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MINISTRY OF TRANSPORT

Domestic Transport Costs and Charges

Information session – Social, Health and Environmental costs

25 August 2022

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Results included in this file may be subject to revision as the project team finalises the estimates for the DTCC Final Report.

Air quality and greenhouse gas emissions

Gerda Kuschel - Emission Impossible

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Terminology

Air quality (harmful) emissions

Carbon monoxide (CO)

Volatile organic compounds (VOCs)

Oxides of nitrogen (**NO_x**)

Sulphur dioxide (SO_2)

Particulate matter <10µm (**PM_{10}**)

Impact **locally** so exposure (location) matters

Greenhouse gas emissions

Carbon dioxide (CO_2)

Methane (CH_4)

Nitrous oxide (N_2O)*

Impact **globally** and usually converted to **CO_2e**

* Not to be confused with nitrogen dioxide (NO_2) which is a harmful gas included in NO_x

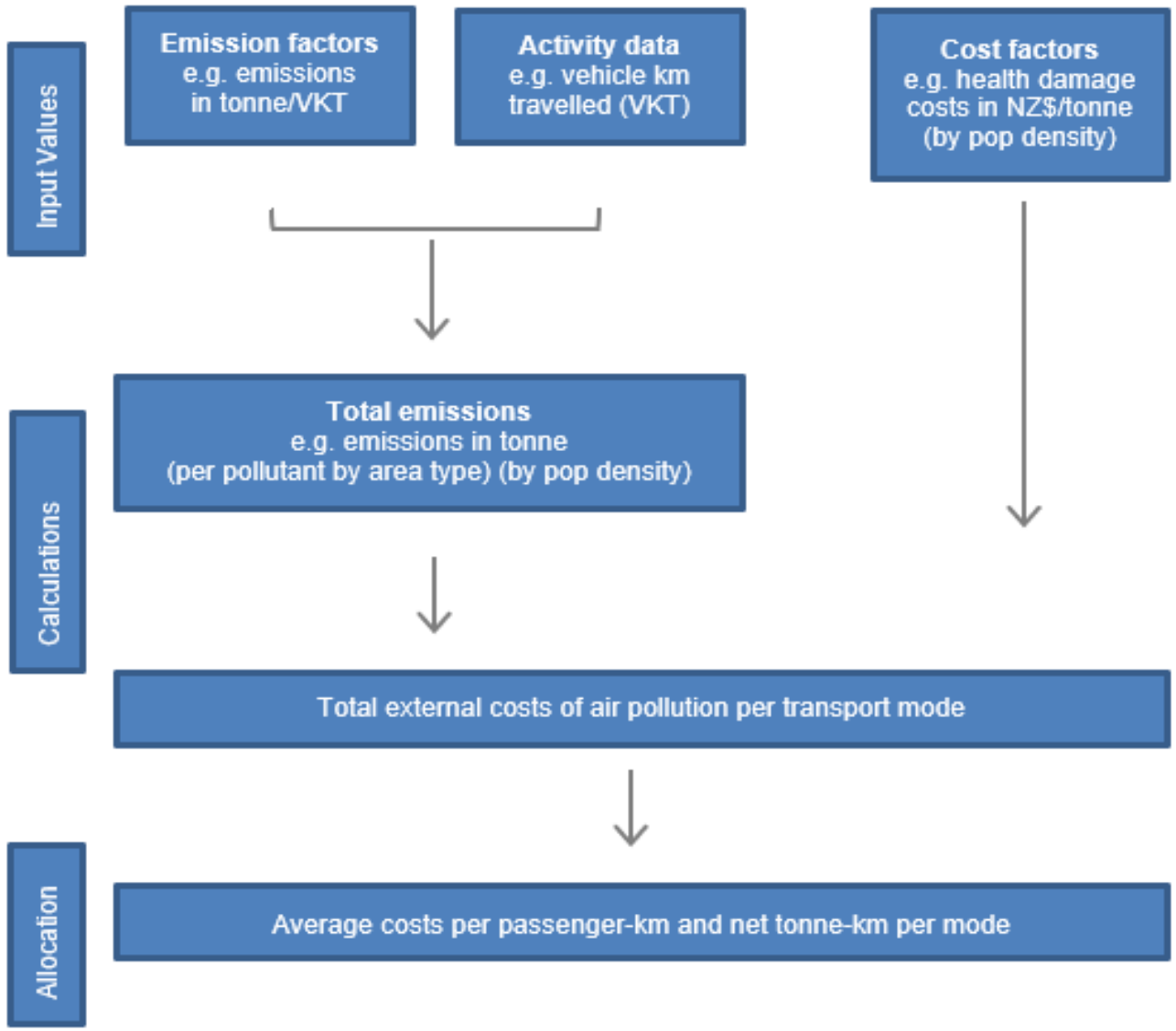
Assessing impact of transport-related air emissions

Approach adopted for estimating emissions can be:

- Top-down (e.g. using national data)
- Bottom up (e.g. using local data)

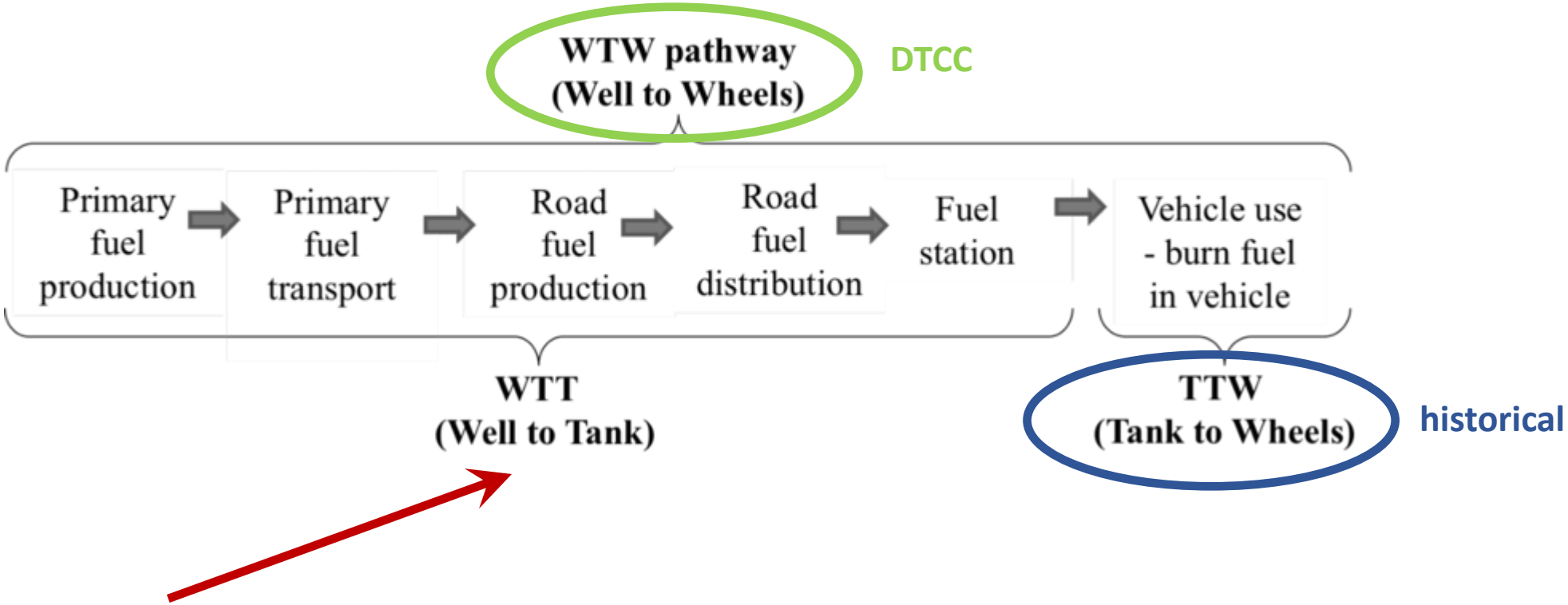
Approach actually taken depends on data availability for each mode

Figure 2. 1 Generic methodology for calculating total and average costs of air pollution (Essen et al 2019)



Note: A similar methodology is used for GHG emissions

Assessing upstream emissions



Life cycle GHG emission factors available for NZ transport fuels and energy (e.g. electricity)
(Barber & Stenning 2019 and MfE 2019)

Damage costs

Urban areas typically have estimated resident populations > 1,000 people and population densities > 400 residents or 200 address points per square kilometre.

Table 2. 1 Damage costs for use in project evaluations in $/tonne in the MBCM

Pollutant	Costs in NZ$/tonne	Value base date (at end June)
PM_{10}	$460,012	2016
NO_x	$16,347	2016
VOC	$1,310	2016
CO_2e	$65.58	2016
CO	$4.13	2016

Table 2. 2 Revised damage costs used in the DTCC study in $/tonne in June 2019 prices

Pollutant	Costs in NZ$/tonne Urban	Costs in NZ$/tonne Rural	Value base date (at end June)
PM_{10}	$503,346	$38,480	2019
SO_2	$36,491	$2,790	2019
NO_x	$17,887	$1,367	2019
VOC	$1,433	$110	2019
CO_2e	$88	$88	2019
CO	$4.52	$0.35	2019

Note: All costs are based on a road safety VoSL of $4.530 million (NZ$) at end June 2019 by multiplying the 2016 damage costs (Table 2.1) by 1.094 (=4.530/4.140) to derive these 2019 urban values.

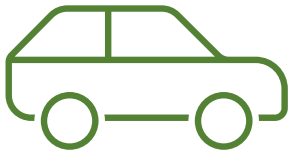
DTCC costs currently based on earlier HAPINZ

- Updated for 2019
- Split by urban and rural (different exposure)
- Added in SO_2
- Revised CO_2e based on Treasury CBAx

Latest HAPINZ has much higher damage costs for NO_X but yet to be incorporated

Road transport

- Fleet profile from VFEM (as %VKT)
- Emission factors from VEPM6.1 (speed-based)
- VKT data by local roads vs SH, heavy vs light, sealed vs unsealed
- Typical EV energy consumptions
- Occupancy by NZ Household Travel Survey
- Freight from MoT plus WiM sites



All road transport, including freight and long-distance passenger buses

Excluding urban PT and school buses

Bottom up approach

E = EF x VKT Equation 3.1

Where:

E = emission of a pollutant (g/yr)

EF = emission factor (**EF**) of the pollutant by speed for vehicle type (g/km)

VKT = total vehicle kilometres travelled (**VKT**) by vehicle type on the network (km/yr).

Emissions were estimated bottom-up, using speed and VKT data for regions across New Zealand as well as urban/rural splits. Estimates were then aggregated to provide national emissions.

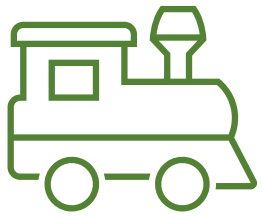
Rail transport

- Fleet profile based on fuel type only
- Emission factors from Tier 1 EMEP/EEA (fuel-based)
- Freight locomotive energy use, NTK from KiwiRail
- Long-distance passenger rail data from KiwiRail

All rail transport, including freight and long-distance passenger services

Excluding urban PT rail

Top-down using fuel/energy consumption



$$E = EF \times FC \qquad \text{Equation 4.1}$$

Where:

E = emission of a pollutant (g/yr)

EF = emission factor (EF) of the pollutant by fuel type (kg/tonne fuel)

FC = total fuel consumption by that vehicle type on the network (t/yr).

Emissions were estimated top-down, using fuel consumption data for New Zealand and split for urban/rural accordingly.

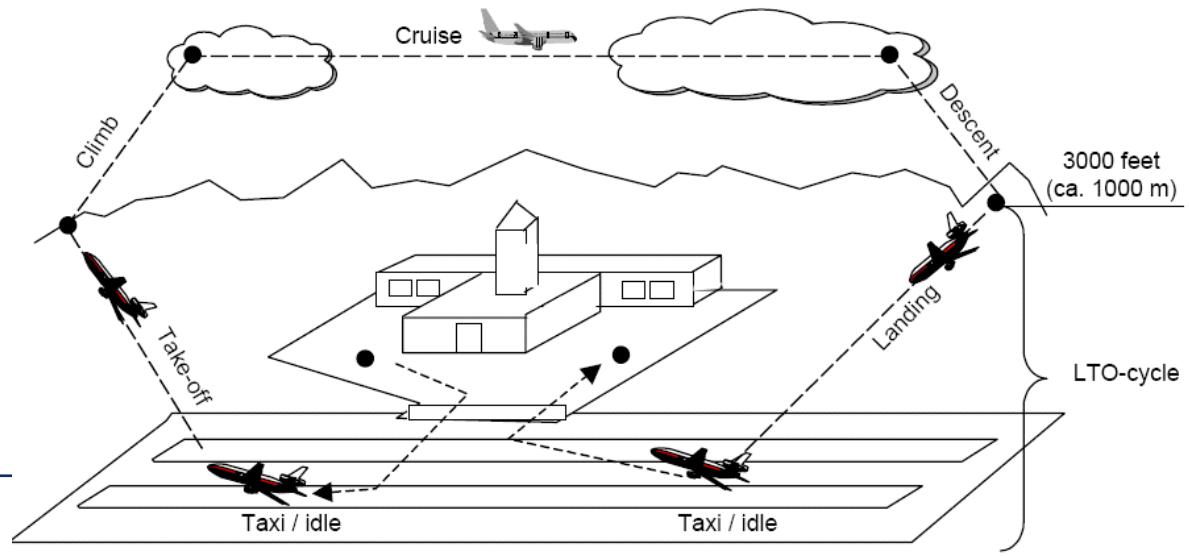
Domestic aviation

- Fleet profile based on AirNZ domestic fleet (3 types)
- LTO factors from Tier 1 EMEP/EEA (LTO-based)
- CCD factors from fuel use less LTO (GHG only)
- Movements (main airports) from Airways Ltd
- Passenger #s from Air NZ

All domestic passenger travel on scheduled services only

Excluding domestic air freight

Combination of top-down and bottom up



E = EF x LTO Equation 5.1

Or

E = EF x FC Equation 5.2

Where:

E = emission of a pollutant (g/yr)

EF = emission factor of the pollutant by aircraft type (kg/LTO) for the landing and take-off phases or by FC (g/l fuel) for the climb, cruise and descent phases

FC = total fuel consumption by that aircraft type (l/yr)

LTO = number of landing and take-off movements for the type of aircraft per year.

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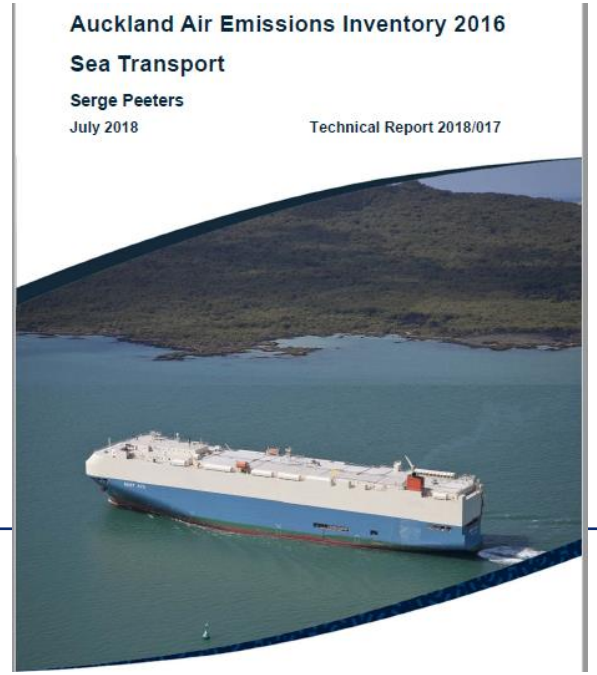
Coastal shipping

- Fleet profile based on NFDS categories (3 types)
- At berth factors from Akl Emis Inv (visit-based)
- At sea factors from fuel use less at berth (GHG only)
- Port visits from NFDS data plus Rockpoint
- Freight volumes from Rockpoint

Coastal freight services only

Excluding passenger ferries and cruise ships

Combination of top-down and bottom up



E = EF x PV Equation 6.1

Or

E = EF x FC Equation 6.2

Where:

E = emission of a pollutant (g/yr)

EF = emission factor of the pollutant by vessel type (kg/PV) for the at-berth phase or by FC (g/litre fuel) for the at-sea phase

FC = total fuel consumption by that vessel type (l/yr)

PV = port visits for the type of vessel per year.

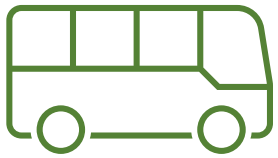
Public transport

- Bus fleet profiles from Councils (urban) & MoEd (rural)
- Urban rail fleet profile from Akl & Wgtn councils
- Urban ferry fleet profile from AT
- Emission factors from VEPM6.1 or EEA/EMEP (fuel)
- Passenger #s from Waka Kotahi plus MoEd

Urban buses, urban rail and urban ferries

Including school buses

Bottom up approach



E = EF x VKT Equation 7.1

Or

E = EF x FC Equation 7.2

Where:

E = emission of a pollutant (g/yr)

EF = emission factor of the pollutant by speed for buses (g/km) or fuel type for rail and ferries (g/litre fuel)

VKT = total vehicle kilometres travelled by that bus type on the public transport network (km/yr)

FC = total fuel consumption by that vehicle type on the public transport network (l/yr).

Alternative modes

- Relative costs only (not total due to limited data)
- E-cycling energy use from Wgtn E-Bike website
- Ride-hailing assumed hybrid (100% dead running)
- Scooter data from Electric Scooter Guide & o'seas
- Emission factors (ride-hailing) from VEPM6.1

Walking, cycling, e-cycling, ride-hailing, micro-mobility (private+rental e-scooters)

Assuming urban travel only

$$E = EF \times VKT \qquad \text{Equation 7.1}$$

Or

$$E = EF \times FC \qquad \text{Equation 7.2}$$

Where:

E = emission of a pollutant (g/yr)

EF = emission factor of the pollutant by speed for buses (g/km) or fuel type for rail and ferries (g/litre fuel)

VKT = total vehicle kilometres travelled by that bus type on the public transport network (km/yr)

FC = total fuel consumption by that vehicle type on the public transport network (l/yr).

DRAFT RESULTS

Total costs

- Road transport the major contributor
- Urban/rural costs dominance depends on whether AQ or GHG

Table 9. 1 Total costs of domestic transport air quality impacts in New Zealand in 2018/19

Mode	Urban costs ($M)	Rural costs ($M)	Total costs, $M (June 2019 prices)
Road transport	$897.6	$155.3	$1,052.9
Rail	$15.0	$4.2	$19.3
Domestic aviation	$18.5	$0.4	$18.9
Coastal shipping	$47.2	$0.4	$47.6
Public transport	$66.7	$0.8	$67.5
All modes	**$1,045 M**	**$161 M**	**$1,206 M**

Table 9. 2 Total costs of domestic transport greenhouse gas impacts in New Zealand in 2018/19

Mode	Urban costs ($M)	Rural costs ($M)	Total costs, $M (June 2019 prices)
Road transport	$523	$927.3	$1,450.3
Rail	$2.8	$10.6	$13.3
Domestic aviation	$22.4	$81.0	$103.4
Coastal shipping	$3.1	$80.7	$83.7
Public transport	$20.9	$3.2	$24.2
All modes	**$572 M**	**$1,103 M**	**$1,675 M**

DRAFT RESULTS

Normalised costs - passenger

- Rail **best** per PK
- Urban ferry **worst** per PK

Table 9. 4 Normalised costs of greenhouse gas impacts for domestic passenger transport vehicles in New Zealand in 2018/19

Passenger transport category	Urban		Rural		National average	
	c/VKT	c/PK	c/VKT	c/PK	c/VKT	c/PK
Passenger car	2.4	1.5	2.4	1.5	2.4	1.5
Coach	9.4	0.7	9.4	0.7	9.4	0.7
Other bus	8.5	0.6	8.5	0.6	8.5	0.6
Motorcycle	0.9	0.9	0.9	0.9	0.9	0.9
Long-distance rail	28.6	0.1	28.6	0.1	28.6	0.1
Domestic aviation	n/a	0.4	n/a	5.1	n/a	1.4
Urban bus	12.2	1.6	-	-	12.2	1.6
School bus	-	-	8.4	1.0	8.4	1.0
Urban rail	12.3	0.2	-	-	12.3	0.2
Urban ferry	232.0	4.1	-	-	232.0	4.1

Note: Emissions and costs for urban bus, urban rail and urban ferry were only assigned to urban, whereas emissions for rural school buses were only assigned to rural. VKT data for aviation were not available.

Table 9. 3 Normalised costs of air quality impacts for domestic passenger transport vehicles in New Zealand in 2018/19

Passenger transport category	Urban		Rural		National average	
	c/VKT	c/PK	c/VKT	c/PK	c/VKT	c/PK
Passenger car	2.7	1.7	0.3	0.2	1.3	0.8
Coach	26.6	2.0	2.1	0.2	7.6	0.6
Other bus	21.9	1.6	1.7	0.1	6.3	0.5
Motorcycle	5.8	5.8	0.5	0.5	2.5	2.5
Long-distance rail	179.8	0.9	13.7	0.1	43.6	0.2
Domestic aviation	n/a	0.3	n/a	0.02	n/a	0.3
Urban bus	38.6	5.0	-	-	38.6	5.0
School bus	-	-	1.7	0.2	1.7	0.2
Urban rail	13.1	0.2	-	-	13.1	0.2
Urban ferry	884.4	15.7	-	-	884.4	15.7

Note: Emissions and costs for urban bus, urban rail and urban ferry were only assigned to urban, whereas emissions for rural school buses were only assigned to rural. VKT data for aviation were not available.

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DRAFT RESULTS

Normalised costs - freight

- Rail **best** per NTK
- Light commercial vehicles **worst** per NTK

Table 9. 5 Normalised costs of air quality impacts for domestic freight transport vehicles in New Zealand in 2018/19

Freight transport category	Urban		Rural		National average	
	c/VKT	c/NTK	c/VKT	c/NTK	c/VKT	c/NTK
LCV	9.0	18.0	0.8	1.6	4.0	8.1
MCV	16.4	6.5	1.3	0.5	4.7	1.9
HCV	27.0	2.6	2.1	0.2	7.7	0.7
Electric locomotive	n/a	0.0	n/a	0.0	n/a	0.0
Diesel locomotive	n/a	2.3	n/a	0.1	n/a	0.5
Coastal freighter	n/a	1.2	n/a	0.03	n/a	0.9

Note: Domestic air freight was not assessed. VKT data were not available for freight locomotives and coastal vessels.

Table 9. 6 Normalised costs of greenhouse gas impacts for domestic freight transport vehicles in New Zealand in 2018/19

Freight transport category	Urban		Rural		National average	
	c/VKT	c/NTK	c/VKT	c/NTK	c/VKT	c/NTK
LCV	3.3	6.6	3.3	6.6	3.3	6.6
MCV	5.4	2.2	5.4	2.2	5.4	2.2
HCV	10.9	1.0	10.9	1.0	10.9	1.0
Electric locomotive	n/a	0.1	n/a	0.1	n/a	0.1
Diesel locomotive	n/a	0.4	n/a	0.3	n/a	0.4
Coastal freighter	n/a	0.1	n/a	6.5	n/a	1.6

Note: Domestic air freight was not assessed. VKT data were not available for freight locomotives and coastal vessels.

DRAFT RESULTS

Normalised costs – alternative modes

- Relative to an "average" car in the fleet, walking and cycling **best**

Table 8. 5 Normalised greenhouse gas costs and net benefits (relative to an average passenger car) of different alternative modes in urban areas of New Zealand in 2018/19

Vehicle mode	Urban greenhouse gas costs		Net benefits	
	c/VKT	c/PK	c/VKT	c/PK
Walking and cycling				
Walking	0	0	4.7	3.0
Cycling	0	0	4.7	3.0
E-cycling	0	0.01	4.7	3.0
Ride hailing				
Hybrid <3.5t	2.2	1.0	2.5	2.0
Petrol car <3.5t *	4.6	2.1	0.1	0.9
Micro-mobility				
E-scooter (private)	0.02	0.02	4.7	3.0
E-scooter (rental)	0.3	0.3	4.5	2.8

Note: The ride-hailing costs per PK include costs associated with 100% dead running.

Table 8. 4 Normalised air quality costs and net benefits (relative to an average passenger car) of different alternative modes in urban areas of New Zealand in 2018/19

Vehicle mode	Urban air quality costs		Net benefits	
	c/VKT	c/PK	c/VKT	c/PK
Walking and cycling				
Walking	0	0	2.7	1.8
Cycling	0	0	2.7	1.8
E-cycling	0	0	2.7	1.8
Ride hailing				
Hybrid <3.5t	1.3	1.2	1.4	0.6
Petrol car <3.5t *	2.0	1.8	0.8	0.0
Micro-mobility				
E-scooter (private)	0	0	2.7	1.8
E-scooter (rental)	0.1	0.1	2.6	1.6

Note: The ride-hailing costs per PK include costs associated with 100% dead running.

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Recommendations for future work

- Improve **road dust** (sealed and unsealed) emission factors
- Obtain/record actual **loads** for commercial vehicles
- Refine **motorcycle exhaust** emission factors
- Improve resolution of **school bus** data (especially PK estimates
- Obtain/record better data on domestic **shipping fuel** use
- Update all costs with **HAPINZ 3.0** estimates (once decision on VoSL)