instrument List full references for all reports [citation & link]		
Other comment		

ANNEX C: REPORT 'TAKING-UP OF RESEARCH-BASED SOLUTIONS TO DO BETTER BUILDING – INTERNATIONAL RESEARCH REVIEW'

Taking-Up of Research-based Solutions to Do Better Building

International Research Review

LR0508

28 April 2017

Bev James (PP&R), Nina Saville-Smith and Kay Saville-Smith (CRESA), Nigel Isaacs (VUW)

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TABLES

FIGURES

1. INTRODUCTION

The issue of how New Zealand can improve the performance of its dwellings has been a focus for many years. There is an often expressed view that the building industry treats the standards set out in statute as its target rather than a minimum level of performance. That, combined with a sense that changes in the regulatory regime is both slow and frequently unacceptable politically, mean that attention has been turned to other levers to get prompt the building industry to deliver better performing dwellings. This report is one of a series of preliminary reports arising from an analysis of how research based solutions have or have not been taken-up by the building industry and delivered improved stock.

The overall research programme funded through the BRANZ levy is focused on doing better in energy/thermal related and accessibility related performance. It explores three dimensions of research-based innovation associated with going beyond the minimum and doing better. Those are the:

i. Extent to which research-based findings completed over the past two decades could lead to 'beyond code' dwelling performance and are still current or superseded.
ii. Extent to which those research-based solutions have been recognised and promoted by the building industry or demanded by consumers in both new build and renovations.
iii. Determinants of take-up or non take-up of those research-based solutions.

Two reports have been completed to date. The first provided an overview of the Building Code and identified the requirements and performance required around energy efficiency and accessibility.[1] The second, *Doing Better: A review of beyond New Zealand Building Code research and traction through residential accessibility and energy efficiency tools*,[2] addressed i- and ii- above through reporting on the way in which beyond code performance standards had been integrated into householder or industry decision tools and guidelines. Those reports both noted that while there were a series of tools which were both evidence based and could take the industry beyond code, they seemed to have limited traction with the industry.

This report looks specifically at research which considers the dynamics of industry take-up of innovation and available product, materials and design solution. The report recognises that there is a significant, albeit limited, set of research and research reviews around these issues. Consequently, the report summarises the findings of previous but recent New Zealand reviews around this issue prior to considering whether the findings evident in those reviews have been changed by the also limited but more recent research available internationally.

This report is structured as follows:

- Section 2 comments on scope and method.
- Section 3 considers what research and research reviews prior to 2012 have found in relation to the dynamics and levers of innovation and take-up in the residential building industry.

[1] Saville-Smith, Isaacs, and James, 2017.
[2] James, Isaacs, Saville-Smith and Saville-Smith, 2017.

- Section 4 presents an analysis of more recent research and asks whether this later research diverges from, elaborates or simply restates the findings of previous research.
- Section 5 provides some concluding comments.

It should be noted that this report is intended to provide an input into a final, integrated report the analysis in which is likely to extend through triangulation, or even possibly modify, interpretation or argument presented in this summary and more preliminary report.

2. SCOPE AND METHOD

This research explores three dimensions of research-based innovation associated with going beyond the minimum and doing better in the residential stock delivered as new builds by the building industry. Those are the:

- Extent to which research-based findings completed over the past two decades could lead to 'beyond code' dwelling performance and are still current or superseded.
- Extent to which those research-based solutions have been recognised and promoted by the building industry or demanded by consumers in both new build and renovations.
- Determinants of take-up or non-take-up of those research-based solutions.

This report focuses on the last of those dimensions and, in particular, international research on the factors affecting the take-up of research-based innovations that would allow the building industry to take dwellings beyond the minimum building performance set out in the 2004 Building Act, its 2013 amendments and its associated regulations including the Building Code.

There have been previous New Zealand reviews of research into the conditions that prompt take up of better than regulated performance by the building industry and consumers both in relation to energy and accessibility. The most recent was commissioned in 2012 by the Ministry of Business, Innovation and Employment (MBIE) in partnership with the Office for Disability Issues. That review focused on identifying the different levers that could be used to improve the supply of housing life-time design housing through an analysis of relevant international research. That research ranged not only over research specifically related to universal design, life-time design and similar approaches to ensuring the accessibility and functionality of dwellings, but also research related to the conditions which prompted take-up of low energy and energy efficiency solutions within the building industry both residential and non-residential.

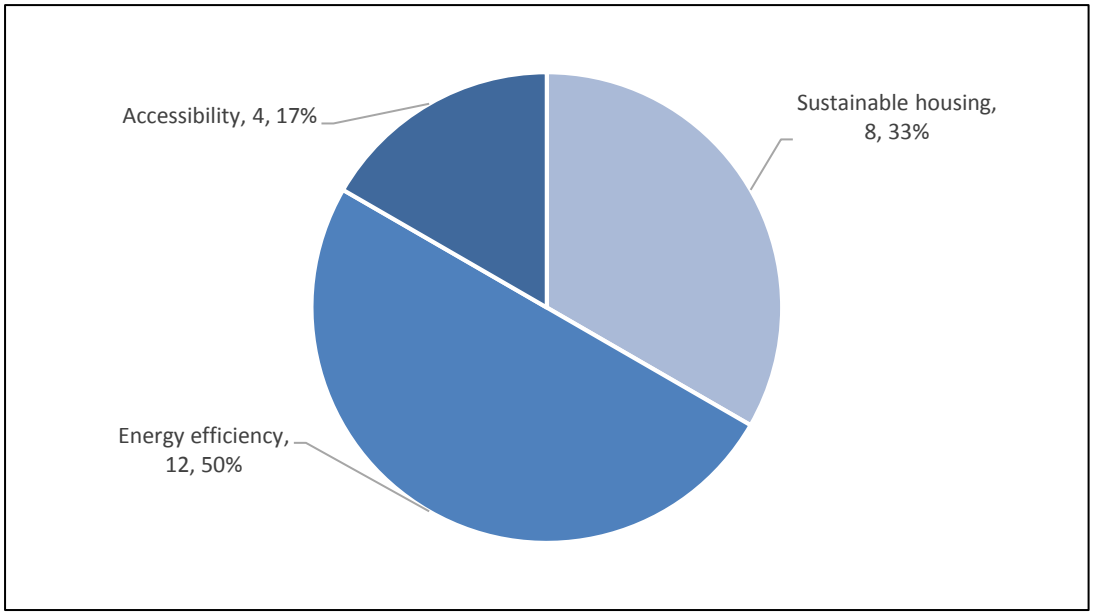
To avoid unnecessary duplication, our approach has been to: review research subsequent to 2012, and consider the extent to which that later research diverges, elaborates or simply restates the findings of previous research. Consequently, the sample for selecting research literature for this review has been bounded by research literature published after 2012. The selection framework has been broad in scope. All non-English language research has been excluded, but in generating the pool of research publications to be analysed the boundary for inclusion has been defined primarily by a focus on take-up, innovation and implementation within the residential building industry of performance standards outside prevailing minimum, regulated requirements.

Literature searches were undertaken through a variety of search engines including Sage, Justor and Google Scholar as well as key websites, including EECA, Lifemark, Beacon Pathway, Homestar and BRANZ. A snowball approach was used to identify other relevant published research literature. A review template was developed to interrogate that research (Appendix A) and captured data related to the following fields:

- Full publication reference
- description of tool or solution to improve dwelling performance
- key aspects of dwelling performance addressed
- description of research conducted
- Key research findings
- Evidence of methods and pathways to encourage consumer take-up
- Evidence of consumer take-up
- Evidence of barriers to consumer take-up
- Evidence of methods and pathways to encourage industry take-up
- Evidence of industry take-up
- Evidence of barriers to industry take-up
- Business case development: quantified benefits to consumers
- Business case development: quantified benefits to industry
- Business case development: quantified public benefits
- Related research & reports
- other comment

In all, 16 papers published since 2013 were reviewed. Most of the literature focused on what might be broadly referred to as sustainable housing. Within that literature, twelve papers focused solely on or included energy efficiency. Eight papers included other sustainability aspects of dwelling performance in addition to energy efficiency. Those aspects included water efficiency, indoor environmental quality, building durability and resilience to natural hazards and climate change, carbon footprint, materials toxicity and dwelling size. Further sustainability aspects considered wider environmental impacts of residential development, such as lot size, dwelling density, walkability, and land impacts. Only four articles were concerned with universal design or accessibility (Figure 2.1).

Figure 2.1 Key Areas of Performance in Post-2013 Published Research Papers



Those papers encompassed research and literature reviews (including reviews of research and/or policy, planning and regulatory documents). Research target groups included home owners and householders, developers, building industry professionals, property managers, planning professionals, state and local government employees, disability service professionals, home maintenance services, financial institutions, and solicitors. All except one paper focused on private residential stock. The exception focused on energy efficiency in commercial buildings, although also commented on energy efficiency in private dwellings. Australia dominated in the research (8 papers), followed by the USA (5 papers). One paper reported on research in the UK, another on Malaysia, and one review of energy efficiency policies and literature covered 14 EU countries. Twelve papers focused on innovation in new builds while six papers focused on or included existing buildings, i.e. renovations, adaptions or repairs.

3. THE DYNAMICS AND LEVERS OF INNOVATION AND TAKE-UP – RESEARCH PRIOR TO 2012

The housing sector and the building industry have been long criticised both in New Zealand and overseas for a lack of innovation and poor take-up of new technologies. The failure to adopt improved performance standards beyond minimums set out in the New Zealand code has implicitly and sometimes explicitly attributed to that alleged resistance to innovation.[3] The 2012 review commissioned by the Office for Disability Issues and MBIE around practical approaches to meeting need and encouraging industry take-up of universal design

[3] Building and Construction Sector Productivity Taskforce, 2009; Burke, 2010; Buxton, 1998; Campagnac, 1998; Fairweather, 2009.

questioned the validity of that universal typification of the building industry as slow adopters of new technologies, processes and products.[4]

That review noted a number of products, materials and design motifs have shown rapid adoption over the years including heat pumps and downlights as well as skillion and low pitched roofs, reduced eaves, and board and plaster cladding. It found that where innovations were taken-up and widely delivered by the building industry those were marked by the following characteristics:

i. The innovation does not require significant reworking of the existing industry relationships, designs, or labour processes. That is, they tend to be 'plug and play' products.
ii. The adoption of new materials or products tend to be driven through manufacturers and product suppliers.
iii. Some innovative products are such as heat pumps and downlighting are promoted by both direct marketing to householders and housing sector suppliers as well as to builders and developers.
iv. The new product, process or materials which have limited impact on building consent requirements and tend to be more attractive to the industry than systems that require consenting. That tendency is particularly evident in the take-up of heat pumps, which, despite piercing the building envelop, have not required building consents unlike enclosed woodburners and solar water heaters.
v. Innovations that generate low or no hump costs for builders and developers are more likely to be adopted as are innovations that perceived to be easily accommodated within pricing structures prevailing in the market.[5]

In the context of this research programme, it is notable that many of the innovations that have become widespread, if not pervasive, have not been directed to optimising performance beyond those required by the Building Code. Indeed, a number of rapidly adopted products and designs have been associated with poor performance outcomes due in part to a failure to understand the particular installation and handling requirements of those materials and products. Research has found deficiencies in the installation and maintenance of heat pumps,[6] a variety of energy efficiency issues associated with downlights,[7] and noted the unfortunate combination of new materials, new design preoccupations, and building practices associated with leaky building syndrome and the considerable impacts associated with it.[8]

What the innovations that do become widespread have in common is that they crossed the chasm between 'early adopters' and the 'early majority'. Innovation theorists argue that the 'tipping point' across the chasm between early adoption and the early majority lies somewhere in the region of a fifth of an innovation's total market potential (Figure 3.1).[9]

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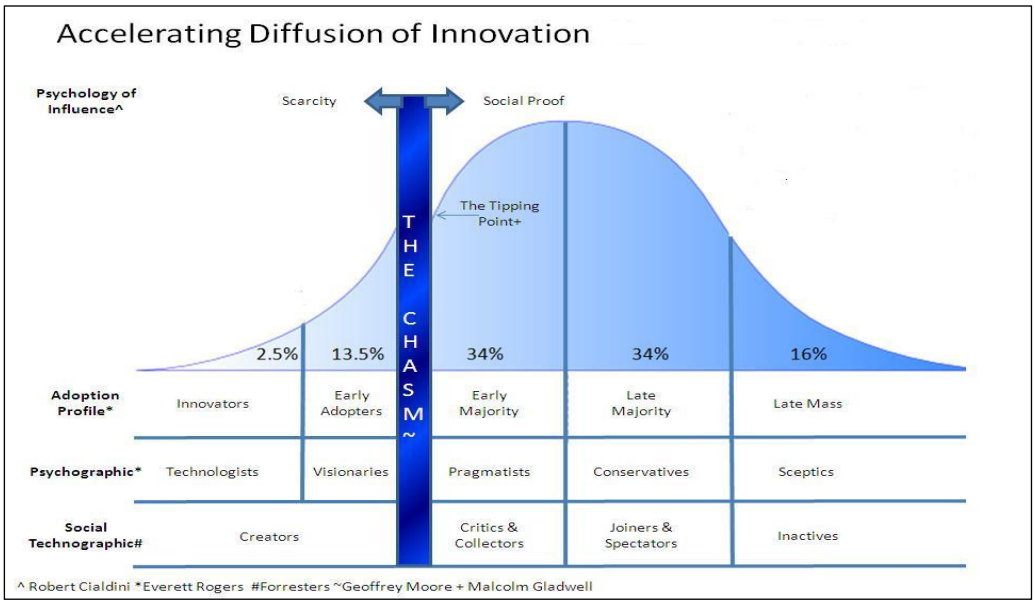
[4] Saville-Smith and Saville, 2012.
[5] Saville-Smith and Saville, 2012: 37.
[6] Burrough, Saville-Smith and Pollard, 2015; Burrough and Saville-Smith, 2011; Burrough and Saville-Smith, 2012; Burrough, 2010.
[7] Easton, 2010; Easton, 2007.
[8] Mumford, 2010; James, Rehm, and Saville-Smith, 2017.
[9] Maloney, 2010; Cialdini, 2001.

Figure 3.1 Innovation Diffusion and Take-up



Jumping the chasm also involves two dynamics. The first being the demonstration of practicality. Innovations, new products, new processes and new designs, need to appeal to the supply chain and consumers because the meet practical problems. The second dynamic is social proof or informational social influence. That is, the phenomenon which sees adoptees taking up innovations simply as an emulation of previous adopters. Under those conditions, the take-up of new products, materials and designs become effectively self-propelling.

What the 2012 review highlighted was an apparent resistance in the building industry not so much to innovation, but the delivery of particular innovations that would improve the performance of the housing stock in relation to the demands placed on it. The particular focus of the 2012 review was, of course, how to address the under-provision of accessible housing functional over the life course as well as to enable people with compromised functionality. In considering the potential for market transformation in that domain, however, the 2012 review noted that there were other domains in which building stock performance improvements were seen as having desirable public as well as private outcomes. In particular, attention was given to the linked domains of improved energy efficiency, improved thermal performance, and the reduction of greenhouse gas emissions.

In all those domains, there was an evidential research base indicating the benefits of transformation. There was also a raft of innovation products, designs and technologies which improve dwelling performance. The challenge was to generate take-up and diffusion of those by the adoption of levers that would:

- Enhance the industry's ability to identify and its capability to deliver dwellings with features that deliver better performance.
- Generate a desire on the part of the industry to adopt innovations which would improve performance by stimulating consumer demand.
- Encourage take-up by reducing the transaction costs of take-up on the supply-side and/or price barriers that might inhibit household demand.

What were the levers that encouraged innovation and take-up of performance enhancements? What levers successfully shifted innovation and performance enhancements from early adopters to and early majority and set off self-generating diffusion? Those questions were at the heart of the 2012 review of domestic and overseas research around take-up of accessible housing. In the realm of accessible housing, that review found that the research identified five key sets of levers:

- Regulatory
- Investment, subsidies and taxation
- Accreditation
- Planning and procurement
- Capability development and demonstration.[10]

In the realm of energy and thermal performance, researchers categorise the levers directed to generating take-up somewhat differently. Davies and Osmani, for instance, arrange their analysis of levers to encourage innovation and improved performance around four categories:

- Regulatory and government controlled instruments
- Economic and market-based instruments
- Fiscal instruments
- Information, leadership and voluntary action.[11]

The differences between these two categorisations are superficial.

The promotion of improved performance and arguments for introduction of different levers to encourage performance improvements typically referenced at least some research around the benefits of performance improvements and the efficacy of certain innovations in delivering those improvements. However, the 2012 review noted that there was limited research as to the comparative merits of either each set of levers or the merits of specific instruments within those sets.[12]

In 2007, however, there was a cluster of work in the domain of sustainability, greenhouse emissions and energy efficiency concerned with a comparative analysis of the different levers directed to generating market transformation. In New Zealand, Beacon Pathway involved various industry actors and regulatory stakeholders in a consensus conference like process to identify and promote a particular mix of interventions.[13] A more robust and comprehensive study, the United Nations Environment Programme (UNEP) analysis of the efficacy of different levers to reduce greenhouse gas emission, was highlighted in the 2012 review.[14]

That UNEP research clustered a range of instruments into the four sets of levers previously described. Both the four sets of levers and the instruments within them were assessed in relation to three dimensions. Those dimensions were respectively:

- effectiveness;
- cost-effectiveness; and,
- the conditions on which success was contingent.

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[10] Saville-Smith and Saville, 2012:47.

[11] Davies and Osmani, 2011.

[12] Jaffe and Stavins, 1995.

[13] Stancu C., G. Finlay, S. Gunn, 2007.

[14] Koeppel and Urge-Vorstaz, 2007.

Table 3.1 sets out the UNEP assessment of those lever sets and the specific instruments within those sets.[15]

Table 3.1 UNEP Assessment – Efficacy of Levers to Reduce Contribution to Greenhouse Gas Emissions by Buildings

Levers Category	Specific Instrument	Effectiveness	Cost-effectiveness	Success Contingencies
Regulatory and Government Control	Mandatory standards	High	High	Agreed and updated standards maintained by an independent body support by information, communication and education.
	Building codes	High	Medium	Dependent on enforcement.
	Mandatory audits	Variable	Medium/High	Effective standards, tools and reporting processes required. Suitable for some stakeholders only.
	Mandatory labelling, certification or disclosure	High	High	Depends on ability of end-user to assess and continuous end-user engagement.
	Procurement regulation	High	High/medium	Ambitious targets needed if to provide demonstration to the market, clear standards required and tools to measure compliance against standards.
Economic & market-based Instruments	Co-operative procurement	Medium/High	High/Medium	Establishes economies of scale.
Fiscal Instruments	Taxation	Low/Medium	Low	Dependent on price elasticity.
	Tax or fee exemptions or reductions	High	High	Need to be properly structured and monitored.
	Capital subsidies, grants, loans	High/Medium	Variable	Can be cost-effective when properly targeted to households confronting price barriers.
Information, Leadership & Voluntary Action	Public leadership	Medium/High	High/Medium	Useful to demonstrate new technologies and practices.
	Voluntary compliance with standards	Medium/High	High/Medium	Effective if combined with fiscal incentives and possibility of regulation.
	Voluntary labelling, certification or disclosure	Medium	Medium	Clear standards and comparative tools needed.
	Promotional information and campaigns	Low/Medium	Medium/High	Potential is limited unless supported by other instruments. Clear and properly targeted messages

[15] From Saville-Smith and Saville, 2012.

				needed.

Both the UNEP assessment and Beacon's consensus conferencing agree that encouraging improved building performance requires not only a research platform but the institution of multiple levers for change. The UNEP also highlighted that:

- Regulatory and control instruments can be effective in themselves and may be necessary if other forms of leverage are to be effective, but issues of avoidance, compliance and price impacts need to be actively managed.
- Subsidies and informational levers may have mixed results if implemented in isolation from each other and regulatory levers, but they are frequently important as part of a mutually reinforcing package of levers and can successfully address price barriers for consumers among whom take-up is desirable but is inhibited by problems of affordability.
- Transformation requires a package tailored specifically to and takes account of:
  - current and changing institutional, cultural and market condition, and
  - all stages of the chains of supply and demand.

Those conclusions were consistent previous relevant international research and analysis.[16]

The 2012 review noted that the array of levers directed to promoting accessible housing delivery have not been subject to the comparative assessment undertaken by UNEP. Notwithstanding, the efficacy of the regulatory requirements around accessibility in different international jurisdictions had been subject to some research and evaluation. That research and evaluation found that the enforcement of regulation tends to be poor. In addition, where regulation allowed considerable discretion and trade-offs, there was considerable gaming. Those tendencies were exacerbated by a tendency for statutory levers, standards and solutions to lack clarity or be contradictory. Finally, regulation failed to engender innovation where the building industry did not have the capability to deliver accessibility solutions,[17] or where regulatory requirements under-challenged existing industry performance and practice.[18]

Internationally, best practice in promoting the building industry's willingness and ability to deliver accessible housing was characterised by:

- the implementation of an array of levers that included but was not restricted to regulation; and,
- being undertaken as one aspect or component of a wider societal commitment to universal design and accessibility.

In many European jurisdictions, accessible housing was pursued in the context of a cross-sectoral adoption of universal design.[19] That integrated approach was evident in Norway's strategic goal to be universally designed by 2025 which was supported by action plan which encompassed priority action in: building and construction; planning and outdoor areas; transport; and, information and communication technologies.[20] Similarly, the Greater London Authority's (GLA) implementation of inclusionary zoning and Lifetime Homes standards for all new homes, conversions and refurbishments irrespective of dwelling size or typology was

[16] See also Birner and Martinot, 2003.

[17] Bichard *et al*., 2007; McDermott *et al*, 2006; Savills, 2008.

[18] Beerepoot and Beerepoot, 2007.

[19] Ginnerup, 2009 review of European universal design initiatives and cross-sectoral reach.

[20] Norwegian Ministry of Children and Equality, 2009.

introduced in the context of the strategy for "Accessible London". That strategy identified twenty implementation points for an accessible city and a series of associated actions and accountabilities.[21]

4. RECENT RESEARCH ON THE DYNAMICS AND LEVERS OF INNOVATION AND TAKE-UP IN THE BUILDING INDUSTRY

The following discussion reviews more recent research into the dynamics of take-up of performance enhancing innovations, technologies and design solutions. In particular, asks whether this later research diverges from, elaborates or simply restates the findings of previous research. Appendix B provides a summary overview of each of the reviewed publications.

The lack of innovation and poor take-up of new technologies noted in section 3 as a long-standing critique in New Zealand is also echoed in the international papers reviewed here.[22]

Analysis of that literature presented here focuses on the following themes, central to the previous 2012 review. Each theme considers whether there is divergence, elaboration or a simple restatement of previous research findings.

- Barriers to take-up
- Critical factors or characteristics supporting innovation and take-up
- When innovation does not result in improved performance
- Levers to encourage innovation and take-up

[21] Greater London Authority, 2004; Greater London Authority, 2010, Greater London Authority, 2011.
[22] Eisenberg, 2016; Fletcher *et al,* 2015; Manley and Miller, 2014; Shearer *et al,* 2016; Yang and Yang, 201; Warren-Myers and Heywood, 2016.

Barriers to innovation and take-up

Previous research has discussed a wide range of barriers to innovation and take-up. Broadly those barriers concern policy, regulatory and enforcement inadequacies, financial barriers, lack of capability and attitudinal barriers. Essentially, the literature reviewed here reinforces and elaborates on previous findings about those barriers.

With regard to policy, regulatory and enforcement barriers, the research literature highlights:

- Poor policy and regulatory mix, compatibility and integration, including conflicting policies and lack of policy clarity. [23]
- Lack of appropriate targeting of policy and programmes, including poor understanding of values, motivations, characteristics, needs and practices of consumers. This can inhibit innovation and take-up. [24]
- Poor implementation of policies, regulations, instruments and standards.[25]
- Regulatory process barriers, including slow permitting/consenting processes.[26]
- Poor enforcement of standards and regulations, lack of or inadequate monitoring tools and unproductive responses to non-compliance that do not encourage take-up or doing better.[27]
- Political unacceptability of tools.[28]

The research literature reiterated financial factors that affect the investment in innovation by industry and householders, as well as by policy and regulatory agencies. Those financial factors include:

- Lack of government funding for innovation.[29]
- Difficulties in designers and providers accessing private sector finance.[30]
- High initial costs of products, materials and services.[31]
- Builders' and home owners' actual or perceived poor rate of return for investment in innovation.[32]
- Low consumer uptake of financial incentives.[33]
- Lack of investment into technology research and development.[34]
- Low costs of, or no financial disincentives for maintaining status quo behaviour.[35]

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[23] Eisenberg, 2016; Greiman and Ravesloot, 2016 ; Gröçmen and LaGro, 2016; Henderson *et al,* 2016; Judson and Maller, 2014; Larkin *et al,* 2015; Yang and Yang, 2015; Ward *et al*, 2014.
[24] Gabriel and Watson, 2013; Judson and Maller, 2014; Karatas *et al,* 2016.
[25] Rosenow *et al*, 2016; Warren-Myers and Heywood, 2016.
[26] Eisenberg, 2016; Gröçmen and LaGro, 2016; Rosenow *et al*, 2016; Shearer *et al,* 2016; Yang and Yang, 2015.
[27] Eisenberg, 2016; Gröçmen and LaGro, 2016; Larkin *et al,* 2015; Rosenow et al, 2016; Yang and Yang, 2015.
[28] Eisenberg, 2016; Rosenow *et al,* 2016.
[29] Eisenberg, 2016; Yang and Yang, 2015; Shearer *et al,* 2016.
[30] Henderson *et al,* 2016; Shearer *et al,* 2016; Gröçmen and LaGro, 2016.
[31] Henderson *et al,* 2016; Judson and Maller, 2014; Karatas *et al,* 2016; Olanrewaju *et al,* 2015 ; Ward *et al*, 2014.
[32] Henderson *et al,* 2016.
[33] Gabriel and Watson, 2013.
[34] Yang and Yang, 2015.
[35] Karatas *et al,* 2016.

Two broad capability barriers are identified in the literature reviewed. Those are firstly, industry professionals' lack of knowledge and capability.[36] This barrier can manifest in uneven knowledge, experience, skills and capacity in different professions and industries, different stages of the supply chain and at different scales of operation. Secondly, there is a lack of consumer knowledge and provision of information and advice to increase consumers' understanding and assessment of the performance and benefits of innovations.[37]

With regard to attitudinal barriers, the literature reviewed identified both industry and consumer attitudes as inhibiting innovation and take-up. The following were noted:

- Risk-averse industry, e.g. fear of financial risk, reluctance to change practices.[38]
- Industry perception of lack of consumer demand.[39]
- Industry and consumer beliefs that the innovation is too expensive.[40]
- Consumer views that product/design/innovation is not relevant to personal circumstances.[41]
- Consumer taste and aesthetics.[42]
- Lack of consumer confidence in making change.[43]

Critical factors or characteristics supporting innovation and take-up

The 2012 review noted that innovation and take-up happen where it is easy and inexpensive for the industry to incorporate into existing practice, where it has limited impact on consenting requirements and where there is direct marketing to householders. The review of more recent literature reiterates reinforces the importance of those factors.[44] To go beyond the tendency for the building industry to take-up what might be referred to as cosmetic innovation that appear to have little profound impact on performance improvement, to innovation which may have limited cosmetic appeal but has performance benefits, the research identified the importance of:

- Development of professional capability.[45]
- Technology and design research and development.[46]
- Ability to use innovation to differentiate from competitors.[47]
- Clear value cases around the rewards and benefits of take-up.[48]

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[36] Fletcher *et al,* 2016; Gabriel and Watson, 2013; Gröçmen and LaGro, 2016; Judson and Maller, 2014; Olanrewaju *et al,* 2015; Shearer *et al,* 2016; Yang and Yang, 2015; Ward *et al,* 2014; Warren-Myers and Heywood, 2016.

[37] Fletcher *et al,* 2016; Karatas *et al,* 2016; Larkin *et al,* 2015 ; Ward *et al,* 2014 ; Warren-Myers and Heywood, 2016.

[38] Manley and Miller, 2014; Shearer *et al,* 2016; Yang and Yang, 2015; Ward *et al,* 2014; Warren-Myers and Heywood, 2016.

[39] Henderson *et al,* 2016; Shearer *et al,* 2016; Ward *et al*, 2014; Warren-Myers and Heywood, 2016.

[40] Larkin *et al,* 2015; Olanrewaju *et al,* 2015 ; Warren-Myers and Heywood, 2016.

[41] Fletcher *et al,* 2016; Ward *et al,* 2014.

[42] Judson and Maller, 2014.

[43] Gabriel and Watson, 2013; Henderson *et al,* 2016.

[44] Larkin *et al,* 2015; Yang and Yang, 2015; Ward *et al*, 2014 ; Warren-Myers and Heywood, 2016.

[45] Göçmen and LaGro 2016; Judson and Maller, 2014; Yang and Yang, 2015.

[46] Yang and Yang, 2015.

[47] Henderson *et al,* 2016; Warren-Myers and Heywood, 2016.

- Innovative collaboration in design, development and marketing among stakeholders, including regulators, designers, providers and consumers. [49] Yang and Yang (2015) consider this to be the "fundamental" factor affecting implementation.

When innovation does not improve performance

The failure of innovation to improve building performance outcomes was a theme identified in the 2012 review. This theme is confirmed in the literature reviewed here. For example, there is evidence that many energy-efficiency interventions result in temporary changes to energy use, rather than sustained changes over time, or even increase resource use.[50] Several studies found that effectiveness was limited by deficiencies in assessment of appropriate product/technology or installation.[51]

These studies suggest that improved performance is not simply due to the adoption of an innovation. It was observed that an essential condition for improved performance is to enable the consumer to engage with the innovation, learn how to use it to maximise benefits, and easily incorporate it into daily activities.[52] Another key finding was that innovations must work together. This is elaborated in the section following.

Levers to encourage innovation and take-up

The 2012 report's conclusions about the most effective levers for a transformational approach are presented in section 3 of this report. Essentially, those conclusions are supported by the recent literature considered here. In particular, that literature places a strong emphasis on the efficacy of a package of instruments for transformation, tailored to institutional, market and cultural conditions and with a set of unifying goals.[53] There is also support for legislation and regulation as a fundamental component to drive change. Voluntary standards and informational levers are considered to be important, but insufficient and often ineffective on their own. [54]

The 14 EU country review of energy efficiency policies elaborates a more detailed understanding of the interaction of multiple levers. It observed that most research focuses on individual levers or policies, rather than how policies complement or trade-off one another. [55] The review noted key shortcomings in current energy efficiency levers, including the selection of instruments in an ad hoc manner, the haphazard emergence rather than conscious design of policy mixes, overlapping and consequently inefficient instruments, and tensions resulting from conflicting policy goals. The review identified the most effective mix of instruments, focusing on four board instrument areas highlighted in the 2012 review. i.e,:

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[48] Yang and Yang, 2015.
[49] Gabriel and Watson, 2013; Eisenberg, 2016; Larkin *et al,* 2015; Yang and Yang, 2015.
[50] Judson and Maller, 2014; Karatas *et al,* 2016.
[51] Gabriel and Watson, 2013; Greiman and Ravesloot, 2016; Ward *et al*, 2014 ; Warren-Myers and Heywood, 2016.
[52] Gabriel and Watson, 2013; Judson and Maller, 2014. ; Karatas *et al,* 2016; Warren-Myers and Heywood, 2016.
[53] Eisenberg, 2016; Karatas *et al,* 2016 ; Rosenow *et al*, 2016.
[54] Karatas *et al,* 2016; Larkin *et al,* 2015; Yang and Yang, 2015; Ward *et al*, 2014.
[55] Rosenow *et al*, 2016.

- Regulatory and control instruments, such as regulations to set legally enforceable minimum standards and obligations.
- Funding incentives, such as taxes, pricing, tax rebates, grants, loans and capital investment financing.
- Accreditation, such as voluntary agreements and labelling schemes.
- Capability development: the 14 EU country review focused on consumers' capability development, e.g. through information, advice, and in the energy field, billing feedback and smart metering. Other studies have also noted the importance of industry education, training and professional development in the mix of levers.[56]

In terms of 'what works', the 14 EU country review concluded that:

- Instruments must be designed and/or customised to address the problem(s) identified and for the context in which they are intended to be used.
- Instruments should be complementary and avoid those that overlap or fail to meet at their boundaries.
- Multiple financial incentives are required.
- Policies that appear to always interact in a complementary way with other instruments include: energy or CO_2 taxes, standards and norms, information, advice, billing feedback and smart metering.
- Standards and norms, energy-labelling schemes and information and feedback measures reinforce and facilitate all other policy types.
- Taxes such as those applied to energy consumption and CO_2 reduction are compatible with all other instruments, and increase incentives for users to take up financial incentives and adopt more efficient technologies.
- Most policies would not function without the implementation of standards and norms to measure efficiency. These are the foundation for all other instruments.

5. CONCLUSIONS

It is well accepted that designs, technologies and products exist which would allow the building industry to deliver housing that exceeds the minimums of energy and thermal performance and accessibility in the current Building Code. The report in this programme[57] refers to research that shows that accessible design can be delivered with minimal marginal cost. There is an array of research that also shows there is a desire for comfortable, energy efficient homes. Similarly, there is a desire for homes with many of the features required in New Zealand's LifeMark for homes that are accessible and functional for people of 'all ages and stages'. Moreover, there is also a long chain of research showing that even where

[56] Eisenberg, 2016; Fletcher *et al,* 2015; Gröçmen and LaGro, 2016; Larkin *et al,* 2015; Yang and Yang, 2015; Ward *et al*, 2014.

[57] James, B., N. Isaacs, N. Saville-Smith and K. Saville-Smith, 2017.

consumers ask for energy efficiency or thermal performance they struggle to leverage those from the building industry.[58]

There has been a tendency to attribute these problems to a fundamental and persistent inertia in the building industry manifest in a hesitancy to adopt new designs, practices, materials and products. That view, however, sits uneasily with the succession of building typologies which have emerged in the market over time. Nor does it sit easily with the building industry's adoption of a changing array of products and materials including heat pumps, sheet cladding, and downlights. Nor can the tendency be attributed about a lack of clarity around the pathways to better performance. Our previous report shows that both in the domain of energy and thermal performance and in accessible function housing there are well-specified, research based accreditation tools.[59]

Although there is a limited range of research regarding the efficacy of particular levers or sets of levers, experiential evidence combined with research evidence suggests that the delivery of improved performance is contingent on:

- A multi-layered approach to supporting innovation that includes a range of co-ordinated instruments and tools including an actively implemented regulatory framework.
- Attention needs to be given to the building industry capability but also enabling those commissioning buildings and using dwellings.
- The implementation of policies and instruments that interact in a complementary way with other instruments both within the building and construction sector but also other sectors, particularly housing, health, disability, income support and tax sectors.

[58] For example, East Harbour Management Services (EHMS), 2007; Saville-Smith *et al*., 2007; Saville-Smith, Fraser and Saville-Smith, 2016; Saville-Smith, 2000.

[59] James, B., N. Isaacs, N. Saville-Smith and K. Saville-Smith, 2017.

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APPENDIX A

REVIEW TEMPLATE INTERNATIONAL RESEARCH ON TAKE-UP

Publication reference: Author, title, date, publication, etc.	
Code relevance	
Solution description	
Key aspects of dwelling performance the solution addresses	
Description of research conducted (method, number)	
Key research findings	
Evidence of methods & pathways to encourage consumer take-up	
Evidence of consumer take-up	
Evidence of barriers to consumer take-up	
Evidence of methods & pathways to encourage industry take-up	
Evidence of industry take-up	

Evidence of barriers to industry take-up	
Business case development: Quantified benefits for consumers	
Business case development: Quantified benefits for industry	
Business case development: Quantified public benefits	
Related research / reports	
Other comment	

APPENDIX B

SUMMARY POST-2013 RESEARCH REVIEW OF TAKE-UP

Paper	Country	Primary Research or Research Review	Research target groups	Dwelling performance features	New builds or existing dwellings	Enabling tools	Uptake barriers
Eisenberg, 2016	USA	Review	Government bodies	Climate change Energy efficiency Water efficiency Dwelling durability and resilience Carbon footprint Land impact Materials toxicity	New builds	Regulatory and control mechanisms Accreditation Capability development	Poor policy and regulatory mix, compatibility and integration Regulatory process barriers Political unacceptability of tools Low professional capability Poor enforcement Financial constraints
Fletcher *et al,* 2015	USA	Review	Builders Architects/designers	Access	New builds	Regulatory and control mechanisms Accreditation Capability development	Consumer and industry attitudes to ageing and universal design Lack of consumer and industry knowledge and information Low professional capability
Gabriel and Watson, 2013	Australia	Research	Householders	Energy efficiency Water efficiency	Existing	Funding incentives Capability development	Lack of consumer knowledge, information and confidence Financial incentive programmes not user-friendly Low professional capability
Greiman and Ravesloot, 2016	USA	Research	Householders	Access	New builds Existing	Regulatory and control mechanisms Funding incentives	Poor policy and regulation
Göçmen and LaGro 2016	USA	Research	Local government Planning professionals	Energy efficiency Water efficiency Dwelling density Dwelling size Lot size Land impacts Environmental impacts	New builds	Regulatory and control mechanisms Planning and procurement initiatives	Low professional capability Environmental attitudes of planning professionals Poor enforcement Conflicting policies Financial constraints Planning barriers Lack of regulations Lack of monitoring tools

Henderson *et al,* 2016	UK	Research and Review	Builders Developers	Energy efficiency Water efficiency Waste reduction Zero carbon emissions	New builds	Regulatory and control mechanisms	Lack of consumer confidence Consumers risk adverseness Financial constraints Unclear policy and regulation Inadequate or untested technologies Industry attitudes and culture Poor marketing
Judson and Maller, 2014	Australia	Research	Householders	Energy efficiency	Existing	Regulatory and control mechanisms	Poor policy understanding of consumers' needs and household composition Financial constraints Inconvenience to householders Poor aesthetics
Karastas, *et al,* 2016	USA	Research and Review	Householders Commercial building employees	Energy efficiency	Existing	Regulatory and control mechanisms Funding incentives Capability development	Financial constraints Lack of consumer knowledge and information
Larkin *et al* 2015	Australia	Research	Architects/designers Disability service professionals Consumers	Access	New builds	Regulatory and control mechanisms Funding incentives Accreditation Capability development	Poor design practices Poor standards enforcement Unproductive responses to non-compliance Lack of consumer demand Belief that universal design features are more expensive Poor and unappealing marketing
Manley and Miller, 2014	Australia	Proposed research	Registered builders	Energy efficiency Waste minimisation in construction	New builds	Not covered	Builders' beliefs about innovation
Olanrewaju *et al,* 2015	Malaysia	Research	Home maintenance services Home owners	Energy efficiency Water efficiency Dwelling durability and resilience	Existing	Financial incentives	Home owner financial constraints Low professional capability
Rosenow *et al,* 2016	14 EU countries	Review	Government bodies	Energy efficiency	New builds Existing	Regulatory and control mechanisms Funding incentives Accreditation Capability development	Political unacceptability of tools Poor policy mix, compatibility and integration Poor standards implementation
Shearer *et al,* 2016	Australia	Research	Developers Architects/designers Financial institutions Solicitors State and local government	Climate change adaptive capacity of residential buildings Energy efficiency Resource re-	New builds	Not covered	Financial constraints Risk aversion Regulatory process barriers Lack of industry knowledge of climate change housing adaptation Lack of consumer

				use			demand
Yang and Yang 2015	Australia	Research	Government bodies Developers Architects/designers Builders Other housing professionals Financial institutions Real estate agencies	Energy efficiency Indoor environmental quality	New builds	Regulatory and control mechanisms Funding incentives Accreditation Planning and procurement initiatives Capability development	Financial constraints Lack of policy or regulations Regulatory and planning barriers Lack of leadership Lack of collaborative integration Conflicting/confusing policies/legislation Low professional capability Insufficient research demonstrating cost-benefits Lack of monitoring and measurement tools Inadequate or untested technologies or materials Building practice inertia Insufficient media promotion
Ward *et al,* 2014	Australia	Research	Developers Builders Architects/designers	Access	New builds	Regulatory and control mechanisms Funding incentives Accreditation Capability development	Industry risk averseness Industry perception of lack of demand Building practice inertia Low professional capability Financial constraints Lack of consumer demand Consumer and industry attitudes to universal design Lack of consumer knowledge, information and advice Lack of regulations
Warren-Myers and Heywood, 2016	Australia	Research	Volume builders	Energy efficiency	New builds	Accreditation Capability development	Lack of consumer demand Lack of consumer knowledge, information and advice Poor implementation of government incentives Poor implementation of regulations Industry perception of expense of innovations Building practice inertia Low professional capability Dominance of standardised products and house plans

ANNEX D: NZ DATABASE SEARCH

NZ Database Search

In order to find what, if any, research had been undertaken on aspects of domestic accessibility or energy efficiency relating to the New Zealand Building Code in recent time, a selection of research publication databases were keyword searched:

- NZResearch.org.nz (NZResearch)
- Index New Zealand (INNZ)
- BRANZ library
- VUW Restricted Archive

The databases searched use double quotes (") to link words together to request a search for the exact phrase or entire text string. For this section, the search terms are underlined in order to show the search text as entered. For example, "building code" accessible searches for the phrase "building code" in conjunction with the word accessible. The searches were undertaken during May and June 2017. As the databases are modified each day, it is possible that similar searches might result in slightly different counts, but it is expected the overall findings would be unchanged.

NZResearch (www.nzresearch.org.nz) states that it is: "New Zealand's most comprehensive selection of research papers and related resources. This site includes peer-reviewed and other research from universities, polytechnics, and research organisations throughout New Zealand."

NZResearch is a "harvester" using information collected by DigitalNZ (http://www.digitalnz.org/) about documents stored in New Zealand research repositories and assembling it into a single database. The original documents are held in the originating institutions, although NZResearch provides an abstract. The 53,286 records include papers and other research sources (including doctoral, masters and undergraduate theses) available from the publicly available institutional databases. NZResearch was set up in 2013 and is updated nightly using the DigitalNZ entries. As well as university research, it includes material from BRANZ and Motu Research.

NZResearch categorises each entry under two headings:

- **Scholarly research**: thesis (doctoral, masters, undergraduate), books, some conference papers, some research reports, some journal articles
- **All**: non-thesis publications including research reports, articles, papers, journal articles

For each entry, NZResearch provides the title, author, date of publication, abstract and a link to the original catalogue record. Each search provides a set of filter terms which are also used to provide a statistical summary based on the catalogue entry metadata including: by institution; author; thesis level; date (reported in the analysis by year, decade and century); title; usage rights; and primary collection. Not all metadata is provided for each entry, so analyses based on the metadata do not necessarily given consistent totals e.g. if the date metadata is missing from 2 entries, then the sum of publications by institutions will be 2 higher than the sum of publications by date.

NZResearch does not include material held in each institution's "restricted" research archive, although as an example, at VUW these items are listed in the Library Catalogue. The VUW Restricted Archive holds 8,672 items, many of which are theses for which the Library does

not hold suitable permissions to allow full public access in electronic (soft) form, although it would appear these can be borrowed in hard copy form through the normal inter-loan process. A search of the VUW Restricted Research Archive for the phrase: "building code" accessible returned 120 results, of which only one dealt with building accessibility - NZS4121:1985 as it applied to Wellington CBD office buildings. While it is possible the other university restricted research archives may hold relevant records, these have not been explored.

Index New Zealand (INNZ) is normally accessed through the National Library of New Zealand website. INNZ is a searchable database containing abstracts and descriptions of articles from about a thousand New Zealand periodicals and newspapers published from the 1950s to the present day. The periodicals range from academic research journals to magazines. Around 3,000 new records are added monthly from 460 current titles. The approximately 850,000 records can be searched using a wide range of methods including title, author, subject and keyword to find abstracts and descriptions of articles that reflect the social, historical, political, scientific and economic issues in New Zealand and South Pacific over the last 25 years.

INNZ Subjects include general and special interest material, social research, the environment, science, agriculture, current affairs, the arts and the humanities. Included are New Zealand book reviews, poems, short stories, and biographical articles. Also included are feature articles from the weekend metropolitan newspapers and the Otago Daily Times. For each entry INNZ provides the title, source (including volume, issue and date), a brief summary or abstract and details on accessing the item through the relevant catalogue. No summary statistics are provided.

BRANZ maintains an extensive library of relevant publications, the catalogue of which is available for off-site web search. The BRANZ library collection includes over 35,000 books and reports, approximately 170 current journal and access to more than 130 electronic journals, standards, building codes, trade literature from approximately 400 building product manufacturers, CD-ROMs and DVDs, a growing number of full-text electronic documents linked through the catalogue, and a wide range of bibliographic and full-text databases via the BRANZ Library Website. It includes almost all publications from BRANZ and its predecessor organisations.

The catalogue subject coverage includes all aspects of building construction, including management, energy efficiency, sustainable design, construction and materials, together with information relating to research into building techniques and resources, and fire engineering. The online catalogue provides the ability to search and retrieve records from over 43 000 items. The library catalogue was searched for selected key terms. A search for the phrase: "building code" accessible returned 17 results none of which were for NZ, while the phrase: "New Zealand building code" returned 160 results, which had either been obtained through other investigated resources or were not relevant to this research. As a result it was decided that adequate access would be obtained through the use of NZResearch and INNZ.

The NZResearch and INNZ databases were searched for publications relating to the NZ Building Code and the two specific topics related to domestic buildings –energy efficiency and accessibility.

The table below gives the count of results returned for both INNZ and NZResearch for the listed search word or phrase, and whether or not quotes where used around the phrase ('-' is used for 'not applicable' and a blank when no publications found). For NZResearch also gives the counts for the "Scholarly research" and "All" categories. As would be expected, the "All" category includes additional items when compared to the "Scholarly research" category. In some cases the search phrase was not found in NZResearch. For example, the term Lifemark was not found, nor was "accessible design" (with quotes) although items with the separate words (accessible design) without quotes where found. It should be noted that the counts are not mutually exclusive – for example energy efficiency may also be included in an item with New Zealand building code. For the purpose of this research, the reported analysis is based on the "All" search results.

Search Phrase	INNZ		NZResearch			
			Scholarly	All	Scholarly	All
	No quote	Quotes	No quote		Quotes	
NZBC	106	-	8	27	-	-
New Zealand building code	166	25	139	168	31	48
NZ building code	228	35	33	38	3	4
building laws	481	348	95	108	2	6
building code	438	238	222	265	74	107
"building code" minimum	15	-	10	12	-	--
Energy efficiency	634	510	494	622	174	284
Accessible design	44	3	205	225		
Lifetime design	29	10	66	67		
barrier free	106	60	83	90	2	2
Lifemark	14	-			-	-

Count of Results for INNZ and NZResearch by Search Type

These counts include material that is not directly relevant (e.g. not related to domestic buildings) and duplicates (some material is listed twice for unknown reasons). The individual items were then reviewed and where relevant copied into a MS Word document. Each item was reviewed for other possible search terms, and compared to known material to ensure all possible references had been obtained. Further searches, selection and extraction were then undertaken. A final review of the document ensured the application of consistent selection criteria and also removed any accidental duplicates or non-relevant publications. These results were then used for the analysis reported in the next section.

Year	Organ.	Type	Title	Author	Topic
1996	BRANZ	Report	A practical study of retrofit air tightening of old houses for energy efficiency	M R Bassett	Airtightness
1998	BRANZ	Report	Surveys of insulated glazing use in NZ housing as an energy efficiency micro-indicator 1994-1998	J C Burgess	Glazing
2001	Canterbury	Report	Domestic Hot Water: Options and Solutions	A G Williamson & S Clark	DHW
2003	Lincoln	Report	Energy efficiency of buildings with heavy walls	L A Bellamy & D W Mackenzie	Heating
2005	BRANZ	Report	$100 worth of comfort: the real value of energy technologies	A Stoecklein et al.	Heating
2005	BRANZ	Report	The value of low energy technologies for occupant and landlord	A Stoecklein et al.	Mixed
2006	CHRANZ	Report	The Impact on Housing Energy Efficiency of Market Prices, Incentives and Regulatory Requirements	I McChesney et al.	Mixed
2007	BRANZ	Report	The effect of mandatory insulation on household energy consumption	M Camilleri et al.	Heating
2009	Otago	**Masters**	Alleviating fuel poverty in NZ through improving the energy efficiency of the residential sector	M F Callaú	Mixed
2009	Otago	**Masters**	Heat Losses and Gains in Residential Housing in Southern NZ	T W Bishop	Mixed
2009	Unitec	**Masters**	Passivhaus – a NZ adaption : an evaluation of NZ's potential to adopt German energy saving standards for residential architecture	S Hendry	Mixed
2009	Auckland	Paper	Energy Efficiency, Indoor Air Quality and Health in NZ's Traditional Domestic Architecture	P Leardini	Heating
2009	VUW	**Masters**	A Cost Benefit Analysis of Secondary Glazing as a Retrofit Alternative for NZ Homes	N Smith	Glazing
2010	Beacon	Report	Clawback of heating services in Beacon research homes	A Pollard & N Buckett	Heating
2010	BRANZ	Report	Higher than NZBC thermal insulation in new housing cost-benefit analysis	J Fung	Heating
2010	BRANZ	Report	Clawback of energy efficiency upgrades in NZ households	A. R. Pollard & N R Buckett	Heating
2010	VUW	**Masters**	Efficacy of Energy Efficiency and Thermal Comfort Related Retrofit for Existing NZ Houses	Y Zhang	Heating
2011	Unitec	Report	The carbon footprint of the increase in home insulation levels in NZ	J Andric	Heating
2011	Unitec	Journal	The impact of passive design factors on house energy efficiency	B Su	Heating
2012	Unitec	Paper	The impacts of high performance glazing on typical light timber framed houses in a NZ winter	K Davies et al.	Glazing
2013	Auckland	Paper	Building passive houses in subtropical climates? A lesson learnt from NZ	P Leardini et al.	Mixed
2014	Otago	Paper	Personalized Energy Priorities: A User-Centric Application for Energy Advice	R Ford et al.	User
2014	Unitec	Journal	Future Housing Energy Efficiency Associated with the Auckland Unitary Plan	Su, Bin (2014)	Mixed
2015	Unitec	Paper	The efficient house innovation : healthful, efficient & sustainable housing for northern & southern climates	T Gillies & B Poulin	Mixed
2016	BRANZ	Report	The selection and hygro-thermal modelling of new NZ dwellings (pilot)	R Jaques et al.	Heating
2016	Unitec	**Masters**	Long live the state house: an investigation into the possibilities of retrofit solutions to existing problems with post-war state houses	H Young	Mixed

Research and Theses Examining Domestic Energy Efficiency

Year	Organ.	Type	Title	Author	Topic
2001	BRANZ	Book	Homes without barriers - a guide to accessible houses	A Bulleyment	Accessible
2011	BRANZ	Report	Fire design for aging residential occupancies	A P Robbins	Fire
2011	BRANZ	Report	Lifetime housing - the value case	I C Page & M D Curtis	Mixed
2012	Waikato	**Masters**	Positive Ageing in Place: Older Māori in Traditional and Non-traditional Place	C Williams	Accessible
2016	BRANZ	Report	Valuing Sustainability fact sheet 3: Incorporating universal design features in a new build or renovation	(no authors given)	Accessible

Research and Theses Examining Domestic Building Accessibility

ANNEX E: ANNOTATED BIBLIOGRAPHY

Contents

TAKE-UP & INNOVATION

Papers since 2012

#	Year	Description
1.	2016	**Shearer, Heather, Coiacetto, Eddo, Dodson, Jago, Taygfeld, Pazit, 2016, How the structure of the Australian Housing Development Industry Influences Climate Change Adaption, *Housing Studies*, 31:7** http://dx.doi.org/10.1080/02673037.2016.1150430 Investigates how the institutional structure of the Australian private housing development industry influences its risk profile and the capacity for innovation in the types of housing produced. Key findings: the adaptive capacity of players in the housing development industry is influenced by their position in the broader structure of the housing and finance market; the Australian housing industry is generally risk-averse and conservative, however it frequently innovates, albeit in an often partial, inconsistent and conflicted fashion
2.	2016	**Rosenow, Jan, Fawcett, Tina, Eyre, Nick and Oikonomou, Vlasis, 2016, Energy Efficiency and the Policy Mix, *Building Research and Information*, 44:5-6, 562-574** http://dx.doi.org/10.1080/09613218.2016.1138803 Reviews existing literature on policy mixes in energy efficiency, with a focus on how to design effective policy mixes from a European perspective. Finds a combination of multiple financial incentives is desirable. Ideally there are three stages to designing effective policy mixes: primary selection of the instruments most suitable from the range of possible instruments; design and/or customisation of the instruments for the context in which they are intended to be used; and design of a set of different and complementary policy instruments to address the problem(s) identified. Suggests policy makers should "favour" instruments that are complementary and avoid those that overlap.
3.	2016	**Warren-Myers, Georgia and Heywood, Christopher, 2016, Investigating Demand-side Stakeholders' Ability to Mainstream Sustainability in Residential Property, *Pacific Rim Property Research Journal*, 22:1, 59-75** http://dx.doi.org/10.1080/14445921.2016.1161870 Australian research that investigates how theoretical arrangements between demand and supply of new sustainably housing thwart adoption of sustainability as a mainstream practice and asks if reconceptualising the demand and supply relationship could be used to achieve permeation of sustainability into the mainstream. Argues that developing a demand side approach that targets volume builders and their interaction with consumers could aid in mainstreaming sustainability in new housing. Solutions include: inform and educate consumers to empower them to demand change; provide easily accessible options and mechanisms for adoption; identify stakeholders that can drive change in the supply chain; engage consumers to create latent demand and leverage their dominance over the market to direct sustainability requirements to the supply chain; and demonstrate practicability to the user

#	Year	Description
4.	2016	**Greiman, Lillie and Ravesloot, Craig, 2016, Housing Characteristics of Households with Wheeled Mobility Device Users from the American Housing Survey: Do People Live in Homes that Facilitate Community Participation, *Community Development*, Volume 47, No 1, 63-74** http://dx.doi.org/10.1080/15575330.2015.1108989 Examines accessibility issues in the American housing stock and the relationship between impairment, home ownership and housing accessibility using data from the American Housing Survey (2011) to determine accessibility of housing units across 6 groups of tenure and impairment status. Reports disability related fair housing complaints have constituted 55.6% of all complaint cases investigated by HUD. Only 14-29% of 14 facilities examined in Kansas were compliant with fair housing standards set for public housing facilities. A large proportion of households that had an occupant with a mobility impairment did not have accessibility features. Renters were more likely than owners to lack accessibility features. Over one half of tenants in all groups had a step "to negotiate" at the front entrance. The potential for programmes to support people with mobility impairments into work is low if these people are "unable to access their communities". This may help explain why beneficiary take up of the "ticket to work" programme under the Work Improvement Incentives Act has been very low. Inaccessible housing may result in fewer opportunities to access preventative medicine and health services. In combination with isolation, which is a risk factor for poor self-care, this can result in higher health care usage and costs. Inaccessible features put residents at increased risk of falls and ill health that for older adults, may lead to institutionalisation and high costs of institutionalised care.
5.	2016	**Henderson, Cara, Ganah, Abdulkadir, John, Godfaurd, A., 2016, Achieving Sustainable Homes by 2016 in the UK: The Current Status, *Environ Dev Sustain*, 18:547-560** The "Code for Sustainable homes" developed out of the EcoHomes scheme (2006) by the Building Research Establishment and meets the non-industrial sector for the Building Research Establishment Environmental Assessment Model (BREAM) equivalent. Implementation of CSH in England began in April 2007 and became mandatory for all new homes in May 2008. CSH measures the sustainability of a home against design categories and rates it as a whole. Factors assessed include: energy/CO2 pollution; water; health and well-being; materials; management; surface water run-off; ecology; and waste. Most respondents believed the likelihood of achieving the objective for zero carbon emissions in all new homes was low. Fifty percent of respondents were working towards levels above the mandatory minimum of CSH. Of this 50%, 54% were working towards code level 5, and none were working towards zero carbon (level 6). Factors that motivated respondents to build beyond the minimum standards included: planning regulations (32%); differentiation from competitors (22%); internal sustainability policy (20%); known customer demand (10%); perceived customer demand (12%); internal CSR policy (19%). Respondents did not rate issues around the supply of green/renewable technologies as a significant barrier to sustainability, suggesting these technologies are available in the supply chain at a reasonable cost. Builders do not want to invest if they do not expect a good rate of return on investment, and buyers and owners do not have confidence in the market to make investment worthwhile.

#	Year	Description
6.	2016	**Karatas, Alison, Stoiko, Allisandra and Menassa, Carol, C., 2016, Framework for Selecting Occupancy-Focused Energy Interventions in Buildings, *Building Research and Information*, 44:5-6, 535-551** http://dx.doi.org/10.1080/09613218.2016.1182330 Aims to identify occupants' impact on the energy consumption of buildings and develop a framework to aid in the design of effective energy efficiency tools for both residential and commercial buildings. Identifies the most effective interventions based on occupant energy use, characteristics and MOA levels. Uses a case study of an energy efficient company in Madison Wisconsin, equipped with an intelligent building automation system with centralised monitoring and controls, and a survey of 19 employees. Suggest a multi-level strategy tailored to a wide range of occupant characteristics. Energy policy tools have often failed to result in the predicted outcomes. One reason is because they tend to focus on ease of implementation rather than the energy actions and behaviour of occupants. It is essential to identify the characteristics of occupants that significantly contribute to energy problems and factors that make sustainable behaviour appealing. People are more likely to make permanent changes to their energy behaviours if they can easily access resources and new behaviours are easy and convenient to implement.
7.	2016	**Eisenberg, David, A., 2016, Transforming Building Regulatory Systems to Address Climate Change, *Building Research and Information*, 44:5-6, 468-473** http://dx.doi.org/10.1080/09613218.2016.1126943 Explores challenges to addressing climate change intrinsic in the regulatory industry. Based on observations from more than 20 years working to incorporate sustainability in the US building regulatory system. Need to develop comprehensive, well integrated regulatory system with clearly articulated goals and formal processes to identify and address emerging risks and hazards. Recommends a systems based approach for understanding risk and responsibility with a formal co-ordinated process to identify assess and balance hazards, including emerging issues and knowledge about the impacts of previously accepted practices. Key instruments include: fostering attitudes that recognise the importance of innovative approaches, materials and designs; effective enforcement of regulations and standards; training; and provision of reliable funding mechanisms. The design community (architects, engineers, consultants, interior designers, planners) could influence policy makers and officials to provide leadership and support for regulatory changes. There is a need for greater public involvement to reinforce desire for sustainable change.
8.	2016	**Göçmen, Z. Asligül, and LaGro, James A. Jr, 2016, Assessing Local Planning Capacity to Promote Environmentally Sustainable Residential Development, *Journal of Environmental Planning and Management,* 59:8** http://dx.doi.org/10.1080/09640568.2015.1080673 US research exploring the extent to which local planning capacity encourages sustainable residential development and the impact of development pressures, community characteristics and planning capacity on sustainability planning at a local government level. Planning and development of best practices have been implemented unevenly over time, resulting in disparate patterns in the structure, function and sustainability of the built environment. The factors most commonly associated with smart growth development included: community values; zoning and subdivision regulations that facilitate implementation; residents' education; planners' concerns about the impact of development on the environment; and residents' education levels.

#	Year	Description
9.	2015	**Yang, Jay, and Yang Zhengyu, 2015, Critical Factors Affecting the Implementation of Sustainable Housing In Australia, Housing and the Built Environ; 30 (2):275-292** Reports on qualitative and quantitative research investigating the factors influencing key stakeholder decisions around the adoption of sustainable housing. Identified critical factors for implementation of sustainable housing including: innovative collaboration with a clear stakeholder structure; defined leadership and individual roles; communication of benefits for stakeholders; establishment of a clear reward system; establishment of a government supported, scientific, longitudinal, cost benefit research regime; government funding. Research and development, professional education and training and public education and awareness – are more influential in boosting market scale than regulations, but are slower than regulations in driving reform.
10.	2015	**Larkin, Helen, Hitch, Danielle, Watchorn, Valerie, and Ang, Susan, 2015, Working with Policy and Regulatory Factors to Implement Universal Design in the Built Environment: The Australian Experience, *International Journal of Environmental Research and Public Health.* 12(7) pp.8157-8171** Research exploring the role of policy and regulatory factors in influencing the uptake of universal design. Successful implementation of UD requires a combination of legislation, taxation, education and smart design and engagement of a diverse range of user groups as early as possible in the design process. The focus must be shifted from disability provision to universal and inclusive provision.
11.	2015	**Fletcher, Valerie et al., 2015, The Challenge of Inclusive Design in the US Context, *Applied Ergonomics*, 46: 267-273** Considers the evolution of thought and practice around inclusive deign in the US since 1993. Implementation of Universal Design requires a shift from "the long-standing US obsession with youth and the prevalent delusional attitudes of the realities of ageing". The only documented teaching of universal design, in professional design education, has been by faculty supported by the Universal Design Education Projects (UDEP) in the College of Design at North Carolina State University. Currently interior design is the only design discipline incorporating UD terminology in their accreditation programmes for degrees. Within the housing industry, universal design is seen as being "desirable solely to one or more niche markets," rather than as a framework for thinking about design. Builders, developers and planners more likely to engage with universal design than architects and designers. However, a growing number of architects are now exploring the role of architecture in social change.
12.	2015	**Olanrewaju, AbdulLateef, Tan, Seong Yeow, Lee, Lim Tat, 2015, Rethinking Sustainable Housing Maintenance Delivery, *Applied Mechanics and Materials*, Vol. 802, 682-687** Poorly maintained housing is expensive to operate, consumes more water and energy than necessary, generates more waste, results in "sick building syndrome," is potentially unsafe and is a risk to users "and the community" Approximately 25% of maintenance organisations felt strongly that sustainability was too expensive to implement. Maintenance organisations uncertain about what sustainability means in practice. The majority of organisations viewed sustainability as predominantly being about reducing energy costs. However 66.7% of respondent acknowledged that home maintenance was "very important" in terms of fostering practices that reduce energy and water use and promote safety, health and social interaction. Attention is often focused on the design and construction side, for which the client is viewed to be responsible. Inappropriate to blame the client when it is the industry's responsibility to lead.

#	Year	Description
13.	2014	**Judson, Ellis, P. and Maller, Cecily, 2014, Housing Renovations and Energy Efficiency: Insights from Homeowner's practices, *Building Research and Information*, 42:4, 501-511** http://dx.doi.org/10.1080/09613218.2014.894808 Australian research investigating the extent to which low energy and other environmental concerns come into play in renovations. Key conclusions: renovation practices are informed by four key elements - rules , materials, skill/"know-how" of renovators, professionals and contractors, and common understandings around when and why to undertake renovations. Renovation practices are often shaped by understandings of livability and sociability which were not always consistent with energy efficient aims. Narratives of environmental efficiency are associated with products and technologies, rather than changes to daily routine to reduce consumption. In some cases consumption was likely to have increased following renovation, despite implementation of energy efficient technologies. The incorporation of energy or environmental interventions to reduce consumption ultimately depends on their compatibility with practices such as caring for family, socialising, maintaining thermal comfort, and other aspects of ordinary routines. Increasing energy costs are a driver for renovators across age groups, but particularly those who were retired or approaching retirement and wanted to make the house warm, livable and more economical for their future needs.
14.	2014	**Manley, Karen and Miller, Wendy, 2014, Innovative Design: Developing Strategies to Improve Developer Attitudes to Sustainable Housing, in World Sustainable Building Conference (SB14), Barcelona, Spain** Paper outlines research that had yet to be undertaken to explore adoption of "manufactured high performance green house and/or house components", focusing on the role of builders and their beliefs.
15.	2014	**Ward, Margaret, Franz, Jill and Adkins, Barbara, 2014, Liveable Housing Design: The Voluntary provision of Inclusive Housing in Australia, *Journal of Social Inclusion*, 5 (1)** Investigates attitudes and barriers to implementation/uptake of the Livable Housing Design initiative, a voluntary strategy to provide minimum access features in all new, Australian housing by 2020. Took samples of 11 newly constructed dwellings "in and around" Brisbane, including privately developed housing, social housing and affordable housing (developed by Queensland Government's former Urban Land Development Authority). Data collected from site visits, examination of building documents and 28 semi-structured interviews with developers, designers, site representatives and builders involved with the dwellings Legislation is the most effective measure and is most successful when reinforced by education and training. The "highly competitive and risk-averse nature of the industry works against a voluntary approach for inclusive housing". Housing providers preferred a regulatory approach that required compliance from all providers, to minimise risk, reduce uncertainty and maintain competitiveness within the industry. Voluntary initiatives are seen as barriers in themselves: as there is no reason to adopt practices that other providers might not take up they are generally ineffective. State and local governments are reluctant to regulate the construction and design of housing.

#	Year	Description
16.	2013	**Gabriel, Michell and Watson, Phillipa, 2013, From Modern Housing to Sustainable Suburbia: How Occupants and their Dwellings are Adapting to Reduce Home Energy Consumption, *Housing, Theory and Society*, 30:3, 219-236** http://dx.doi.org/10.1080/14036096.2013.775183 Examines how occupants and their dwellings are adapting to improve energy efficiency, drawing on householders' experience of installing solar hot water systems using three case studies (from Watson's PhD project) in Tasmania. Barriers to consumer take-up of the programme included: limited interaction and communication with product providers/installers; tight timeline for use of the rebate; complications with loan applications; lack of confidence; lack of knowledge; availability of experienced tradespeople; physical capacity and "Tacit acceptance of predetermined standards embedded in mass-produced and standardised building design"

EVIDENCE OF TASTE AND INNOVATION PREDISPOSITIONS OF INDUSTRY AND CONSUMERS AND DEGREE OF ALIGNMENT BETWEEN THE TWO

#	Year	**Description**
1.	2017	**Greenan, R., and Muir, B., 2017, New Zealand's Building Performance Pathways, *International Journal of Sustainable Development and Planning*, 12 (2)** https://www.witpress.com/elibrary/sdp-volumes/12/2/1460 Comparisons of Irish, Australian and NZBCs, utilisation of Passive House thermal performance (using U-values), and comparative analysis of LEED (Leadership in Energy and Environmental Design, North America) DEAP (Dwelling Energy Assessment Procedure, Ireland) and Homestar (NZ) rating systems are carried out. The Living Buildings Challenge (LBC) ratings tool is discussed in relation to the Tangata Whenua. New Zealand building codes have not caught up to innovations in other countries. "Comparatively, NZBC is pre 1995 England and pre 1997 Ireland code for minimum thermal performance of the building envelope." Theoretically NZBC intended to encourage better performance and innovation however the fall-back position is that solutions achieving minimum standards are adhered to. The minimum NZBC for thermal performance is in need of adjusting when compared to EU and Passive House Standards.
2.	2015	**Curtis, M.D., 2015, New House Owners' Satisfaction Survey 2014, SR 328 2015, BRANZ** Explores how new home owners rate their builder and how satisfied they are with the performance of their home. A sample of new home owners identified from consents taken out between April 2013 and March 2014. Excludes consents where the house was spec build, the owner built their own house or the house was built by a family member. Short postal survey sent to owners in 31 NZ regions. 2975 surveys were sent out, 650 responses were received. Approximately 12% of new owners who built with independent builders and 10% who built with franchise builders chose to build because they wanted to include sustainable features in their home. Approximately 9% of owners who chose a one off design with an independent builder and 8% who chose a one off design with franchise builders did so because they wanted to include sustainability features in their new home.

#	Year	Description
3.	2015	**Jaques, Roman, 2015, Measuring Our Sustainability Progress: Benchmarking New Zealand's New Detached Residential Housing Stock, BRANZ Study Report SR342, Wellington, New Zealand** Objective – to further develop a robust and useful set of sustainability indicators quantifying NZ's new build (stand alone) housing stock and establish a Year Zero baseline of where NZ stands in terms of key indicators. The uptake of independent tools to assess residential sustainability, such as Homestar, has been limited and these homes constitute a small and unrepresentative proportion of the housing stock. It is probable "these rated homes will remain very much a fringe activity for the foreseeable future given their small uptake so far". When asked the extent to which an independent rating and official certificate for the home's performance would contribute to a premium price, 49% thought the contribution would be high or very high. "The demand for comprehensive, whole-house sustainability-related certifications in 2012 was close to nil. This result seems at odds with the large number of surveyed respondents who thought an independent home rating certificate would contribute to a premium price on a house's sale" The concept of universal design is "hard to sell as it's benefits derive principally from creating a better everyday experience for users, which is easily overlooked".
4.	2013	**Barton, Barry et al., 2013, Energy Cultures: Implications for Policymakers, Centre for Sustainability, University of Otago** http://www.otago.ac.nz/centre-sustainability/research/energy/otago055630.pdf The Energy Cultures research project (2009-2012) was organised as a number of research projects headed by different disciplines but linked through a conceptual framework. Objective is to identify the relationship between personal values and energy use (using a laddering method) to help inform policymaking around residential energy use and energy efficiency in New Zealand. The policy segment presents key findings of the project and provides recommendations on how these findings can be used to develop and implement more successful policy measures. Found that tradespeople can influence household energy decisions and there is a need for better training in energy efficient products and services, and better incentives to supply them. In many instances an underlying value for a behaviour could not be identified and often there is no consistent relationship between values and energy behaviours. Identified 3 stages: the desire to change; choosing what to change; and implementing change. Policy needs to be designed to support people in each stage.
5.	2012	**Bond, Sally, 2012, Assessing NZ Householders' Energy Use Behaviours: A Pilot Study (Draft), 18th Pacific Rim Real Estate Society Conference, Adelaide, Australia, 15th-18th Jan** https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/5070/Bond_NZ_household_Energy_Use_Behaviour.pdf?sequence=1 Part of 2 parallel pilot studies: Surveyed housing sector participants who are members of the NZ Green Building Council in 2011. Survey distributed to industry professionals at NZGBC forums in Christchurch and Wellington. 25 (of 95) surveys were completed and returned; and a full scale survey of 4,000 householders was underway at the time of writing. Factors affecting the willingness of householders to improve sustainability features and behaviours in their home include: the time involved; effort required; level of comfort provided; cost; and long pay-back period.

#	Year	Description
6.	2012	**Saville-Smith, Kay, and Saville, James, 2012, Getting Accessible Housing: Practical Approaches to Encouraging Industry Take-up and Meeting Need, Report Prepared for The Office of Disability Issues and Building & Housing Group, Ministry of Business, Innovation and Employment** Review of literature around housing, ageing and disability, material related to innovation/innovation potential of the residential building industry and housing sector and material exploring approaches and levers used to address other aspects of building such as thermal performance and energy efficiency. Interviews with a small set of key researchers and practitioners in Australia, the UK and North America. Wide range of findings: NZ housing stock is inadequate for people with impairments and costly to adapt; no significant technological barriers to improved performance in the building industry; financing legislation and incentives differ between the housing sector and the building industry; housing sector is characterised by low levels of innovation and uptake of new technologies, processes, products and designs; weak regulatory environment arises in part from a societal belief that lifetime homes are for people different to everyone else. Vicious cycle of blame: Supply chain in the building industry (investors, developers, builders, designers and material and product suppliers) rationalise their failure to deliver technically achievable results by citing barriers presented by other stakeholders (e.g. householders won't pay)
7.	2012	**Barton, B., 2012, Energy Efficiency and Rental Accommodation: Dealing with Split Incentives, University of Waikato Centre for Environmental, Resources and Energy Law, Hamilton, NZ** http://www.otago.ac.nz/centre-sustainability/otago055632.pdf Explores how existing New Zealand laws can be used to support the introduction of energy efficiency measures in the rental sector, and instruments utilised for improving energy efficiency in the rental market in Australia and the UK. Conventional policy instruments to improve efficiency, such as subsidies, rebates and certificates, are less effective in the rental sector due to the issue of split incentives. Tenants must ask for consent to alter the dwelling, which they may be reluctant to do, and landlords have the right to deny improvements. Simplest way to improve energy efficiency in the rental sector is to improve public housing – does not require law reform, only funding. Furthermore, HNZC legislation requires it to act in a way that exhibits "a sense of social and environmental responsibility." More vigorous use of the Housing Improvement Regulations 1947 could be made to ensure housing provided is free from damp. Publicity and education around the regulations may result in scrutiny, and increase willingness of Tenancy Tribunal adjudicators to enforce measures to improve habitability and a better outcome for tenants. Review of Housing Improvement Regulations could provide a requirement that rentals be free from undue heat loss – as allowed by parent Act. A minimum standard could be developed and applied, rather than a general standard such as "reasonable fitness for purpose." Modern requirement for residential rentals could be developed and expressed as an obligation for landlords to provide premises in a state that can be kept warm and damp free at reasonable expense. This could potentially be incorporated in Section 45 of the Residential Tenancies Act 1991 or the Construction Orientation Building Act. Minimum Energy Performance Standards (MEPS) are an option under the Energy Efficiency and Conservation Act 2000, which could be amended to include dwellings. Could include new general requirements, such as a building warrant of fitness, subject to periodic inspection to confirm compliance. Information disclosure mechanisms should be introduced. A complex technical framework would be required for assessors to make meaningful ratings as well as attention to tenants at the bottom of the market who may be unable to turn down dwellings with poor ratings.

#	Year	Description
8.	2011	**Page, I.C. and Curtis, M.D. 2011, Lifetime Housing – the Value Case, Study Report 263, BRANZ** http://www.branz.co.nz/cms_show_download.php?id=df6a37ef0403bc0b9774a88183a2b563646c1b25 Comparison of the cost of fitting Lifetime Design (LTD) or User Friendly (UF) features in new and existing homes – 83 new homes, 112 existing homes. In terms of internal changes prior to construction, about 80% of houses require nil or minor changes to layout, doors and strengthening of bathroom fittings, adding a cost of about $500 to the total house cost. About 20% require substantial changes, adding an average of $8,000 to the total cost, without altering the internal layout. Numerous dwellings require changes to access, including wider parking areas and better approaches to the front door which add approximately $1,200 to the house cost. More cost effective to include UF features in new builds than to retrofit. Changes to existing homes typically cost over $15,000 per house for internal work and approximately $7,000 if a ramp or other access features are required. More publicity about the benefits of lifetime design needed. 87% of new home owners surveyed by BRANZ in 2011 had not heard of Lifetime design.
9.	2010	**Mirosa, Miranda, Gnoth, David, Lawson, Rob and Stephenson, Janet, 2010, Characteristics of Household Energy Behaviours, Report Prepared for the Energy Efficiency and Conservation Authority, Centre for the Study of Agriculture, Food and Environment (CSAFE), Kā Rakahau o te Aro Tūroa, University of Otago, New Zealand** http://www.otago.ac.nz/centre-sustainability/otago055634.pdf Conducted 28 face to face interviews concerning possible energy saving practices in the home, energy related investment and household demographics and energy costs using a laddering technique. Interviews ceased once no new data was being collected. Distributed 1100 household surveys (return rate 34% - 369 surveys) to gather detailed data on house and householder characteristics, space and water heating, appliances, insulation, heating behaviour, recent changes in technologies and sources of energy related information. Found personal values were not always a good predictor of behaviour and participants were often unable to articulate rationale behind behaviours, especially energy inefficient ones. Despite inconsistencies in values and behaviour, four values were strongly aligned with energy efficient behaviours. These included: being capable; being intelligent; protecting the environment; and enjoying life. Findings indicate that inability to pay is not the main driver for energy related decisions
10.	2010	**Isaacs, N.P. (editor), Camilleri, M., Burrough, E., Pollard, A., Saville-Smith, K., Fraser, R., Rossouw, P. and Jowett, J. 2010, Energy Use In New Zealand Households: Final Report on the Household Energy End-use Project (HEEP), BRANZ Study Report 221, BRANZ Ltd, Judgeford, New Zealand** Research established actual energy use and energy end-uses in a national sample of houses.

#	Year	Description
11.	2008	**Vujcich, Hayley, 2008, Valuing Warm Homes – Exploring New Zealanders' Home Heating Choices, (Doctoral Dissertation) Environmental Studies 593, School of Geography, Environment and Earth Sciences, Victoria University of Wellington** http://www.healthyhousing.org.nz/wp-content/uploads/2011/03/Vujcich-08-Valuing-warm-homse-NZers-home-heating-choices.pdf Quantitative survey drawing on the University of Otago's (Wellington) Heating Housing and Health study plus focus group research. Held two focus groups with a total of 26 participants. Participants aged 18+ from Newton, Mt Victoria and Karori, Wellington Policy interventions need to acknowledge consumers hold diverse attitudes and preferences and provide a range of responses. Community based social marketing may be useful in cases where domestic social norms hamper the uptake of more efficient technologies or behaviours. The value participants of the Heating Housing and Health survey placed on energy efficient heaters was generally below market price, despite provision of information on the attendant benefits. Found a range of barriers to consumer take up but considered affordability was the major barrier.
12.	2008	**New Zealand Business Council for Sustainable Development, 2008, Better Performing Houses for New Zealand: Making it Happen, Wellington, New Zealand** https://www.sbc.org.nz/__data/assets/pdf_file/0008/99422/Better-Performing-homes-for-New-Zealanders.pdf Collaborative research project by NZBCSD, commenced in 2007. Worked with 19 organisations in the building sector. Consulted with 7 organisations interested in sustainable building. Developed 5 point solution to improve existing housing stock. Greatest potential for better performing homes is upgrading existing stock. One million existing homes whose performance could be significantly improved. There is a lack of shared vision and a need for a clear, overarching strategy between industry, central and local governments. Necessary to work with owners and occupants to understand their aspirations and communicate this with the building industry. The products and services required to make improvements are known and available. Manufacturers, retailers and builders need to collaborate to develop solutions which meet the needs of owners and occupants. Mandatory performance rating providing sustainability certification would offer owners and occupiers a marked valuation "reward" for the cost of hidden retrofit features such as insulation.
13.	2008	**Howell, M., and Birchfield, D., 2008, Best Practice Policy Approaches to Encourage Sustainable Residential Building and Renovation: Survey and Literature Review Results, Report HR2420/2 (DRAFT), Beacon Pathways Ltd, Auckland, New Zealand** First stage of research in the Best Practice Policy Approaches project which aims to: evaluate existing policy provisions; identify successful policy approaches; gauge preference for the types of provisions; develop resources for local government to encourage a more sustainable housing sector; and develop a package of model provisions for uptake by other councils. Questionnaire based interviews with officers from 17 local authorities. Found: participating councils displayed a strong interest in sustainability and evidence of existing policy initiatives. However, research revealed limited resources, knowledge gaps and "piecemeal" approaches to initiatives. Uncertainty around parameters of possible interventions, especially in regard to what can be specified in a District Plan and the scope of application of financial incentives. 14 of 17 councils that agreed to participate aimed to encourage sustainable building or renovation. Three of the councils approached declined interviews as they felt there was not enough activity in that area to warrant a reply.

#	Year	Description
14.	2007	**Easton, Lois 2007, Beacon's High Standard of Sustainability: Implications for the Sustainable Development of the Residential Built Environment, Paper PR 109/5, 2nd International Conference on Sustainability, Engineering and Science (NZSSES), 20-23 February, Auckland, New Zealand** http://www.thesustainabilitysociety.org.nz/conference/2007/papers/EASTON-Beacon's%20High%20Standard%20of%20Sustainability.pdf Introduces benchmarks for Beacon's HSS and discusses existing housing stock in NZ. "Most New Zealanders are not engaged in the performance of their homes." Leadership from the public and private sector is required to move towards sustainability in the residential sector.
15.	2007	**Clark, Melony, 2007, National Value Case for Sustainable Housing Innovations: Making the Case for the National Benefit to be Gained from Transforming New Zealand Housing Stock – Both New and Existing – to Improve Sustainability, Beacon Pathways Ltd, Auckland, New Zealand** http://www.beaconpathway.co.nz/images/uploads/National_Value_Case_booklet_final30Nov07.pdf Assessment of the national value case for bringing NZ housing stock up to a High Standard of Sustainability. Evaluation of 6 energy and water saving innovations. Examines possible benefits and costs of those innovations in 4 areas: private economic benefit; environmental benefit; social/other private benefitr; national resource use benefit. Direct burdens on economy of poorly performing housing include: higher than necessary need for health, police and emergency services, energy demand and carbon emissions relating to climate change. Indirect burdens include reduced workplace productivity and educational attainment. The benefits to individual households, via lower energy costs, are not sufficient to encourage voluntary uptake of insulation retrofits. Individuals benefit in terms of improved health, but "the main gains go to the government via significantly lower health costs and to businesses that have lower overheads due to fewer days lost to sickness."
16.	2007	**Saville-Smith, Kay., James, B., Fraser, R., Ryan, B., and Travaglia, S., 2007, Housing and Disability: Future Proofing New Zealand's Housing Stock for an Inclusive Society, Wellington, CHRANZ** http://www.lifetimehomes.org.uk/data/files/Reports/housing-and-disability-future-proofing-new-zealands-housing-stock-for-an-inclusive-society.pdf Explores the changing experience of people with moderate to severe mobility impairments by assessing the extent that demand for accessible and functional housing is supplied through the housing market and disability sector. On the demand side: Survey of 121 people with moderate to severe disabilities; Survey of 31 parents with one or more disabled child living at home; Focus groups with disabled people, their families and carers across the North and South Islands (39 participants). On the supply side: Survey of 89 community based housing providers, 54 of whom identified as providers with disabled clients; Survey of 81 real estate agents in Auckland, Christchurch, Hamilton, Wellington and Dunedin; In depth interview with a private housing developer; and in depth interviews with HCNZ officials involved with the development and renewal of housing stock. To date little uptake of accessible features that would ensure even a basic level of accessibility. Supply side of the housing market does not widely recognise opportunities for providing basic levels of accessibility and functionality in new builds.

#	Year	Description
17.	2007	**Stancu, C., Finlay, G. and Gunn, S., 2007, Market Transformation Interventions: Creating Demand and Supply for Sustainable Housing, Report MT 105 for Beacon Pathway Ltd** Research to identify best practice in market transformation through an international review, use this to generate a list of potential interventions to influence supply and demand, analyse using recognised scenarios for NZ housing; develop short list as potential projects via workshops with industry professionals and undertake a survey of 86 companies in the housing sector. Range of findings including: key players in the market (suppliers, distributers, traders, intermediaries, consumers) are more likely to support transformation when their concerns and motivations are considered in the design of the intervention; because of the complexity of the market and various players, no single instrument can achieve a sustainable change – intervention programmes require a mix of instruments; building codes and ratings require sound enforcement and political consensus; may not effectively penetrate market as they only apply to new homes or homes undergoing major retrofits; codes need continuous development of new materials/practices/climate change otherwise they can become a barrier to adoption of better practices; awareness raising interventions and performance indicators should be specifically developed for each demographic; self-perpetuating cycle – lack of consumer demand leads to few drivers for reduced costs, better information or improvements to industry capacity; consumers more concerned with the function of their home and what suits their lifestyles than sustainability aspects; information provision, without systemic drivers and financial incentives may be unsuccessful in convincing homeowners to spend money on sustainability.
18.	2007	**Hall, Alison, 2007, Barriers to Sustainable Renovations and Incentives that Local Governments Can Offer, Conference Paper PR 201/7, North Shore City Council, Takapuna, Auckland** Outlines initial research for a Masters of Planning to identify barriers to sustainable renovations. Aims to gauge residents' awareness of the availability of sustainable products and ideas and why some residents chose not to install these products. Survey of homeowners granted Building Consent for Additions and Alterations in 2006. 857 surveys distributed, total response 185 surveys. Most common reason for renovation was to upgrade the home, followed by wanting more space. Few owners renovated their home for the intention of selling and 5% of North Shore City renovations were carried out on a home rented to tenants. The main reasons respondents did not install energy efficient products they considered were cost (61%) and lack of space or feature hadn't been factored into the initial design (25%). 7% had been told they did not need these features. Reasons for not installing water management features were cost (30%) not incorporated in the design stage/not enough room (34%), didn't have enough information to feel confident installing and using products (17%). Many respondents did minor renovations as they did not want to spend money on professionals or deal with the council. Some respondents indicated that they would have liked to have been more sustainable but thought a more complex design would be difficult to get consent for

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19.	2004	**V. Heslop, V.P. Lysnar, J. Dixon, C.T. Eason, 2004, Understanding Developers' Perspectives in Sustainable Urban Design, in: Third International Conference on Urban Regeneration and Sustainability: The Sustainable City III, Auckland,** Pilot study to identify the barriers perceived by developers in incorporating sustainable design features. Interviewed 10 developers involved with construction of medium density housing in Auckland and Christchurch over four years. Commercial property developers and 3 not for profit organisations providing community housing. A number of the developers were driven by personal motivations, values or philosophies to incorporate elements of sustainable design into their developments. Wanted the development to have a long-term positive influence on the community. Huge variance in how developers defined 'sustainability' and in their level of knowledge/understanding. Definitions included aspects such as: durability; infrastructure and zoning; long term market satisfaction; longevity and livability; environmental and social considerations. Some developers asserted that it was more affordable to undertake developments that did not incorporate sustainable features as they were more likely to meet council requirements. Market drives delivery. If consumers don't understand the options or benefits developers are unlikely to change the way they operate
20.	2001	**Bulleyment, Alan, 2001, Homes Without Barriers: A Guide to Accessible Homes, BRANZ, Porirua City, New Zealand** http://www.branz.co.nz/cms_show_download.php?id=f67d42b2b445fc3b2e2404c3e2539d90b76c97f1 Works through aspects of dwelling design and presents some options for older people and people with disabilities that can be implemented in new or existing houses.

ENERGY EFFICIENCY – NZ RESEARCH PUBLICATIONS

#	Year	Description
1.	2016	The selection and hygro-thermal modelling of new New Zealand dwellings (pilot) Roman Jaques; Brian Berg; Stephen McNeil (Nov 2016) BRANZ Study Report SR 2016 BRANZ This pilot study is the first of a series of reports examining background issues around the current settings for clause H1 Energy efficiency and the related clauses of E3 Internal moisture and G4 Ventilation in the New Zealand Building Code (NZBC). It is part of a multi-year collaborative project between BRANZ and the Ministry of Business, Innovation and Employment (MBIE). (NZResearch.org.nz)http://nzresearch.org.nz/records/37398721?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=%22energy+efficiency%22+building+code

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2.	2016	Long live the state house : an investigation into the possibilities of retrofit solutions to existing problems with post-war state houses Young, Harriett (2016) Thesis Unitec With the built environment contributing to a large proportion of greenhouse gas emissions, there is great potential to reduce its environmental impact by addressing the ways in which we construct and use buildings. The residential sector shows the greatest potential for improvement, with 25% of global end use demand consumed by houses alone. Retrofitting provides promise for existing houses; increasing their life span whilst enabling upgrades in energy efficiency and spatial qualities. New Zealand's existing house stock is varied but one of the most prominent house types is the post-war state house, built between 1940-1960 across New Zealand. These houses make up the largest proportion of existing houses in New Zealand. The design of post-war state houses supported and promoted the nuclear family; an ideal which is becoming increasingly irrelevant in modern New Zealand. These houses remain stalled in the era in which they were designed and are now socially out of date, failing to meet the variety of needs of New Zealanders today. Changes in society and the way that we use our houses are explored and translated into architectural problems, which are addressed through the design of retrofit solutions. Long Live the State House asks the question: “How can the development of a spectrum of architectural interventions be used to retrofit existing post-war state houses, in order to extend their lifetime and usability, thus improving social, environmental and economic sustainability?” To answer this, the project explores retrofit solutions to current problems prevalent in these post-war state houses and aims to demonstrate alternative solutions to traditional housing models. The outcome is flexible and adaptable to suit a variety of applications across New Zealand. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/37765981?locale=en&search%5Bpage%5D=26&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
3.	2015	The efficient house innovation : healthful, efficient and sustainable housing for northern and southern climates Gillies, Tony; Poulin, Bryan (2015-12-22) In M. Panko and L. Kestle (Eds.). Building today - saving tomorrow : Sustainability In Construction And Deconstruction Conference Proceedings. (pp. 44-57). Auckland, New Zealand: Unitec Institute of Technology. Retrieved from: www.unitec.ac.nz/epress/ Conference paper Unitec This paper tracks the Efficient House Innovation (EHI) from 2000 to 2015. The main idea of ‘Dynamic Air’ behind EHI is associated with John Timusk (1987) who recognised existing housing solutions were not sufficiently healthful, efficient or robust. His solution was to bring relatively cool, dry air dynamically through the walls instead of the usual air-tight, static construction. However some problems remained. Starting in 2000, the authors of this paper extended and added features to Timusk’s solution to arrive at the EHI. Initial tests of EHI prototypes indicate the reliable fresh air, robustness of structure and energy efficiency that Timusk envisioned. This paper focuses on EHI prototype testing from 2008 to 2015, with implications for housing in cold, temperate and sub-tropical climates. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/36513016?locale=en&search%5Bpage%5D=20&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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4.	2014	Personalized Energy Priorities: A User-Centric Application for Energy Advice Ford, Rebecca; Sumavsk, Ondrej; Clarke, Auren; Thorsnes, Paul (2014) Presented at the HCI International 2014 Conference, Crete Conference item University of Otago This research presents a new web-based application, called Personalised Energy Priorities (PEP), that provides households with personalised and tailored advice on practices or technologies they might adopt to improve the energy efficiency of their home. PEP proceeds in a manner similar to an online energy audit, but combines a user centric design approach with relatively new choice modelling software that allows recommendations to be tailored to individual preferences. The tool also provides links to further information about each energy recommendation, creating a more successful, one-stop-shop for persuasion. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/35343367?locale=en&search%5Bpage%5D=4&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
5.	2014	Future Housing Energy Efficiency Associated with the Auckland Unitary Plan Su, Bin (2014) World Academy of Science, Engineering and Technology. International Journal of Civil, Architectural, Structural and Construction Engineering, 8 (7), pp.750-754. Journal article Unitec Based on energy consumption of 200 Auckland sample houses, mean extra winter energy is a large portion (28.4%) of mean winter energy. Mean total winter energy consumption is also a large portion (32.3%) of mean total annual energy consumption of the sample houses. Building thermal design for energy efficiency of Auckland housing should focus on building thermal performance under the winter climate conditions. This study uses relationships between winter energy consumption and building design data of the Auckland sample houses to estimate the future mean housing winter energy consumption associated with the Auckland Unitary Plan. The study uses the mean daily energy usage per unit volume (m3) of house indoor space (kWh/m3day) as the basic energy consumption unit because winter extra energy consumption is mainly related to indoor thermal conditions. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/36143724?locale=en&search%5Bpage%5D=2&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
6.	2013	H1 code compliance / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Apr/May 2013; n. 135:p. 36 ; Build (Wellington, N. Z. : Online), Apr/May 2013; n. 135 Discusses the NZ Building Code clause H1 'Energy efficiency' and looks how this is implemented in an Acceptable Solution under standard H1/AS1. Discusses the three options for compliance - the schedule method, calculation method and building performance index, and looks at the modelling method for buildings failing to meet the criteria of the previous methods. Notes minimum R-values (heat insulation efficiency) contained in E3/AS1 and the use of NZS 4218:2009. (IndexNZ)

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7.	2013	Building passive houses in subtropical climates? A lesson learnt from New Zealand Leardini, Paola; Iliffe, J; Gronert, R (2013) "17th International Passive House Conference, Congress Center Messe, Frankfurt, Germany, 19 Apr 2013 - 20 Apr 2013. A solid foundation for the energy revolution. Conference item The University of Auckland Library New Zealand's construction industry proves to be extremely conservative, reluctant to accept new products and technologies already established overseas. However, the country now faces the global issues of natural resource depletion and increased energy consumption, exacerbating its endemic problems concerning living conditions. Despite numerous studies proving the deleterious effects of unhealthy and uncomfortable dwellings on human wellbeing, there is still lack of pragmatic guidance on methods and technologies for future-proof constructions, both comfortable and energetically self-sustained. Even the most recent update of the current New Zealand Building Code is still insufficient to ensure comfortable indoors, imposing R-values that are just a fraction of those required by the European regulation in similar climatic areas. In the meantime, Europe is considering the Passive House (PH) standard as the means to achieve the requirements of the new Energy Performance of Buildings Directive, which requires all new constructions to be highly energy efficient, enabling the very low amount of energy required to be significantly covered by renewable sources. The success of the PH standard led to the question of whether it was applicable to New Zealand's 'unique' climatic, social and market conditions. Referring to the construction process of the first certified PH built in New Zealand (and in Australasia), this paper reveals the challenge of introducing the standard to what is perceived as a sub-tropical country. After having debunked the local 'myth' of the climate, it traces the brief but rapid evolution of the PH in the country, from the first prototypes, to the first certified detached house recently completed in Auckland, finally to the ultimate projects - already in their completion phase – of 'zero energy' PHs, which are equipped with on-site renewable energy generation systems. In order to verify if the PH standard is a viable solution for New Zealand, results of PHPP calculations produced for the NZ's first certified PH and two 'zero energy' PHs currently under construction in the North Island are analysed and compared to the PHPP calculation of a Code compliant house. The economic feasibility of this model is also assessed by running a simplified cost analysis and comparing the results to standard NZ construction costs for the same building category. Results show that the PH standard represents a suitable solution even for a sub-tropical country such as New Zealand: despite market constraints, PHs prove to be economically viable, especially considering long term benefits due to energy and health costs savings. At the national scale, the success of the most recent 'active' solutions could contribute to revitalize the image of New Zealand as a green country, which has greatly invested in clean energy but not on energy conservation strategies, first of all in the building sector, one of its biggest energy sinks. (NZResearch.org.nz)http://nzresearch.org.nz/records/32997090?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=energy+building+code

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8.	2012	The impacts of high performance glazing on typical light timber framed houses in a New Zealand winter Davies, Kathryn; Birchmore, Roger; Tait, Robert (2012) in Skates, H. (Ed.) 46th Annual Conference of the Architectural Science Association (ANZAScA) 2012 : Building on Knowledge: Theory and Practice. Griffith University, Gold Coast Australia. Conference paper Unitec This paper reports on a project which uses two full-scale, three-bedroom standard houses to identify the impact of changes in building elements and materials on indoor environmental quality. The lightweight, timber framed, stand-alone houses are characteristic of New Zealand construction, and meet the requirements for the current New Zealand Building Code in terms of materials and insulation. One of the houses served as the test case for the research and incorporated high performance argon-filled Low-E double glazing. The second house acted as a control, with identical design and location but built using standard construction practice including conventional double glazing. The paper details the impact of the Low E argon filled double glazing on internal temperature during a monitoring period which ran over the New Zealand winter. It compares results for this wintertime period to the results of previous testing of the same houses over the summertime period, and also examines results in relation to the short-term laboratory-predicted impacts of material thermal performance. Findings indicated that throughout the wintertime period, both houses performed similarly. In both cases the most notable issue was the high internal temperatures reached on cold sunny days. There were minor performance differences between the standard double glazing and the Low-E glazing. The temperatures reached in the Low-E test house on cold sunny days were less extreme than in the control house, but overnight and early morning temperatures were lower with the high performance glazing. On cold overcast days there was negligible difference between the two double glazing types. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/32317657?locale=en&search%5Bpage%5D=5&search%5Brecordset%5D=all&search%5Btext%5D=New+Zealand+building+code

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9.	2011	The carbon footprint of the increase in home insulation levels in New Zealand Andric, Jovan (2011) Unitec Department of Construction CONS 7819 Industry Project, Student Report Report Unitec As an energy saving measure, part of an integrated response to mitigate climate change, the New Zealand Government raised the legal minimum requirements for the thermal performance of new homes. A carbon footprint provides a means to quantify the effect this action has had to reduce the impact our new homes have on the environment. To date however, no study has been conducted to ascertain the carbon footprint of this change. This industry research project addresses this issue by determining the carbon footprint of the increase in home insulation levels in New Zealand. An investigation was made to quantify the additional embodied energy required to meet the new standard, and the resulting savings in electrical home space heating energy use. A scientific test and control method was employed. A standard timber framed three bedroom house design complying with the new thermal insulation standard was tested against the same design complying with the old standard over an operational life of 50 years. The test was conducted in New Zealand's three climate zones with the aid of a computer thermal simulation programme. It was found that double glazed windows make up the bulk of the additional embodied energy and carbon. The benefits of the increase in thermal insulation increased with the colder climate zones which produced the smaller carbon footprint. The heating schedule employed within the home proved to be the most influential factor to both the carbon footprint size and the rate of environmental/carbon payback. It was also found that while current fluctuations in emissions from electricity generation, or even a potential increase in emissions from non-renewable energy sources had little effect on the rate of carbon payback, electricity from all renewable, clean energy sources lengthened carbon payback time six fold. The study showed that carbon payback for the increase in embodied energy could not be reached through heat energy savings within the 50 year operational life of the building if a typical low heating schedule was used powered through electricity generated by all renewable energy sources. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/32317224?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=%22warm+homes%22
10.	2011	The impact of passive design factors on house energy efficiency Su, Bin (2011) Architectural Science Review. 54 (4) : 270-276 Journal article Unitec The energy consumption of a house can be affected simultaneously by many building design factors related to its main architectural features, building elements and materials. The relationship between the building design data and energy consumption data of houses can still be identified. This study focuses on the impact of building design factors on the extra winter energy consumption of houses. This information can be used to estimate the approximate saving in extra winter energy consumption, which would result from a changed design datum for future house development, and to identify the major design problems for energy efficiency. The quantitative relationships between building design data and extra winter energy consumption data are also valuable for developing passive design guides for housing energy efficiency. There is a focus on the effects of the passive features used in the architecture. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/32317594?locale=en&search%5Bpage%5D=2&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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11.	2010	Clawback of heating services in Beacon research homes Andrew Pollard; Nikki Buckett (28-Feb-2010) HR2420/12 Report Beacon Pathway Ltd Increased energy efficiency of hot water and space heating should reduce the cost of providing these services. However, the phenomenon of 'clawback' - where occupants use the improved heating system to increase comfort, can alter the effect of energy efficiency upgrades. In this work, the data from the Papakowhai Renovation Project, and the Waitakere NOW Home® are used to assess the clawback from the water heating and space heating services in ten New Zealand homes. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/35194375?locale=en&search%5Bpage%5D=14&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
12.	2010	Higher than NZBC thermal insulation in new housing cost-benefit analysis J Fung (2010) BRANZ Study Report SR 230 BRANZ This report examines the costs and benefits of installing insulation at the minimum New Zealand Building Code level compared to higher than Code levels for new housing. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146929?locale=en&search%5Bpage%5D=5&search%5Brecordset%5D=all&search%5Btext%5D=New+Zealand+building+code
13.	2010	Clawback of energy efficiency upgrades in New Zealand households A. R. Pollard; N.R. Buckett (2010) BRANZ Conference Paper CP 161. Presented at the 5th Australasian Housing Researchers' Conference, Auckland, 17-19 Nov 2010 BRANZ Beacon Pathway's Papakowhai Renovation project measured energy services and the indoor temperatures from nine households subject to energy efficiency upgrades midway through the three-year monitoring project. The extent to which 'clawback' is occurring within these houses is examined using a graphical approach highlighting those houses for which increased temperatures are taken in preference to reduced space heating. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/30224918?locale=en&search%5Bpage%5D=2&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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14.	2010	Efficacy of Energy Efficiency and Thermal Comfort Related Retrofit for Existing New Zealand Houses Zhang, Yanguang (2010) Master's thesis Victoria University of Wellington Many New Zealand studies have argued that house energy retrofit produces limited benefits, but the issue of how existing house retrofitting can lead to better energy performance and comfort improvement is little explored. The aim of this thesis was to examine the influence of house retrofit on energy efficiency and thermal comfort, using house model simulation and calculation. This study gives a holistic house retrofit approach in thermal comfort improvement and energy conservation. Three house retrofit categories were defined by household energy breakdown: Space Heating Retrofit, Hot Water System Retrofit and Appliances Retrofit. This study started with an investigation of New Zealand existing house stock. A typical house model was defined by the summarized common physical characteristics. This house model was used for retrofit testing. For the building space heating retrofit study, a series of thermal simulations was completed with different retrofit options. Thermal simulation results were compared both in thermal comfort and space heating energy requirement. It was discovered that the optimum level full insulation retrofit significantly reduced space heating energy requirement and also improved thermal comfort. Retrofit solutions for water heating, lighting and appliances were compared by cost and energy saving. Cost effectiveness cross comparison for all of the retrofit solutions was carried out. Retrofitting for space heating system and hot water system can be considered for long term cost effectiveness. Appliances and lighting retrofit have a higher efficacy than other retrofit options in terms of energy saving and cost benefit cycle. These findings are used to provide suggestions for retrofitting of existing houses. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/1818943?locale=en&search%5Bpage%5D=2&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
15.	2009	H1 and renovations Bruce, Eddie Build (Wellington, N. Z.), Feb/Mar 2009; n. 110:p. 25-26 Offers designers advice on options available to achieve compliance with 'New Zealand Building Code Clause H1 Energy Efficiency' for repairs/replacements, alterations and additions. Provides an example with practical steps to work out compliance. (IndexNZ)

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16.	2009	Alleviating fuel poverty in NZ through improving the energy efficiency of the residential sector Callaú, Maria Fernanda (2009) Master's thesis University of Otago viii, 175 leaves :ill., maps ; 30 cm. Includes bibliographical references. University of Otago department: Physics This thesis presents the minimum housing upgrade needed to eliminate fuel poverty for various house types (typologies) and climate zones in NZ. The analysis is presented for a 50 year period considering initial and operational cost and CO2 emissions. Fuel poverty is a condition where households would need to pay more than 10% of their household income on all fuel sources in order to keep their house at a satisfactory indoor temperature. A thermal modelling package is used to estimate the level of upgrade needed to provide an adequate indoor thermal environment, for various climate zones in NZ and building typologies, while ensuring that the households spend less than 10% of the household income on all energy demands. The results of the analysis are extrapolated to the national stock. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/35825761?locale=en&search%5Bpage%5D=2&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
17.	2009	Heat Losses and Gains in Residential Housing in Southern New Zealand Bishop, Timothy Wyman (2009) Master's thesis University of Otago The majority (70%) of houses in New Zealand were originally built before energy efficiency regulation came into force. Since the first standard was introduced in 1977, methods for controlling heat loss in new builds have gradually improved; these requirements have focused on insulation and the control of air insulation. In recent years, many local programs have focused on "easy" upgrades to existing housing, which typically involve insulating the floor and ceiling. Recent studies have questioned the efficacy of floor and ceiling insulation, showing minimal increase in indoor ambient temperature along with minimal decrease in energy use for space heating. These findings are more pronounced in cooler parts of the country, such as in Dunedin. This thesis investigates heat loss control retrofit options for New Zealand homes. The study examines two houses, which were retrofitted in stages, as a range of improvements were made to the building envelope. Heat loss was measured at each stage, and heat loss from infiltration was estimated by measuring the air ingress. The experimental technique used was a novel total house calorimetric method known as co-heating. With the exception of ceiling insulation, the observed upgrade performance matched predictions calculated using lumped thermal resistances. After the addition of wall, floor, and ceiling insulation, overall construction (lumped) thermal resistance increased from 0.8 m2KW-1 to 1.6 m2KW-1. After the upgrades, costing from around $123/m2 the heat loss was reduced by 32% for the entire house retrofit and 54% in the case of the living area-only retrofit. The study also found that the addition of insulation alone would not allow a house to achieve adequate indoor temperatures at a space heating cost (using electric resistive heating) that might be affordable. Choice of heating systems must also be considered when renovating houses. In addition the aspect of consumer preferences for energy efficient housing was investigated using a survey of Dunedin house insulation levels and heating practices. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/35340142?locale=en&search%5Bpage%5D=22&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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18.	2009	Passivhaus – a New Zealand adaption : an evaluation of New Zealand's potential to adopt German energy saving standards for residential architecture Hendry, Sasha (2009) Thesis Unitec New Zealand's reputation as an ecologically advanced nation is brought into question when our architecture is assessed at an international level. The implementation of Green Star New Zealand has brought to public attention the need for environmental principles to become standard practice within the building industry. At present the scheme does not recognise residential buildings, which form one of the largest sectors of energy consumption in NZ. The apprehension of society to adopt the principles of energy efficient residential architecture have led experts to suggest that NZ is many years behind current practice in Germany, where buildings often generate more energy than they consume. NZer's desire to attain the "Kiwi Quarter Acre Dream' has been identified as the base of NZ's energy problems, where heating and cooling of single family houses release excessive amounts of C02 into the atmosphere causing its degradation. NZ lacks the distinction between 'sustainable' and 'energy' architecture that has been identified overseas. There is currently no built example of energy architecture which strictly regulates the Kwh/ (m2a) the building consumes. It is suggested that initiates formed in Germany such as the Passivhaus, which use highly insulated facades to eliminate the need for heating and cooling may have application in NZ. The project aims to identify and compare the Passivhaus and the New Zealand Green Star standards to produce an amended set of principles that will act as a design template. Demonstration and testing of the way energy principles can engage with density and offer alternatives to inner city living will generate an opportunity for public exposure of new ideas towards sustainable intensification and energy efficient architecture. The application of the amended standards, design methods and rating the developed design against selected software will give both architectural and energy efficient results. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/32316886?locale=en&search%5Bpage%5D=9&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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19.	2009	Energy Efficiency, Indoor Air Quality and Health in New Zealand's Traditional Domestic Architecture Leardini, Paola (2009) 4th ENERGY FORUM on Solar Architecture & Urban Planning, Bressanone, Italy, 02 Dec 2009 - 05 Dec 2009 Conference item The University of Auckland Library NZ has often been held up as a pristine, natural place, but this state appears to be at risk from the rampant growth in energy demand and poor living conditions. Besides being energy-consuming, NZ homes are known for having cold, damp and uncomfortable interiors. Furthermore, the country has one of the highest incidences of asthma and respiratory related illnesses in the developed world. Considering that around 900,000 homes of the country's current housing stock of approximately 1.6 million is made up of poorly performing homes in terms of both energy and Indoor Environmental Quality (IEQ), their renovation appears the most sustainable approach to provide comfortable and healthy living standards while preserving the architectural heritage. Besides old timber frame buildings, which were – and often still are – completely uninsulated, many new and renovated homes have been designed and built with low quality insulation and heating systems, and a lack of adequate ventilation. Furthermore, the energy performance upgrade of the existing building stock, ongoing since 1978, has changed the buildings' physical behaviour, generating new and unexpected problems. This paper addresses the lack of information about IEQ in NZ's homes, investigating the existing building stock – from early colonial cottages to contemporary buildings - in relation to present-day multi-layered wellbeing needs and energy efficiency requirements. It focuses on the urban fabric of Auckland - major NZ metropolitan area and perfect example of contemporary sprawl – and identifies the most representative building clusters and typologies, providing a detailed assessments of selected types in order to develop new retrofitting procedures. Starting from the analysis of the existing building stock, in relation to orientation, construction details, insulation level, ventilation and humidity, the paper finally provides practical recommendation for the refurbishment of existing dwellings in order to enhance building energy performance and occupants' living condition. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/30042097?locale=en&search%5Bpage%5D=3&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

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20.	2009	A Cost Benefit Analysis of Secondary Glazing as a Retrofit Alternative for New Zealand Homes Smith, Nick (2009) Master's thesis Victoria University of Wellington Homes with single glazing represent a large majority of the New Zealand housing stock. With the recent changes to the NZ Building Code Clause H1 Energy Efficiency, new homes require higher glazing thermal performance. This will lead to an increased need for cost effective methods to improve window thermal performance in existing single glazed homes without completely replacing the windows, which includes 'secondary' glazing. There are several secondary glazing options available including 'stick-on' plastic glazing as well as aluminium framed glass solutions that are installed inside the existing joinery. Secondary glazing is marketed as a cost effective alternative to insulated glazing units, providing both improved acoustic and thermal insulation to existing windows. There is little information regarding the in-use performance and cost benefits of secondary glazing in New Zealand. This thesis explores the efficacy of the secondary glazing products when installed in existing single pane frames. A guarded hotbox was used to make thermal resistance measurements on a typical single glazed aluminium window with timber reveal liner. Four common secondary glazing systems were retrofitted into the window - (1) thin plastic film; (2) magnetically-attached acrylic sheet; (3) aluminium framed secondary glazing; and (4) aluminium framed low emissivity (low-E) secondary glazing. Models of 'typical' New Zealand homes created in the ALF building thermal simulation programme were used to explore the heating energy savings and cost benefits provided by the different secondary glazing systems in a range of locations. Of the tested products, the low-E secondary glazing produces the largest cost-benefits. At current energy and material costs, secondary glazing was found to not be a financially viable solution in warmer climates such as Auckland. In cooler climates such as Christchurch and Dunedin, secondary glazing was found to be a cost effective retrofit alternative for existing single glazed homes (NZResearch.org.nz)http://nzresearch.org.nz/records/1737313?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=%22energy+efficiency%22+building+code
21.	2007	The effect of mandatory insulation on household energy consumption Dr Michael Camilleri; Lisa French; Nigel Isaacs (2007) XXXVth International Association of Housing Science World Congress on Housing Science, Melbourne 4-6 September 2007. BRANZ Conference Paper 130 BRANZ Insulation has been required in new houses in New Zealand since 1978, intended to improve energy efficiency, reduce energy consumption and expenditure, and improve comfort and health. What has been the effect of insulating houses? On its own, insulation has been shown to be associated with less energy consumption. However, increases in heating temperatures, and the larger floor area of newer houses, have taken up some or all of the potential savings. There are major differences depending primarily on the heating type, with little or no overall reductions in electricity consumption, but significant reductions in other fuels. The implications for retrofitting insulation as an energy conservation measure are discussed. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146965?locale=en&search%5Bpage%5D=7&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

#	Year	Description
22.	2006	The Impact on Housing Energy Efficiency of Market Prices, Incentives and Regulatory Requirements - CHRANZ Research Bulletin Ian McChesney, Norman Smith and James Baines (2006-10-01) CHRANZ Research Bulletin 5 Report Centre for Housing Research Aotearoa New Zealand The research investigates the effect of prices, incentives and regulations on energy efficiency within households, and recommends options for regulatory and market-based instruments that will further encourage greater levels of residential energy efficiency in New Zealand. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/21138443?locale=en&search%5Bpage%5D=3&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
23.	2005	$100 worth of comfort: the real value of energy technologies Albrecht Stoecklein; Yuan Zhao; Lauren Christie; Lisa Skumatz (2005). 39th Annual Architectural Science Association (ANZAScA) Conference 17-19 Nov 2005.BRANZ Conferenced Paper 111 BRANZ This paper presents some of the Zero and Low Energy House (ZALEH) research results conducted by BRANZ over the last three years. The ZALEH project has for the first time in New Zealand captured a wide range of these other lifestyle benefits in a quantitative manner. The authors conducted in-depth interviews to quantify benefits of, and barriers to, energy technologies and included occupants of three groups of houses: known New Zealand low energy houses, Housing New Zealand Corporation houses (which received insulation upgrades), and results from an online internet survey. The research examines the overall non-energy benefits (NEBs) and sources of NEBs, including improvements in comfort, bill control, health, noise, maintenance, the environment. Results suggest most residents place a much higher value on the lifestyle benefits from energy efficiency features of their homes than on energy savings, and that the relative level of benefits is in the order of those seen in United States programmes. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146279?locale=en&search%5Bpage%5D=7&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
24.	2005	The value of low energy technologies for occupant and landlord Albrecht Stoecklein; Yuan Zhao; Lauren Christie; Lisa Skumatz (2005). ANZSEEE 2005 “Ecological Economics in Action” Conference, 11-13 Dec 2005. BRANZ Conference Paper 112. BRANZ This paper summarises some of the outcomes of the Zero and Low Energy House (ZALEH) project which is the first NZ research project attempting to quantify a wide range of non-energy benefits (NEBs) for home occupants. These include outcomes such as improvements in comfort, bill control, health, noise, maintenance and the environment. Both positive and negative impacts were investigated to identify the net value that the occupant and other stakeholders place on the outcomes. The results suggest that most residents place a much higher value on the lifestyle benefits from energy efficiency features of their homes than on energy savings. Benefits to landlords tend to be of similar magnitude as the energy savings. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146977?locale=en&search%5Bpage%5D=7&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

#	Year	Description
25.	2004	The calculation method for insulation / by Eddie Bruce Bruce, Eddie Build (Wellington, N. Z.), Feb/Mar 2004; n. 80:p. 12 Describes the calculation method for determining minimum R-values for wall and ceiling insulation. Discusses the relationship and constraints of the New Zealand Building Code (NZBC) Clause E3 Internal Moisture to meet acceptable insulation requirements. (IndexNZ)
26.	2003	Energy use in the residential sector / by Ian Page Page, I. C. (Ian C.) Build (Wellington, N. Z.), Feb/Mar 2003; n. 74:p. 14-15 Considers domestic electricity prices currently and in the future. Discusses price rises and the some of the reasons for them. Compares NZ electricity prices with other countries. Calls for more investment into energy efficiency requirements for the NZ Building Code. (IndexNZ)
27.	2003	Use more insulation to save money / by Ian Page Page, I. C. (Ian C.) Build (Wellington, N. Z.), Apr/May 2003; n. 75:p. 145-15 Looks at insulation levels required by the New Zealand Building Code and at a new Code of Practice being prepared by Standards New Zealand that will encourage higher levels of insulation. Discusses the R-values (heat insulation), economics, and future cost savings from various insulation options. (IndexNZ)
28.	2003	One of the many mysteries of building design / by Eddie Bruce Bruce, Eddie Build (Wellington, N. Z.), Apr/May 2003; n. 75:p. 20-22 Notes Clause H1 of the New Zealand Building Code, covering thermal insulation. Shows how to use the 'schedule method' of NZS 4218:1996 to obtain the minimum insulation requirements for construction, providing step by step instructions and a worked example, and noting the desirability of better than minimum insulation. (IndexNZ)
29.	2003	Energy efficiency of buildings with heavy walls L A Bellamy; D W Mackenzie (2003) BRANZ Study Report 116 The Cement and Concrete Association of New Zealand and the Building Research Association of New Zealand commissioned this research to investigate the effect of thermal mass in exterior walls on the comfort and heating energy use in New Zealand houses. The research was also commissioned to test the accuracy of selected building energy programmes for predicting the effect of wall thermal mass on building thermal performance. Both aspects of the project utilise a side-by-side test building facility built previously at Lincoln University. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146826?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency

#	Year	Description
30.	2001	Domestic Hot Water: Options and Solutions Williamson, A G; Clark, Sue (2001), Centre for Advanced Engineering, Christchurch Discussion / Working Papers University of Canterbury Library This book endeavours to bring together in one place the information and experience needed to provide good initial design of water heating systems and effective upgrades of existing systems, with particular reference to New Zealand domestic practice. Topics cover: an introduction to water heating systems; the properties of water; hot water use in domestic dwellings; hot water storage, pressure, control and temperature management; safety aspects of water heating systems and the NZ Building Code; distribution and delivery of hot water; and alternative sources of energy for water heating. (NZResearch.org.nz)http://nzresearch.org.nz/records/36481497?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=energy+building+code
31.	1998	Surveys of insulated glazing use in New Zealand housing as an energy efficiency micro-indicator 1994-1998 J C Burgess (1998). International Liaison Subcommittee Meeting, Coeur d'Alene, Idaho, 6-10 October 1998. BRANZ Conference Paper 58 Paper(NZResearch.org.nz)http://www.nzresearch.org.nz/records/20146951?locale=en&search%5Bpage%5D=4&search%5Brecordset%5D=all&search%5Btext%5D=energy+efficiency
32.	1997	Where to, windows? Donn, Michael. Architecture New Zealand, Jul/Aug 1997; p. 116-120 Discusses the lack of government action in requiring energy efficiency in building design, and the resultant lack of consumer knowledge. Looks at the availability of energy-efficient windows on the market, and at the NZ Building Code (NZBC) in relation to 'good practice'. Mentions to CBPR window-related research projects at the Schools of Architecture and Design building, Wellington, addressing the lighting and natural ventilation of large-scale buildings. (IndexNZ)
33.	1996	A practical study of retrofit air tightening of old houses for energy efficiency M R Bassett (1996) IPENZ Annual Conference, 9-13 February 1996. BRANZ Conference Paper 27 Paper (NZResearch.org.nz) Explored effectiveness of weatherstripping old houses through measurements on 15 houses with two different approaches – standard carpentry practices and foam strip materials. Overall the program showed that relatively large (about 50%) improvements to the airtightness of weatherboard homes constructed in the 1950's are achievable, but that the trade skills of the operator are the controlling factor in achieving useful weatherstripping.

ACCESSIBLE BUILDINGS – NZ RESEARCH PUBLICATIONS

(Only in houses/homes – excludes offices, tourist facilities, transport, etc)

#	Year	Description
1.	2016	New strategies for a changing population / by Joanna Jefferies Jefferies, Joanna New Zealand property investor (Rotorua, N. Z.) (Rotorua, N. Z.), May 2016; n. 150:p. 28-33 Discusses NZ's changing demographics, such as the rapid ageing of the population and change to ethnicity in the population including a rise in Asian ethnicities. Looks at how landlords can respond to these changes, discussing accessibility and provision for the aged in house design, the disabled as high calibre tenants for appropriate dwellings, increasing immigrant populations and how landlords might look at housing extended family groups, trends towards single-parent families and a demand for higher-density and lower maintenance dwellings, and how investors might design homes towards the retiring Baby Boomer generation. (IndexNZ)
2.	2016	Aiding the visually impaired / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Feb/Mar 2016; n. 152:p. 38-40 ; Build (Wellington, N. Z. : Online), Feb/Mar 2016; n. 152 Looks at design features to residential and public buildings to improve accessibility for blind or visually impaired people. Looks at features for residential buildings, including good lighting, the use of contrast and colour to improve visibility, and the use of handrails and other features to make movement safer. Looks at design features for public buildings unfamiliar to those visiting, including acoustic design and providing sound and tactile cues, good lighting design, the use of contrast, colour and tactile indicators, signage, building layout, outdoor layouts and avoiding hazards. Looks at the use of technology aids, describing the use of the Apple BlindSquare and BlindSquare BPS (beacon positioning system) apps. (IndexNZ)
3.	2016	Valuing Sustainability fact sheet 3: Incorporating universal design features in a new build or renovation (Nov 2016) BRANZ Valuing Sustainability Fact Sheet 3 BRANZ Universal design produces environments that are accessible and attractive to everyone regardless of their age, abilities or status in life. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/37398724?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=accessible+design
4.	2015	Accessible building access / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Dec 2015/Jan 2016; n. 151:p. 39-42 ; Build (Wellington, N. Z. : Online), Dec 2015/Jan 2016; n. 151 Notes that Building Code clause D1. 3. 2 requiring access routes for people with disabilities does not apply to private houses, but can offer guidelines for accessible design useful for residential buildings. Discusses access to public buildings and accessible route requirements. Looks at applying these residentially, including vehicle access, car parking and garages, paths, ramps and stairs, level entry to the house, and accessible mailboxes. (IndexNZ)

#	Year	Description
5.	2015	Accessibility hardware / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Oct/Nov 2015; n. 150:p. 40-42 ; Build (Wellington, N. Z. : Online), Oct/Nov 2015; n. 150 Looks at hardware for universal accessibility in homes. Examines handrails for stairs and ramps, grip rails for safety (as in toilets and showers), shower controls and taps, other bathroom fixtures, door and window controls, and light switches. (IndexNZ)
6.	2015	Universal design for wet areas / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Apr/May 2015; n. 147:p. 34-38 ; Build (Wellington, N. Z. : Online), Apr/May 2015; n. 147 Discusses accessible design for bathrooms and laundries. Notes NZ lagging in application of universal design, and discusses the special problems in making wet areas such as the bathroom accessible to those affected by disabilities, such as being in a wheelchair. Notes the need for non-slip matting in baths, lever handles and fix grip rails. Notes access for laundries. Notes the legislation that applies and the use of the Lifemark. (IndexNZ)
7.	2015	Universal design for indoors / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Aug/Sep 2015; n. 149:p. 41-44 ; Build (Wellington, N. Z. : Online), Aug/Sep 2015; n. 149 Gives advice on universal design for house interiors, ensuring access for people with physical disabilities, wheelchairs and the elderly. Looks at open plan design, at dealing with hallways and small spaces, problems with narrow doors, sliding vs hinged doors, stair design when stairs are necessary, and the use of stairlifts and domestic elevators. (IndexNZ)
8.	2015	Universal design for kitchens / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Jun/Jul 2015; n. 148:p. 36-39 ; Build (Wellington, N. Z. : Online), Jun/Jul 2015; n. 148 Discusses the design of kitchens for accessibility to the disabled and those with restricted movement. Looks at space needs (such as for wheelchairs), work surface heights, the use of shallow sinks and lever taps, cupboard and shelf design, and the positioning of appliances. (IndexNZ)
9.	2015	Accessible building access / by Alide Elkink Elkink, Alide Build (Wellington, N. Z.), Dec 2015/Jan 2016; n. 151:p. 39-42 ; Build (Wellington, N. Z. : Online), Dec 2015/Jan 2016; n. 151 Notes that Building Code clause D1. 3. 2 requiring access routes for people with disabilities does not apply to private houses, but can offer guidelines for accessible design useful for residential buildings. Discusses access to public buildings and accessible route requirements. Looks at applying these residentially, including vehicle access, car parking and garages, paths, ramps and stairs, level entry to the house, and accessible mailboxes. (IndexNZ)

#	Year	Description
10.	2014	Universal design goes mobile / by Roman Jaques Jaques, Roman A Build (Wellington, N. Z.), Oct/Nov 2014; n. 144:p. 88-89 ; Build (Wellington, N. Z. : Online), Oct/Nov 2014; n. 144 Review the 'Universal Design' app developed by Liveable Housing Australia, designed to help developers include liveable housing design features. Compares the app with NZ tools. (IndexNZ)
11.	2014	Think design, think everyone / by David Matthews Matthews, David Build (Wellington, N. Z.), Oct/Nov 2014; n. 144:p. 8 ; Build (Wellington, N. Z. : Online), Oct/Nov 2014; n. 144 Gives his opinion of designing in accessibility features right from the start with new homes. Comments on access needs and a shortage of accessible properties, the costs of retrofitting, and the results of creative thinking by architects and builders. (IndexNZ)
12.	2013	Design hub / by Roman Jaques Jaques, Roman A Build (Wellington, N. Z.), Aug/Sep 2013; n. 137:p. 70 ; Build (Wellington, N. Z. : Online), Aug/Sep 2013; n. 137 Describes a BRANZ online library of design solutions for universal design (design for life, barrier-free design) of residential housing, looking at a survey showing the need for such a resource and the features of the site. (IndexNZ)
13.	2012	Positive changes : more access to more homes Without limits, Jul 2012; p. 10-11 Talks to Lifetime Design Strategy and Development Director, Travis O'Keefe about future accessibility in residential homes and the Lifemark design standards(IndexNZ)
14.	2012	Councils can save on housing New Zealand local government, May 2012; v. 48 n. 5:p. 12 Explains the Lifetime Design standard that aims at making housing sustainable and adaptable to residents' needs over their lifetime. Talks to strategy and development director of the not-for-profit enterprise, Travis O'Keefe, about the five key principles underlying the standard and gives examples of the types of features it includes. Notes the average costs of fitting the features into new houses compared to retrofitting them later. Touches on the savings to government bodies of incorporating Life Design features into building social housing. (IndexNZ)

#	Year	Description
15.	2012	Homes fit for a lifetime / by Ian Page Page, I. C. (Ian C.) Build (Wellington, N. Z.), Feb/Mar 2012; n. 128:p. 54 Discusses design of NZ's housing stock to match the needs of older people. Looks at the economics of new builds vs retrofits to Lifemark standards and the case for making lifetime design features mandatory for new builds. (IndexNZ)
16.	2012	Positive Ageing in Place: Older Māori in Traditional and Non-traditional Place Williams, Cassandra (2012) Master's thesis University of Waikato This thesis examines the role of place in experiences of ageing for older Māori, and the extent to which places of choice facilitate a sense of positive ageing. Particular attention is given to multiple experiences of home and the complexities surrounding Māori affiliations to place.
17.	2011	Futureproofed / by Margo White White, Margo New Zealand listener (1994), 15 Oct 2011; v.230 n.3727:p.48-49 Talks about designing houses with possible future disabilities associated with aging in mind. Highlights the premise of the Lifemark programme, which provides an independent seal of approval for residential housing that is usable, adaptable, accessible and inclusive. Speaks to Wellington architect Ron Pynenberg who has been promoting accessible residential design since the 1970s.
18.	2011	Homes to last a lifetime / by Andrew Olsen Olsen, Andrew Build (Wellington, N. Z.), Apr/May 2011; n. 123:p. 42-43 Looks at upcoming shifts in NZ demographics, and how these affect designing and building houses for long-term occupancy. Mentions the Lifemark seal of approval for building design, and discusses the sort of features that make houses more accessible to the elderly, people with disabilities, and others. (IndexNZ)

#	Year	Description
19.	2011	Fire design for aging residential occupancies A. P. Robbins (2011) BRANZ This report was prepared during research into fire safety design associated with residential occupancies that are predominately older adults. Older adults (65+ years) represent 12% of our community. This is predicted to increase to approximately 25% in 30 years. Older adults are a vulnerable part of our community with high fire risk resulting in a disproportionate representation in fire casualties. Older adults fall into the lower percentiles of the parameters describing emergency egress of the general population, such as mobility, sensory response, cognitive response, etc. , therefore reducing the likelihood of successful escape. However residential design that is intended for the sole use of older adults uses parameter values based on the general population. Age alone does not provide a direct measure of capability in terms of successful self-evacuation of a building. There are many aspects of an individual's ability to identify an incident, respond with a self-evacuation plan and execute a plan or gain assistance to escape. Capabilities and limitations of the occupancy relate to both age and other influencing factors such as levels of disability due to accident, illness, etc, whether long-term or temporary. Metrics of use when characterising an intended building occupancy for emergency evacuation during a fire must cover the three major areas of functionality: physical, sensory and cognitive functionality. Data sets considered from various surveys (e. g. for healthcare, disability access, assisted care programs, etc.) must be interpreted in relation to the context of the initial collection intent and how that influences the range of results in terms of the applicability of use characterising intended building occupants during an emergency event. Design of buildings to facilitate access for people with disabilities during normal activities is fundamentally different to design of accessible emergency escape. That is, an accessible route is not an accessible escape route. Similarly, an escape route is not an accessible escape route. Fire safety design must be specifically tailored to the fire safety design objective for the intended functionality of the building and usage by the intended occupancy. A draft for a common framework, for various fire-safety related analysis of performance-based building design approaches, to be used in the selection of fire-safety scenarios for the assessment specific designs are included and discussed in terms of potential application to residential building with intended older adult occupancies. (NZResearch.org.nz)http://nzresearch.org.nz/records/30225112?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=building+accessibility
20.	2011	Lifetime housing - the value case IC Page; MD Curtis (2011) BRANZ Much of our housing stock is less than user-friendly in terms of access, mobility and general safety. Provision of features addressing these aspects is of benefit to all age groups that may occupy a house over its lifetime. Provision of such features is generically called UF design and the particular specifications that have been developed include LTD NZS4121 and Universal Design. These features are not mandatory in housing. This report examines typical New Zealand houses and estimates the cost of installing UF features in both new and existing housing, using the LTD specification. (NZResearch.org.nz)http://www.nzresearch.org.nz/records/30225091?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=lifetime+design
21.	2010	Accessible homes / by Virginia Linton Linton, Virginia Family care New Zealand, Aut 2010; n. 14:p. 37-38 Talks to home design specialist Richard Hobbs about building and renovating homes which allow barrier-free access for homeowners. Discusses steps to take in regards to paths, garages and covered parking. Recommends kitchen products which promote easy access. (IndexNZ)

#	Year	Description
22.	2010	House design that lasts a lifetime / by Helen Coolen Coolen, Helen Build (Wellington, N. Z.), Feb/Mar 2010; n. 116:p. 48-49 Describes the purpose of 'Lifemark', an independent seal of approval for building design that aims to give NZers greater choice about where and how they live while eliminating the need for costly renovations to cope with changing needs over time. Looks at 'lifetime design'. (IndexNZ)
23.	2009	Moving with mobility in mind / by Zinzan Cunningham Cunningham, Zinzan New Zealand INsite Oct/Nov 2009; v. 4 n. 1:p. 7 Looks at how the Lifemark makes sure you and your mobility are considered whether you are planning to move home or designing a new home. Looks at some issues around the purchase of stair-lifts and wheelchairs. (IndexNZ)
24.	2008	Designs for a lifetime Smythe, Michael Prodesign, Apr/May 2008; n. 94:p. 37-38 Examines the Lifestyle Design Foundation, an initiative to encourage inclusive design as populations live longer, focusing on the ease of adaption of products and places as needs change over time. Lays out the principles of Lifetime Design and comments on the development of standards (starting with housing) and training programmes. (IndexNZ)
25.	2008	Designing for life; Launching Lifetime Design and the Lifemark / by Zinzan Cunningham Cunningham, Zinzan Insite (Online), Dec/Jan 2008; v. 2 n. 1:p. 4 Talks to Saffron Gardner about the drivers behind the Foundation's work. Stresses that they are not just designing for our ageing population but for families in which several generations may live together. (IndexNZ)
26.	2001	Homes without barriers - a guide to accessible houses BRANZ This book is all about houses which are not disabling. It was developed in conjunction with many people working in the health and disability fields. It is packed with diagrams and advice for building designers, builders, health professionals, homeowners and anyone involved in the design or alteration of houses for those with disabilities or the elderly. (NZResearch.org.nz)http://nzresearch.org.nz/records/35155696?locale=en&search%5Brecordset%5D=all&search%5Btext%5D=building+accessibility