Micromobility's contribution to decarbonization

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Matt Ensor

Bachelor of Engineering (Hons), Auckland University, 1990

Certificate in Arts (Social Sciences), Massey University, 1998

PGDipBusAdmin, Massey University, 2003

INSEAD AMP, 2012

Business Director - Advisory, Beca Ltd

matthew.ensor@beca.com @matthewensor

ABSTRACT

This paper has calculated the impact on decarbonisation from the forecast mode shift to micromobility. It demonstrates the impact that policy and infrastructure interventions could make to New Zealand's transport carbon footprint.

Waka Kotahi's research report 674 *Mode shift to micromobility* forecasts the mode shift to micromobility to be between 3% and 11% of urban trips by 2030, dependent on a number of factors including the amount of safe infrastructure (cycle lanes and shared paths) that is provided. It also forecasts a mode shift from car trips to public transport trips for urban areas of between 0.4% and 1.3% due to the increased use of micromobility for the first/last mile of trips.

A mode shift to micromobility would incur carbon emissions through the manufacturing of micromobility and additional public transport vehicles, while reducing the operating emissions of light internal combustion vehicles.

By 2030, micromobility has the potential to reduce the carbon footprint of transport by between 0.52% and 2.60%. To capture this difference of 2.08% (between the lowest and highest mode shift scenario) will require a mandate for increased investment in enabling the mode shift to micromobility. Changes in land use which reduce the proportion of longer trips will both reduce emissions from less veh-km of travel and increase the attractiveness of mode shift to micromobility.

The investment and land use changes are aligned with the recommendations of the NZ Climate Commission's 2021 draft report.

This research provides a methodology for the calculation of global reductions in emissions due to mode shift to micromobility, filling a significant gap in the global evidence base.

INTRODUCTION

The introduction of small, electric-powered transport devices such as e-scooters and e-bikes has gained momentum in recent years, to the point where transport practitioners, urban designers, and design professionals are interested in how significant the future impact of micromobility could be on the ways people choose to travel.

He Pou a Rangi – the Climate Change Commission's draft advice recognises the potential of active modes to contribute to reducing transport emissions.

RESEARCH OBJECTIVE

International literature search shows that there is a gap in knowledge on the potential impact of growth in micromobility use on global transport emissions.

The objective of the research outlined in this paper is to fill this current gap in knowledge by identifying the potential contribution of micromobility to decarbonisation in the New Zealand transport sector. This will provide a framework to extend the research to other national transport sectors and fill the gap in global knowledge.

MICROMOBILITY

The term 'micromobility' is an umbrella term for transportation using small, electrically powered transport devices, including e-scooters, e-bikes, and mobility chairs. In March 2021, Waka Kotahi regulates micromobility to a maximum power output of 300W (Waka Kotahi NZ Transport Agency, 2021)

E-scooters and e-bikes dominate the micromobility mode in New Zealand and this research paper is focussed on the impact of these two types of micromobility.

The term active transport used by the NZ Climate Change Commission (2021) refers to the general activities of "walking and cycling". Micromobility is a subset of active travel, excluding non-powered cycling and walking.

LITERATURE REVIEW

The purpose of the literature review was to identify the relevant results from the Waka Kotahi research report 674 Mode Shift to Micromobility, identify the means of calculating the different carbon intensities of transport modes adjusted for New Zealand's mix of sustainable generation, and then identify the potential relevance to the advice of He Pou a Rangi – the Climate Change Commission (draft advice as of March 2021).

Waka Kotahi research report 674 – Mode shift to micromobility

The objective of this research (Ensor, Maxwell and Bruce, 2021) was to forecast mode shift from private cars to micromobility for short trips and the initiatives that can be taken to encourage or remove barriers to this mode-change. Similarly, the research examined the potential for micromobility to enhance the use of public transport through providing quicker and more convenient 'first/last mile' connections on micromobility.

Distance of travel for trips that mode shift to micromobility.

In section 5.3.3 of RR 674 (Ensor et al., 2021) the distribution of trip lengths is illustrated on Figures 5.12 to 5.15. These show a combination of scenarios around uptake of micromobility and the maximum trip distance that people would use a micromobility device for. They show how the attractiveness of a mode shift to micromobility is related to trip length. Figures for e-scooters and e-bikes are reproduced below as Figure 1 and Figure 2.

The numerical data used in the two Figures 1 and 2 has been re-calculated to provide the results in Table 1. In RR 674, mode shift is forecast for specific brackets (range) of trip lengths which has a corresponding median trip length. To calculate the average trip distance for the mode shift to each micromobility mode, that scenario’s mode shift forecast (%) for each trip length bracket is turned into the number of trips and then multiplied by the median trip length. The product of number of trips and trip lengths are summed to give the total veh-km for that mode and scenario. This is shown in Equation 1.

Equation 1:

$$\textit{Average trip distance (micromobility)} = \sum_{i \text{ to } n} (\textit{mode shift to micromobility } \%_{i} * \textit{number of veh trips}_{i} * \textit{median trip distance}_{i}) / \textit{number of mode shift micromobility trips}$$

The percentage change in veh-car distance is calculated by dividing the total mode shift to micromobility veh-km calculated in Equation 1 by the total car veh-km of travel. This is shown in Equation 2.

Equation 2:

$$\textit{Percentage change in veh-km (car)} = \textit{veh-km (micromobility) from mode shift} / \textit{veh-km (car)}$$

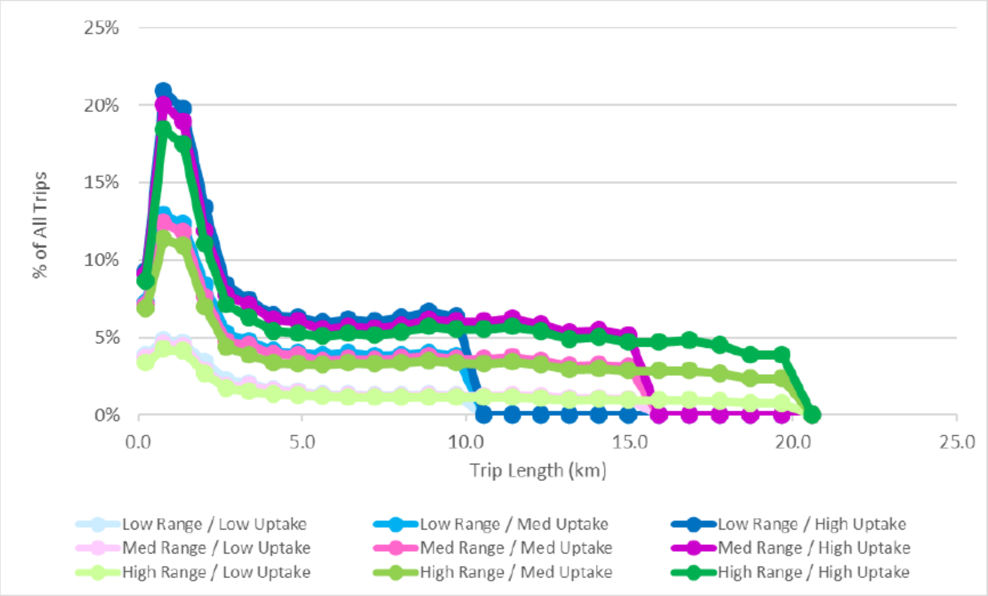

Figure 1 – Mode Share for e-bikes under various scenarios, by trip length (source: Ensor, Maxwell and Bruce, 2021)

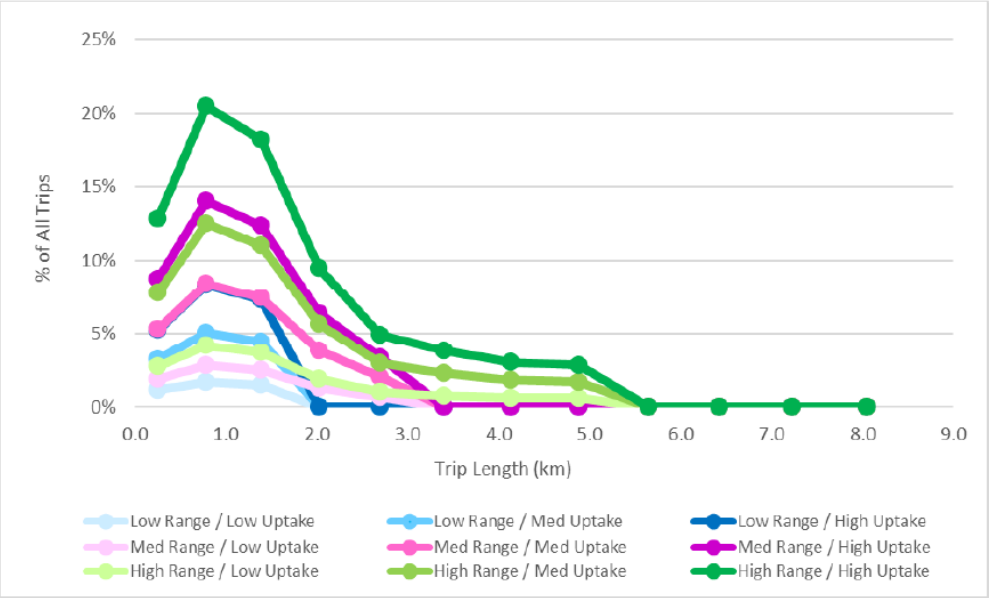

Figure 2 – Mode Share for e-scooters under various scenarios, by trip length (source: Ensor, Maxwell and Bruce, 2021)

Micromobility Mode	Scenario	Average Trip Distance (km)	% of car veh-km
E-Scooters	Low Range Low Uptake	1.04	0.02%
	Med Range Med Uptake	1.48	0.24%
	High Range High Uptake	1.93	0.94%
E-Bikes	Low Range Low Uptake	3.20	0.65%
	Med Range Med Uptake	4.02	2.16%
	High Range High Uptake	4.55	3.69%

Table 1 – Average Trip Distance for Micromobility Modes and Scenarios

Mode shift from car trips to public transport trips due to micromobility first / last mile

Ensor, Maxwell and Bruce (2021) forecast the range of mode shift for different scenarios of land use and micromobility availability. This is shown in Table 2.

Access to micromobility scenarios	Major city suburbs/ regional city fringe (high levels of PT)
Limited access to micromobility (low to moderate availability of shared devices, low rate of device ownership)	Car usage down 0.4%
Moderate access to micromobility (high availability of shared devices, low to moderate rate of device ownership)	Car usage down 1.0%
Easy access to micromobility (high availability of shared devices, high rates of device ownership)	Car usage down 1.3%

Table 2 – Scenarios for Mode Shift to Public Transport from first/last mile micromobility

The majority of public transport passenger veh-km will occur in the 'Major city suburbs / regional city fringe' category and the mode shift from car (0.4%, 1.0%, 1.3%) in this category is used to calculate the decarbonization impact of first/last mile of PT trips on micromobility.

Model for the calculation of transport carbon by mode

The International Transport Federation (ITF, 2020) published research in September 2020 which examines the climate impact of personal and shared electric kick-scooters, bicycles, e-bikes, electric mopeds, as well as car-based ride-sharing services. This study analyses the life-cycle performance of a range of new vehicles and services based on their technical characteristics, operation and infrastructure requirements.

The fuel component for electrically powered devices and vehicles is based on a carbon intensity of the electricity generation of 563 g CO_2e/kWh (156 g CO_2e /MJ).[1]

New Zealand has the third highest rate of renewable energy as a portion of primary supply in the OECD (after Norway and Iceland). 41% of our primary energy comes from renewable sources (MBIE, 2019) and 80% of our electricity generation comes from renewable sources (MBIE, 2019)

The carbon intensity in New Zealand of electricity generation and distribution was 110 g CO_2e /kWh for the 2018 New Zealand generation mix (MBIE, 2020). It is expected that this will continue to fall.

He Pou a Rangi – the Climate Change Commission

In February 2021, He Pou a Rangi – the Climate Change Commission released draft advice outlining recommendations for reducing emissions in Aotearoa and suggests the direction of policy that Aotearoa could take to get there (Climate Change Commission, 2021).

Chapter 4b includes coverage of reducing emissions for the Transport sector. It notes Transport has been the most rapidly increasing source of emissions. Out of the 35.1 megatonnes (Mt) of gross carbon dioxide (CO_2e) emissions Aotearoa produced in 2018, approximately 16 Mt (45%) were from transport. Road transport is the main source of emissions from transport. Cars, utes, vans and SUVs

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[1] Carbon dioxide equivalent or "**CO_2e**" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, **CO_2e** signifies the amount of CO_2 which would have the equivalent global warming impact.

are the predominant cause of these emissions, though emissions from trucks have doubled in the last 20 years. In 2018, light passenger vehicles accounted for about 53% of emissions from road transport (8.5 Mt) which is 24.3% of total emissions.

In Table 4b.2: Opportunities and challenges for reducing transport emissions, the Climate Commission discuss how shifting to active and shared travel types has the potential to reduce carbon dioxide emissions from transport, particularly in urban areas.

CALCULATION OF TRANSPORT SYSTEM CARBON

The literature review showed that the CO_2e produced by electricity generation is substantially less than for global comparisons. The ITF assumption of 563 g CO_2e /kWh has been replaced by 110 g CO_2e /kWh, reflecting New Zealand's relatively 'green' electricity, and this has produced the results shown in Table 3 and Figure 3 below.

The ITF model calculates a component from the construction of infrastructure. This has not been included in the analysis of the decarbonization shown in Table 4, as it is assumed that the overall percentages of transport network infrastructure will not change significantly within 10 years.

Device / Vehicle	Vehicle (g CO2e / p km)	Fuel (g CO_2e / p km)	Infrastructure (g CO_2e / p km)	Operational (g CO_2e / p km)	Total (g CO_2e / p km)
Private e-scooter	26	1	9	0	37
Shared e-scooter	66	1	9	25	101
Private e-bike	13	2	9	0	24
Shared e-bike	37	2	10	25	74
Private car - ICE	24	126	12	0	162
Bus - ICE	8	72	4	8	91
Metro/urban train	2	10	11	0	23

Table 3 – g CO2e / passenger kilometer travelled

The Climate Change Commission (2021) suggests that the CO_2e emissions from active modes are close to zero, this is only referring to the operational energy used in Table 3.

The table also reinforces that public transport typically has significantly lower carbon dioxide emissions per passenger km compared with single occupancy vehicles.

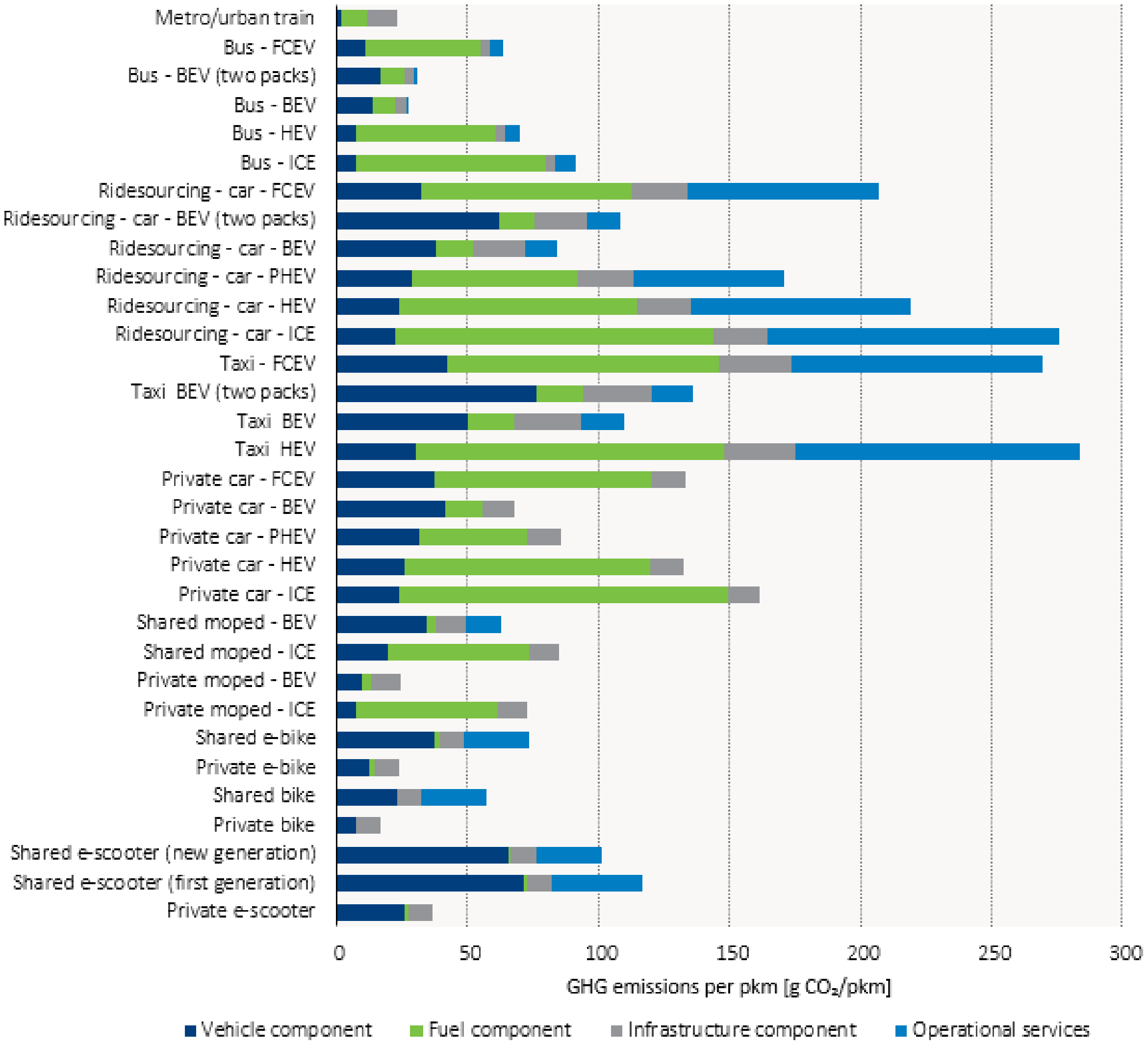

Figure 3 – Carbon Emissions per passenger km by transport mode (using NZ electricity generation)

The cost difference per km of using shared micromobility (where the costs of charging, relocating and damage is passed on to users via the operators' charges) and personally owned (which are mostly the purchase cost), strongly suggests that the majority of veh-kms of travel for micromobility will be on privately owned devices. Based on the assumption of 90% of micromobility trip distance will occur on privately owned devices, then the carbon emissions per passenger km is 34 g CO_2e /p km, and for an e-bike 20 g CO_2e /p km.

For private cars we've assumed 95% of veh-kms are through owned vehicles, and 5% of veh-kms are in a taxi or equivalent. This gives a carbon emissions per passenger km of 150 g CO_2e /p km.

This provides the following information in Table 4:

Device / Vehicle	Total for Mode (g CO_2e / p km)
E-scooter	34
E-bike	20
Car - ICE	150
Bus - ICE	88
Metro/urban train	12

Table 4 – Carbon Intensity of transport modes per passenger km.

For the purposes of calculating the carbon emissions from a mode shift to public transport, information on the mode shift split between bus, ferry and train is not available. Based on the information for the year to July 2019 on Auckland's public transport use (Auckland Transport, 2019; Auckland Council, 2019), the average figure for CO_2e per passenger km for the increase in PT usage has assumed a 75% mode shift by veh-km to Buses, 25% mode shift by veh-km to trains, giving an average figure of 69 g CO_2e /p km for Public Transport.

This information is used as the basis of examining the difference in CO_2e emissions due to a mode shift to micromobility.

CARBON REDUCTIONS DUE TO MODE SHIFT TO MICROMOBILITY

The calculation of carbon emissions will be based on the reduction in emissions from car travel due to a mode shift to micromobility and public transport.

Part of the assumptions in the RR 674 research paper (Ensor, Maxwell and Bruce, 2021) is the apportioning of the modes that shift to micromobility. Table 5.6 of that report details the mode shift assumptions from the car, with 40% of e-Scooter trips mode shifting from a car trip, and 50% of e-bike trips shifting from a car trip.

In RR 674 (Ensor et al., 2021), trips were considered a market available to mode shift to micromobility, and for each band of trip lengths there was a calculated mode shift value.

Using this information and the following equations, Table 5 illustrates how the range of forecasts made in RR 674 translate into reductions of veh-km for car trips, which is then converted into a percentage reduction in carbon emissions for all car trips occurring. Equation 4 illustrates the calculation for mode shift to public transport due to micromobility.

Equation 4:

$$\text{Change in total urban veh-km (car) (\%)} = \text{mode shift to public transport (veh-km)} / \text{total veh-km (car)}$$

The public transport calculation assumes that the distance travelled is unchanged but will occur at the carbon intensity of public transport as compared to that of a car. This is shown in Equation 5.

Equation 5:

$$\text{Reduction in g } CO_2e \text{ (\%)} = \text{mode shift from car (\%)} * (\text{g } CO_2e / \text{p km (car)} - \text{g } CO_2e / \text{p km (public transport)})$$

Device	g CO_2e per km	% of total urban veh-km (Car)	% mode shift from car	Reduction in CO_2e
E-Scooter (low)	34 (77% saving)	0.02%	40%	0.01%
E-Scooter (med)		0.24%		0.07%
E-Scooter (high)		0.94%		0.29%
E-Bike (low)	20 (87% saving)	0.65%	50%	0.29%
E-Bike (med)		2.16%		0.94%
E-Bike (high)		3.69%		1.61%
Public Transport (low)	69 (54% saving)	0.4%	100%*	0.22%
Public Transport (med)		1.0%		0.54%
Public Transport (high)		1.3%		0.70%
Total (low)				0.52%
Total (med)				1.55%
Total (high)				2.60%

Table 5: Reductions in CO_2e emissions for a range of scenarios.

* This is already the reduction in car veh-km as the distance travelled by new public transport trips is assumed to be the same as the car trip it replaces.

The combined impact of micromobility on transport could be a saving of between 0.5% and 2.6% in carbon emissions from urban light vehicle transport.

CONCLUSIONS & RECOMMENDATIONS

This research has examined the potential annual reduction of the carbon emissions for the transport sector due to a forecast mode shift to micromobility.

Given the range of assumptions in mode shift for 2030, the drop in emissions is estimated to be between 0.5% and 2.6%.

The associated investment to increase this from the lower bound to the upper bound is predominantly safe cycling infrastructure (separated cycle lanes and shared paths).

On the basis of the contribution of micromobility to decarbonisation, a suitable mandate is required to increase spending on active mode infrastructure.

The forecast reduction in emissions due to micromobility is related to the proportion of total trips that are within the range of micromobility. Changes in land use which reduce the proportion of longer trips will both reduce emissions from less veh-km of travel and increase the attractiveness of mode shift to micromobility.

The investment and land use changes are aligned with the recommendations of the NZ Climate Commission's 2021 draft report.

This research provides a methodology for the calculation of global reductions in emissions due to mode shift to micromobility, filling a significant gap in the global evidence base.

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ABBREVIATIONS AND ACRONYMS

BEV	Battery Electric Vehicle
CO_2e	Carbon Dioxide equivalent
FCEV	Fuel Cell Electric Vehicle
g CO2e / p km	Grams of Carbon Dioxide equivalent per passenger kilometre
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
Micromobility	Small electrically powered transport devices such as e-bikes and e-scooters
PT	Public Transport
Veh-km	Vehicle kilometres travelled

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AUTHOR CONTRIBUTION STATEMENT

The research in this paper is original research of the Author.

DECLARATION OF COMPETING INTERESTS

The author declares no competing financial interests.