Call for evidence

Interim Climate Change Committee

We are calling for evidence on options available to reduce greenhouse gas emissions over the period 2022 to 2035.

Why are we doing this?

The Interim Climate Change Committee is the precursor to the proposed Climate Change Commission, expected to be established in late 2019 under the Zero Carbon Bill[1]. The Bill provides a framework to help New Zealand deliver on the objectives of the Paris Agreement.

A key part of the proposed Commission's work will be to advise the Government on emissions budgets.

Emissions budgets set the total emissions of all greenhouse gases permitted in the relevant budget period. The Government will set emissions budgets based on the proposed Commission's advice.

Why are we doing this now?

We are running this call for evidence now as foundation work for the proposed Climate Change Commission to enable it to start work immediately as soon as it is set up.

It will help identify relevant information for developing these emissions budgets, and to maintain a broad, robust and transparent approach in developing the proposed Commission's evidence base.

We have been asked to do this through our Terms of Reference. This work is also outlined in our letter to the Minister for Climate Change on 7 May 2019 here.

What are we looking for?

We are looking for high-quality, credible, evidence that will support the proposed Commission's work on emissions budgets. This is likely to include knowledge and evidence of technologies and options to reduce emissions, and the economic, environmental, cultural and social impacts of them. We are not looking for personal views or opinions.

What if I have already made submissions on similar topics?

If you have already submitted evidence as part of consultation run by Government agencies, such as the Zero Carbon Bill or the Ministry of Transport's Clean Car Standard and Discount, then we are happy for you to point us to those submissions, noting the key information or material that relates to our call for evidence.

---

[1] Climate Change Response (Zero Carbon) Amendment Bill: http://www.legislation.govt.nz/bill/government/2019/0136/latest/LMS183736.html.

What will we do with the evidence we gather?

We will use this information to inform our initial work on emissions budgets and add to the evidence base the proposed Commission will draw upon.

Confidentiality and data protection

All or part of any written response (including the names of respondents) may be published on our website www.iccc.mfe.govt.nz. Unless you clearly specify otherwise, we will consider that you have consented to both your name and response being published.

Please be aware that any responses may be captured by the Official Information Act 1982. Please advise us if you have any objection to the release of any information contained in your response, including commercially sensitive information, and in particular which part(s) you consider should be withheld, together with the reason(s) for withholding the information. We will take into account all such objections when responding to requests for copies of, and information on, responses to this document under the Official Information Act.

The Privacy Act 1993 applies certain principles about the collection, use and disclosure of information about individuals by various agencies, including the Interim Climate Change Committee. It governs access by individuals to information about themselves held by agencies. Any personal information you supply to the Committee in the course of making a response will be used by the Committee only in relation to the matters covered by this document. Please clearly indicate in your response if you do not wish your name to be included in any summary of responses that the Committee may publish.

Call for evidence: response form

We are looking for responses that are evidence-based, with data and references included where possible. Please limit your response to each question to a maximum of 400 words, plus links to supporting evidence, using the template provided. Please answer only those questions where you have particular expertise or experience.

We recommend that you refer to the Climate Change Response (Zero Carbon) Amendment Bill when considering your answers, which can be found here.

If you have any questions about completing the call for evidence, please contact us via feedback@ICCC.mfe.govt.nz. Please include a contact number in case we need to talk to you about your query.

Please email your completed form by **12 noon, Friday 15 November 2019** to feedback@ICCC.mfe.govt.nz. We may follow up for more detail where appropriate.

Contact details

Name and/or organisation	***Building Research Association of New Zealand Ltd (BRANZ)***
Postal Address	
Telephone number	
Email address	

Submissions on similar topics

Please indicate any other submissions you have made on relevant topics, noting the particular material or information you think we should be aware of.
Answer: Submission to the low emission economy report by the Productivity Commission 2018: https://productivity.govt.nz/assets/Submission-Documents/843a817bdb/DR-398-BRANZ.pdf

Commercially sensitive information

Do you have any objection to the release of any information contained in your response, including commercially sensitive information? ***If yes, which part(s) do you consider should be withheld, together with the reason(s) for withholding this information.***
Answer: No

Questions for consideration:

Section A The first three emissions budgets

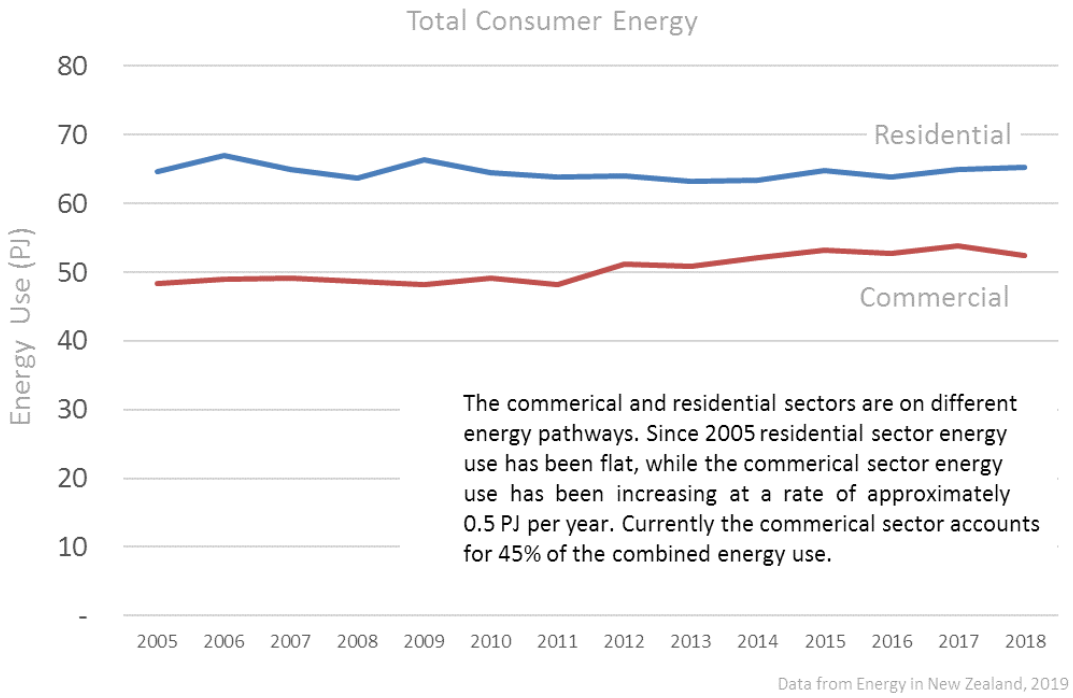
Under the proposed Zero Carbon Bill, the proposed Commission will have to provide advice to government on the levels of emissions budgets over the coming decades.

Currently, the Zero Carbon Bill requires budgets to be set from 2022-2035 (three separate budgets covering 2022-2025, 2026-2030, and 2031-2035). When preparing this advice the proposed Commission will have to consider the implications of those budgets for meeting the 2050 target. The Commission will also need to consider the likely economic effects (positive and negative) of its advice.

Question 1: ***In your area of expertise or experience, what are the specific proven and emerging options to reduce emissions to 2035? What are the likely costs, benefits and wider impacts of these options? Please provide evidence and/or data to support your assessment.***
Answer: **INTRODUCTION** The Building Research Association of New Zealand (BRANZ) is undertaking research that is focussed on mitigating the climate change impact of buildings. BRANZ is launching a dedicated research programme devoted to developing cost effective low carbon solutions to decarbonise new and existing residential and non- residential buildings, and to implement these solutions within the construction industry. The goal of the **Transition to Zero Carbon** research programme is that by 2050 the building and construction industry is delivering net-zero carbon buildings in an affordable way. Whilst BRANZ does not yet have all the answers to this question, our research can point to opportunities, and current and planned research will help to deliver further evidence. In terms of scale, the residential sector has greater demand for energy than the commercial building sector (Figure 1). A description of the characteristics of the New

Zealand residential and non-residential stock are provided in a BRANZ report to MBIE (MacGregor et al., 2019).

Figure 1



The Intergovernmental Panel on Climate Change, in its 2014 synthesis report, provided recommendations relating to the built environment, which are reproduced below. BRANZ has not specifically tested these recommendations for efficacy for our New Zealand building stock, but based on our understanding of New Zealand buildings, they would appear to be relevant:

- For new buildings, the adoption of very low energy building codes is important.
- Retrofits form a key part of the mitigation strategy in countries with established building stocks, and reductions of heating/cooling energy use by 50 – 90% in individual buildings have been achieved.
- Lifestyle and behavioural changes could reduce energy demand by up to 20% in the short term and by up to 50% of present levels by mid-century.
- Most mitigation options have considerable and diverse co-benefits in addition to energy cost savings. These include energy security, health, environmental outcomes, workplace productivity, fuel poverty reductions and net employment gains. Studies that have monetised co-benefits often find that these exceed energy cost savings and possibly climate benefits.
- Strong barriers, such as split incentives (e.g. tenants and building owners), fragmented markets and inadequate access to information and financing, hinder the market-based uptake of cost-effective opportunities. Barriers can be overcome by policy interventions addressing all stages of the building and appliance lifecycles.
- Building codes and appliance standards, if well designed and implemented, have been among the most environmentally and cost-effective instruments for emission reductions.

To answer this question, we have divided the built environment into the following:

1. Existing dwellings.
2. New dwellings.
3. Existing non-residential buildings.
4. New non-residential buildings.

EXISTING DWELLINGS

New Zealand's building stock is very diverse in terms of building design, typologies, use, age and construction materials. The exact number of buildings in New Zealand is not known however, we know that there are an estimated 1,849,000 dwellings as of 30th September 2017 (Statistics New Zealand).

The 2015 House Condition Survey undertaken by BRANZ (White & Jones, 2017) outlines some key areas of concern about New Zealand's housing stock:

- Approximately 53% of our housing stock has sub-optimal roof insulation and/or subfloor insulation, which would benefit from retrofitted insulation.
- 5% of households did not usually heat living areas, and almost half (46%) did not usually heat occupied bedrooms, including those occupied by children and older people.
- Tenants of rental housing had less access to cost-effective heating appliances than owner-occupiers. Rental households were more likely to be reliant on portable heaters that are typically more expensive to run and less effective at heating larger areas.
- Unflued gas heaters, which pose a risk to occupant health, are present in 15% of houses. Portable unflued gas heaters were more common in rental properties and used in 17% of living areas and 6% of bedrooms.
- Damp and mould are key indicators of a poor-quality indoor environment. Rental properties were nearly three times as likely to feel damp than owner-occupied houses. Mould was visible in nearly half of all houses surveyed.

The Household Energy End-use Project (HEEP) undertaken by BRANZ from 1995–2005 found that the average New Zealand occupied dwelling consumes 11,410 kWh of energy per year (7,880 kWh electricity, 1060 kWh gas, 240 kWh LPG, 2,310 kWh solid fuel) at 1.77 tonnes of CO_2eq per house (Isaacs et al., 2010, p.311) and outlined a few characteristics of household energy use:

- The most common energy source was electricity and the most common heating fuel was solid fuel (mainly wood).
- Electricity provides 75% of energy used for hot water, with gas at 20% and wetback 5%.
- Electric hot water cylinders were found in 77% of households with most cylinders over 16 years old and some even up to 40 years old.
- The average energy for a residential building included space heating 34%, hot water 29%, appliances 13%, refrigeration 10%, lighting 8% and cooking 6%.

Since the completion of HEEP, a significant number of heat pumps have been installed into New Zealand households (Burrough, Saville-Smith & Pollard, 2015) and the number of heat pumps in households is expected to grow. It has been estimated that, by 2025, there will be over 1.2 million units installed – a 40% increase from 2012 (MacGregor et al., 2018). Despite the large uptake of heat pumps in New Zealand, Burrough, Saville-Smith and Pollard (2015) found that more than half of householders did not see a reduction in their electricity bill since the installation of the heat pump. Overall Iit is uncertain what the implications are for greenhouse gas emissions for the future use of this technology, for example, with respect to fugitive emissions of refrigerants (Johnson, 2011).

Other changes in household energy use in recent years include an increased use of household photovoltaics for renewable energy/micro-generation. As of March 2016, there were 9,533 solar connections with 9,022 residential, 262 commercial and 249 industrial (MacGregor et al., 2018. p.16). Since HEEP, Jaques (2015) has found that the average new home built to the New Zealand Building Code (NZBC) required twice to three times the amount of space heating energy to maintain thermal comfort conditions compared to houses designed to utilise passive solar design.

BRANZ and Beacon Pathway[2] sought to undertake a retrofit project, to assess how a selection of regular houses could be renovated into high-performance houses (Burgess, et al, 2010; Beacon Pathway, 2019). Nine houses within the suburb of Papakowhai, Porirua and built during the 1960s and 1970s, were selected to be retrofitted. The houses were chosen because it was believed that houses from this era would be difficult to retrofit for energy efficiency (Burgess, et al, 2010; Beacon Pathway, 2019). Before the retrofit began, the houses were monitored for energy, water use, temperature, humidity and the amount of waste produced. This data was collected to compare with post-retrofit data.

During the early months of 2007, the houses were renovated for their energy, waste and indoor environmental quality improvements. However, each house was assigned a different combination of features to be installed, to allow comparison of the effectiveness of different areas of concern. As Beacon Pathway (2019) outlined, the aim of their research study was to determine what combinations of renovations were:

- most cost effective,
- easiest to implement,
- applicable to a range of house types and regions, and
- able to significantly improve how well the homes perform in energy efficiency, water conservation, waste minimisation and indoor environmental quality.

The Papakowhai renovation project found that houses that had a full thermal envelope replaced improved their performance (Burgess, et al, 2010; Beacon Pathway, 2019).

[2] Beacon Pathway is an Incorporated Society committed to transforming New Zealand's homes and neighbourhoods. Further information can be found a www.beaconpathway.co.nz.

The thermal envelope includes the outer walls, roof, suspended ground floor, windows and doors. The thermal envelope is important due to heat transfer between a house's interior and exterior with a temperature difference between them, and weather extremes (Donn & Thomas, 2010). The renovations also saw efficient heating installed to enable the greatest temperature improvement. For example, a comparison between pre- and post-performance monitoring found that homeowners saved between 23% and 33% on energy bills (Burgess, et al, 2010; Beacon Pathway, 2019). The increased insulation also saw a rise in room temperature during winter between 2.5°C and 5.5°C (Burgess, et al, 2010; Beacon Pathway, 2019).

It is interesting to note that other houses with only a partial insulation upgrade experienced modest energy savings, but no major changes in room temperature. The majority of these houses still experienced lower than recommended temperatures (Burgess, et al, 2010; Beacon Pathway, 2019).

The Papakowhai renovation project suggests that, to increase performance in existing houses, it is important to install higher levels of insulation. However, it was also noted that if a house already had some insulation, it was better to add insulation to un-insulated areas before topping up existing insulation (Burgess, et al, 2010; Beacon Pathway, 2019). Wall insulation and double glazing were two features that were believed to make the most impact to homeowners.

There were also a number of features that provided benefit to housing performance**:**

- One of the key areas was the wrapping of poorly insulated hot water cylinders which promoted a 11–33% boost to energy efficiency.
- Other features, such as double glazing and/or increased insulation, also provided other benefits (apart from increased energy efficiency and indoor temperatures).
- The occupants also reported better family health associated with warmer winter indoor environments and, for those with solar water heating, increased access to hot water (Burgess, et al, 2010; Beacon Pathway, 2019).

<u>Specific proven and emerging options to reduce emissions to 2035</u>

Existing and emerging options for existing dwellings are:

- Accelerate existing and develop further incentives for upgrading of existing housing (see the Papakowhai experience above). Where occupants heat to ensure a comfortable temperature, this ensures less energy is needed for heating. Where occupants underheat or do not heat their homes, this ensures that indoor temperatures are in the comfort range for a longer period, which has co-benefits in terms of health. This should include opportunities for improving heating of water, if available (see response to Question 1 under "New Dwellings" and response to Question 2). BRANZ has developed a web resource called Up-Spec which provides costed upgrades to houses applied to different climate zones (www.branz.co.nz/up-spec).

- Mandating a requirement for a building Energy Performance Certificate (EPC) at the point of sale, lease/rent and construction. Nationally mandated building energy rating schemes are virtually ubiquitous in overseas jurisdictions studied. "Practical and high-quality EPC schemes are the prerequisite for any meaningful buildings policy, especially for existing buildings" (Arcipowska et al., 2014). EPCs are used across Europe, where they are required by EU regulation at point of sale, lease and construction. They are also widely used in North American jurisdictions. Incidentally, for commercial buildings over 1000 m^2 in Australia have a mandatory NABERS[3] rating when the building is sold or leased.

Part of the perceived benefit of EPCs is that they are a tool to facilitate a more dynamic market for energy efficiency and emissions reductions. In Europe, some countries accompany the EPC with a CO_2 rating. Familiarity with the visible rating score of an EPC provides incentive for building owners to move beyond minimum standards for energy and CO_2 emissions because a higher rating potentially provides reward in the market (increased value, improved rentability).

- Plug loads – see response under "New Dwellings".

NEW DWELLINGS

The BRANZ longitudinal Benchmarking study (BRANZ study report SR342 (published in 2015) and forthcoming BRANZ study report SR426), shows how New Zealand's new build, stand-alone house stock performs in terms of several metrics.

Beacon Pathway's NOW Home®, is used as a comparative yardstick. Constructed in 2005, it was a proof of concept research house built to show what could be achieved within a tight budget, using off the shelf technologies and systems. It meets a comprehensive variety of environmental, economic and social high-performance goals, thereby providing a robust example of what is practically achievable in New Zealand. The Benchmarking study demonstrates, using randomly selected houses from the year 2012 and 2016, how poorly recently consented stand-alone houses perform compared to the NOW Home® for a multitude of metrics. These houses, and the NOW Home® were simulated in a Christchurch climate zone.

Indoor thermal comfort comparisons were based on sophisticated computer simulations. As an example of the gulf between the NOW Home® and the random new houses, the number of critically cold lounge temperatures was examined. This is where the lounge temperatures fall below 12 degrees Celsius, when no heating appliances are utilised. In the NOW Home®, this occurs only 12 days a year. In the randomly selected houses, this occurs approximately 10 times more frequently. This demonstrates that the commonly consented home today needs considerably more space heating and therefore carbon emissions, than what is easily achievable.

Most houses being consented today do not employ passive design principles and therefore do not realise opportunities for increased thermal efficiency (and occupant benefits in terms of ongoing costs to heat, and health). These principles, which have been well known for many years and were employed in the NOW Home® constructed in 2005,

[3] NABERS is a national rating system that measures the environmental performance of Australian buildings, tenancies and homes.

have largely been ignored. The result is that a house built nearly 15 years ago still outperforms houses assessed in the benchmarking study.

BRANZ has carbon footprinted case study dwellings including the NOW Home® (and commercial office buildings), the results of which will be provided in a forthcoming BRANZ study report (SR437) due early 2020.

These have been developed to better understand the range of carbon footprints currently being achieved by our dwellings, and where the "hot spots" are for mitigating greenhouse gas emissions. Dwellings that have been modelled are specifically:

- 2 single-storey, stand-alone houses designed for NZBC Clause H1 compliance.
- 3 single-storey, stand-alone houses designed to exceed NZBC Clause H1 requirements.
- 1 double-storey, stand-alone house designed for NZBC Clause H1 compliance.
- 2 double-storey, stand-alone houses designed to exceed NZBC Clause H1 requirements.
- 1 medium density housing (MDH), consisting of 8 units, designed for NZBC Clause H1 compliance.
- 1 high density (apartment) building, consisting of 108 units, designed for NZBC Clause H1 compliance, and featuring two levels of retail (ground floor and first floor).

These carbon footprints include the following:

- Foundations and ground floor construction or concrete floor slab.
- External wall constructions including supporting structure.
- Internal wall constructions including supporting structure.
- Roof construction, including supporting structure.
- Windows (frame and glazing).
- Doors (internal and external).
- Painted surfaces (internal and external).
- Floor coverings.
- Garages.
- Decks.
- Wash hand basin and toilet.

Since the primary source of data for materials quantities is derived from Building Information Modelling (BIM), the following are currently excluded from the carbon footprints:

- Flashings.
- Spouting.
- Fixings (nails, nail plates etc).
- Sealants, glues and mastics.
- Scotias.
- Kitchen units, sink and cooker.

- Bathroom shower and bath.
- Plumbing and electrical.
- Hot water cylinder.
- Heat pump.
- Boiler.
- Mechanical heating, cooling and air conditioning, including ducting, if present.
- Window and door furniture.
- Kitchen and bathroom fans.

Dwellings are simulated for operational energy using a network airflow model built in EnergyPlus. Infiltration and natural ventilation are key considerations when modelling energy use in residential buildings. Our models are based on BRANZ measured levels of air tightness (Overton et al, 2013) currently being achieved (0.15 air changes/hour @ 4 Pa). Our models include consideration of plug loads (use of electricity for plug-in appliances) based on NZS 4218. The service life is taken as 90 years, based on Johnstone (1994).

Carbon footprint results for stand-alone housing are presented in Figure 2. These have been obtained using the LCAQuick tool (www.branz.co.nz/lcaquick) which uses the NZ whole-building, whole-of-life framework (www.branz.co.nz/buildinglca), itself based on the standard EN15978. Each house is simulated in three New Zealand climate zones, being Auckland (Zone 1), Wellington (Zone 2) and Christchurch (Zone 3). The graph excludes consideration of biogenic carbon sequestration (carbon neutrality is not assumed.

Climate change impacts in Figure 2 are divided by life cycle stage (as defined in EN 15978). The coding convention we have used for each house is as follows, to maintain anonymity:

- The house number (being 1 to 8).
- An acronym depicting the number of storeys (being SS for single-storey and DS for double-storey).
- Whether the house has been designed for compliance with the NZBC or to exceed the minimum requirements of the NZBC, at least with respect to Clause H1. These are termed “NZBC” and “NZBC+” respectively.
- The location that is energy simulated, being Auckland (Z1), Wellington (Z2) and Christchurch (Z3).

For example, “2. SS, NZBC, Z2” is house number 2 which is single-storey, designed to be compliant with the NZBC and energy simulated as if located in Wellington. The NOW Home® is house number 7.

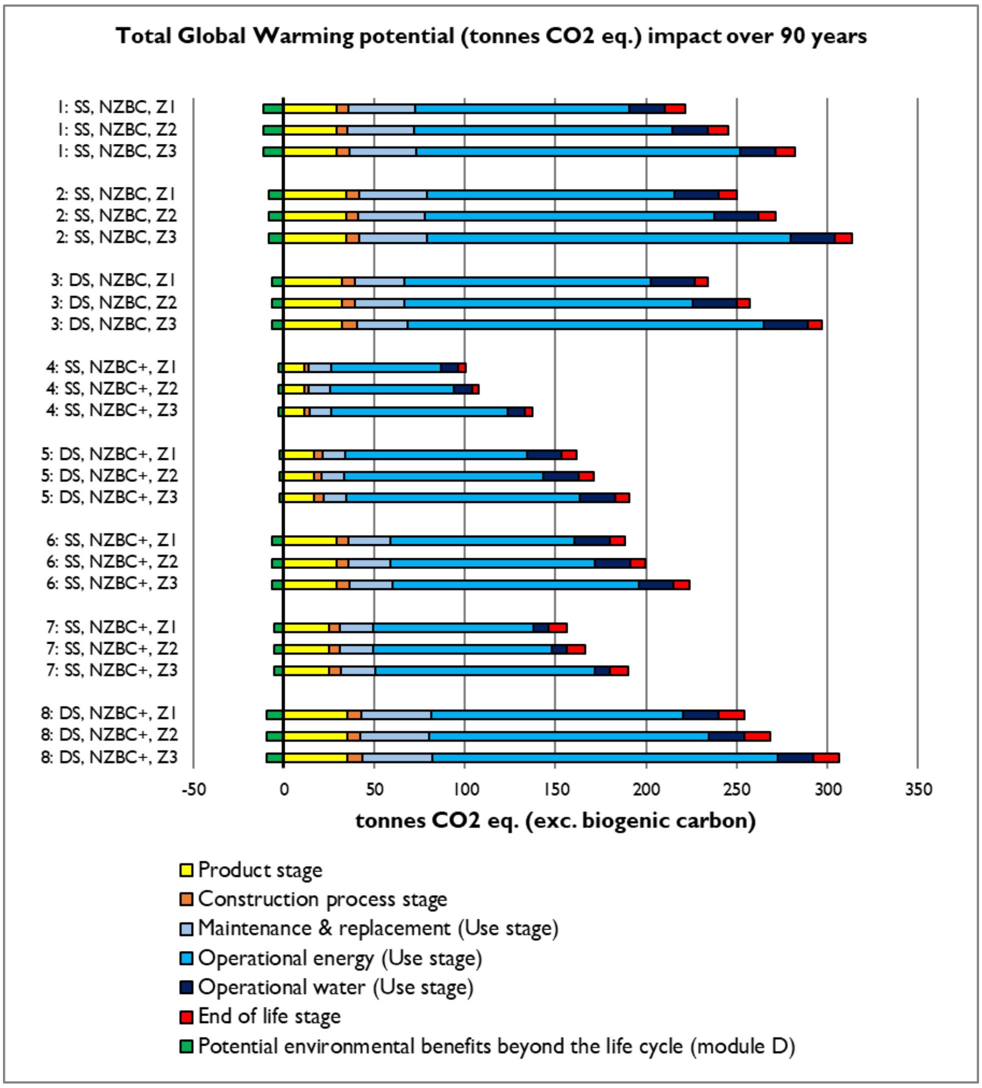
From modelling of these stand-alone houses over a 90 year service life, operational energy accounts for 57 – 65% of life cycle greenhouse gas emissions. Focussing specifically on emissions between 2020 – 2050, this decreases to 44 – 54%.
Embodied carbon accounts for 24 – 35% of life cycle greenhouse gas emissions using a 90 year building service life, and arises from manufacture, transport, installation (including waste), maintenance, replacement and end-of-life of materials. About half of these

emissions occur in a short timeframe (typically within 1 year, and arising from manufacture, transport and installation of materials) prior to occupation of a dwelling.

This material-related contribution increases to 37 – 50% of greenhouse gas emissions, if emissions from 2020 – 2050 are considered only.

New Zealand has typically used timber and engineered wood in residential construction e.g. 90 mm timber framing, timber weatherboards, particleboard floors, MDF units. This, together with the high proportion of renewables supplying our grid electricity, sets us apart from many of our peer countries in Europe, North America and Australia.

Figure 2



<u>**Specific proven and emerging options to reduce emissions to 2035**</u>

In terms of "greenhouse gas hot spots", areas to consider for reducing greenhouse gas emissions in new dwellings are:

1. Address plug loads. Increasing renewables supplying grid electricity is a supply option that will assist with this, but demand-side opportunities exist to increase energy

efficiency of appliances (see response to question 6 below). This also aligns with the IPCC recommendation above.

2. Reduce energy for hot water. BRANZ has a new research project commencing in 2020 that will look at innovative water heating options from a cost, carbon, ability to retrofit, and effectiveness perspective, which will bring new knowledge on this issue. The project will complete in 2022.

3. Heating and cooling contribution varies with climate zone, and makes a minor contribution in a milder Auckland climate and a larger contribution in a Christchurch climate. Therefore, sole focus on improving the thermal envelope of new houses appears to have diminishing returns in locations such as Auckland (from a carbon perspective). There are two key issues here:

   a. The current division of New Zealand into only three climate zones by the Building Code Acceptable Solution H1/AS1 Energy Efficiency is too coarse and could benefit from a greater level of granularity. Higher minimum performance levels of thermal envelopes should be set that are appropriate for these newly defined zones.

   b. BRANZ has commissioned Beacon Pathway to sample and survey 47 new houses currently being built in New Zealand. The work, which is still ongoing, is already showing that the framing ratio (ie. the amount of timber framing in the walls) is significantly higher than expected ie. what is being built does not align with what is in the design documentation. Greater timber framing means more thermal bridging and less room for insulation. Therefore, more energy will be required to heat these houses to comfortable temperatures. This research is due for completion in 2020.

4. Opportunities exist to increase the amount of timber, engineered wood and wood-based products used in our dwellings. Provided this is sourced from sustainable forestry (for example, through schemes such as the Forestry Stewardship Council (FSC)), our buildings have the potential to provide carbon storage of sequestered carbon dioxide for many decades. Figure 3 shows greenhouse gas emissions for our eight reference houses between 2020 – 2050. For each house, the bar on the left excludes biogenic carbon (carbon neutrality is not assumed) and the bar on the right includes it (carbon neutrality is assumed). Houses 4 and 5, which both contain a significant amount of timber and engineered wood, are net carbon negative with respect to manufacture of materials, in comparison with the other assessed homes. Building houses with more timber and engineered wood (from sustainable forestry) means that each new house can be net carbon negative prior to occupation, rather than contributing to climate change before it is occupied.

5. However, we will need other materials in our dwellings. Some of these, such as concrete (e.g. for floor slabs) and steel (for example, in galvanised steel framing, steel reinforcing) have high embodied carbon impacts, due to reliance on fossil fuels in their manufacture. Opportunities already exist to reduce carbon emissions, for example, use of secondary cementitious material in concrete, but barriers (both

technical and behavioural) currently exist to their widespread adoption in New Zealand buildings, which need to be removed.

Figure 3

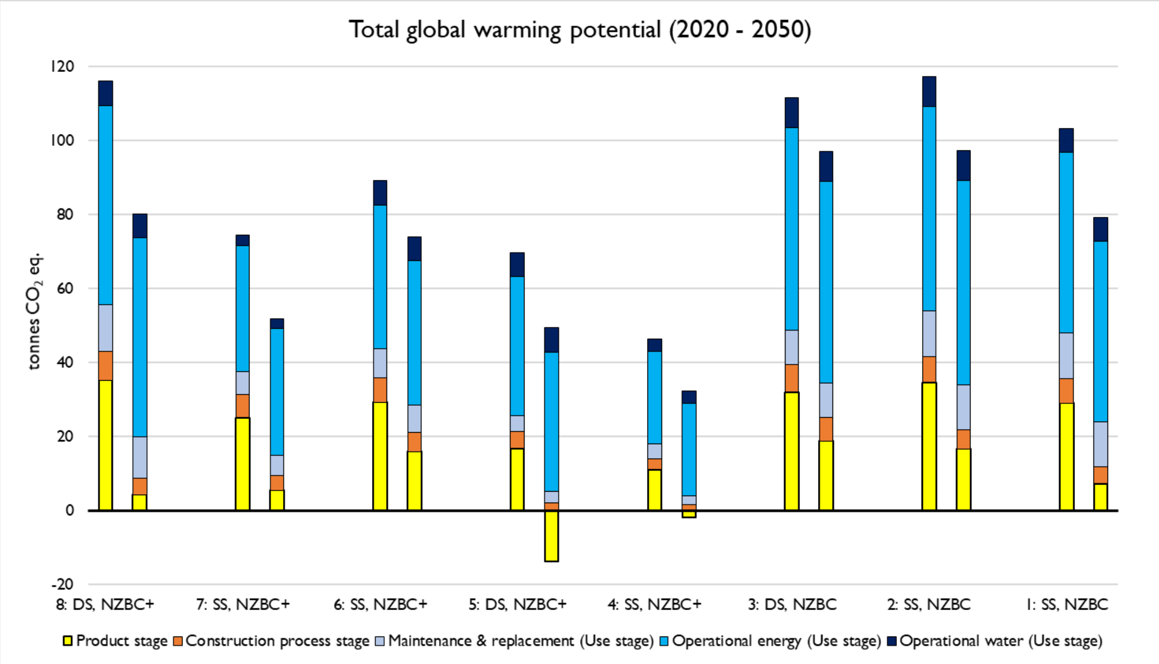
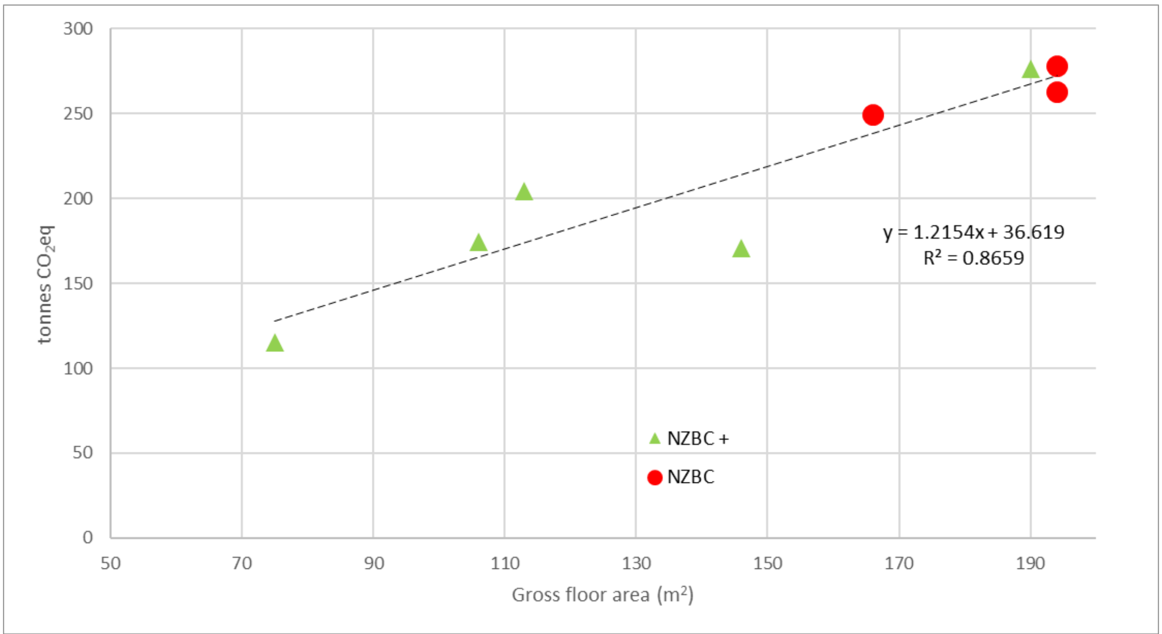


Figure 4



6. Incentivise the building of smaller houses. Currently, typical new houses are 196 m^2 (Statistics New Zealand data, at time of writing). Larger houses require more materials to be manufactured and maintained, and require more heating and cooling loads associated with a larger treated floor area. Figure 4 shows the relationship

between house size and total carbon footprint (taken from the current draft of the forthcoming BRANZ SR437 study report).

Currently in New Zealand, there is a mindset that a large “high performance” house is beneficial for the environment, because it out-performs an equivalent sized Code compliant house, at least with respect to thermal performance. Large high-performing houses are unsustainable and not necessarily low-carbon. Instead, they are less-unsustainable than their Code-compliant alternative.

From Figure 4 (which only comprises 10 stand-alone houses), we can see that there is a strong relationship between gross floor area and total carbon footprint. Building more smaller dwellings should have co-benefits such as being quicker to build, more affordable and cheaper to keep warm, although we have not assessed this.

7. We need a better way of benchmarking the carbon performance of our buildings that is predicated on consideration of planetary boundaries. BRANZ and Massey University have focussed on this question and established carbon budgets for new dwelling typologies (and commercial office buildings) so we can compare the carbon footprint of what is being built now with what should be built, so that greenhouse gas emissions are within allowable limits to achieve no more than a 2ºC or 1.5ºC warming above pre-industrial levels. These carbon budgets will be set out in the forthcoming BRANZ SR437 study report. The method for their calculation was well received at the Sustainable Built Environment conference in Graz, Austria, this year (Chandrakumar et al. (2019), please note that the reported carbon budget stated in this paper has now been superceded based on our latest research).

EXISTING NON-RESIDENTIAL BUILDINGS

Ghose’s 2017 PhD thesis used life cycle assessment (LCA) to assess the potential climate change (and other environmental) impact of upgrading and subsequent use of New Zealand’s existing commercial office building stock.

Ghose assessed the environmental impacts of refurbished buildings that have adopted multiple energy efficiency strategies (providing the equivalent of a deep retrofit) under three proposed interventions to reduce greenhouse gas emissions:

- Installation of photovoltaic panels on the roof of each refurbished building to encourage on-site renewable energy generation.
- Increase the marginal share of renewables supplying grid electricity to >90%.
- Widespread adoption of best-practice construction methods, such as sourcing all materials from manufacturers using renewable energy and diverting the final disposal of construction waste from landfills.

Ghose’s results highlight that the existing office building stock can potentially reduce greenhouse gas emissions by 40–65% and achieve this without increasing the embodied carbon impacts. Ghose also showed that, by focusing refurbishment on medium to large-sized commercial buildings (≥3,500 m^2), greenhouse gas emissions from energy use for the refurbished buildings can be reduced by 40–45%. Moreover, refurbishing buildings located in Auckland, Wellington and Christchurch can reduce greenhouse gas emissions by 50–70% (Ghose, 2017).

With respect to building characteristics, Ghose et al. (2017) found that the façade material, thermal resistivity of the wall, window-to-wall ratio, number of heat pumps installed, annual energy consumption and building location were factors significantly influencing the impact of large refurbished buildings. All Ghose's results (Ghose, 2017; Ghose et al., 2017; Ghose et al., 2019) indicate that deep energy refurbishment can substantially reduce the environmental impacts associated with non-refurbished offices. However, the environmental performance could be optimised if specific policies are prioritised.

Specific proven and emerging options to reduce emissions to 2035

Key findings include the following:

- The adoption of better construction practices such as increased recycling and reuse of materials reduces the total impact. Furthermore, if the construction materials are sourced from regions where a high share of renewable energy is used for material production, the carbon impacts reduce by approximately 30–40%.
- In large buildings, efficient heating, ventilation and lighting equipment and smaller wall-to-window ratios should be prioritised to reduce environmental impacts.
- In small buildings, the choice of façade materials with low embodied impacts should be prioritised to reduce environmental impact.

NEW NON-RESIDENTIAL BUILDINGS

BRANZ has undertaken less research for commercial offices. Nevertheless, BRANZ has carbon footprinted 10 New Zealand office buildings located in Auckland, Wellington or Christchurch, which vary from 1500 to more than 9000 m^2 gross floor area. Each building has been simulated for energy use in each of Auckland, Wellington and Christchurch, providing a data set of 30 buildings across 3 climate zones. Currently, these carbon footprints consider structure and thermal envelope only, and use a service life of 60 years.

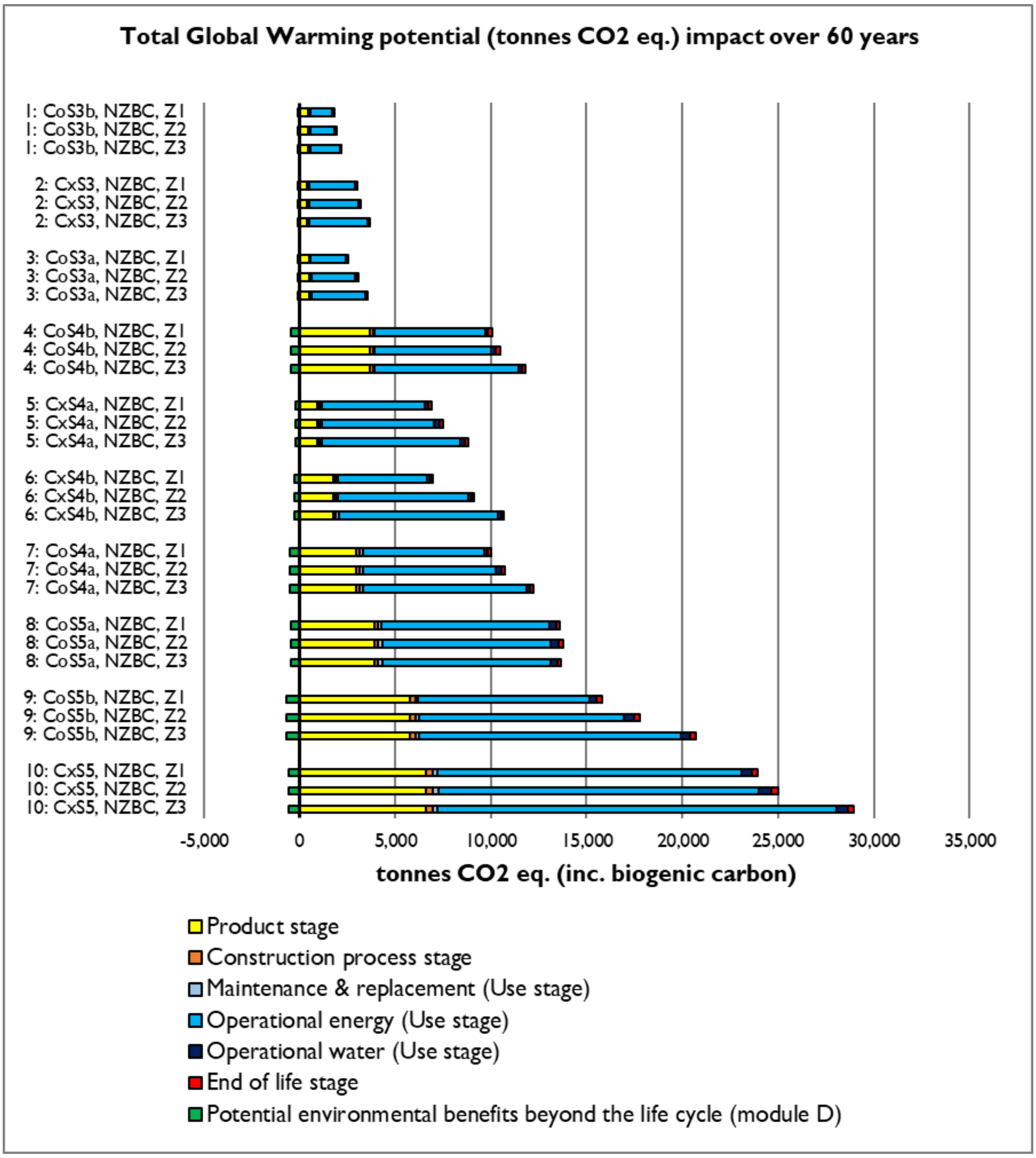
Results of this carbon footprinting research are summarised in Figure 5 below (taken from the forthcoming BRANZ SR437 study report). The coding convention we have used for each commercial office is as follows, to maintain anonymity:

- Numbering (1 to 10).
- Co = Commercial office and Cx = commercial mixed. The "mixed" category has some other activities occurring in the building e.g. retail, gym, café.
- S3, S4 and S5 refer to BEES strata sizes based on gross floor area, where S3 is 1500 - <3500 m^2, S4 is 3500 - <9000 m^2 and S5 is 9000 m^2 +.
- "a" or "b" is used to denote different buildings with the same office designation and strata size.
- NZBC Z1, NZBC Z2 and NZBC Z3 denote the climate zone in which the building has been simulated for energy use.

Further information about the buildings is available in the BRANZ SR350 study report (Berg et al., 2016).

BRANZ has a current research project (with BECA) to investigate the contribution of building services to commercial office building carbon footprints. Research overseas by the Carbon Leadership Forum (2019) in USA estimates that mechanical, electrical and plumbing can add 40 – 75 kg CO_2 eq/m² whilst fit out elements (finishes, furniture and fixtures) can add another 45 – 135 kg CO_2eq /m².

Figure 5



<u>**Specific proven and emerging options to reduce emissions to 2035**</u>

BRANZ research shows that:

- Materials make a significant contribution to the life cycle greenhouse gas emissions. This is, in part due to the 60 year service life used for commercial buildings (compared to 90 years for residential) and partly due to the greater likelihood of use of carbon intensive materials such as in-situ and precast reinforced concrete, structural steel and curtain walls.
- Energy use is primarily driven by tenant plug loads and heating, ventilation and air conditioning (HVAC). Increased efficiencies in these areas will yield carbon savings. Note, mechanical systems are frequently over-sized (to ensure the system has capability and capacity) but this means it is not operated at optimal levels.
- The need for HVAC is driven by the tendency to use curtain walls on commercial buildings. The large solar gains that frequently result mean that HVAC is required to provide sufficient cooling. Designing commercial buildings with passive solar design principles, and moving away from use of curtain walls, will have carbon benefits. Care must be taken to consider the indoor environment at expected temperatures in the future with climate change.

FUTURE RESEARCH OF RELEVANCE TO THIS QUESTION

To date much of the literature is speculative on the costs, benefits and effectiveness of implementation of greenhouse gas emission reduction strategies. Substantive evidence needs to be undertaken for buildings.

Some new research at BRANZ (beginning April 2020) is attempting to fill this gap in knowledge. The BRANZ research will scope the development of Marginal Abatement Cost Curves (MACC or MAC curve) in order to provides a simple, visual representation and comparison of the $ cost of different carbon abatement technologies/strategies per tonne of carbon saved (from least $ cost or highest $ saving, through to highest $ cost).

The BRANZ project will work with stakeholders to ascertain what data exist in New Zealand to support development of MAC curves, and the scope and methodology to be used for their development. Dwellings (new and existing) and non-residential (new and existing) will be within scope for this research. Given the relatively low carbon intensity of the New Zealand Grid, and different costs associated with materials and technologies in New Zealand in comparison with many European countries, it is likely that New Zealand-specific MAC curves may look quite different. The project ultimately aims to deliver NZ-specific MAC curves for:

- New dwellings.
- Existing dwellings.
- New non-residential buildings.
- Existing non-residential buildings.

Cited References in this Section

Arcipowska, A., Anagnostopoulos, F., Mariottini, F. & Kunkel, S. (2014). *Energy performance certificates across the EU: A mapping of national approaches*. Brussels, Belgium: Buildings Performance Institute Europe. Retrieved from http://bpie.eu/wp-content/uploads/2015/10/Energy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf

Beacon Pathway (2019) Papakowhai renovation project. Retrieved from: https://www.beaconpathway.co.nz/existing-homes/article/reports_and_presentations_-_papakowhai_renovation_project

Berg B, Dowdell D and Curtis M (2016) *New Zealand whole-building whole-of-life framework: Development of reference office buildings for use in early design* BRANZ Study Report SR350. Judgeford, New Zealand: BRANZ Ltd.

Burgess, J. Buckett, N. Camilleri, M. Burrough, L. Pollard, A. & P. Hancock (2010) *Sustainable Renovations of 1970s New Zealand Homes*. Conference paper TE106/21, SB10 New Zealand.

Burrough, L., Saville-Smith, K. & Pollard, A. (2015). *Heat pumps in New Zealand.* Study Report SR329. Judgeford, New Zealand: BRANZ Ltd.

Carbon Leadership Forum (2019); *LCA for low carbon construction - Estimates of embodied carbon for mechanical, electrical, plumbing and tenant improvements*

Chandrakumar C, McLaren S, Dowdell D and Jaques, R (2019); *A top-down approach for setting climate targets for buildings: the case of a New Zealand detached house*; Sustainable Built Environment Conference 2019 (SBE19 Graz), IOP Conference Series: Earth and Environmental Science 323

Donn, M and Thomas, G. (2010) *Designing Comfortable homes: guidelines on the use of glass, mass and insulation for energy efficiency* 2nd edition. Wellington: Energy Efficiency and Conservation Authority and Cement and Concreate Association of New Zealand

Ghose, A. (2017) *Environmental evaluation of energy efficiency refurbishment in New Zealand's commercial office buildings* (PhD thesis). Massey University, New Zealand.

Ghose, A. McLaren, S. Dowdell, D. & Phipps, R. (2017). *Environmental assessment of deep energy refurbishment for energy efficiency – case study of an office building in New Zealand.* Building and Environment, 117, 274–287.

Ghose, A., Pizzol, M., McLaren, S., Vignes, M. & Dowdell, D. (2019). Refurbishment of office buildings in New Zealand: Identifying priorities for reducing environmental impacts. *The International Journal of Life Cycle Assessment, 24*(8), 1480–1495. https://doi.org/10.1007/s11367-018-1570-5

Intergovernmental Panel on Climate Change (2014). *Summary for policymakers - climate change 2014: Mitigation of climate change. contribution of working group iii to the fifth* *assessment report of the intergovernmental panel on climate change*. Technical report, IPCC, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Isaacs, N., Camilleri, M., Burrough, L., Pollard, A., Saville-Smith, K., Fraser, R., Rossouw, P. & Jowett, J. (2010). *Energy use in New Zealand houses: Final report on the Household Energy End-use Project (HEEP)*. BRANZ Study Report SR221. Judgeford, New Zealand: BRANZ Ltd.

Jaques, R. (2015). *Measuring our sustainability progress: Benchmarking New Zealand's new detached residential housing stock*. BRANZ Study Report SR342. Judgeford, New Zealand: BRANZ Ltd.

Johnson (2011). Air-source heat pump carbon footprints: HFC impacts and comparison to other heat sources; Energy Policy 39 pgs 1369 – 1381.
Johnstone I (1994); *The mortality of New Zealand housing stock*; Architectural Science Review

MacGregor, C, Blackwell, S. McChesney, I. and R Jaques (2019) *Research and regulatory responses to the role of buildings in mitigating and adapting to climate change: a literature review*. Commissioned report by Ministry of Business, Innovation and Employment- Building System Performance team. Wellington, New Zealand.

MacGregor, C., Dowdell, D., Jaques, R., Bint, L. & Berg, B. (2018). *The built environment and climate change: A review of research, challenges and the future.* BRANZ Study Report SR403. Judgeford, New Zealand: BRANZ Ltd.

Overton, G., Bassett, M., and McNeil, S. (2013). *Ensuring the New Zealand building stock is moisture tolerant.* In Proceedings of the 19th CIB World Building Congress, 5-9 May 2013, Brisbane, Australia.

White V & Jones M (2017). *Warm, dry, healthy? Insights from the 2015 House Condition Survey on insulation, ventilation, heating and mould in New Zealand houses*. BRANZ Study Report SR372. Judgeford, New Zealand: BRANZ Ltd.

Question 2:

In your areas of expertise or experience, what actions or interventions may be required by 2035 to prepare for meeting the 2050 target set out in the Bill? Please provide evidence and/or data to support your assessment.

It is difficult to predict timing for possible interventions, as this will depend on the nature of any regulation, take-up of technology, ability of the industry to deliver, and acceptance by consumers (for example). Depending on these (and other) factors, some of the suggested interventions below may be appropriate in the timescales set out in Question 1. Similarly, some of the interventions listed in Question 1 may be appropriate for this question.

Potential interventions listed here concern:

- Water heating.
- Glazing.
- Decarbonising energy supply.
- Ripple control.

Water heating

Our carbon footprint research (outlined in Question 1) has shown that water heating is a "hot spot" for greenhouse gas emissions. Electric resistance water heaters, common to approximately 68% of all existing households are likely the most greenhouse-intensive way of heating water. With new, potentially more efficient and lower carbon water heating technologies available – such as heat pumps with refrigerants with no or low global warming potentials, and direct solar PV systems – incentives should be provided to encourage their uptake.

Internationally, Australia and California are addressing this issue. Australia's phase out was implemented piecemeal – starting in late 2010. Greenhouse gas intensive hot water systems can no longer be installed in new buildings under their Building Code. The Northern Territory, Queensland and Tasmania have not adopted these rules, however. Victoria has introduced a requirement for either a solar water heater or a plumbed rainwater tank to be installed.

California now has two main technologies to decarbonize its domestic hot water use: heat pump water heaters (HPWHs) and solar hot water heaters (SHWHs)with electric resistance backup. These technologies can be used to replace fossil fuel-based water heaters, or inefficient electric resistance heaters to accelerate the decarbonization of water heating in the state (source).

In Canada, water heating technologies for sale will need to meet an energy performance of more than 100% by 2035. This is according to Building sector strategy - Build Smart. Sits under the Pan-Canadian Framework on Clean Growth and Climate Change.

In January 2019, the California Public Utilities Commission (CPUC) affirmed the carbon shift by launching a proceeding devoted to decarbonizing buildings. "...the real breakthrough is the money — $200 million over four years — authorized under the bill to be invested in programs to advance low-carbon space and water heating technologies in both new and existing buildings." (source)

Glazing

Glazing is a thermal weak-link in dwellings. In colder climate zones where space heating is more important this is especially true. This is because the glazed component has typically about 1/10th the thermal resistance of walls, and accounts for around 30% to 50% of the heat loss of a newly built-to-Code house (BRANZ, 2014). This, however, assumes that the glazing-wall junction detail has been installed well, so the specified thermal resistance values are met in-situ. This rarely occurs. The introduction of a practical checking/verification system could improve the current whole building thermal performance considerably – where the glazing industry provides proof of practical, tailored solutions to ensure specified thermal performance is met without compromise to the buildings weathertightness performance. Some glazing suite-specific education might be required for glazing installers – which would most likely be provided by the glazing industry. BRANZ is currently engaged in with the Windows and Glass Association of NZ (WGANZ) and related industries in a research project looking at “high performance junction details for double glazed windows”.

Decarbonising energy supply

In January 2019, Vancouver City Council voted unanimously to join other subnational jurisdictions, including London and California, in declaring a climate emergency (OneCity Vancouver, 2019). The effect of this vote is that Vancouver is seeking to tighten its ambition with regards to achieving net-zero carbon emissions before 2050 and hasten the transition to renewable energy sources. California is included because of a wide-ranging climate change focus and similarities to New Zealand in terms of electricity supply – a strong focus on electrification of space and water heating and a carbon-free electricity goal by 2045.

California has recently committed to a building decarbonisation programme. The policy framework is still being developed but it is expected to be focused strongly on building electrification and zero carbon emissions from buildings (Cunningham, Ralston & Wu, 2019).

Ripple control

Clever energy load management for buildings – essentially a more sophisticated application of the old ripple control’ system used to remotely control water heating tanks - has the potential to lower the carbon impact of grid electricity. The idea is to dynamically manage when electricity is supplied to large loads which have some flexibility in when energy is needed to them - typically water heating tanks. This has the potential to reduce the frequency and length of times when the grid relies on carbon intensive generation. Technically, the challenge is, though, that this would likely require an electricity market restructure.

This type of smart control is being trialled by FLICK Electric and GoodMeasure currently[4]. It provides real-time, direct access to power meter data to the consumer - for them to make informed decisions. Currently they are working on a product using If This Then That (IFTTT) technology where consumers can define a simple chain of events based on carbon consumption (“if this”) which if they occur automatically turns power heavy appliances on and off (“then that”).

Wider picture

It is important that the lifetime implications (including opportunity cost) are robustly assessed when any promising technology is examined. Sometimes, the net carbon benefits (or detriments) are counterintuitive. For example, recently, there have been several New Zealand-specific studies examining the various sustainability aspects of residential technologies available today. The most comprehensive were produced by the Concept Consulting Group, exploring the likely environmental, economic and social

[4] https://thespinoff.co.nz/politics/15-01-2019/fight-the-power-the-technology-giving-consumers-control-of-their-electricity/

implications associated with widespread uptake of grid-connected PV and electric cars for New Zealand (Concept Consulting Group, 2016a, 2016b, 2017). These three reports, using various sensitivity studies and future scenarios, concluded that, for New Zealand, micro-generation – i.e. residential based PV - whether immediately supplying energy (on-site) or via delayed storage (battery-assisted) - are not particularly beneficial at reducing carbon. This is because of New Zealand's usual electricity generation mix that is powered mainly via highly efficient low-carbon renewables, chiefly hydro. They predict that the uptake of residential-installed grid-tied battery-less solar PV panels in New Zealand will likely result in fewer, considerably lower-emission hydro-power stations being built to meet demand. As stated in the report: "These conclusions appear robust against a range of different scenarios relating to fuel prices, CO_2 prices and electricity demand growth." (Concept Consulting Group, 2016b, p. iii). This finding was supported by another New Zealand-centric report (Schwartfeger & Miller, 2015), which also mentions other potential environmental issues with PVs, such as the (typically) carbon-intensive manufacturing process, the use of carcinogenic materials and uncertainties in end-of-life disposal.

The caveat to this is that this technology is rapidly changing, and will need to be reviewed every few years, the development of low carbon (organic-based) PV's, 'hot water diverters', and phase change water heaters, etc.

Cited References in this Section

BRANZ (2014); House insulation guide 5th edition.

Concept Consulting Group. (2016a). *Electric cars, solar panels and batteries – how will they affect New Zealand's greenhouse gas emissions?* Wellington, New Zealand: Concept Consulting Group Ltd.

Concept Consulting Group. (2016b). *Electric cars, solar panels, and batteries in New Zealand Vol 2: The benefits and costs to consumers and society*. Wellington, New Zealand: Concept Consulting Group Ltd.

Concept Consulting Group. (2017). *What is the case for electricity efficiency initiatives?* Wellington, New Zealand: Concept Consulting Group Ltd.

Cunningham, A., Ralston, M. & Wu, K. (2019). *California's building decarbonization opportunity: Knowing where we are and delivering what we need.* Los Angeles, CA: Building Decarbonization Coalition. Retrieved from www.buildingdecarb.org/uploads/3/0/7/3/30734489/bdc_report_1_ca_s_building_opportunity.pdf

One City Vancouver (2019). *Climate emergency motion*. Retrieved from www.onecityvancouver.ca/climate_emergency_motion_jan_2019

Schwartfeger, L. & Miller, A. (2015). *Environmental aspects of photovoltaic solar power: The New Zealand context*. Paper presented at EEA Conference & Exhibition 2015, Wellington, New Zealand, 24–26 June.

Question 3: ***In your areas of expertise or experience, what potential is there for changes in consumer, individual or household behaviour to deliver emissions reductions to 2035? Please provide evidence and/or data to support your assessment.***

Behavioural interventions for consumers, individuals and households in relation to the built environment are complex. Research to date relating to high performance buildings has found a number of key barriers:

- Behaviour is often driven by regulation – Research undertaken amongst consumers about their experiences of sustainable, high-performance building found that there is an inherent belief that the New Zealand Building Code is a quality assurance mechanism rather than the minimum performance level with which buildings must comply. This misunderstanding of the Building Code is an important barrier to building beyond Code (MacGregor and Donovan, 2018: 22). This means that in order to influence consumer and industry behaviour to reduce greenhouse gas emissions in buildings, there is a need to create regulation that sets out a requirement to do so.
- Cost is a major barrier to designing and building high performance buildings. Consumers typically do not value "higher performance features", especially those that are not visible e.g. increased insulation, when buying houses (Page, 2016). They do place some value on visible features e.g. photovoltaic panels, although these may not necessarily provide the optimum low-carbon option (Page, 2016).
- Barriers to the uptake of solar power – Stoecklein and Jaques (2016) highlight a number of barriers that may affect the large-scale adoption of solar power in New Zealand. While many consumers felt informed about the technology, there were a number of information gaps that were required by consumers namely concerned with the track record of the product and company, the personal power cost savings and how the solar power would affect the dwelling's energy and sustainability performance (Stoecklein and Jaques, 2016). Some other key financial barriers to the uptake of solar power included: the high initial upfront cost of solar systems, buy-back rates (ie feed - in tariffs) from power companies (Stoecklein and Jaques, 2016). Stoecklein and Jaques (2016) assert that giving the issue of buy-back rates and a reported lack of clear information about buy-back rates, this is a critical factor that needs addressing for more effective promoting and uptake of solar technology in New Zealand.
- The building and construction Industry workforce often lack the skills and training needed to offer consumer advice that would facilitate behaviour change – for example, a large proportion of New Zealand's homes require insulation to enable them to be warmer, drier and healthier. However, BRANZ-funded research undertaken by Alkema, McDonald and Stokes (2018) found that the key driver of consumer choice with regard to retrofitted insulation was the cost of insulation. Cost equated to the weighing up of price against affordability and benefits expected while the consumer lives in or rents their property. Larger issues identified in the study concerned that there is no career or qualification pathway for those working solely in the insulation industry and a misalignment of the information provided by advisors (specific product

information) rather than the information consumers want (how to make their homes warmer, drier and healthier in an affordable way) Training provided to in the insulation industry was seen as minimal and reliant on individuals' self-educating through reading about products and standards.

- There is a lack of financial incentives to design and build high-performance sustainable homes - A BRANZ funded study by Reid, Groom, and Green (2019) found that sustainability features are not being accounted for in house valuations. Further, banks do not typically record sustainability / high-performance features in home loan applications, as they often assume it was reflected in valuations. The whole-of-life cost and future benefits of houses with high-performance features are not considered.

  There is a global move towards green mortgages, particularly in Europe and Australia, closely tied in with green bonds as a funding mechanism. However, the creation of green loans/mortgages within New Zealand to encourage sustainable, high-performance homes presents a number of issues, namely:

  - The relatively small size of the New Zealand home loan market presents challenges around scalability when it comes to developing such specific home loan products – banks also believe there is little customer awareness of, or demand for, such features

  - A single consistent benchmark or measure, particularly around energy efficiency, defined and mandated by legislation, would create clarity for the banking, insurance, and valuation sectors, and could be easily recorded

  - Such a measure would drive changes in consumer behaviour and demand, and would raise awareness of the value of integrated features that contribute to energy efficiency. Banks would also then have clearer criteria for developing a green mortgage product.

- Behavioural interventions are needed but industry is not equipped to design, implement and evaluate these interventions. For example, by making choices such as to design and build a low carbon building, change energy behaviours, buy/design smaller sized houses etc are choices that could help reduce greenhouse gas emissions. However, the building and construction sector lacks the incentives, tools, ability and resources to design, implement and evaluate behavioural interventions. Therefore, there is a need for building and construction industry professionals to collaborate with social science professionals to plan and co-ornate climate change action within the building and construction industry (MacGregor, et al, 2018).

<u>Cited References in this Section</u>

Alkema A, McDonald H and Stokes F (2018) Retrofitting insulation in residential properties How might the advice to landlords and homeowners be improved? BRANZ Study Report ER 32 Judgeford, New Zealand: BRANZ Ltd.

MacGregor C. & Donovan E (2018) *The choice to exceed: Consumer perspectives on building beyond Code in New Zealand.* BRANZ Study Report SR402. Judgeford, New Zealand: BRANZ Ltd.

MacGregor C, Dowdell D, Jaques R, Bint L & Berg B (2018). *The built environment and climate change: A review of research, challenges and the future.* BRANZ Study Report SR403. Judgeford, New Zealand: BRANZ Ltd.

Page I (2016) *The value of sustainability- cost and benefits of sustainability and resilience features in houses*. BRANZ Study Report 346 Judgeford, New Zealand: BRANZ Ltd.

Reid A, Merewyn Groom M & Green S (2019) *Green Mortgages Financial incentives to design and build high-performance homes*. BRANZ Study report ER43. Judgeford, New Zealand: BRANZ Ltd

Stoecklein A & Jaques R (2016); *The value of sustainability: an investigation into barriers and enablers for solar power in New Zealand*. BRANZ Study Report SR353. Judgeford, New Zealand: BRANZ Ltd.

Question 4:

When advising on the first three emissions budgets and how to achieve the 2050 target, what do you think the proposed Commission should take into account when considering the balance between reducing greenhouse gas emissions and Our removing carbon dioxide from the atmosphere (including via forestry)?

The built environment provides significant opportunities for early greenhouse gas emissions savings. Good passive solar design can yield energy savings whilst increased use of timber and engineered woods (sourced from sustainable forestry) in all building typologies provides opportunities to sequester carbon for decades within our buildings.

Thus, pursuing policies that will result in higher performing, low carbon (from an energy and materials perspective) buildings has the dual benefit of decarbonising our built environment *and* stimulating forestry.

Furthermore, opportunities exist now for decarbonising our buildings that do not have to rely on technological development, but rather, breaking down of current barriers and changing of incentives and behaviours.

In Europe and North America, there is a strong shift towards zero-energy buildings (ZEBs). In Europe, the main driver to mandate requirements has been EU regulation, which requires the 28 member states to set in place national regulations for nearly zero-energy buildings', operational from 31 December 2020.

ZEBs are an important international trend that is determining the trajectory and specifics of buildings codes and regulations in many countries. Currently, however, there is no universally agreed definition or specification for ZEBs (Zhang et al., 2015) and the definitions that exist do not include embodied carbon. Further information is available in MacGregor et al. (2019).

Zhang and others note: “Despite the apparent similarity in [zero-energy building] terms, there are significant differences in the definitions, policies and support mechanism [which] … make it difficult to understand and evaluate global progress toward lower-energy buildings and create confusion for other countries” (Zhang et al., 2015, p.1299).

Jurisdictions that are at the forefront of ZEB adoption use several approaches that have policy implications that New Zealand could consider:

1. ZEB definitions should be outcome based and consider regional conditions. For example, when defining ZEB for New Zealand, we would need to address regional variation such as climate differences.
2. Providing several performance levels that become incrementally tighter. A phased approach could help ensure a stable, long-term ZEB target that the building industry can aim for and work towards. For example, the Danish Government clearly signalled to their building and construction industry that the ZEB goal will be mandatory in the building code by 2020. Since 2006, the Danish building code provided three different performance levels (Class 2010, Class 2015, Class 2020) for builders to choose from. In 2010, Class 2015 and Class 2020 were considered “premium options” (Energy Efficiency Watch, 2019).
3. Evolving ZEB policies – it would be important to plan for updating policies as technologies and markets change (Zhang et al., 2015).

Cited References in this Section

Energy Efficiency Watch. (2019). *Energy efficiency policies in Europe: Case study: Danish Building Code – Denmark*. Retrieved from www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Case_Studies_EEW3/Case_Study_Danish_Building_Code_final.pdf

MacGregor, C, Blackwell, S. McChesney, I. and R Jaques (2019) *Research and regulatory responses to the role of buildings in mitigating and adapting to climate change: a literature review*. Commissioned report by Ministry of Business, Innovation and Employment- Building System Performance team. Wellington, New Zealand.

Zhang J, Zhou N, Hinge A & Feng W (2015); *Zero-energy buildings – an overview of terminology and policies in leading world regions.* ECEEE Summer Study Proceedings, 1299–1311.
www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2015/6-policies-and-programmes-towards-a-zero-energy-building-stock/zero-energy-buildings-8211-an-overview-of-terminology-and-policies-in-leading-world-regions/2015/6-169-15_Zhang.pdf/

Question 5: ***What circumstances and/or reasons do you think would justify permitting the use of offshore mitigation for meeting each of the first three emissions budgets? And if so, how could the proposed Commission determine an appropriate limit on their use?***
BRANZ has not provided a response to this question.

Section B Emissions reduction policies and interventions

The proposed Commission will also need to consider the types of policies required to achieve the budgets it proposes. This consideration should include:

- sector-specific policies (for example in transport or industrial heat) to reduce emissions and increase removals, and
- the interactions between sectors and the capability of those sectors to adapt to the effects of climate change.

Question 6: ***What sector-specific policies do you think the proposed Commission should consider to help meet the first emissions budgets from 2022-35? What evidence is there to suggest they would be effective?***
Policy options that BRANZ believes the Commission should consider are (in no specific order, see previous questions for evidence): 1a. Introduce energy-related Energy Performance Certificates and carbon metrics to both new and existing dwellings. 1b. Progressing 1a., consider the introduction of a design carbon threshold (based on life cycle carbon emissions) for new buildings which becomes progressively more stringent over time and trend towards the planetary boundaries carbon thresholds. 2. Accelerate efforts to disincentivise and phase out use of energy inefficient appliances e.g. fridge freezers. Extend MEPS[5] and 1 Watt maximum stand-by power for all new always-on appliances. 3a. Introduce MEPS for shower heads, phasing out the less water-efficient ones. 3b. Introduce MEPS for lighting, phasing out lower efficiency/quality LED's quality. 4. Incentivise product stewardship and initiatives to significantly reduce construction and demolition waste. 5. Disincentivise larger sized dwellings. 6. Disincentivise all gas appliances. 7. Encourage deep retrofit (i.e. include: roof/wall/floor insulation installation where possible plus air tightening) to dwellings.

[5] www.eeca.govt.nz/standards-ratings-and-labels/equipment-energy-efficiency-programme/

8. Disincentivise over-shading by neighbouring houses via improved District Plans requirements.

9. Encourage development of Environmental Product Declarations by manufacturers to improve data availability for building carbon footprinting.

Question 7:

What cross-sector policies do you think the proposed Commission should consider to help meet the first emissions budgets from 2022-35? What evidence is there to suggest they would be effective?

Future carbon emissions will not be confined to existing sectoral areas. The electrification of transport will see an increased use of in-home electric vehicle charging with electricity usage recorded by the household electricity meter increasing with an accompanying decrease in fossil fuels sold. Providing the high proportions of renewable energy contributing to the energy mix of the electricity grid is maintained, electrification of transport is a desirable outcome.

Question 8:

What policies (sector-specific or cross-sector) do you think are needed now to prepare for meeting budgets beyond 2035? What evidence supports your answer?

One of the biggest issues facing the building and construction industry is the scale and timing of training needed to educate and implement new requirements within the industry that will result in reduced greenhouse gas emissions in buildings (Duncan, Kingi & Brunsdon, 2018). As this upskilling and the embedding of behaviours transition into new industry practices takes time. It is therefore recommended that emissions budgets take a staged approach to the setting of decarbonisation performance levels which the building and construction industry must deliver are required well in advance. Advance warning of potential change means that industry can prepare, institute training and create support structures that may be required. Such an approach has been adopted in Europe (see MacGregor, et al, 2019 for more detail).

<u>Cited References in this Section</u>

Duncan A, Kingi V & Brunsdon N (2018) *Adopting new ways in the building and construction industry.* BRANZ Study Report SR406. Judgeford, New Zealand: BRANZ Ltd.

MacGregor C, Blackwell S, McChesney I and Jaques, R (2019) *Research and regulatory responses to the role of buildings in mitigating and adapting to climate change: a literature review*. Commissioned report by Ministry of Business, Innovation and Employment-Building System Performance team. Wellington, New Zealand.

Section C Impacts of emissions budgets

The proposed Commission will need to consider the potential social, cultural, economic and environmental impacts of emission budgets on New Zealanders, including how any impacts may fall across regions and communities, and from generation to generation. Potential impacts may be either positive or negative.

Question 9: ***What evidence do you think the proposed Commission should draw upon to assess the impacts of emissions budgets?***
A broad range of measures are required to assess the impacts of emissions budgets. Much data that would be of interest, does not exist within present datasets, and attention needs to be focussed on ensuring that this data is collected in the future. For example, an important social impact is equity and more accurate information on energy hardship would be beneficial.
Question 10: ***What policies do you think the proposed Commission should consider to manage any impacts of meeting emissions budgets? Please provide evidence and/or data to support your assessment.***
BRANZ has not provided a response to this question.

Section D Other considerations, evidence or experience

Question 11: ***Do you have any further evidence which you believe would support the future Commission's work on emissions budgets and emissions reduction policies and interventions?***
BRANZ has not provided a response to this question.

Please email your completed form to feedback@ICCC.mfe.govt.nz by **12 noon, Friday 15 November 2019.**

If you have any questions about completing the call for evidence, please contact us via feedback@ICCC.mfe.govt.nz.