BRANZ

ISSUE 651 BULLETIN

CLIMATE CHANGE, NET-ZERO CARBON AND THE BUILDING INDUSTRY

June 2020

- Recent calculations suggest that the built environment accounts for up to 20% of New Zealand's greenhouse gas emissions.
- Both new and existing buildings will need to produce fewer emissions to help meet net-zero carbon targets set in law.
- This bulletin provides an introduction to the impacts of climate change and the move to a net-zero carbon economy on the New Zealand building industry.

1 INTRODUCTION

1.0.1 Human activities, and burning fossil fuels in particular, have led to large quantities of gases such as carbon dioxide, methane and nitrous oxide being released into the atmosphere. These gases are acting like a greenhouse, changing climate patterns and lifting temperatures.

1.0.2 Most of the excess heat is absorbed by the oceans, and as the water gets warmer, it expands, leading to rising sea levels. Additional water is coming from melting polar ice and glaciers. Sea levels around New Zealand have risen by around 220 mm in the last century and are expected to rise by 300–400 mm in just the next few decades. This will have huge impacts. A study published in 2019 indicates that 15,000 New Zealanders live almost on the high tide mark, 71,000 within 1 metre and 240,000 within 2 metres of the mean high tide line. Another report estimated that a rise of 500 mm could put at risk roading and other infrastructure valued at $2.7 billion.

1.0.3 Globally, climate change will lead to enormous economic and social disruptions and significant natural changes including a growing risk of extinction for many species.

1.0.4 There are significant implications for the New Zealand built environment and the construction industry. A few examples:

- Communities may need to make a managed retreat from areas where the frequency and severity of flooding from storms and rising seas becomes unacceptable.
- Hotter summers may lead to more water shortages and more demand for air conditioning (and greater energy use).
- Extremes of heat and/or flooding can have a disastrous impact on infrastructure such as electricity and water supply and sewerage services.
- Both existing and new homes will need to become vastly more energy efficient.

1.0.5 New Zealand is a signatory to the Paris Agreement, a United Nations initiative where countries commit to take action to reduce the threat of climate change. Under this agreement, New Zealand committed to keeping its 2030 net emissions (gross emissions less carbon sequestration from forestry) at least 30% below its 2005 gross emissions. The global aim is to keep a temperature rise well below 2°C above pre-industrial levels. There is also a more aspirational aim to keep the temperature rise to no more than 1.5°C. Work published by the Intergovernmental Panel on Climate Change based on measured climate changes and forecast changes now suggests that the 1.5°C target should be our main target.

1.0.6 New Zealand has set in law (the Climate Change Response Act 2002) a target to reduce net emissions of greenhouse gases (except methane from plants and animals) to zero by 2050. One of the purposes stated in the Act is to "contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels".

1.0.7 Given that houses built today must have a functional lifespan of at least 50 years, houses being built today will be part of the net-zero carbon world after 2050.

1.0.8 A 2019 study by Massey University and BRANZ scientists calculated how much carbon dioxide new 3-bedroom homes can emit in their lifetimes to help meet climate targets (see 4.0.3). New Zealand house construction and operation currently produces too much carbon dioxide by several multiples.

1.0.9 Some of the actions that can be taken to reduce the environmental impact of houses are backed by solid science and widely accepted. Locating and orienting a new house on site to maximise passive solar gains and adding external shading devices to reduce summer overheating are examples. In some other areas, there is still uncertainty. Actions once thought to be obviously good steps in reducing carbon – such as installing photovoltaic (PV) generation systems – have turned out to be more complicated.

1.0.10 This bulletin provides a general introduction to climate change, the move to a net-zero carbon economy and implications for the building industry. BU650 *Building beyond Code minimums* provides more practical guidance for building industry practitioners.

2 CLIMATE CHANGE AND THE BUILT ENVIRONMENT

2.0.1 The greenhouse gas emissions that buildings and infrastructure account for can be broadly divided into two categories:

- The emissions accounted for by the structure of a building itself – the manufacture of construction materials, transport of materials to site, construction methods, construction waste, maintenance and end-of-life disposal.
- The emissions that come from use of the building. These are primarily the fossil fuel component in energy used for space heating, water heating, ventilating, cooling, lighting, food storage, cooking, clothes washing/drying and other appliance use.

2.0.2 Just what contribution these make to New Zealand's total emissions has been subject to discussion. Some reports, taking a narrow view and considering the energy use of buildings only, found New Zealand buildings accounted for just 5% of emissions. As the consultancy firm thinkstep pointed out in a 2018 report, however, these figures do not consider the impact of a building's materials, construction and demolition, and they present the carbon footprint of what is produced in New Zealand rather than what is actually consumed. Considering the full life cycle of buildings increases the figure to 13% (Figure 1). Add what is consumed here rather than just produced here, and the built environment's share of emissions in New Zealand rises up to 20%. Around half of the emissions were embodied in building materials (buildings and infrastructure) and around half were from operating buildings, with a tiny amount from end-of-life processes.

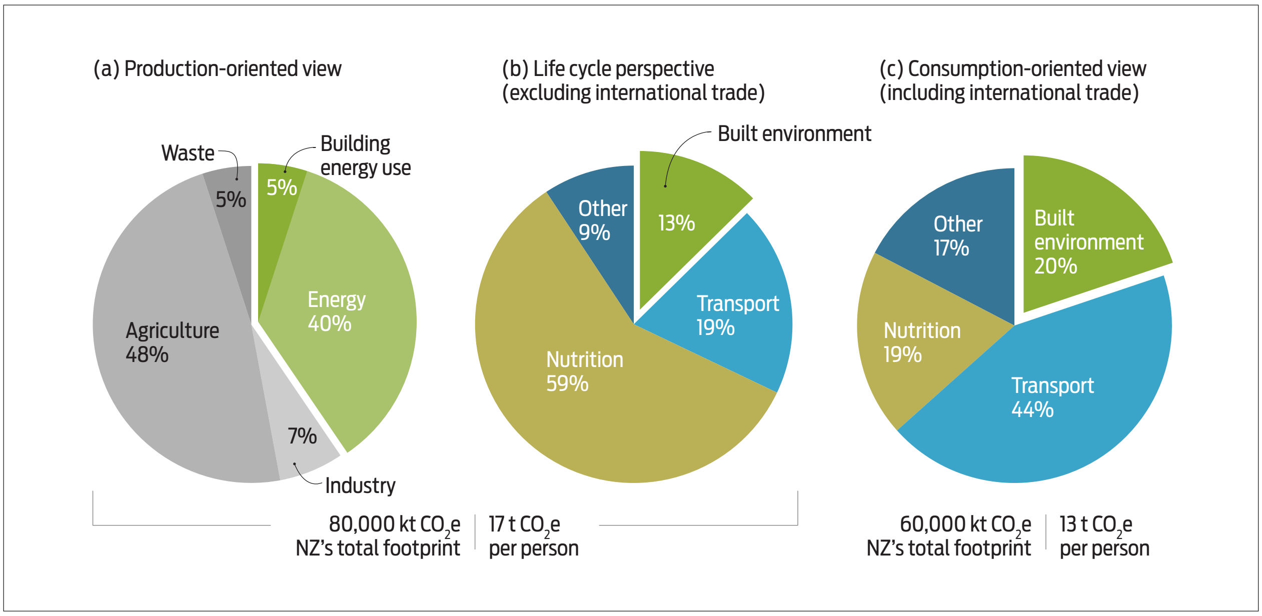

Figure 1. New Zealand's carbon footprint from (a) a production view, (b) a life cycle view and (c) considering what is actually consumed here (Vickers, Fisher & Nebel, 2018).

2.0.3 A 2019 report by thinkstep found that "At the national level, the carbon footprint of new-build construction and renovation was calculated to emit at least 2,900 kt of CO_2 equivalent per year – equivalent to more than 1 million passenger cars on New Zealand's roads" (Gamage, Vickers, Fisher & Nebel, 2019).

2.0.4 Stats NZ data shows that greenhouse gas emissions by the construction sector increased by 65.9% in the period 2007–2017. Emissions increased at a faster rate than the contribution to GDP (in real terms).

2.0.5 There is a link between emissions and house size. In 1970, the average new home was around 140 m^2. By 1990, it had grown to 166 m^2. In the 2000s, it passed 200 m^2. While there are some recent indications that the trend has stopped or even reversed, our houses remain much larger than they were. University of Otago research published in 2017 found a downside to this from an energy efficiency perspective. While requirements around thermal insulation have increased three times since the first national mandatory requirements came into effect in 1978, we still use roughly the same amount of energy to heat houses today as we did then because our homes are much bigger. In other words, larger houses have offset energy efficiency gains.

2.0.6 To address climate change, the two key actions that the construction industry needs to pursue are adaptation and mitigation:

- Adaptation means changing our buildings and communities to be more resilient to what is happening. This means building (and adapting existing buildings) to better cope with more extreme weather events, rising sea levels and flooding and stronger winds or higher temperatures in some locations.
- Mitigation means making changes to reduce the amount of emissions produced in and by the built environment.

3 ADAPTATION

3.0.1 Adaptation – making buildings more resilient – applies to the existing built environment as well as houses being built now and in the future. Two examples of the climate change risks that adaptation need to address are rising temperatures and rising sea and high tide levels.

3.0.2 Considering hotter temperatures, our houses – including new builds – have a way to go before they will be able to cope effectively with the changes forecast. BRANZ undertook computer modelling of the performance of 70 randomly selected Christchurch houses consented in 2016. Overheating in the lounge (a temperature above 25°C) was a common problem, with the average house overheating for 435 hours per year (Figure 2). With climate change forecast to bring hotter temperatures in many areas, designers will clearly need to put more thought into building features such as shading.

3.0.3 A 2017 report from the New Zealand Climate Change Adaptation Technical Working Group found 68,000 buildings are at risk from sea level rise, with a replacement cost estimated at $19 billion.

3.0.4 A joint report from the Ministry for the Environment and Stats NZ in October 2017 found that "with rising seas, we can expect tides, waves, and storm surges (commonly known as extremely long, slow waves) to reach further inland more regularly, resulting in more frequent and serious flooding".

3.0.5 Some councils have declared 'closed zones' in existing settlements, where further subdivision, new buildings and extension/replacement of existing habitable buildings closer to the shore are prohibited.

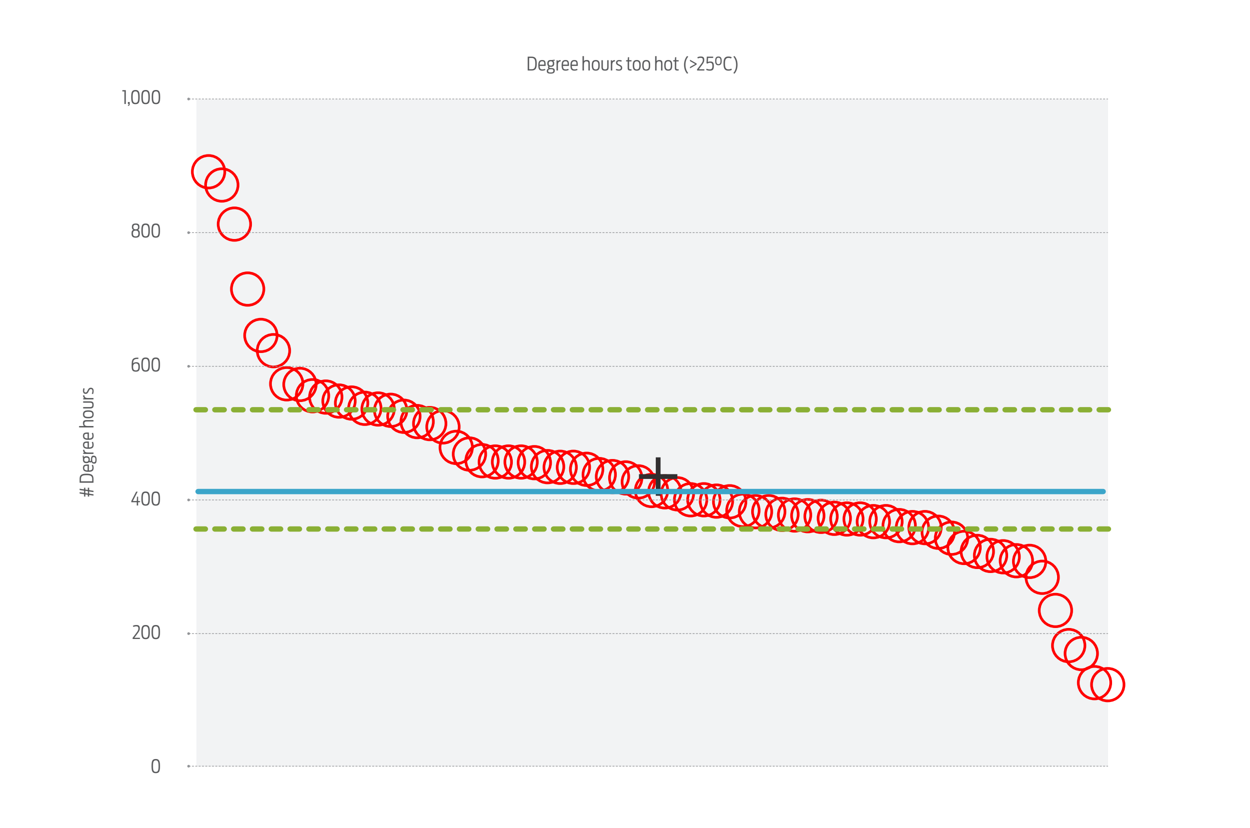

Figure 2. Overheating severity in the main living room for 70 new Christchurch houses (assessed through computer modelling).

3.0.6 For new house construction, adaptation means that some locations that could have been built on in the past may no longer be suitable because of:

- the threat of damage from flooding or erosion
- inability to get insurance – the Reserve Bank noted in late 2018 that some insurers are adjusting their policies and premiums to reflect climate risks, and some existing properties could ultimately become uninsurable
- local authority restrictions – under the Resource Management Act 1991, local authorities are required to have particular regard to the effects of climate change.

3.0.7 Residents in the most vulnerable locations face extremely difficult decisions around their future as the costs of flood protection and flood recovery grow to be unaffordable. Managed retreat must be considered – relocating communities from lower ground to higher ground.

4 MITIGATION

4.0.1 Given the calculations that the built environment accounts for up to one-fifth of New Zealand's greenhouse gas emissions, there is a need to reduce the emissions coming from construction, operation and end-of-use processes in buildings.

4.0.2 To give direction to this requires understanding and measuring the level of emissions today and then setting targets for approximately how far they need to fall.

4.0.3 A study by scientists from the New Zealand Life Cycle Management Centre at Massey University and BRANZ calculated how much carbon dioxide new 3-bedroom homes could emit in their lifetimes if they were to meet climate targets (Figure 3). The estimates were:

- 39 tonnes CO_2 equivalent to meet the more ambitious Paris Agreement target of limiting global temperature rises to 1.5°C above pre-industrial levels (the figure given in the Climate Change Response Act)
- 55 tonnes CO_2 equivalent for the Paris Agreement target of 2°C.

4.0.4 BRANZ researchers then calculated the carbon footprints of 10 New Zealand houses. A mix of single-storey and double-storey, the houses range from 75–194 m^2 gross floor area. Some have been designed to comply with New Zealand Building Code clause H1 *Energy efficiency* minimum requirements and some designed to exceed them.

4.0.5 As shown in Figure 3, the climate impact of the new-build houses vastly exceeds the 1.5°C figure referred to in the Climate Change Response Act. There is a wide gap between the carbon footprint of what we are typically building and the carbon budget of what we need to be building. It is imperative to focus on closing this gap, applying this to mainstream construction as soon as possible.

4.0.6 There is considerable evidence from research by BRANZ and other organisations that one key area of focus for residential construction should be energy and energy efficiency.

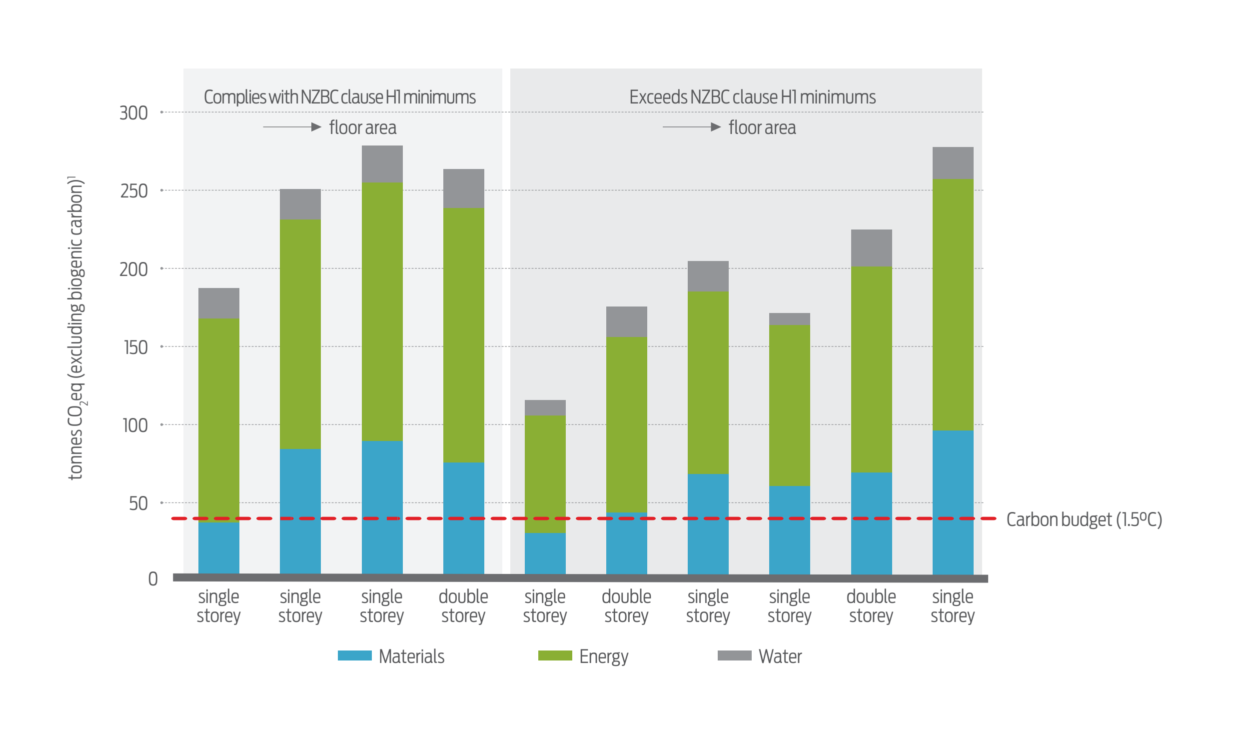

Figure 3. Total global warming potential (tonnes CO_2 equivalent) over 90 years calculated for 10 stand-alone houses.

Note 1. This excludes consideration of CO_2 sequestered by sustainable forestry used for manufacture of timber and engineered woods.

Note 2. The energy includes plug loads. Many improvements will come from more-efficient appliances, outside the control of building design.

5 ENERGY AND ENERGY EFFICIENCY

5.0.1 Energy use is a large contributor to emissions in the residential built environment (Figure 3), and a push to energy efficiency has been under way for many years. It is having a result. Residential electricity use per capita has been flat or falling since 1990. For almost two decades, it was broadly stable at around 3 MWh per capita, then from 2009, it has fallen 13%. Part of the reason is that people are buying more-efficient electrical appliances. From 2015 to 2019, for example, annual sales of energy-efficient LED lights more than doubled from around 248,500 to over 604,000.

5.0.2 A number of recent studies have found considerable potential for further energy efficiency (and hence carbon reduction) measures. For example, in its 2018 Statement of Intent, EECA calculated that improving the quality and energy efficiency of New Zealand's housing stock would produce savings of more than $470 million each year.

5.0.3 Concept Consulting Group (2017b) calculated that a reduction in peak electricity demand (typically in the evenings after 5pm) of approximately 30%, with considerable carbon savings, was possible through actions such as:

- moving electric water heating to off peak and encouraging heat pump water heating
- switching lights to LEDs
- installing more timers on appliances and underfloor heating
- identifying optimum options for space heating.

5.0.4 A rapidly growing (from a tiny base) source of renewable electricity into the grid comes from rooftop solar photovoltaic (PV) systems. Total installed capacity has grown from 25 MW in 2015 to over 119 MW at the end of March 2020, mostly driven by residential installations. (To put this number in perspective, total installed hydro capacity is over 5,000 MW and wind capacity is 690 MW.)

5.0.5 While PV systems have long been favoured for the renewable energy they provide, recent New Zealand research has suggested that they are not particularly beneficial at reducing carbon. This is partly because over 80% of New Zealand grid electricity is already produced from highly efficient low-carbon renewables such as hydro and wind. Looking at PV from a whole-of-life perspective, the majority of PV systems imported and used in New Zealand are also produced in countries that have carbon-intensive manufacturing processes, which increases their embodied carbon. This is due to their reliance on fossil fuel-based electricity.

5.0.6 Rating PV as a generating option, Concept Consulting Group (2017a) found that "rooftop solar is a very expensive form of generation compared to grid-scale low-carbon generation alternatives. Even with very high carbon prices and significant solar PV cost reductions it is not economic compared to grid-scale wind generation." The report expected that the uptake of (higher-cost) solar PV will largely displace (lower-cost) wind generation that would otherwise be built. It is unknown how the combination of solar PV and water tank stores changes the carbon equation.

5.0.7 Solar water heating systems are in a slightly different position because the water tank stores energy collected during the day. Solar water heating systems can replace both peak and non-peak electricity generation.

5.0.8 As noted earlier, one of the most effective means of achieving energy efficiency and therefore reducing emissions – likely the most effective means – is optimising passive solar design and determining the best orientation for a building on its site. BRANZ examined 210 randomly selected new houses that complied with the Building Code but did not take advantage of passive solar design. Computer modelling software found that the average house required two to three times the amount of space heating energy to stay warm compared to a house of similar price that incorporated passive solar design.

6 MATERIALS AND MATERIAL SELECTION

6.0.1 As energy efficiency in new builds and existing houses is improved and the carbon resulting from building operation falls, greater focus is being paid to reducing the greenhouse gases emitted in the production of building materials.

6.0.2 Selecting different building materials and construction methods can have a huge impact on the emissions embodied in buildings. Some materials require vast amounts of energy in their production. What doesn't make it into buildings also represents a big impact – construction and demolition waste makes up 40–50% of New Zealand's total waste going to landfill. By one estimate, each home constructed generates an average of 4 tonnes of waste. If this wasted material was instead used, it would reduce the need for virgin material production. Therefore, selecting materials and construction methods carefully and reducing waste can significantly reduce the carbon footprint of a building.

6.0.3 Life cycle assessment (LCA) provides useful information around materials and construction systems that can help when making choices about material use. LCA models the use of materials and energy and calculates environmental impacts from extraction, processing, manufacturing, transportation, use, reuse, maintenance, recycling and eventual disposal. LCA plays a crucial role in work around carbon footprinting and climate change – it was used in the work to produce the results shown in Figure 3, for example.

6.0.4 One output of LCA up to the point of construction can be calculation of the embodied carbon associated with a building – the total greenhouse gas emissions produced in the extraction, processing, manufacture and delivery of building materials to the building site. The BRANZ CO_2NSTRUCT resource on the BRANZ website has more information.

6.0.5 In 2019, thinkstep calculated that steel and concrete together account for half the carbon footprint of New Zealand's buildings (excluding fit-out and building services) (Gamage et al, 2019).

6.0.6 Environmental product declarations (EPDs) are one way that product manufacturers can robustly and consistently communicate the emissions and other environmental impacts of their products.

6.0.7 As with energy efficiency, the largest reductions in emissions from materials can only be achieved with coordinated input from all sectors: government, manufacturers/suppliers and building practitioners.

6.0.8 Substitution of materials at the design stage is one pathway to reducing materials emissions. Examples of this could include:

- replacing concrete made with ordinary Portland cement with concrete containing supplementary cementitious materials
- favouring building materials from producers who use renewable energy in their plants
- selecting new building materials with lower-carbon profiles – New Zealand is a leader in the development of laminated timber structural elements, for example.

7 CONTINUING WORK

7.0.1 A considerable amount of work into carbon and the built environment is under way. For example, BRANZ and partners are working on these initiatives:

- How can New Zealand construction deliver low to zero impact buildings? (2018–2022). This work establishes a common methodology and derives benchmarks to assess life cycle-based carbon emissions caused by buildings.
- The multi-year *Transition to a low-carbon built environment programme* (begun in 2019), which is examining climate change and its impact on New Zealand's buildings.
- The 2-year, innovative low-carbon water heating project, starting in 2020, which aims to provide clarity on which water heating options are the least impacting.

7.0.2 In 2019, the New Zealand Green Building Council, in partnership with Enviro-Mark Solutions, released a net-zero standard for existing buildings. At the time of publication of this bulletin, work was under way on a zero-carbon standard for new construction.

7.0.3 The fact that this science is evolving and that research work is still under way should not be used as an excuse for holding off on taking action. This is not a situation where delayed or slow incremental changes will produce the desired effect. Many of the solutions New Zealand's built environment needs are already available and ready to be used.

8 MORE INFORMATION

BRANZ BULLETINS

BU596 *An introduction to life cycle assessment*

BU608 *Building life cycle assessment*

BU650 *Building beyond Code minimums*

BRANZ STUDY REPORTS

SR403 *The built environment and climate change: A review of research, challenges and the future*

SR406 *Adopting new ways in the building and construction industry*

SR419 *A consumer survey of attitudes to exceeding minimum standards for refurbishments and retrofits*

BRANZ TOOLS

Three free Excel-based tools accessible on the BRANZ website provide resources to help those looking further into life cycle assessment and embodied carbon:

- BRANZ CO_2NSTRUCT provides values for embodied greenhouse gas and energy for some construction materials. The values are provided to the manufacturer's factory gate – they do not include transport to the construction site or wastage on site.
- LCAQuick helps building practitioners assess the environmental impact of buildings from a life-cycle perspective. (The carbon figures given in Figure 3 were developed using LCAQuick.)
- MaCC Tool (Materials and Carbon Comparison Tool) for determining the embodied carbon in building elements – floors, wall, windows and roofs.

OTHER ONLINE RESOURCES

EPD Australasia – https://epd-australasia.com/.

Intergovernmental Panel on Climate Change – https://www.ipcc.ch/

Interim Climate Change Committee (a Ministerial advisory committee appointed by the Climate Change Minister) – https://www.iccc.mfe.govt.nz/

Ministry for the Environment – https://www.mfe.govt.nz/climate-change

New Zealand Green Building Council – https://www.nzgbc.org.nz/

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ISSN 1178-4725 (Print) 2537-7310 (Online)