Housing stock strategies responding to New Zealand's 2050 carbon target

Building and operating housing makes up around 10% of Aotearoa New Zealand's total carbon footprint. Improving the carbon performance of housing therefore provides a significant opportunity to contribute to the goal of net-zero carbon emissions by 2050. The research project described here identifies and quantifies potential areas for significant reduction in the carbon footprint of New Zealand's housing stock.

The research findings provide clear evidence that, to reduce carbon emissions from housing by a large amount, we need to go well beyond a business-as-usual approach. Two ambitious scenarios are considered – Emergency and Emergency Plus. Each results in a reduction in the carbon footprint of our housing stock between 2020 and 2050 that is more than twice the reduction achieved under a Business as Usual scenario.

Methodology

The carbon footprint of New Zealand residential buildings was calculated based on several residential reference buildings (detached houses, townhouses and apartment buildings) for which carbon footprint and modelled energy use data is available.

The carbon footprint covers the whole life cycle of a building (Figure 1), including the product stage (raw material supply, transport and manufacturing of building products), the construction stage, building operation (water and energy use, maintenance and replacement) and end of service life (deconstruction/demolition, recycling and waste disposal). The energy use impact associated with each reference dwelling was estimated for each of the six climate zones.

The research uses consumption-based carbon accounting, which estimates the carbon emissions associated with all goods and services consumed within a country, including those that arise outside of the country's borders such as the embodied emissions associated with the production and transport of imported goods. This takes into account the fact that a large proportion of New Zealand's building materials are imported.

The carbon footprint is expressed as annual and cumulative greenhouse gas emissions 2020–50. The methodology is described in detail in BRANZ Study Report SR478 *Housing stock strategies responding to New Zealand's 2050 carbon target*.

This building-level information is combined with BRANZ projected residential building activity 2020–50 to estimate the overall carbon footprint of the residential sector for three scenarios:

- Business as Usual
- Climate Emergency (Emergency)
- Climate Emergency Plus (Emergency Plus).

These scenarios are not predictions of future outcomes but are used to explore how combinations of possible strategies can contribute to carbon savings and estimate the speed and magnitude of those savings.

For the purposes of this study, 'existing' buildings are those built before 2020 while 'new' buildings are those built in or after 2020.

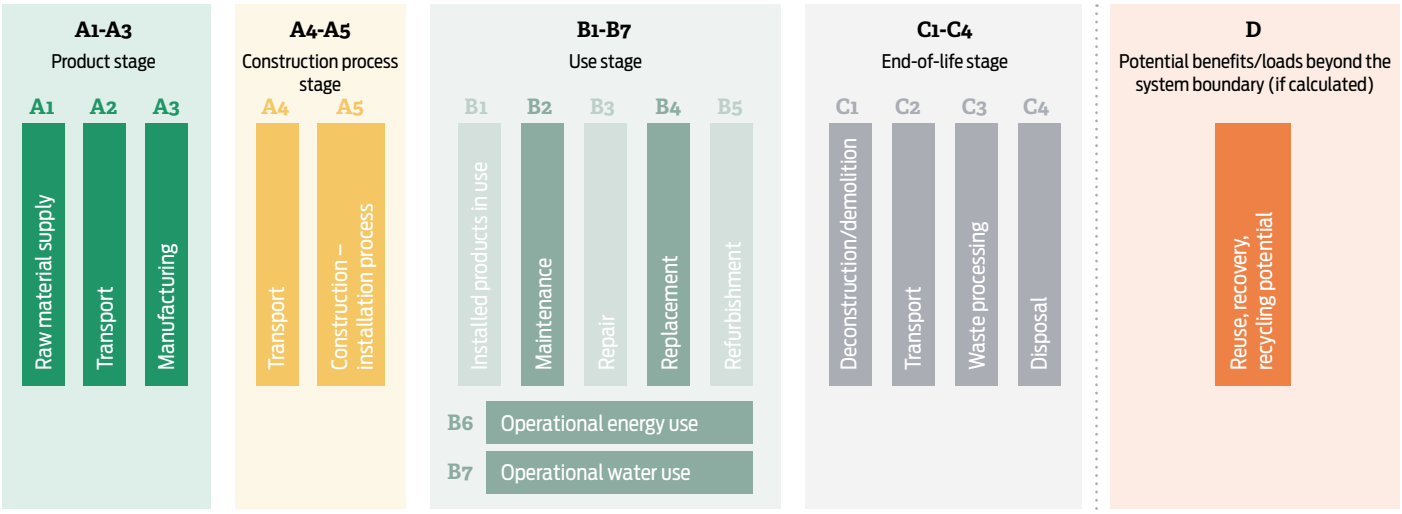

Figure 1. Building life cycle stages as defined in BS EN 15978 *Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.*

Business as Usual

This scenario reflects current projections incorporating observed market trends, current legislation and anticipated regulatory changes.

- Gas is phased out by 2030 in new housing and by 2050 in existing housing.
- In new housing, 80% of space heating is provided by heat pumps by 2050 and 60% in existing housing by 2050.
- There is a 20% reduction in water use in all housing by 2050.
- From 2030, 10% of water heating in new houses is provided by heat pumps. For existing housing, gas water heating is phased out by 2050 and 10% of electric water heaters are converted to heat pumps.

Emergency

This scenario explores a more ambitious and urgent response that is technically feasible and practical (for example, replacement of existing technology at end of life).

- The proportion of renewable generation supplying the New Zealand grid is assumed to be 95-98% by 2030 and 100% by 2050.
- New Zealand achieves increasingly challenging embodied carbon emissions thresholds for new housing compared to the Business as Usual scenario of >190 $kgCO_2eq/m^2$. It assumes 84 $kgCO_2eq/m^2$ by 2025-30, 60 $kgCO_2eq/m^2$ by 2031-35 and 40 $kgCO_2eq/m^2$ by 2036-2050.
- Gas is phased out by 2030 in new housing, by 2031 in existing apartments and by 2035 in existing stand-alone houses and townhouses.
- No gas water heaters in new housing from 2025 (all new water heating is by heat pumps). For existing housing, gas water heating is phased out by 2040.
- 32% reduction in water use by 2050 in both new and existing housing.

Emergency Plus

This scenario expands on the Emergency scenario by assuming smaller new homes with much higher performance.

- The thermal envelope area (and conditioned volume) of new homes reduces to 114 m².
- New dwellings must meet high-performance requirements from 2023 (with Beacon Pathway's Waitākere NOW Home a reference building).
- For existing homes, there is a 5% reduction in heating energy demand from thermal upgrades by 2030-40.
- In all housing, by 2030, 50% of space heating will be by heat pumps. By 2050, this rises to 95% for new housing and 70% for existing housing.

In new housing, from 2025, all water heating will be by heat pumps. In existing housing, 50% of water heating will be converted to heat pumps by 2040.

Results – Business as Usual

- The annual carbon footprint of residential dwellings overall falls by 28% between 2020 and 2050 (Figure 2).
- The biggest reduction occurs in operational energy use, largely due to anticipated

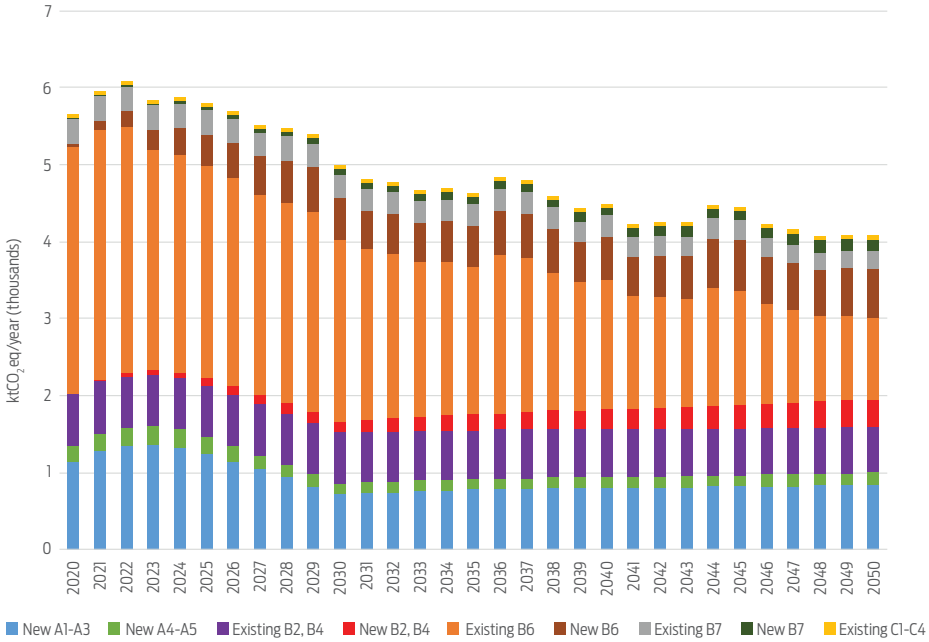

Figure 2. Business as Usual carbon footprint by year and life cycle module. (See Figure 1 for further details of modules such as A4, B2 etc.)

reductions in carbon emissions associated with electricity generation.
- Other operational energy use reductions come from improvements in the thermal envelope of new houses, the phase-out of gas, a transition to heat pump technology and improvements in heat pump efficiency.

Results – Emergency

- The annual carbon footprint for all residential dwellings falls by 71% between 2020 and 2050 (Figure 3).
- Compared to business as usual, the total annual carbon footprint in 2050 is 60% lower and there is a 40% reduction in operational emissions.
- Operational energy use of existing dwellings makes up 41% of the total carbon footprint of housing in 2050. This reflects the challenge of reducing operational energy in existing homes.
- There is a significant reduction in the carbon footprint in 2025 due to an approximately 60% reduction per dwelling in embodied emissions. Smaller reductions in embodied emissions also occur in 2031 and 2036.
- Accelerated decarbonisation of electricity generation results in a 68% reduction in greenhouse gas emissions per kWh of electricity in 2050 compared to 2020.

Results – Emergency Plus

- The annual carbon footprint for all residential dwellings decreases by 82% between 2020 and 2050 (Figure 4).
- The annual carbon footprint in 2050 is 37% lower than in the Emergency scenario and 75% lower than the Business as Usual scenario.
- Operational energy use of existing dwellings remains significant, but the contribution is reduced to 36% of the total carbon footprint in 2050.
- This scenario reflects an even more accelerated reduction in carbon emissions from electricity generation, with an 83% reduction in emissions per kWh of electricity in 2050 compared to 2020.

Detached houses, townhouses and apartments

A key feature of the results is the dominance of detached houses compared to townhouses and apartments (Table 1). This dominance is seen in all three scenarios and throughout the study period. In 2020, detached dwellings account for 82% of the carbon footprint in all scenarios. In 2050, the proportion of impacts due to detached dwellings varies between 78% (Business As Usual) and 81% (Emergency).

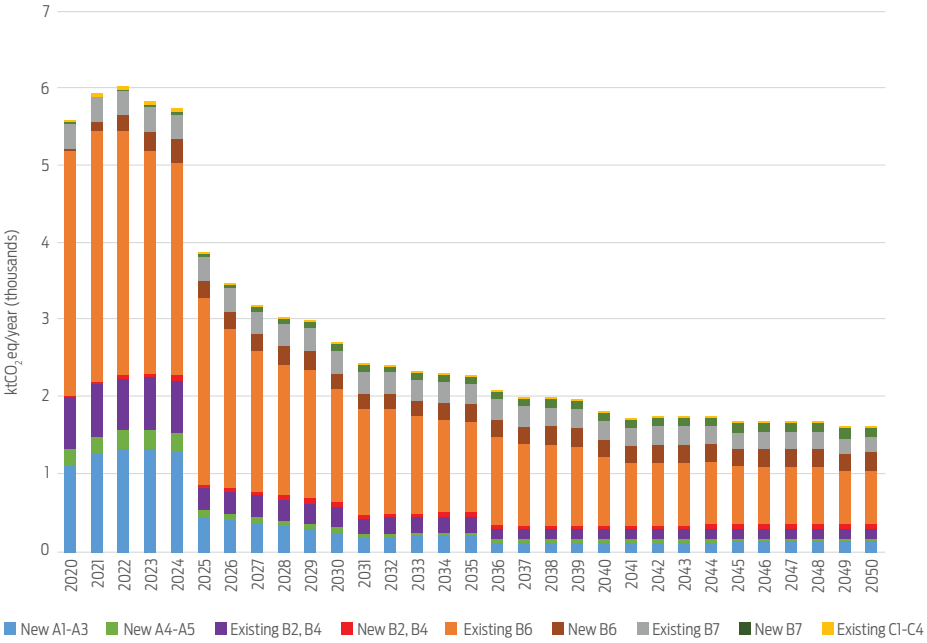

Figure 3. Emergency carbon footprint by year and life cycle module.

Existing versus new housing

This study defines new dwellings as those built in or after 2020. Their cumulative number increases over time. New dwellings account for 48% of the total annual carbon footprint in 2050 in the Business as Usual scenario, 39% in the Emergency scenario and 35% in the Emergency Plus scenario.

The differences between the three scenarios in 2050 reflect the different focus of improvement measures. A focus on reducing new house size in the Emergency Plus scenario results in a lower contribution from new dwellings compared to the Emergency scenario. Similarly, more improvements for new dwellings compared to existing houses in both the Emergency and Emergency Plus scenarios results in a lower carbon footprint contribution from new dwellings compared to the Business as Usual scenario.

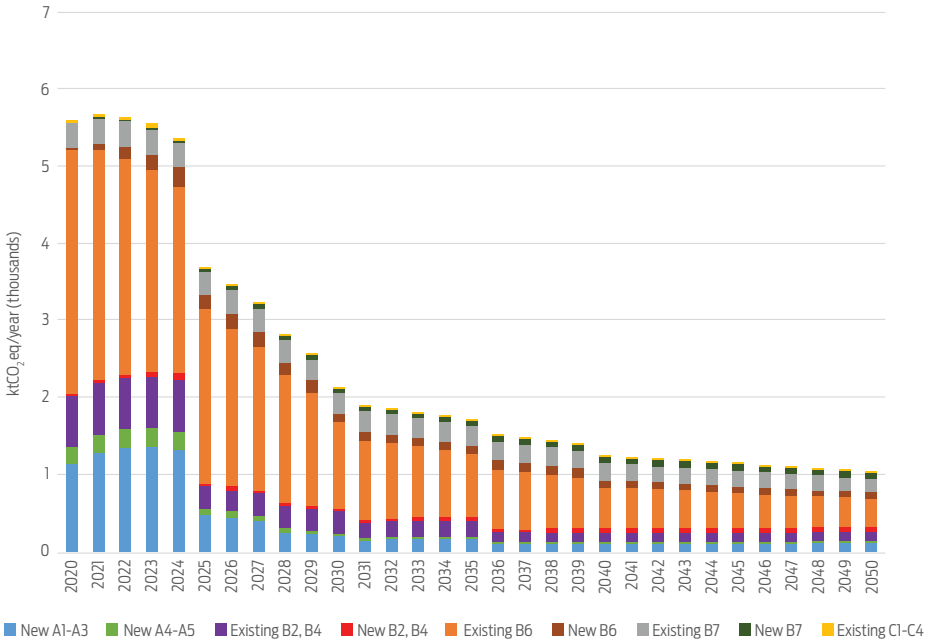

Figure 4. Emergency Plus carbon footprint by year and life cycle module.

Conclusions

We need to go beyond a business-as-usual approach to get the biggest reductions in carbon emissions. The Emergency and Emergency Plus scenarios each reduce the carbon footprint of our housing stock between 2020 and 2050 by more than twice the reduction achieved under the Business as Usual scenario.

However, the study suggests that, even with the most drastic of initiatives modelled, it is highly unlikely that we will meet a 2050 zero-carbon dwelling-related goal for the residential construction sector. This is true even with 100% renewables supplying the grid. This is a reflection of the scale of the challenge facing us. It doesn't detract from the critical role (and associated responsibility) the residential construction sector has in assisting New Zealand to meet its 2050 carbon targets. Given the pace and scope needed for significant change, commitment and action from the government, the construction industry and consumers are now crucial.

Specific findings and conclusions:

- Addressing operational energy use is key. Operational energy use is the largest contributor to the total cumulative 2020–50 carbon footprint in all scenarios, accounting for 52–56% of the total carbon footprint. Most of this is due to existing dwellings – accounting for 81–91% (Business as Usual) to 91% (Emergency Plus) of the impacts and reflecting the number of existing dwellings in existence. With efforts to reduce operational energy, the embodied carbon of retrofit strategies must be considered.
- Detached dwellings are important. They account for 84% of all dwellings over the 2020–50 study period and for 82% of the carbon footprint in all scenarios in 2020 and 78–81% in 2050.
- Decarbonising the generation of electricity is vital. An assumed reduction in the emissions from electricity generation in the Emergency and Emergency Plus scenarios accounts for 37–42% of the reduction in the carbon footprint of the housing stock between 2020 and 2050. (Under the Business as Usual scenario, the carbon footprint would increase rather than decrease if there was no reduction in the carbon emissions from electricity generation.)
- Gas must be phased out. If gas use remains unchanged at 2020 levels, the 2020–50 carbon footprint of the housing stock would increase by 3–13.5%.

Table 1. Summary of the carbon footprint of the New Zealand housing stock in 2020 and 2050 under the three scenarios.

Scenario	Typology	Carbon footprint in 2020 ($kgCO_2eq$)	Carbon footprint in 2050 ($kgCO_2eq$)	Reduction achieved between 2020 and 2050 ($kgCO_2eq$)
Business as Usual	Detached	4,616	3,199	31%
	Townhouses	688	565	18%
	Apartments	339	308	9%
	Total	**5,643**	**4,072**	**28%**
Emergency	Detached	4,587	1,327	71%
	Townhouses	685	217	68%
	Apartments	338	91	73%
	Total	**5,610**	**1,635**	**71%**
Emergency Plus	Detached	4,583	816	82%
	Townhouses	685	152	79%
	Apartments	338	66	80%
	Total	**5,606**	**1,033**	**82%**

- The embodied carbon footprint of new builds is an important contributor to the overall carbon footprint of the housing stock. As the impact of operational energy use is expected to decrease over time, the role of embodied impacts will become increasingly important. House size is a key consideration.
- The combined carbon footprint associated with water use, maintenance, replacement and end-of-life impacts is significant, accounting for 24–27% of the total carbon footprint between 2020 and 2050. The assumptions in the Emergency and Emergency Plus scenarios include reductions in these impacts. Without these assumed reductions, the total impacts would make a much more significant contribution – 37% of the total cumulative carbon footprint of the housing stock in the Emergency scenario.

Carbon-reduction measures that can be carried out immediately:

- Encourage/incentivise a switch to heat pumps for both space and water heating, ideally with very low or zero global warming potential (GWP) refrigerants.
- Implement requirements for limits on embodied carbon and design for low operational energy use in new builds as soon as possible.
- Restrict use of gas in new builds.
- Encourage/incentivise the construction of smaller, high-performance houses.
- Implement measures to minimise construction waste.
- Encourage/incentivise replacement of household appliances at end of life with the most efficient options.

Most important medium-term carbon reduction measures:

- Identify and implement the most cost-effective measures to reduce operational energy use in existing dwellings.
- Decarbonise electricity generation and production/supply of building materials – these are not directly influenced by building design or use but are important contributors to the carbon footprint of dwellings.
- Identify and test alternative low-carbon building materials.

More information

SR478 *Housing stock strategies responding to New Zealand's 2050 carbon target (2023)* www.branz.co.nz/pubs/research-reports/sr478-housing-stock-strategies-responding-to-new-zealands-2050-carbon-target