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Should Councils measure road network CO_2?

THINK PIECE PAPER

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ABSTRACT

On the path towards New Zealand becoming carbon neutral, road transport is one of the big levers to be pulled. Road Controlling Authorities (RCAs) have a vital role and this paper investigates whether they currently have sufficient knowledge of their road network CO_2 emissions to be able to define and follow an effective emission reduction pathway. Historically, Councils rarely estimate and forecast CO_2 emissions on their road network which raises questions on their ability to plan and achieve sufficient emission reductions. The Vehicle Emissions Mapping Tool (VEMT) being developed by Waka Kotahi NZ Transport Agency promises to enable consistent estimates across the country, however the tool's forecasting capabilities and the terms of its use by other RCAs remain unclear. Road network CO_2 emissions can be factored into business cases and guide the policy-making process serving as a reality check. It is important for Councils as RCAs to reliably measure emissions to ensure their emission reduction pathway is consistent with national climate targets as well as any self-imposed local targets. The risk is that future transport policies and programmes maintain or increase CO_2 emissions, and that the aspirations of carbon reducing policies do not meet the challenge.

AUTHOR CONTRIBUTION STATEMENT

Data collection, analysis and redaction undertaken solely by Benjamin Walch.

INTRODUCTION

Transport CO_2-e emissions represent 21% of New Zealand's (MfE, 2018 data) and 44% of Auckland's (Auckland Council, 2016 data) greenhouse gas emissions. When only considering long lived gases (i.e. excluding biogenic methane), the share of transport emissions rises to 36% nationwide, of which 91% originate from land transport and only 7% and 2% respectively are emitted by aviation and shipping (Climate Change Commissions, 2021). Addressing road transport emissions is therefore one of the big levers to reduce NZ's greenhouse gas emissions and Road Controlling Authorities (RCAs) play an important role in this regard.

The Climate Change Commission delivered draft advice on the 31st of January 2021 offering a pathway for NZ to reduce emissions in line with its commitment to a maximum global warming of 1.5 degrees and to become carbon neutral by 2050. The responsibility for reducing transport emissions will be shared by RCAs, possibly in the shape of emission budgets specifying by how much emissions need to drop on their road network. RCAs should therefore be able to quantify where their section of the public road network stands with CO_2 emissions and propose a pathway to cutting their fair share too.

This paper seeks to inform discussions by taking stock of existing examples of estimating and forecasting road network CO_2, and by drawing out the ways in which this data can be used to plan and follow emission reduction pathways.

So are there examples of RCAs already measuring and forecasting road network CO_2? Is data readily available? How important is it for RCAs to measure and forecast road network CO_2, and how can they benefit from using this information?

CASE STUDIES

I start by reviewing examples of work done in this area to date, as well as methodologies used and their limitations.

National initiatives

Waka Kotahi New Zealand Transport Agency engaged Jacobs to develop a national vehicle emission dataset called "NVED2016". Initially a spreadsheet, it was progressed to a GIS based Vehicle Emission Mapping Tool (VEMT) illustrated in Figure 1 (Waka Kotahi, 2021). This tool has been through successive refinements allowing estimates of pollutants to be calculated including carbon dioxide (CO_2) based on factors such as traffic volume, speed, fleet profile, gradient, tyre and brake wear, and average regional temperatures, for all public roads in NZ (Jacobs, 2018).

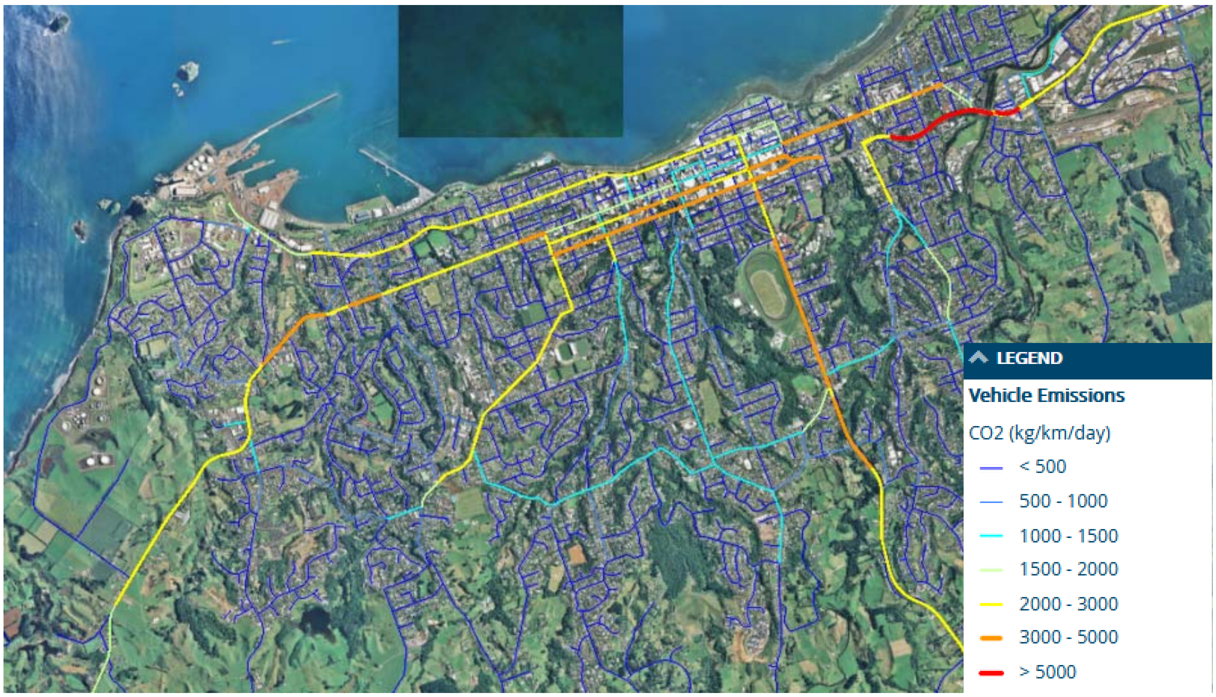

Figure 1: Snapshot of CO_2 emissions on New Plymouth's road network (Waka Kotahi, 2021)

Queries can be run on the dataset to summarise emissions on all roads controlled by an RCA, generating an estimate of road network CO_2 emissions for an entire City or District. However, a review mentioned that the "model is constrained at the regional level by a lack of good quality data from territorial and local authorities" (Aecom, 2020).

Current work on the tool is improving its capability to test scenarios and their impact on CO_2 emissions. This is useful in assessing the CO_2 emission impact of changes in traffic volumes or speeds, or the evolution of the fleet profile. Mode shift can be reflected indirectly in the model through a reduction in Vehicle Kilometres Travelled (VKT) and a change in the vehicle fleet composition. Rail travel is not included so far.

In terms of Climate Change planning however, the VEMT's shortcoming is that it is not explicitly set up for long term forecasting yet.

Council-led initiatives

Historically, some Councils have measured various types of emissions through Air Emission Inventories. These inventories had more of a public health lens rather than a climate change lens and therefore mainly focused on emissions with potential adverse health impacts such as suspended particles (PM10), carbon monoxide (CO), sulphur oxides (SOx), and nitrogen oxides (NOx) rather than greenhouse gases like CO_2. When CO_2 emissions were estimated as part of the Air Emission Inventories, the focus was on urban areas (Nelson, Tokoroa & Morrinsville, Blenheim) rather than the road network or the whole district (Environet 2014 & 2017, Waikato Regional Council, 2016).

In 2020, Queenstown Lakes District Council (QLDC) sought to find out the amount of carbon emissions generated by vehicles travelling on their entire road network in the past year (2018/19) and commissioned Abley to calculate estimates. This enabled annual road transport emissions to be forecast across the district up to 2048.

Using Vehicle Kilometres Travelled (VKT) data extracted from the Queenstown-Lakes Transportation Model alongside Ministry of Transport (MoT) fleet composition projections and Ministry for the Environment (MfE) emission factors, Abley modelled the impact of increasing VKT (projected by the traffic model) as well as changes in the fleet composition (projected by MoT) over the years.

It was estimated that road transport emissions in the district would peak in 2029/2030 (see Figure 2) under a base scenario, an important data point for Council's climate mitigation policies.

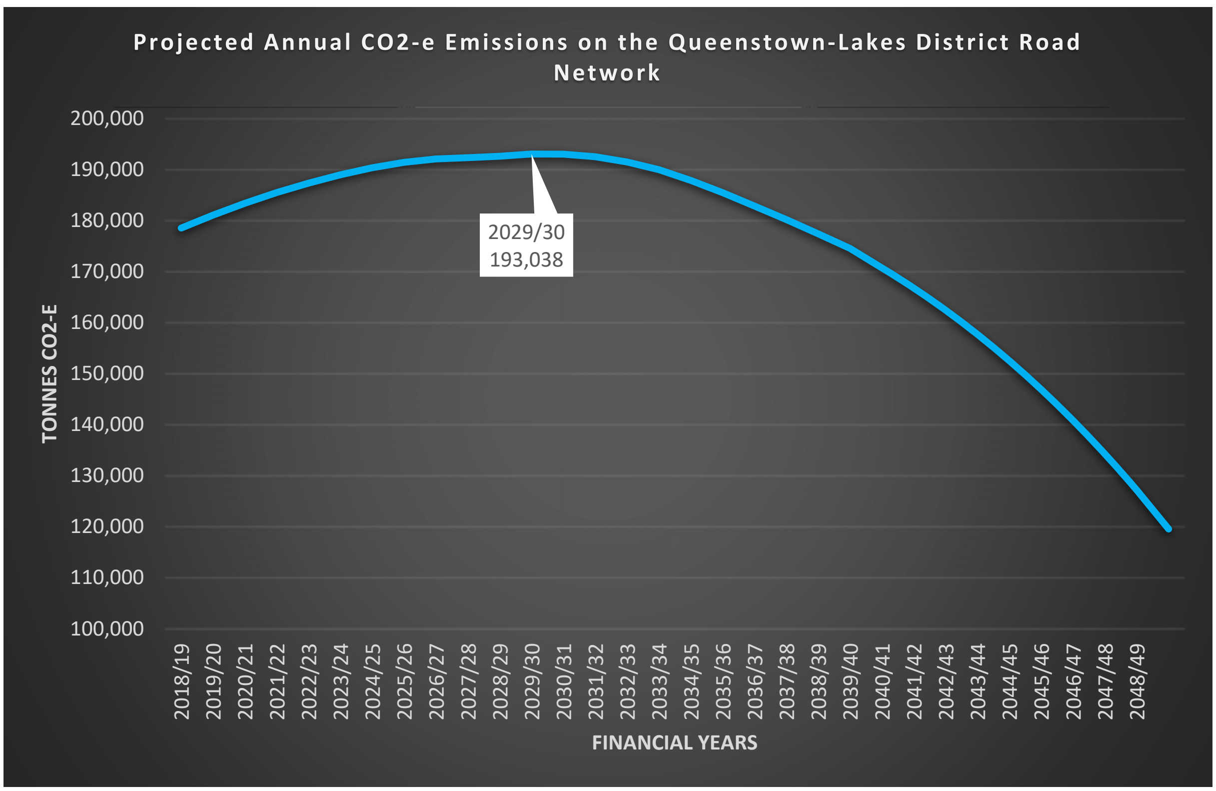

Figure 2: Projected CO_2-e Emissions on the QLDC Road Network

In the short term, reducing the VKT (through a mode shift away from private vehicle usage) will be the most effective action to reduce emissions, whereas in the longer term the increasing share of electric and hybrid vehicles in the fleet will allow a reduction in road transport emissions even if total VKT increases. Overall, when accounting for the transport programme intended to be delivered through ongoing transport business cases, total emissions on QLDC's road network were projected to drop by 29% between 2018 and 2048. The below table shows how tailpipe emissions from different vehicle types are forecasted to evolve over time, as well as the total emissions.

Table 1: QLDC road network CO_2 emissions forecast (tonnes CO2-e).

Fleet/fuel type	2018	2028	2048	2018-48 Change	2018-48 %age Change
Diesel (excluding HGV)	25,406,026	28,246,726	3,574,994	-21,831,032	-86 %
Diesel plug-in[1]	5,168	639,064	8,891,556	8,886,388	+171,950 %
Electric	52,337	1,532,241	17,120,198	17,067,861	+32,611 %
Petrol	134,572,852	132,984,105	41,307,278	-93,265,574	-69 %
Petrol plug-in[1]	63,791	2,162,195	8,513,247	8,449,456	+13,246 %
Hybrid diesel[1]	8,085	17,825	13,566	5,481	+68 %
Hybrid petrol[1]	1,367,794	7,784,077	29,263,020	27,895,226	+2,039 %
Heavy Vehicles	17,059,353	19,243,641	18,479,864	1,420,511	+8 %
Total (kgs CO2-e)	178,535,406	192,609,874	127,163,723	-51,371,683	-29 %
Total (tonnes C02 -e)	**178,535**	**192,610**	**127,164**	**-51,372**	**-29 %**

The output data was provided in a format that QLDC's emissions team can combine with other emission sources in their inventory and emission reduction pathway. The data allows a reality check against QLDC's emission reduction ambitions.

Data sources and limitations

A review of how road transport network CO_2 emissions have been measured, and in some cases projected by RCAs, has revealed that the practice throughout New Zealand is currently relatively new and ad hoc. National efforts led by Waka Kotahi are promising, however it is unclear how other RCAs will be able to access or use information from the VEMT so far.

Applying emission factors to VKT for each vehicle type seems to be the core methodology in all examples found, including the "Transport2030" (https://transport2030.org) work presented in the second part of this paper. The VEMT is the most advanced tool currently available as it accounts for the most comprehensive range of factors including gradients and speeds. Obtaining robust local data is currently a challenge and RCAs could have a role to play in improving data quality, for example by installing more automatic traffic counters.

The MoT monitors and forecasts vehicle fleet composition to 2040 using the Vehicle Fleet Emissions Model (VFEM) (MoT, 2021). The model generates several scenarios with varying pace of new technology adoption, change in travel habits, and population growth, basing on the 2017 Transport Outlook scenarios, some of which are summarised below.

[1] "Diesel plug-in" and "petrol plug-in" describe hybrid vehicles with an electric battery that can be charged when plugged into a charging point. Hybrid diesel and Hybrid petrol vehicles are hybrid vehicles with a battery that cannot be charged from a charging point but instead recovers and stores energy from other parts of the vehicle such as the braking mechanism.

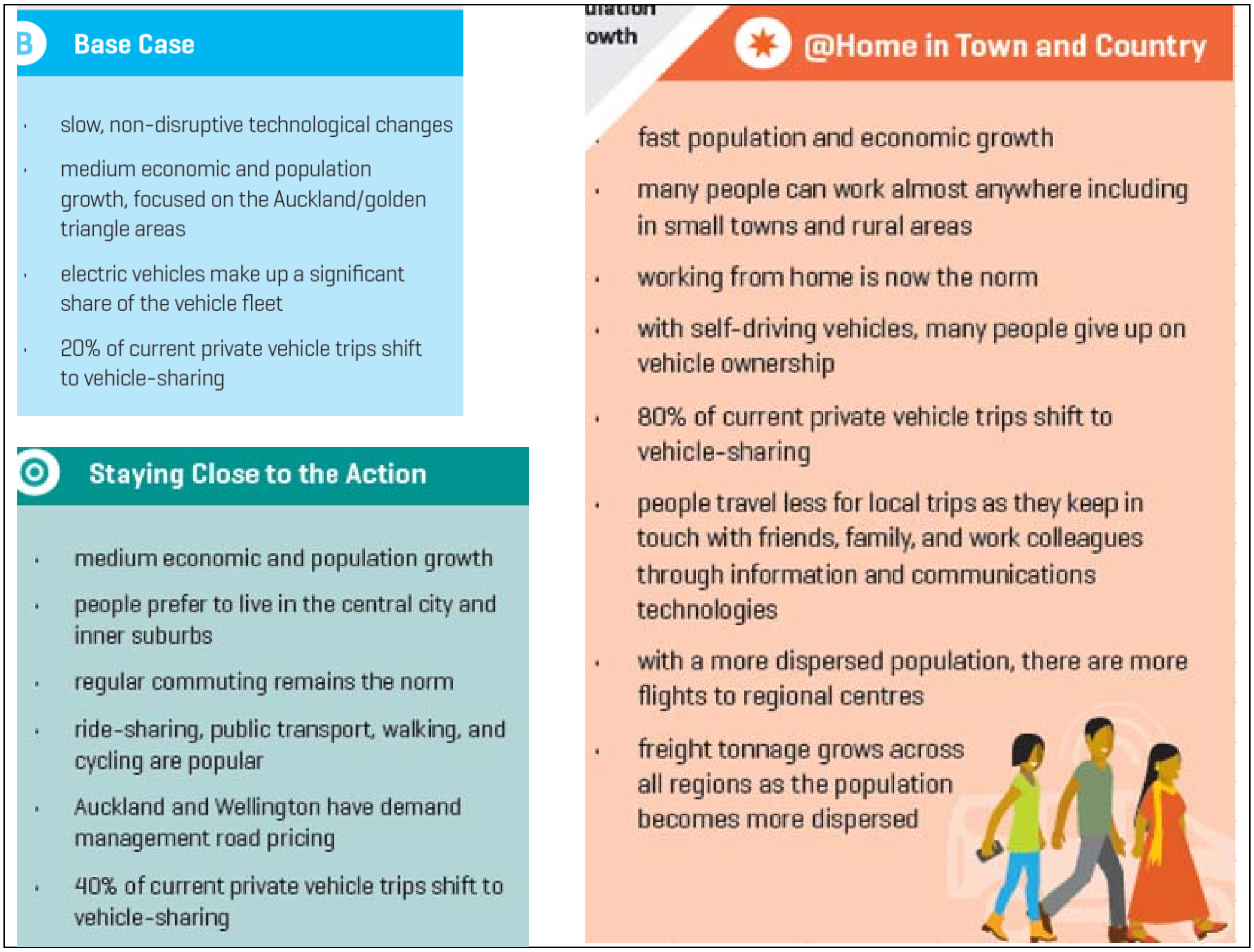

Figure 3: Examples of MoT 2017 Transport Outlook Scenarios (MoT, 2021)

Fleet composition at a local level is likely to vary from the national fleet which presents a challenge for RCAs seeking to use a locally relevant fleet composition. For Air Emission Inventories commissioned by Councils in the past, local registrations have been used to estimate local fleet composition. However, this approach does not seem appropriate in areas where tourism and long-distance freight represent important proportions in overall traffic as local registrations would not capture the contribution of vehicles from other regions. Another option, used in the QLDC case, is to estimate local fleet composition based on traffic counts. This works well to determine the proportion of heavy vehicles in the fleet, but the counts may not be granular enough to differentiate light commercial vehicles from private cars.

Forecasting future road transport emissions requires an additional dataset to account for the evolution of vehicle emissions as they become more efficient over time, for example capturing that the standard 2025 hybrid car is likely to have lower emissions than the 2018 one. This evolution is projected by the Vehicle Emissions Prediction Model (VEPM) and made available as a spreadsheet by Waka Kotahi (Waka Kotahi, 2021).

At regional level, emissions from internal combustion engine vehicles could be estimated based on volumes of fuel sold in the territorial area. The limitations of this approach are similar to using local registrations as vehicles from outside the region may not be accounted for. Additionally, emissions from other fuel types (electricity, and in the future hydrogen) would not be captured by this approach.

Finally, where Vehicle Operating Cost (VOC) data has already been calculated for road links, Waka Kotahi provides a methodology to infer CO_2 emissions from VOC. This can be done since fuel cost is about 50% of running costs (Waka Kotahi, 2020a), and emission factors can be applied to fuel quantities to obtain CO_2 emissions.

USES OF ROAD CO_2 DATA FOR DECISION-MAKING

The second part of this paper reviews current and potential use cases of data on road network CO_2 emissions by RCAs. How important is it for RCAs to measure and forecast road network CO_2, and how can they benefit from using this information?

Use of CO_2 emissions in business cases

There is an expectation in the 2019 Climate Change Response (Zero Carbon) Amendment Act that the land transport system reduces emissions from transport in line with the Government's carbon budgets. In the context of business cases and of calculating Benefit Cost Ratios, CO_2 emissions from vehicles can currently be considered a non-monetised measure of the benefit cluster "Changes in climate" by Waka Kotahi (Waka Kotahi, 2020b). It is also considered a companion measure to resource efficiency, mode shift from single occupancy private vehicles, and ambient air quality. The following graph illustrates how using CO_2 emissions as a measure can enrich a business case through its linkages to other aspects.

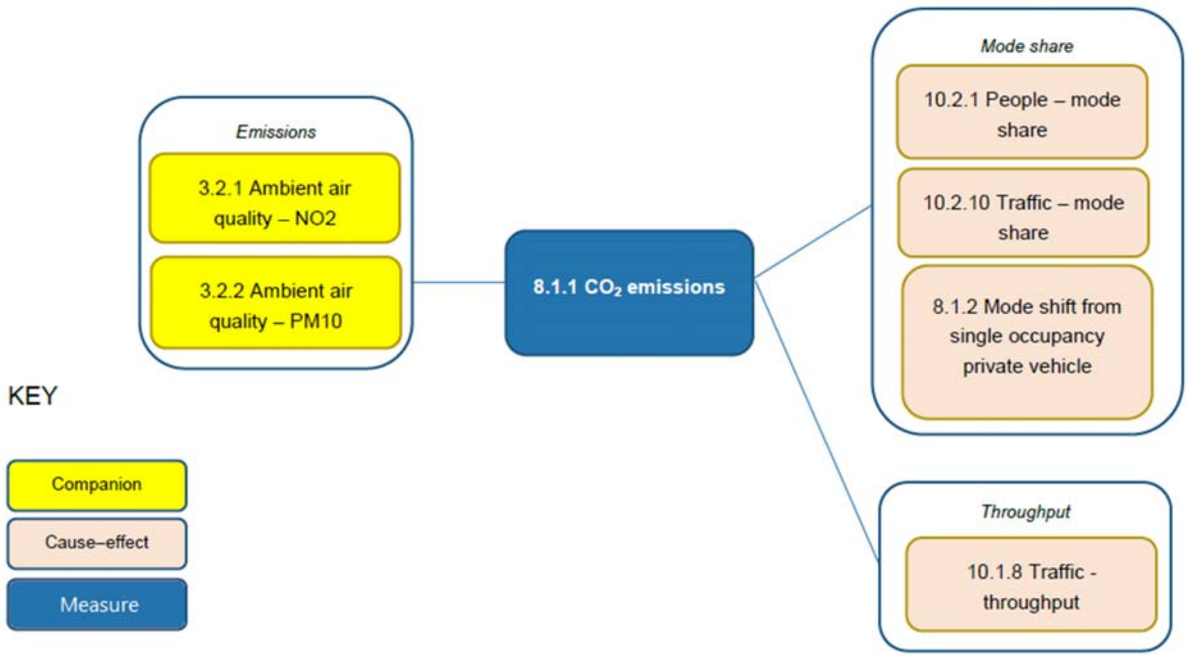

Figure 4: Linkages between CO_2 emissions and other business case measures (Waka Kotahi)

While Waka Kotahi has clearly defined guidance to consider carbon emission impacts in business cases, a standardised forecasting methodology is not yet available for this measure, and business case teams must develop a local forecast and document their methodology within their business case (Waka Kotahi, 2020b). The corresponding study area will also vary depending on the scale of a transport scheme and whether effects on emissions are only considered at the intervention site or network-wide.

In addition to being a non-monetised measure reported in tonnes, CO_2 emissions can be monetised through the price of a tonne of CO_2. This price is highly variable depending on the carbon market (for example it is more expensive in NZ than the international average) and depending on the use case of carbon pricing. For carbon offsetting applications, i.e. buying carbon units to balance emissions, the price of CO_2 sequestration depends on the way it is sequestered. For example, a reforestation programme may have a different cost structure from a programme that replaces coal boilers for example. The Monetised Benefits and Cost Manual provides direction on the CO_2 price to be used for calculating Benefit Cost Ratios, specifically NZD65.58 per tonne of CO_2 emissions. This price is higher than the current carbon price in NZ which lies around NZD40.

Waka Kotahi specifies a focus on damage costs in the following note:

> "The monetary value adopted to reflect the damage costs of CO_2 emissions in project evaluations has no relationship to the level of carbon tax or carbon price that the government might consider as a policy instrument to restrain CO_2 emissions." *(Waka Kotahi, 2020a, p.45)*

The implications of factoring CO_2 emissions in business cases both as an environmental indicator and as a monetised measure are significant. With long-term infrastructure projects, RCAs can be locked on an emission pathway and they should therefore ensure it is a low-emission pathway. When comparing business case options, low emission options can stand out with a better monetised value whereas options that prolong or reinforce high-emission outcomes are at odds with climate targets. If RCAs have visibility on current and future emissions of their transport network, they can automatically disqualify schemes that are inconsistent with climate targets and put forward stronger cases for low-emission alternatives.

However, if RCAs do not have sufficient data to understand how proposed schemes and programmes could impact on their CO_2 emissions, they cannot make informed decisions towards supporting climate targets. Hence the importance of measuring and forecasting emissions across their road network.

Strategic Planning

With central government committing NZ to no more than 1.5 degrees change and becoming carbon neutral by 2050, RCAs need to understand the role they will need to play in achieving climate targets. In terms of a road network, this involves understanding the do-minimum scenario and forecasting how planned investment will contribute to reaching targets.

In Auckland, the 1 point 5 project (https://1point5.org.nz) has presented policy makers with a reality check. Research undertaken by the group suggests near complete decarbonisation of road transport by 2030 is a necessity to achieve Council's ambition of halving all emissions by 2030, as other sectors will not be able to reduce their greenhouse gas emissions by as much. The project team reviewed which transport policies and changes will allow sufficient regional road transport emissions reductions.

Led by Paul Winton and supported by MR Cagney, the team developed the https://transport2030.org interactive dashboard which allows for testing a range of scenarios in a simple interface. A range of Public Transport projects (e.g. City Rail Link and Eastern Busway) can be factored in and various parameters adjusted, such as the rate at which Public Transport and cycling mode shares grow, the pace of fleet electrification, and the evolution in VKT both from the quantum of trips and trip distances. As in previous examples, the data mainly relies on applying emission factors to VKT for each vehicle type.

The dashboard shows which levers have the greatest impact on forecast 2030 transport emissions and which levers are less significant. Figure 5 (left graph) shows a scenario where planned Public Transport projects are implemented, where cycling investment and public transport ridership double, and where 10% of the vehicle fleet is electric by 2030. These changes, although they can seem significant, would only produce a slight reduction from 2018 emissions, but demonstrate a marked reduction from the projected 2030 baseline (do nothing scenario). Figure 5 (right graph) shows a scenario where the target (green dotted line – 70% reduction in transport emissions from 2018) is achieved. This second scenario requires a 50% reduction in trips taken and a 30% reduction in average trip length on top of all changes included in the first scenario, for the target to be achieved.

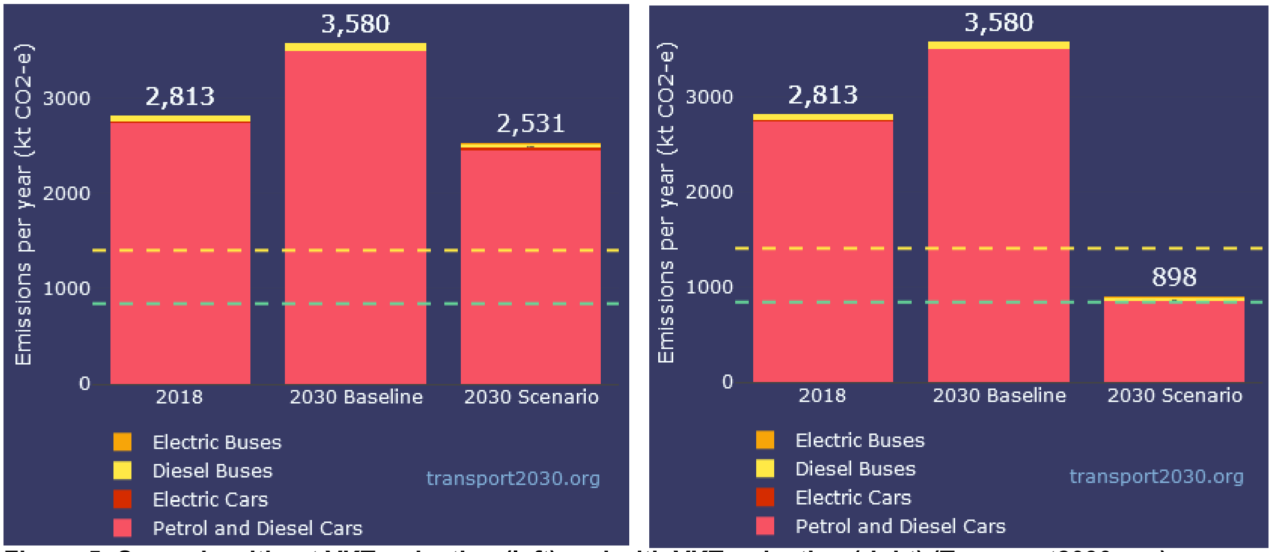

Figure 5: Scenario without VKT reduction (left) and with VKT reduction (right) (Transport2030.org)
Key: the yellow dotted line represents a 50% reduction of transport emissions from 2018 and the green dotted line 70%.

The main finding from this tool is that Public Transport and cycling investment in Auckland are unlikely to meet emission reduction targets in isolation, even if investment in these modes is significantly increased. Policies that would be the most effective at reducing transport emissions are policies that would directly reduce VKT as an outcome.

This example shows that Councils run the risk of making decisions that are not the most effective in reducing road transport emissions unless they can reliably measure and forecast emissions on their road network. Similarly, realising that road transport emissions are only projected to peak in 2029/2030 (as was the case in Abley's forecast for the Queenstown-Lakes district), can provide decision makers with a renewed sense of urgency more aligned with the effort required for the country to be carbon neutral by 2050.

CONCLUSION

The practice of estimating and forecasting CO_2 emissions due to land transport activity in New Zealand is not widespread. This means that RCAs are largely operating without a steer on road network emission reduction. National work led by Waka Kotahi to develop a map-based tool (the VEMT) is likely the most promising effort. If this were to be available to other RCAs, it has the potential to improve their understanding of current emissions on their network and provide a consistent methodology across the country to measure road network CO_2 emissions. The limited availability of robust local data (e.g. traffic counts, fleet composition) is still a challenge at this stage.

Measuring and forecasting road network CO_2 is an essential piece of information to guide RCAs in their decision-making framework and should become routine for all RCAs. Waka Kotahi provides a clear methodology to include CO_2 emissions (in tonnes) and their monetary value (in NZD) as a measure in business cases. However, as the data is still rarely available RCAs run the risk of not properly factoring CO_2 outcomes into their business cases and therefore investing significant resources in programmes that are not the most effective in reducing road transport emissions. The likely consequence is that transport schemes are funded which are inconsistent with national and local climate change targets. Similarly, there is a risk that when emission reductions are pursued the policies to deliver reductions are insufficient to achieve emission targets. Transportation practitioners have a role to play in requesting this information and challenging its absence from the policy-making process.

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