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Best practice urban form for emissions reduction. Carbon neutral neighbourhoods.

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Project LR14441

University of Canterbury, funded by the Building Research Levy

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ABSTRACT

This report summarises the carbon-neutral neighbourhoods project. It highlights the project outputs; both the online web-based dashboard and the associated reports produced. The project aimed to help identify ways to support well-functioning urban environments that would lead to reductions in greenhouse gas emissions. Further, the project sought to summarise the wealth of international evidence on the potential benefits of neighbourhood to city-scale planning, to reduce greenhouse gas emissions using case studies of successful implementation. The overarching aim was to better understand the potential avenues for meeting carbon reduction ambitions.

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EXECUTIVE SUMMARY

What if neighbourhoods were designed so that people could live sustainably with minimal effort? What can Aotearoa New Zealand learn from successful examples or case studies both here and worldwide? To increase understanding of the relationship between urban form (the density, size and configuration of a place) and emissions, this project developed tools to support urban designers and planners.

The Carbon Neutral Neighbourhoods project has been undertaken by an interdisciplinary team of Geographers, Geospatial experts and Engineers at Te Whare Wānanga o Waitaha | University of Canterbury. The research team first looked for relevant international examples of best practice, focusing on places where modifications to the built environment had resulted in changes to travel behaviour. Then, analysing and explaining the subsequent impacts on the populations in each of the case study areas, how this could apply to construction and development in a New Zealand context. Further, we designed and deployed a web-based tool and scenario planner to help better understand emissions profiles of neighbourhoods. This allows the user to develop bespoke scenarios based on interventions, or changes to transport, at the local level. The tool also allows better estimation of the potential impacts of urban development options, with emission reduction in mind. The tools, available through the carbon neutral neighbourhoods map platform, are freely accessible online. This means that anyone can explore real-world impacts of potential changes. The tools can be used by those thinking about development or building, or for policy and decision-making, by local or central government. We have also summarised more specific carbon reduction interventions in two working papers, outlining the consequences and trade-offs between urban form which sprawls outwards, or an urban area that is more concentrated and centralised by densification of existing suburbs.

INTRODUCTION

The project looked systematically at case studies from across the world and focused on various aspects of emission reduction best practice. After a brief overview of the location and background, we discussed the neighbourhood design characteristics and interventions, with a focus on the specific plans or policies enacted, then turning our attention to the impact of the policies and plans in these places. We concluded each case study with relevant thoughts and potential applications to the New Zealand context. Each case study was designed to give a summary of the relevant impacts and applications that could be most useful in our context.

A key challenge internationally, which also relates to New Zealand, is the challenge of emission reduction (see the figure 1). Approximately 74.5% of transport emissions globally come from road vehicles, with 45.1% from passenger transport by road. If we focus in on New Zealand, we can see from Figure 2, that agriculture dominates emissions, with transport as the second most important contributor to our emissions. Therefore, reducing emissions from transport, which are linked to urban form and structure, as well as transport mode choice, will be one critical way in which to reduce overall greenhouse gas or carbon emissions, which have been declining slowly for many years, as can be seen in Figure 3. Our project offers a way in which the building industry could explore how to play its part in the emission reductions for New Zealand around how we could travel to and from our homes.

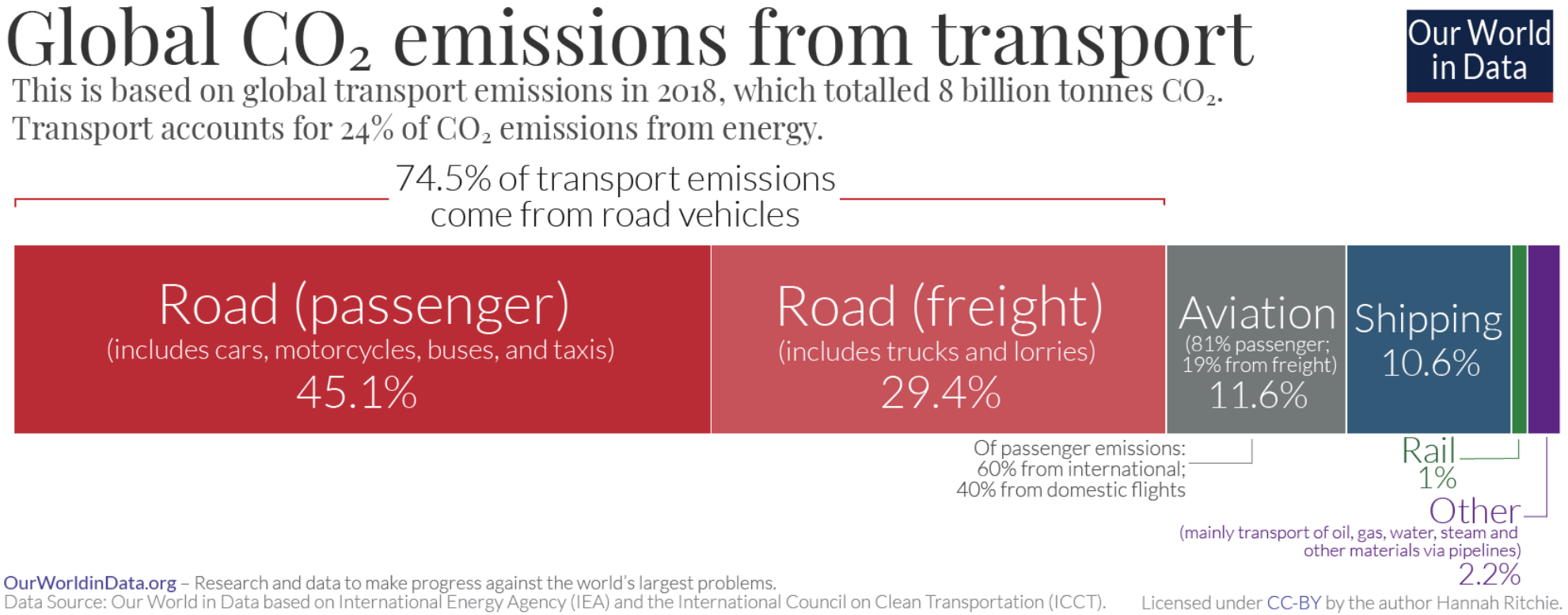


Figure: 1 Global CO^2 emissions from transport

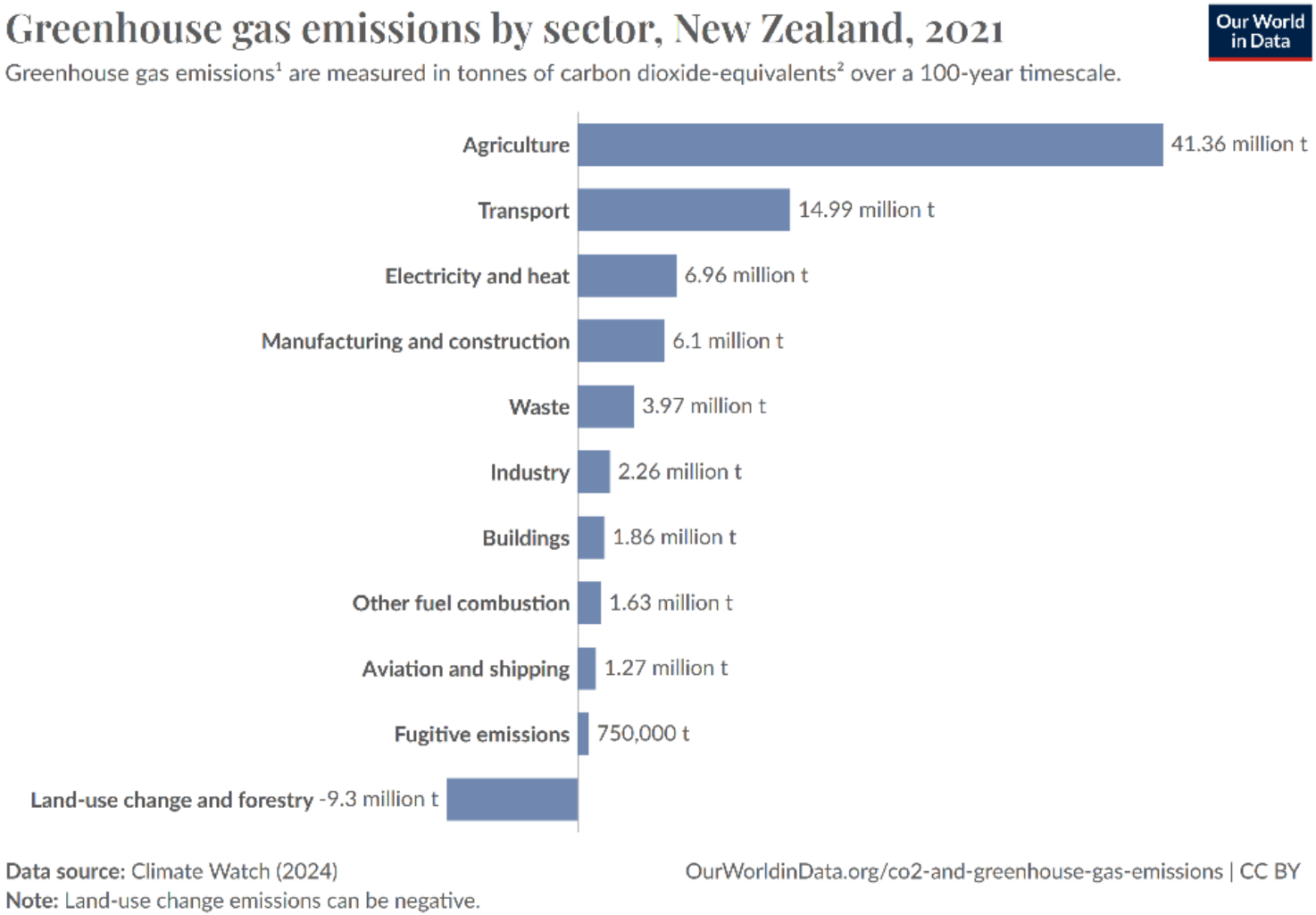


Figure 2: Green House Gases per sector, New Zealand

Per capita greenhouse gas emissions (tonnes per person)

Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources,including land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.

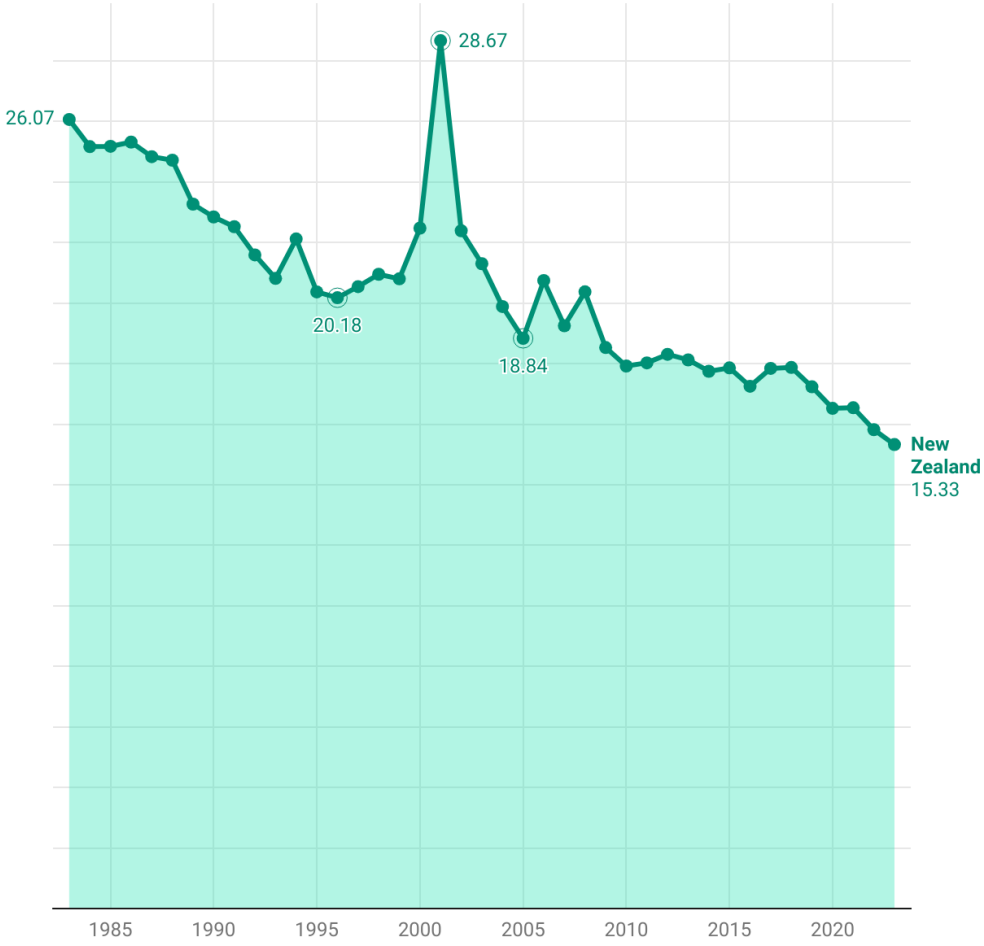


Chart: Prof. Malcolm Campbell • Source: Data sources: Jones et al. (2024)Population based on various sources (2024) – with major processing by Our World in Data • Created with Datawrapper

Figure 3: GHG per capita, 1983-2023, New Zealand

FINDINGS: KEY RESULTS

Our case studies on urban development practices in eight locations, six in Europe (Barcelona, Freiburg, Houten, Grenoble, Vitoria-Gasteiz, Helsinki) and two in North America (Ann Arbor and Vancouver), gave an overview of exemplars of greenhouse gas emission reduction. Moreover, the study areas differed in population, density, and socio-political context, yet we found several common threads that inform future development aimed at reducing emissions. Centrally, we found the encouragement of transport modes which aim to reduce emissions. This means that increased use of public transport (for example buses or trams) as well as more investment in active transport modes (walking and cycling) was a feature of our case studies. There were also strong connections observed between land-use and transport planning. This is where there is some divergence in responsibilities between land use and transport planning which can become a potential issue for policymakers, who may have responsibility for a specific aspect, or aspects, of urban development, often at differing spatial scales.

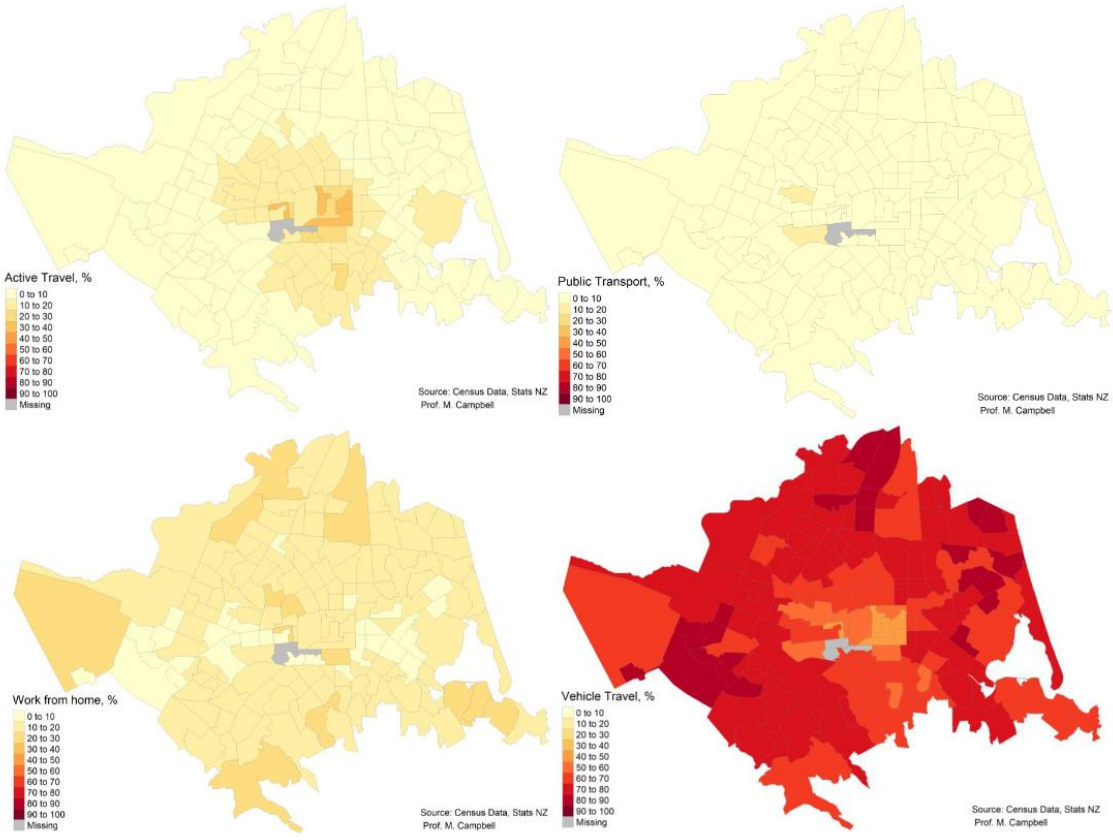
New Zealand can learn from the modification and increased use of transport systems to reduce emissions. Increased density of the built environment appears to facilitate a shift to lower carbon forms of transportation. Additionally, using a 'carrot' and a 'stick' approach to transport mode shift either by easing access to charging for Electric Vehicles (EVs) or by increasing parking zones and charges, can deliver positive outcomes. The idea that time spent travelling or commuting can be seen as an effective use of time, or even of value per se, may well be relevant to an New Zealand context. Altering the value given to the time spent travelling or commuting that can be productive, for example on public transport, could alter key parameters of the cost-benefit analysis related to different transport modes. We found that densification and mixed-use neighbourhoods, combined with a shift in transport mode was likely to be the most effective approach to reducing transport emissions in New Zealand.

The responsibility for reducing our greenhouse gas emissions in New Zealand's urban centres, lies with multiple stakeholders. This makes it potentially challenging and complicated to manage and identify where responsibility lies for each of the intersecting areas of interest. Some of the key stakeholders are: The Ministry for the Environment | Manatū Mō Te Taiao (MfE), the Ministry of Housing and Urban Development | Te Tūāpapa Kura Kāinga (MHUD), the Ministry of Transport | Te Manatū Waka (MoT), the New Zealand Transport Agency | Waka Kotahi (NZTA), and the Climate Change Commission | He Pou a Rangi at a central government level. At a regional, and/or local level, Territorial Local Authorities and Regional Councils, as well as developers, private planners and even individuals, have a role to play. We noted that ultimately, there is a complex web of different organisations who have some responsibility for how our towns and cities function and evolve. This means that sometimes optimum outcomes don't always occur, due to competing priorities and interests alongside political realities.

In our second set of working papers, we addressed a key question that was raised in respect of urban development, the potential to either densify existing urban areas, such as those close to the centre, or to open up new suburban developments around the edge of an urban area. We undertook modelling to quantify how the choice of location can impact on the emissions profile, not just of the specific area, but of the

wider urban area or region. In these working papers, a model of suburbs which fit the "up" vs "out"; the more central, dense development as opposed to the less dense peripheral development is parameterised in a scenario using travel data from the Census in 2018, and a revised version using the 2023 Census.

Our results from these penultimate working papers demonstrated that it is likely to be better to develop centrally, or closer to a greater concentration of amenity, or workplace destinations, on the assumption that employment is centred closer to the core of an urban area. Emission reduction is likely to be easier by combining fuel type shift as well as this form of development in particular locations. In tandem with fuel type shift, thinking about public transport - which could help to facilitate shifts from private vehicles to either public or active transport - is highly likely to further reduce emissions. The figure below (figure 4) shows the potential for mode shift as an emission reduction strategy, using the most recent census data from 2023 for the Christchurch Urban Area. Mode shift is the change from one mode of travel to another, for example, swapping between driving a car and taking a bus to get to and from work. To demonstrate the current state, the figure below visualises the majority of the modes of travel to work in the Christchurch example are by Vehicle (dark reds), while active or public transport modes are centrally concentrated (top left, figure 4).



Travel to work (usual residence). TopLeft: Active (walk, cycle); TopRight – Public Transport; Bottom Left – Work from home; Bottom Right - Vehicle

Figure 4: travel data, Census 2023, New Zealand

CONCLUSION: RECOMMENDATIONS

Our key recommendations from this project are outlined below. These are summaries of the most important conclusions from all of the outputs and working papers of the project, including the scenario modelling work that was undertaken during this project. If we think about the role of the building industry in creating change, there is a key role in thinking about how increased density, particularly close to regular or rapid transport, is an opportunity to create attractive transit-oriented development in larger urban areas of New Zealand. More recent comments from The Minister of Transport, Housing and Infrastructure, appear to signal the opportunity to maximise the attractiveness of medium or high density by selecting locations close to transport corridors[1], as well as recognising the wider economic and social issues associated with housing while grappling with the trade-offs of development closer to, or further from, the centre of Urban areas.

The key recommendations and conclusions focused on policy are:

1. **New Zealand should learn from the modification and increased use of public transport systems to reduce emissions as demonstrated in the international case studies.**

2. **Increased density of the urban form facilitates lower carbon forms of transportation.**

In other words, transportation and densification that result in mode shift are entangled and therefore work best in tandem. Developers could be encouraged to think about younger generations concern for the environment, which is greater than older generations, and how their transport choices are one central issue in choosing where to live. The wider context for recommendations 1 and 2 above are that, using a 'carrot' and a 'stick' approach to transport mode shift by easing access to charging for EVs, increasing parking charges and zones for example, is a likely way to change transport options and choices for individuals and lead to a lower emissions environment. Specific examples of recommendation 2 include the Superblock model, an example of how to retrofit existing urban development, or, in Vancouver, where mixed-development residential neighbourhoods and infill clusters of higher-density areas around transport and employment created fewer emissions. We also found that the use of rapid transport as a public transport option is something that could be given (re)consideration in many more of New Zealands larger urban areas. Moreover, reallocating road space in favour of pedestrians, mass rapid transport and/or buses

[1] https://www.beehive.govt.nz/speech/speech-committee-auckland-0

could be seen as an opportunity to improve the efficiency of the transport network and also would lead to emissions reduction. This reduction in emissions from policy changes such as charges or reallocation of space, would also promote sustainability and improve population health. However, there are political realities to consider in making these trade-offs, which can be contentious.

3. Travel time can be seen as an productive and valuable use of time, in some cases.

In thinking about how to alter key parameters of the cost-benefit analysis related to different transport modes, there is a view that travel time, in any mode, is wasted time. However, being able to work, or to relax, on public transport for example, could be **considered productivity-enhancing** or indeed valuable in its own right, in comparison to modes of transport that do not allow this to occur, e.g. driving. Similarly getting exercise through active transport can also been beneficial. This could be seen as a way to market developments which allow for choice in commute to maximise individual leisure or productivity when travelling and has been shown to add a **premium to property values**[2].

4. Active transport is a key enabler of rapid emission reduction and should be encouraged where possible

Crucially, densification and mixed-use neighbourhoods **combined with a shift in transport mode** are likely to be the **most efficient and effective way to go about reducing emissions in our towns, cities and regions** around New Zealand. Evidence also further refines these recommendations, to make clear that specific types of interventions or changes are likely to result in the most dramatic reductions in transport related emissions. Shifting fuel type, for example from a petrol to an electric car, will deliver emission reduction, but the reductions resulting from active travel can be more than 30 times lower for each trip than driving a fossil fuel car, and about 10 times lower when compared to driving an electric car. In addition, shifting to active modes also delivers additional co-benefits such as enhanced physical activity and improved mental wellbeing. This is one way in which marketing a buildings proximity to active transport infrastructure could be attractive, especially to climate conscious consumers.

In summary, **mode shift is likely to be a much more rapid and important source of emission reduction for the places we live, work and play**. Mode shift would likely result in more disposable income for those who choose active transport and likely improve the efficiency of the transport network through reduced congestion. Active travel modes will also bring many health and environmental benefits, both for individuals who choose to move to active travel modes, and also for New Zealand as a whole, with a healthier, more active population.

[2] https://doi.org/10.1016/j.tra.2024.103979

In conclusion, whilst shifting fuel choices away from fossil fuels is valuable to reducing emissions, future research could further examine the motivations for transport mode shift, especially to those modes with the lowest emissions - such as active or public transport - to create carbon-neutral neighbourhoods in New Zealand. Also, it would be interesting to more fully examine the extent to which the choice of where to live in our towns and cities can be driven by climate considerations specifically. As consumers and home buyers are increasingly climate conscious, being able to quantify or highlight the possibility of alternative transport choices is likely to help attract a premium for new buildings and developments.

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Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/co2-and-greenhouse-gas-emissions' [Online Resource]

WORKING PAPERS

The key outputs created and disseminated during this project on carbon-neutral neighbourhoods are shared on a website (see the link below), which is the portal to all the project outputs. This website includes links to the four substantive working papers, and instructions on how to use the web tool, which is hosted on the website with our partners in the Geospatial Research Institute (GRI). The tool itself currently has two key views: one is the emissions scenario visualisation; the other is the trends in travel mode. There are tabs on several locations around New Zealand; Auckland, Hamilton, Wellington, Christchurch, Oamaru and Queenstown, which visualise the patterns for both emissions and commuting data.

The four working papers were titled; *International case studies report for in greenhouse gas emissions reductions: A selected portfolio of international examples of greenhouse gas emission reduction exemplars,* and *Lessons learned on how to design Aotearoa New* Zealand's urban centres to better enable low(er) carbon living which focused on summarising the international evidence and case studies. Followed by two working papers on the choice between *densification and sprawl* or *"Up" vs "Out". Carbon emission scenario planning in Aotearoa New Zealand's urban centres,* with the latter working paper an updated version with new data Scenarios for carbon-neutral neighbourhoods in Aotearoa New Zealand's urban centres.

You can find more details of the project at https://carbon-neutral.app.geospatial.ac.nz/about

(distributed online through SSRN, peer reviewed)

Campbell M, Conrow L, Logan T, Kingham S International Case Studies Report for in Greenhouse Gas Emissions Reductions: A Selected Portfolio of International Examples of Greenhouse Gas Emission Reduction Exemplars. (October 31, 2022). Available at SSRN: https://ssrn.com/abstract=4410167 or https://dx.doi.org/10.2139/ssrn.4410167.

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