NZ Transport Agency - Emissions Modelling Review

New Zealand Transport Agency

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NZTA - Land Transport Greenhouse Gas Emission Modelling Review: Parts A/B

(A review of models used for greenhouse gas emission projection and transport mode shift)

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(A review of models used for greenhouse gas emission projection and transport mode shift)

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4	9-March 2020	Final feedback from NZTA included	Maurice Marquardt Team Leader Sustainability and Resilience	

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1.0 Introduction

AECOM have been commissioned by the New Zealand Transport Agency (NZTA) to conduct research into the current greenhouse gas (GHG) emissions and mode shift modelling for the transport sector in NZ.

NZTA have identified models that are currently being used in NZ to inform the scale of the GHG emission reduction challenge for the NZ transport sector. The scope of this project is focussed on obtaining a better understanding of these models' potential to improve knowledge and measurement of GHG emissions from transport mode shift.

The work examines how each model addresses mode shift and how they differ in this respect and what they may offer in terms of providing useful data for shifts between different transport modes. The following sections provide a brief overview of model content, structure, method and outputs with a view to providing the reader extra context based mainly on the scope of the project.

When using the information in this report it important to note the project was completed within a tight-timescale (approximately 4 months) and it was not possible to complete an in-depth review of each aspect of a model's methodology for calculating emissions. It was accepted from the outset that the models or pieces of work included were not necessarily originally designed for the purpose investigated. It also is noted that some limitations highlighted may be issues with modelling generally, but these are included as they are still relevant for the consideration of mode shift.

1.1 Method summary

This review consisted of two approaches; a desktop review to understand the different inputs, outputs, scenarios and assumptions used by the models, alongside targeted interviews with the model owners/operators to provide greater depth of understanding. The project has been completed in two parts, namely PART A and PART B. PART A focuses on NZ models or pieces of work while PART B extends the work in PART A to cover other NZ models and relevant models developed internationally.

The models/studies considered in PART A were:

Name	Owner	Main purpose & use
Transport Outlook - Future State	Ministry of Transport	The model is designed to provide a base case for measuring greenhouse gas emissions and the influence of mode shift mostly based on technology change. It deliberately does not include any policy initiatives.
Vehicle Emissions Mapping Tool (VEMT)	NZTA (serviced by Jacobs)	The Vehicle Emission Tool is a Geographical Information Systems (GIS) tool which can be used to calculate and display estimated emissions levels for all roads in New Zealand.
Vehicle Fleet Emissions Model (VFEM)	Ministry of Transport	This model projects the makeup of future vehicle fleets and their kilometres travelled, energy (fuel and electricity) use and greenhouse gas (GHG) emissions.
Macro Strategic Model and Macro Public Transport Model	Auckland Forecasting Centre/ Auckland Transport	To examine multimodal trips including private and public transport modes, the number of daily trips, trips in the AM peak, inter-peak and PM peak periods.

Name	Owner	Main purpose & use
Public health - Health consequences of Transport patterns in NZ's largest cities (Integrated Transport and Health Impacts Model-ITHIM)	University of Otago/ CEDAR	To measure the health effects of transport policies modelled through the changes in physical activity, road traffic injury risk, and exposure to fine particulate matter (PM2.5) air pollution. Some versions include GHG emissions.
Summary Insights on Energy-related carbon abatement opportunities (ENZ model)	Concept Ltd	ENZ seeks to identify the least-cost means of meeting demand for transport services, given the underlying market drivers (e.g. population growth, emissions prices, fossil fuel prices and technology costs)
Creating a Positive Drive	Thinkstep Ltd	To investigate the maximum potential for current fleet technology change in transport to reduce emissions, if achieved maximum uptake
Turning the Tide; From Cars to Active transport	Andrew Jackson Consulting Ltd & Sandra Mandic, Otago University (Framework developed during The Active Living and Environment Symposium)	To encourage a commitment to change to sustainable transport beyond the introduction of EVs. Encourage national targets for walking, cycling and public transport etc.

The models/studies considered in PART B were:

Name	Owner	Main purpose & use
Multi Objective Local Environmental Simulator (MOLES) 1.0 integrated land-use and transport model	Organisation of Economic Cooperation and Development (OECD)	The model is designed to investigate environmental economic data for the long-run evolution of urban areas. Still in development the model is being tested using Auckland NZ as a case study.
NZTA Mega Maps	NZTA (serviced by Abley Consultants)	NZ Mega Maps model is designed to understand changes in road speed and how these influence road safety overtime. The model can estimate cost and emissions savings as co-benefits from changes in traffic speeds on different types of road.
Effects on air quality of the low emission zones in Copenhagen, Fredericksburg, Aarhus, Odense and Aalborg	The National Environmental Research Institute (NERI), Aarhus University	A suite of models used to deliver high level spatial resolution of a wide range of air pollutants.
DARTE Annual On-road CO2 Emissions on a 1-km Grid, Conterminous US, V2	Distributed Active Archive Centre for Biochemical Dynamics, NASA	An inventory of US on-road CO_2 emissions built from bottom-up source activity data which establishes a national benchmark for monitoring, reporting, and verification of emissions for regulating greenhouse gases.
National Transport Model (NTM) UK	Department of Transport, United Kingdom	NTM is used to provide a systematic means of comparing the national consequences of alternative national transport policies or widely-applied local transport policies.

1.2 Desktop review and review criteria

A desktop review of methods supporting the models was undertaken. The review focused on the following as specified by the NZTA:

- To develop an understanding of model capability, strengths, weaknesses and;
- To develop a framework for comparing the models and their potential to provide data for future emissions measurement and transport mode shifts towards net zero carbon in 2050.

The review consisted of government publications, industry reports, academic papers and online articles sourced from relevant websites, provided to AECOM by the NZTA, or acquired through search engines such as Google.

Specific criteria captured for each model in the desktop review were:

- Name
- Model owner
- Contact details
- Overall purpose and model description
- Year developed / latest update
- Validation / verification
- Weblink
- Technical specification / details
- Availability / legal terms
- Geography / country developed in
- Scale – national; regional etc
- Emissions quantification
- Future state summary
- Technology assumptions (e.g. electric vehicle)
- Policy assumptions
- Key assumptions underpinning the model
- Scenario summary
- Projected time covered
- Data sources
- PKT / VKT
- Intended users / use cases
- Description of model support
- Model outputs
- Other areas covered e.g. health
- Identified limitations
- Flexibility
- Additional commentary

Information presented in the excel spreadsheet (Appendix A, provided separately) is an initial data repository for NZTA. It is recognised Appendix A does not have a particularly user-friendly interface, and that the spreadsheet content is a starting point for NZTA to inform the developing discussion on mode shift. The data repository could be developed further if useful.

1.3 Interviews and discussions

A series of targeted interviews were undertaken in September and October 2019 by the Sustainability & Resilience team at AECOM to complete PART A.

An interview schedule was developed based on the review criteria agreed with NZTA. The interviews targeted model owners or operators (individuals and organisations) to obtain the most valuable input on the subject matter. In total, seven interviews were completed across seven models (two models were covered in one session at MoT) for PART A with the following individuals / organisations:

- Haobo Wang and Sina Mashinchi, Ministry of Transport: Transport Outlook - Future State and Vehicle Fleet Emissions Model (VEFM);

- Sharon Atkins, NZTA and Keith Hastings, Jacobs Consulting - NZTA Vehicle Emissions Mapping Tool (VEMT);
- Dr Caroline Shaw and Ed Randel, University of Otago, Public health - Health consequences of Transport patterns in NZ's largest cities (Integrated Transport and Health Impacts Model-ITHIM)
- Andrew Jackson, Andrew Jackson Consulting Ltd – Turning the Tide; From Cars to Active transport
- Simon Coates, Concept Ltd - Summary Insights on Energy-related carbon abatement opportunities (ENZ model)
- Jeff Vickers, Thinkstep - Creating a Positive Drive

We were unable to set up interviews with Auckland Transport, but John Davies at Auckland Transport provided written feedback that has been incorporated into this report.

For PART B model owner interviews and / or reviews were not completed with the organisations listed below, apart from Paul Durdin at Abley Consultants.

- Ioanis Tikoudis, OECD – Multi Objective Local Environmental Simulator
- Paul Durdin, Abley Consultants – NZ Mega Maps
- Sven Jensen, The National Environmental Research Institute (NERI), Aarhus University. Effects on air quality of the low emission zones in Copenhagen, Fredericksburg, Aarhus, Odense and Aalborg (Planned Feb 2020)
- Lucy Hutyra. Distributed Active Archive Centre for Biochemical Dynamics, DARTE Annual On-road CO_2 Emissions on a 1-km Grid, Conterminous US, V2
- National Transport Model (NTM) UK.

When possible, internal AECOM experts including Duncan Tindall and Peter Stacey were contacted to provide extra context. We believe that the organisations we interviewed provided enough information to complete this project.

Notes were taken during the interviews, which were then used to update the desktop review findings. The interview questions, notes and summary of findings for each review item can be found in the Excel spreadsheet provided as in Appendix A of this report.

1.4 Quality assessment and Quality Checks

Each model owner or operator was given the chance to provide feedback about content aimed at their respective model included in the Appendix or this report before submission. Where ratings e.g. data quality, are included in Appendix A these are subjective based on the assessment of the AECOM team completing the project.

Quality checks on final deliverables have been completed.

2.0 Desktop review and interview insights

The findings of the project for the models included are below. First, we draw together general findings and observations from the desktop review of the models. Then a summary of each model from PART A and PART B is provided. Finally, the overall findings for PART A and PART B are described, and recommendations for next steps made.

The desktop review and interview insights and findings in respect to each model have been incorporated in the Excel spreadsheet in Appendix A of this report. All participants were open and willing to discuss the benefits and limitations of the models. Our general insights gained in no order of importance:

2.1 Communication and documentation

- Results from models are generally easy to find and readily available to users;
- Model owners generally focussed more on communication of the results of modelling rather than communicating how the model works;
- The supporting information and technical papers for international models were often easier to access than those for NZ based models.

2.2 Purpose and use

- Models deliver on the main goals and scope for which they were initially built;
- Models were often developed to exclude policy considerations some relying on market trends as the basis of change, this was to primarily render models as 'policy neutral', and to create a sandbox for testing interventions. However, this approach is likely to have understated the role of government in the uptake of various technologies and influences on mode shift e.g. EV uptake. Some model owners also mentioned the need to be apolitical as a reason for designing models to be 'policy neutral';
- Several models are actively used to inform policy/decisions at a city or central government level e.g. ATAP; Productivity Commission's Low emission economy inquiry;
- Most models focused on business as usual activities or what is considered possible, rather than examining what may be needed to reduce emissions or deliver sustained mode shift;
- Scenarios in models are designed to address the uncertainty of model results and projections. The scenarios illustrate a defined range of possible results, given the uncertainty of predicting the future;
- A focus on electric vehicles as the main means of achieving transport emissions reduction in the future unnecessarily tempers the role other modes will play in future emission reduction;
- Air pollution models are rarely fully integrated or combined with GHG emissions;
- At least two of the international models investigated have been developed over a long period of time (over 20 years). This extended period has provided the basis for consistent measurements to produced.

2.3 Assumptions and limitations

- Model limitations are difficult to identify and required further discussions with model owners to adequately understand;
- The method for developing the scenarios included in a model is often unclear. Method paper rarely cover how different scenarios are derived or checked against stakeholder views.
- Most models rely heavily on the growth of electric vehicles, more so than other technology or service innovation for emissions reduction;

- Models include a heavy reliance of technology change e.g. use of electric vehicles, and the financial/economic impact of technology change;
- Models usually include cycling, walking and other active transport modes in a simple way.
- A lack of focus on active transport may lead to a significant underestimation of its potential;
- Integration of urban planning to deliver mode shifts is rarely supported in models. In turn the benefits of urban change on emissions or mode shift are not able quantified;
- Models tend to use the same or similar data sources e.g. the household transport survey. In turn, emission predictions within the models may be similar; and tend to suffer from the same data limitations or quality issues;
- Methods and assumptions used by each model are rarely documented well or readily available in background materials;
- Results derived in transport models are rarely tested with stakeholders or wider user opinion;
- In several cases models exclude rail public transport services, focussing on public bus services, even when rail passenger public transport services exist in urban centres. For example, the VFEM and VEMT models currently do not include rail;
- Models often do not include future public transport service innovation. For example, rapid transit bus services or light rail;
- International models developed over long periods have had their assumptions tested and updated over time to increase the accuracy of results.
- Most models are generally too complex for non-expert use.

2.4 Other areas covered

- Results from several models cover the impacts for air pollution and public health issues, as well as emission reduction;
- New Zealand has a small community of expert transport model developers; however, it appeared some modelling teams rarely worked directly together as some models seem to fulfil similar purposes;
- Technical teams rather than multi-disciplinary teams tend to develop models. There is little or no inclusion of social or behaviour change disciplines to counter or balance technical assumptions;
- There is no single method for emissions measurement across models. Some models use a top down fuel consumption approach while others use a bottom up tail pipe emissions approach.

3.0 Summary of findings for NZ-based models PART A

Table 1 below provides a summary table of all domestic (Part A models). More in-depth information on each model is provided below this table and in Appendix A. Please refer to the below key when interpreting the mode shift column.

Table 1: Summary of PART A models

Part A Model	Geography covered	Scale	GHG emissions included	Scenarios used	GIS-based	Forecasting		Addressed in the Model		
						Future GHG emissions	Future fleet	Land use	Extent of mode shift considered	Fleet
Transport Outlook - Future State	NZ	national, regional	Y	Y	N	Y	Y	N		Y
VEMT	NZ	national, regional, urban, rural	Y	Y	Y	Y	Y	N		Y
VFEM	NZ	national	Y	N	N	Y	Y	N		N
VEPM	NZ	national, regional, urban, rural	Y	N	Y	Y	Y	N		Y
Integrated Transport and Health Impacts Model-ITHIM	NZ	regional	Y	Y	Y	N	N	N		N
Concept's ENZ model	NZ	national	Y	Y	N	Y	Y	N		Y
Turning the Tide	NZ	national, regional	N	N	N	N	N	Y	N/A	N
Macro Strategic & Macro Public Transport Models	NZ	regional	Y	Y	Y	Y	Y	Y		Y
Creating a Positive Drive	NZ	national	Y	Y	N	Y	Y	Y		Y

Key – Extent of mode shift considered

Scale	Low	Modest	Ambitious
Key			

3.1 Transport Outlook: Future State - Ministry of Transport, New Zealand

Model details

This model is designed to provide a foundation for greenhouse gas measurement and the influence of mode shift between different technology and active transport modes. The model incorporates data from various supporting models to provide emission projections out to 2050. The model uses five scenarios including key drivers in population growth, technology change and economic growth to illustrate changes in emissions and transport patterns over time. The model has been developed as 'policy neutral'.

Strengths identified

The Transport Outlook model is one of the most sophisticated models in this review. The model can handle inputs from a wide array of supporting models and databases to gain a relatively detailed picture of projected emissions. For example, the model can demonstrate the extent the transport sector drives emissions reductions in comparison to implied GHG reduction targets including NZ's 2030 Nationally determined contribution (NDC) of 30%. The scenarios are useful for examining different options for emission reduction and can also be used as a method of understanding the emissions impact of market changes. The tool can also be used to examine the effect of potential policy initiatives to reduce emissions through shifts in transport mode.

Weaknesses identified

One of the major strengths of the Transport Outlook model can also be viewed as its major weakness. The complexity of the model makes it difficult to understand and use without expert knowledge. At this stage of development, it provides relatively conservative projections of future states. Assumptions for mode shift and public transport services need be developed further to provide understanding of active mode shifts compared to technology changes. For example, both the Household Travel Survey and the VFEM provide important inputs into the model. Both have limitations for projecting shifts to active transport modes.

Comments on use for mode shift

With a greater focus on active transport modes and incorporation of their underlying drivers, coupled with improvements in the data collection the Transport Outlook could be used to examine long-term trends in mode shift more accurately.

3.2 Vehicle Emissions Mapping Tool (VEMT) - New Zealand Transport Agency

Model details

The Vehicle Emission Mapping Tool is a Geographical Information Systems (GIS) tool that can be used to calculate and display estimated 'tailpipe' emissions levels for carbon dioxide and other air pollutants for all roads in New Zealand. The tool was developed by Jacobs for the NZTA (the model owner), who run the model when needed. The tool uses a bottom-up approach to calculate emissions for local roads and state highways.

Strengths identified

The strength of the VEMT model is its ability to estimate emissions for the fleet vehicle profile (excluding rail), for New Zealand. While VEMT does not have explicit 'scenarios', changes in the fleet make up and proportion of a given 'mode' can be calculated, where variables are adequately defined. The outputs of this model are used in several other models e.g., the Transport Outlook: Future State model, owing to the comprehensive assessment of the emissions of a given fleet profile. It can also use outputs from other traffic modelling exercises to estimate impact on emissions.

Weaknesses identified

The weaknesses of this model are the underlying assumptions, primarily the use of average annual speed as a key variable in emission projections. The (user defined) average annual speed reportedly may underestimate emissions from congested routes. To address this, the user must manually set up the model to model traffic congestion in higher resolution. VEMT has implicit assumptions about 'behavioural' impacts on driving (e.g. cold engine start driving practices), limiting its ability to fully calculate tail pipe emissions. The tool underestimates national vehicle emissions when compared to the national GHG inventory (possibly due to different methodologies). This tool is primarily focused on assessing vehicle emissions and may not be able to fully quantify emissions reductions from shifts to active modes. The model is constrained at the regional level by a lack of good quality data from territorial and local authorities. There is a reported 'bottleneck' effect occurring during running of the tool's vehicle emissions prediction module (VEPM) as an input, due to the large number of tables and data that need to be processed (e.g. each fleet profile) for input into the VEPM module.

Comments on use for mode shift

With the inclusion of rail transport and more explicitly defined active transport emissions reduction calculations, and an improved methodology for including the impact of congestion - this tool would be a useful way to understand emissions impacts from versions of the future fleet on specific local roads and state highways. However, any predicted changes to active modes will need to be included by using traffic demand modelling to show the implications for changes in VKT that can later be included as an input to VEMT.

3.3 Vehicle Fleet Emissions Model (VFEM) – Ministry of Transport

Model details

The VFEM model projects the makeup of future vehicle fleets, the kilometres travelled, energy (fuel and electricity) use and greenhouse gas (GHG) emissions. Data is provided for each year within the time period considered. The model produces average fuel consumption per 100km travelled for different vehicle categories. It considers number of registrations and scrappage of vehicles. The Ministry of Transport use the information as an input to other models for mode shift.

Strengths identified

The model is based on good quality data and is considered by users as fit for purpose. The assumptions for fuel for new and used vehicles have been calibrated against real world NZ consumption figures so the projections are robust. Another main strength is the flexibility to include inputs from other models and provide outputs for other more complex models used in the transport sector. For example, VFEM results are regularly used as an input into the Vehicle Emissions Prediction Model (VEPM), to help understand air quality and GHG emissions.

Weaknesses identified

The VFEM only considers bus public transport and no other alternatives such as rail or active modes. The impact of active modes and alternative public transport is only indirectly considered by the VFEM.

Comments on use for mode shift

With adjustment it may be possible to use the VFEM to study the impact of public transport and active mode shift on fleet make up more readily. For example, by factoring in a shift to autonomous vehicles or active modes of transport. In turn, this could help to include these mode changes in other models which use data from VFEM.

3.4 Vehicle Emission Prediction Model (VEPM) – New Zealand Transport Agency

Model details

VEPM is designed to calculate harmful emissions and fuel consumption of vehicles. It was developed to predict emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions. VEPM is a speed-based model with emission factors taken from international emissions databases. The New Zealand fleet profile for the years up to 2050 is provided from the base case Vehicle Fleet Emissions model (VFEM). The model can quantify the emissions associated with a specific fleet profile and from changes in the types of vehicles used in the fleet. VEPM is typically used as an input to other models for air quality modelling, regional emissions modelling or fleet management assessments. VEPM may be used as a sub-module to other transport emission modelling tools.

Strengths identified

The model enables reasonably robust emissions calculations of a specified NZ fleet, providing important insights into how the emission profile changes over time as new and different vehicles are introduced into the fleet. The model is regularly updated and opportunities for improving the model are actively pursed. For example, the 2019 updates have identified several areas for improvement including adding real-world emissions data to more accurately model real-world emissions, bus emission factors and an SUV category to the analysis. Recent portable emission measurement data (NZ Transport Agency research report 658) has shown CO2 emissions can vary by up to 40% from manufacturer type approval labelling. As a result, the model is an important input into other models including the Vehicle Emission Mapping Tool (VEMT).

Weaknesses identified

In terms of mode shift the main limitation of VEPM is that GHG emissions reductions or changes due to modal shift are calculated indirectly through the change to the fleet and use of VKT data. Changes in emissions will be included into the results but it will not be possible to easily show if the change was from/ to bus, rail, walking or cycling or other activities. Rail transport is not included in the model and bus emission factors are currently based on unrepresentative heavy commercial vehicle fleet emissions.

Comments on use for mode shift

Used in combination with transport models VEPM could be used to understand the implications of both technology change to reduce transport emission e.g. greater use of EVs and potentially mode shift. VEPM provides a foundation for other analysis in the transport sector. For example, combined with other models to understand regional emissions from transport in Auckland. Updates to the model including bus emission factors, the inclusion of rail and real-world emissions data may mean VEPM can be used to provide greater data for helping to analyse mode shift interventions that are modelled more directly in other transport models.

3.5 Health Consequences of Transport Patterns in NZ’s Largest Cities (ITHIM) - University of Otago/ CEDAR

Model details

This study used the Integrated Transport and Health Impacts (ITHIM) model to understand the health consequences of transport patterns in five New Zealand cities. The model assesses the health impacts of different modal choices, the emissions associated with increase in active and public transport modes, in addition to public health effects and health cost impacts.

Strengths identified

The strength of ITHIM is the ability to link physical health benefits, economic benefits and emissions reductions with a specified level of mode shift across cities (e.g. CO_2e reductions achieved if other cities had Wellington’s transport patterns). The model is MS excel based and can be adapted by experienced analysts to address other analyses as required. No specific policy assumptions are included so the model can test both baseline and intervention for a given year. The model is freely available to use upon request.

Weaknesses identified

The main weakness of ITHIM is that it does not include any transport or emissions calculation modules within the main model. These are required to be developed outside ITHIM. The model does not project mode shift, but the health effects associated with mode choice and other relevant variables. The study method is standardised to the Wellington transport patterns which may limit application to centres that are substantially different in form. From feedback in the interviews the active mode emission results are limited by data quality issues associated with the Household Travel survey samples that under-sample cycling. The model uses US based data sources in the air quality and physical health models, where NZ data is lacking and may not reflect regional conditions or trends precisely.

Comments on use for mode shift

This model could be used alongside other transport specific models to understand the important health co-benefits associated with mode shift in various New Zealand locations. This model is already in use by the Ministry of Transport and by other NZ academics. It is also used in the Transport Outlook; Future State analyses.

3.6 Summary Insights on Energy-related carbon abatement opportunities (ENZ model) - Concept Consulting

Model details & Scenario Overview

ENZ is a model designed and owned by Concept Consulting and includes a transport module that was used to model transport elements for the Productivity Commission's Low Emissions Economy Inquiry. A range of scenarios was modelled for this Inquiry, with variations exploring factors such as rates of change in EV costs (relative to ICEs), oil prices and scrappage.

Strengths identified

The strength of ENZ is its flexibility to model a range of variables related to transport and possible future states or pathways using MS excel. ENZ's land transport modules are able to calculate the emissions effects from low, medium and high 'variants' e.g. 25% uptake in PT over 30 years (low) vs 70% uptake in 30 years (high), and the flow on effects to passenger, light commercial, and heavy freight. The model reportedly has internally consistent linkages with other modelled sectors of the economy – particularly electricity in terms of electricity demand and price. The model also includes detailed cost assumptions and analysis for scenarios. The inclusion of oil price, international emissions price and vehicle scrappage variables allows for a more complete picture of the wider transport sector changes (e.g. vehicle scrappage and ownership) and challenges.

Weaknesses identified

The limitations of this model are the assumptions included to support mode shift, such as basing future mode shift proportions on scaled-up historical trends i.e. possible future BAU. This model is only able to test mode shift interventions where the policy intervention goals or levels have been set, it cannot be used to back cast or identify mode shift levels required to achieve a certain emissions outcome e.g. net carbon zero in 2050.

There is a strong emphasis on electric vehicle uptake as a driver of emissions reductions. Electric vehicles appear to be prioritised over other modes or technologies e.g. rail, land use change and urban planning considerations are not included in the land transport module.

Comments on use for mode shift

This model has potential to estimate effects of transport changes or packages at the national level. However, in its current form the model is geared towards electric vehicle uptake as the main driver of emissions reductions in the transport sector. A detailed understanding of any single intervention or package of changes would be required to use this model. Multiple public sector agencies e.g. Ministry for the Environment and the Interim Climate Change Commission are investigating this model for further use in setting provisional emissions budgets.

3.7 Turning the Tide - From cars to active transport - University of Otago (TALES Symposium) / Andrew Jackson Consulting

Model details

Turning the Tide: From Cars to Active Transport is a framework proposing active and public transport targets to 2050 and a set of policy recommendations based on NZ and international expert opinion and desktop review. The framework incorporates the NZ Government's Living Standards Framework as context to four themes of sustainable transport policy. The four themes are: (A) Evaluation, Governance and Funding; (B) Education and Encouragement/ Promotion; (C) Engineering (Infrastructure, Built environment); (D) Enforcement & Regulation. The framework sets three targets for proportion of trips by mode; increase walking to 25%, cycling to 15%, public transport to 15% and a reduction of trips by car to 45%.

Strengths identified

Aligning mode shift targets to the Living Standards Framework is useful primarily to integrate mode shift targets within a framework that is being applied more broadly across government for policy development. i.e. creating an opportunity to drive modal shift from other angles. Most of the recommendations are focused at the central government level and provide both legislative and non-legislative, carrot and stick suggestions based on expert opinion and peer reviewed literature to support achievement of sustainable transport outcomes.

Weaknesses identified

The framework does not quantify emissions reductions from mode shift or make any calculations regarding mode shift proportions out to 2050. The targets are designed to engage policy makers in a discussion about driving sustainable transport outcomes, and the policy recommendations have an unknown level of influence in driving the realisation of the targets. It is not known how far the targets support the achievement of national or sector specific greenhouse gas reduction targets at 2050. For example, net zero long lived gases or otherwise.

Comments on use for mode shift

Further work could be done on the emissions impacts from the proposed targets to identify the target level needed to meet net zero carbon for the sector in 2050. Any extra analysis could include mode shift and greenhouse gas impacts of the targets proposed and a supplementary literature review to ensure relevant interventions are captured.

3.8 Auckland Regional Macro Strategic Model (MSM) formerly known as ART; and Macro Public Transport Model (MPTM) formerly known as APT - Auckland Forecasting Centre (Auckland Transport & New Zealand Transport Agency)

Model details

The Macro Strategic Model (MSM) formerly known as ART is a multimodal tool that includes private and public transport modes, daily trip generations and assignment of trips in the AM peak, inter-peak and PM peak periods. Multiple trip purposes are modelled.

The MPTM is a more spatially detailed public transport demand model than MSM that focusses on passenger transport demands. MPTM is used to investigate public transport projects e.g. bus lanes, bus services changes. MPTM is based on much of the same underpinning data and assumptions used for MSM and therefore both models have been covered in this section to avoid repetition.

Strengths identified

MSM is suited to test the regional effects of a major project on both road and public transport demand. It is also designed and has been used to test road pricing / tolling policies. The model splits private and public transport modes (including rail and ferry) and can be used to investigate mode shift away from cars. The models can estimate air pollution metrics in post processing (including particulate emissions and NOx) in addition to carbon emissions. MSM can interface with the forecasting centre's other transport models and can be coupled with land use models for an integrated land use transport modelling of various policies and projects.

MPTM's strength comes from its detailed focus on demand for public transport services. The model can be used for predicting public transport crowding using source data drawn from city-based measurements or data.

Weaknesses identified

Possible weaknesses and limitations of the MSM / ART model were provided in brief, in a 2016 review report. The MSM model uses fixed person trip rates, which reduces the sensitivity of the model to interventions trying to influence behaviour through price-based demand management. The tool is not able to be used for economic, equity assessments that require detailed socio-economic segmentations. The report recommended that the model should also include vehicle classes that reflect ‘high occupancy vehicles’ and taxi and car sharing behaviours. Information to understand methodology, assumptions and limitations of the model are not readily available online.

Comments on use for mode shift

MSM and MPTM are two of a small number of models to give a fuller consideration to mode shift based on public transport in some detail, examining the impact of rail and ferry as well as bus services. The model also includes mode shift public behaviours sometimes not discussed in other models e.g. working from home and parking prices.

It is important to note the model is currently bespoke to Auckland and may need be heavily modified for application in other cities.

3.9 Creating a positive drive - Thinkstep

Model details

The ‘Creating a positive drive’ study targets what can be achieved in the transport sector if all technology improvements available today are implemented overnight. For example, focusing on applying a major shift electric vehicles and available biofuels to the current fleet rather than tracking changes over time. This model uses four scenarios to predict emission reductions. The main difference between the scenarios is the level of resistance to change in the sector, uptake of various fuel/ battery technologies and the amount of shared and collective technologies used, including public transport, cycling, ride sharing etc. All scenarios considered assume the improvements occur from today, indicating that New Zealand has significant potential in the present day to reduce the carbon footprint of our transport fleet, and therefore of our country.

Strengths identified

Unlike many of the other models reviewed, this model attempts to understand how behaviour change may complement the use of technology to reduce emissions in the transport sector. The model projects how using solutions already available through behaviour change, can rapidly decarbonise the NZ transport sector rather than assuming the market will deliver change in the future. This enables users to gain an insight of how they may best use technology or behaviour change to reduce emissions now, and in turn encourages action now rather than in the future. Another strength is the model can be used to examine changes needed for emissions reduction not always covered by transport models. For example, the increase in renewable energy needed for widespread use of electric or hydrogen vehicles (via industrial electrolysis) is factored in to models and included in the results.

Weaknesses identified

The growth of electric vehicles in NZ is assumed to be driven by market forces alone. EV uptake has been slower than expected in NZ when left directly to the market so ability of drivers to shift to EV technology may not be as easy as described in the model. The model relies on the current transport infrastructure and assumes no new technology or methods for mobility will be available in 2050. Active transport is only considered for short trips and the impact of active transport development e.g. e-bikes or e-scooter are not considered.

Comments on use for mode shift

The model has potential to be used for understanding the need for extra biofuels and renewable energy based on updated transport patterns. The assumptions in the model also could be varied to include the influence of urban planning and greater use of active transport in the future.

4.0 Summary of findings for International models PART B

PART B aimed to use the same method as for PART A but focused on models used outside of New Zealand. A short-list of models was chosen by NZTA for further investigation in PART B. Due to the limited number of models included, PART B should not be viewed as a comprehensive review of international models that address transport emissions, but a review of models that NZTA shortlisted for greater attention due to their relevance. More in-depth information on PART B models is available in Appendix A.

Table 2 below summarises key attributes of PART B models.

Table 2: Summary of PART B Models

Part B Model	Geography covered	Scale	GHG emissions included	Scenarios used	GIS-based	Forecasting		Addressed in the Model		
						Future GHG emissions	Future fleet	Land use	Extent of mode shift considered	Fleet
OECD MOLES	Currently being tested in NZ & Chile	urban	Y	Y	Y	Y	Y	Y		Y
NZTA Mega Maps	NZ	national, regional	Y	Y	Y	N	N	N		N
Aarhus University suite	Denmark (used internationally)	regional, urban	Y	Y	Y	N	N	N		N
DARTE	USA	national regional urban	Y	Y	Y	N	N	N		N
National Transport Model (NTM)	UK	national regional urban	Y	Y	N	Y	N	N		Y

Key – Extent of mode shift considered

Scale	Low	Modest	Ambitious
Key			

4.1 Multi-objective Local Environmental Simulator (MOLES) – Organisation for Economic Cooperation (OECD)

Model details

MOLES, is an environmental economic model for the long-run evolution of urban areas, focusing on the quantification of costs and benefits arising from various urban policies targeting land-use and urban mobility. MOLES evaluates the environmental and economic impact that certain policies would have in a specific city, quantifying their costs and benefits and highlighting possible trade-offs between environmental effectiveness and economic efficiency.

Strengths identified

The model is designed to help policy makers distinguish between different interventions that achieve best practice in balancing the trade-offs of increasing economic activity and improvements in environmentally quality. In doing so the model assesses some aspects of quality of life including time savings on leisure time and commuting as well as the environmental impacts including the carbon footprint of the transport sector. MOLES also attempts to factor in trends of urban development including densification of residential zones and expansion of underdeveloped areas. Within the model urban design policies that encourage active modes of transport can be varied e.g. parking policies and policies discouraging car dependency.

Case studies for the use of MOLES that are being finalised at the time of writing including one for Auckland, New Zealand which focusses on GHG emissions mitigation.

Weakness identified

The MOLES model can only be applied (for the moment) to cities/urban areas and cannot be used for rural areas. The model is relatively complex and can require detailed policy information to be accurate. Limitations are often based on the assumptions made about external variables used to develop the model. For example, the variables used to include population, income, and the pre-tax purchase cost of vehicles. The model also doesn’t account for broader environmental and health benefits associated with a high to low carbon transport shift e.g. the potential increased demand for electricity from a rise in the use of EVs. The level of detail the results would provide for the influence of a specific mode shift scheme, for example the City Rail Link is unknown.

Comments on use for mode shift

The consideration of urban development and policies designed to limit the use of cars within MOLES means the model is better placed than many other models to examine the influence of mode shift on GHG emissions. The draft final report on the Auckland case states the OECD cautiously believes the model can be applied elsewhere to cities with similar characteristics to Auckland. However, care needs to be taken because it is unclear the extent to which the spatial characteristics of Auckland drive the model’s results. The model is currently not publicly available, and it is unknown whether the OECD intends to make MOLES available to its member governments.

4.2 NZ Mega Maps – New Zealand Transport Agency

Model details

NZTA Mega Maps is designed to understand how the speeds for individual roads impact road trauma e.g. accidents, with the aim of increasing road safety overtime. The model is also able to estimate travel time (related to average speed), vehicle operating costs, air pollution emissions and provide an economic impact of these variables across New Zealand. The model provides a strategic tool for understanding the impact of policies that change speeds on different types of road, providing data in the form of GIS maps. The model is maintained by Abley Consultants on behalf of NZTA.

Strengths identified

Mega Maps can easily show geographically the influence road speeds can have on GHG emissions and estimate the costs of delivering savings associated with managing the speeds on different road types. While examining emissions savings from changes in speeds is not the primary focus Mega

Maps can be used to illustrate potential benefits of these changes. For example, if speeds on roads were lowered to reduce accidents, these changes would also result in a reduction of 120,000 tCO2e per year. Another strength of Mega Maps is that it can be used at a regional level to a relatively high level of accuracy compared to other models that rely on territorial authority data sources.

Weakness identified

For emission calculations Mega Maps is heavily dependent on other data compiled by the NZTA for the emissions from the current NZ car fleet. Any limitations of these models will influence the results produced by Mega Maps. This model does not directly include any active modes of transport or rail activities. Nor does it account for alternative fuel vehicles including the use of biofuel or the increased use of EVs. It may be inferred that the influence of public transport is included in the underlying assumptions about emissions savings caused by any associated speed reductions.

Comments on use for mode shift

The current version of Mega Maps has limited use for understanding how mode shift can be implemented. To understand policy interventions beyond understanding the current situation, the underlying assumptions would need to be expanded. Mega Maps does have the potential to help policy makers understand the influence of policies designed to encourage mode shift may have, if an intervention would also increase or reduce vehicle speeds. For example, where urban planning may change the speeds on different roads within a region.

4.3 Air pollution modelling suite (DEHM, UBM, OPSM) - AARHUS University (Denmark)

Model details

Aarhus University has developed a modelling suite that has been used for evaluating the effects on air quality for 20 years, most notably to measure the effect of the introduction of low emission zones in major Danish urban centres including Copenhagen. The main models used include the Danish Eulerian Hemispheric Model (DEHM), an urban background model (UBM) and an operational street air quality model (OPSM) and associated meteorology emissions data. Model outputs are displayed geographically with the resolution of mapping increasing over the 20 years the models have been in operations. The models have also been used to model the impacts of air pollutants across the northern hemisphere and occasionally in other parts of the world.

Strengths identified

The wide range of air pollutants that can be modelled by the suite is comprehensive. For example, DEHM includes 73 chemical species, 9 primary particles and 158 chemical reactions. The models are well understood and have been used in a wide range of applications. The models are supported by robust databases including the EU COPERT information that carries updates for road fleets, distribution and vehicle class, fuel type and emission standards. The models are also supplemented by information on annual traffic flows, vehicle distribution and transport speeds. Scenarios can be run for many different types of air pollutants for a region, for different air pollutants in urban and rural areas and for transboundary studies.

Weakness identified

The models do not focus on GHG emissions in detail but lower atmosphere air pollutants. The models do not directly address mode shift but can model the effects of mode shift indirectly through the reduction in emissions of air pollutants. Limitations are mostly related to the high level of data inputs required. For example, the OPSM model needs inputs of global radiation, roof level wind speed, an understanding of building height and geometry, and street length as background data. While the models have been used in the past to examine CO2 emissions this is not the focus of the models, and so it is not always clear how emissions from human induced sources can be included in the different studies.

Comments on use for mode shift

The models do not directly address mode shift but can model the effects of mode shift indirectly through the reduction in air pollutant emissions. In the case of the low emission zone where active transport modes have been included e.g. increased use of public transport and cycle ways, the air pollutant modelling has been used to confirm direct measurements of the reduction of harmful pollutants - not including greenhouse gases.

4.4 DARTE – Distributed Active Archive Centre for Biochemical Dynamics (NASA, USA)

Model details

DARTE is the first nationally consistent inventory of US on-road CO2 emissions built from bottom-up activity data, and establishes a national benchmark for monitoring, reporting, and verification of emissions vital for regulating greenhouse gases. The database provides a benchmark and resources for policy makers, researchers and stakeholders intending to investigate transport emissions.

Strengths identified

The database contains information for a 38-year period from 1980 to 2017 and is open source. The model outputs GIS files that can be used for greater spatial analysis of emissions across an area of the USA. Inventories are provided in 38 individual GeoTIFF files with 1-km spatial resolution. Each GeoTIFF file is a separate year of CO2 emission estimates. A Geodatabase file containing all years of data is also included. The information is relatively accessible and can be used at whatever level is needed by the user to provide a foundation for other investigation of emissions.

Weakness identified

Transport technology assumptions are based on the continued use of conventional internal combustion engine models. It is not easy to understand how the use of EVs or biofuel would be captured in the DARTE data modelling.

Comments on use for mode shift

DARTE provides an open access database for road emissions that can be downloaded and used to study different scenario or policy interventions at the urban and state-wide level. The database does not directly address mode shift but can model the effects of mode shift indirectly through the reduction in emissions from active transport if traffic or the number of vehicles is reduced. Importantly it is useful to have a baseline source that further work on emissions calculation in the USA can be based on.

4.5 National Transport Model (NTM) – Department of Transport (UK)

Model details

The UK's National Transport Model (NTM) is used to provide a systematic means of comparing the national consequences of alternative national transport policies or widely-applied local transport policies. Total tailpipe emissions of three key pollutants - CO2, NOx and PM10 - using emission equations as a function of speed are typically modelled at a detailed level (by time period). The NTM has been developed and updated following 10-year plans for over 20 years. The NTM is used to produce road traffic forecasts out to 2050. Seven scenarios are examined in the latest edition of the forecasts to investigate the influence of GDP growth, population growth, changes in trip rates and the penetration of EVs.

Strengths identified

The NTM has been used to show the impacts on trips, traffic and travel costs of a wide range of policies including improvements to road and rail networks, changes in costs and typical local transport initiatives. Much of the data that supports the NTM is the UK's National Transport Survey (NTS), last updated in 2014. The UK's NTS is a long-running survey which uses a well understood methodology to collect a broad range of information on travel behaviours at the national (e.g. England/Wales) level. The survey covers public transport (both rail and bus) and active transport modes (cycling and walking). This enables walking, cycling and public transport to be included directly in the NTM. The

NTM is flexible as there are several regional or city specific versions to ensure better understanding policy making in different parts of the UK including London, the East Midlands, and Yorkshire.

Weakness identified

Typically, each scenario modelled is based on different assumptions which lowers comparability, although there some aspects that are kept constant such as high or low GDP, fuel prices etc within the seven forecast scenarios. Short walk information is known to be traditionally underrepresented in the NTS and in turn the NTM. The NTM does not include motor cycles nor does it include the relationship describing the impact of cycling on road capacity and traffic congestion. Further development of the NTM is also needed to distinguish travel between cities, medium towns and small towns. The NTM at the time of writing lacks a spatial modelling output. The lack of spatial data limits the range of policy applications the NTM can be used for.

Comments on use for mode shift

The NTM already includes public transport and active transport modes but does not include land use change and urban development that may enhance the use of alternative transport. The main model and its supporting models and database are regularly updated. The semi-regularly emissions forecasts produced by the NTM enable progressive changes in policy and technology approaches to be captured.

5.0 Overall findings and recommendations

Based on our in-depth desktop review and interviews with model owners, we have several key points and recommendations for NZTA to consider.

5.1 Review Limitations

As highlighted above this project was completed in a short-time scale. During this project it was found much of the information needed about the methodology the models examined was not readily available. The lack of information in the public domain or available via direct request prevented a full review of the methods used for each model. For the models that are used as the basis of future decision making or policy development on mode shift it is important to ensure model method papers are readily available and can be accessed by potential users. The review was only able to obtain input from a small sample of stakeholders involved in model development. To decide on the best solutions for modelling active transport modes greater input from users and policy developers is required. When interpreting the results of this review these limitations should be fully considered.

5.2 Summary of Findings

5.2.1 Overall

The most important finding was that none of the models reviewed were able to project or analyse mode shift outcomes in all areas. There is no New Zealand model that stands out as being able to robustly project mode shift changes as a result of different potential interventions. This is largely due to the way public transport and active transport modes have been considered in the models to date.

None of the reviewed models clearly showed New Zealand could meet net zero carbon reduction entirely from vehicle technology change, suggesting an opportunity for greater consideration of the role of active transport and initiatives that would support public and active transport. Most models are focused on technological changes and/ or scenarios that were closely aligned to business as usual and current transport patterns.

However, the review did find that the scenario-based models (including Transport Outlook: Future State, ENZ and Creating a Positive Drive) were sufficiently dynamic and could be set up to test a range of settings and variables, including future use of public and active transport mode shifts. Other models including VEPM can be potentially updated to provide more detailed insights (either directly or indirectly) on the contribution of mode shifts to GHG reductions. In terms of public transport, the models run by Auckland Transport are increasingly able to forecast the implications of changes to transport policy.

In PART B it was observed transport modelling has been planned and developed over a longer period than in New Zealand. The committed development of models has enabled many of the known shortcomings of the models to be addressed. For example, the NTM in the UK has been updated according to agreed and published ten years plans since the late 1990s. The planned development of models has benefits including providing opportunities to receive feedback on improvements from stakeholders, the capture of long-term policy and economic trends and the ability to regularly update model forecasts. The NTM's supporting databases have also focussed more on alternative modes of travel including public transport, cycling and walking and so are more adept at predicting how these may change in the future than many current NZ models.

In the case of the NTM and the Danish Aarhus University suite of models the development of models has had a level of co-ordination applied. This means the models are often more complementary and less likely to be developed in isolation thus increasing the usefulness of their results.

5.2.2 Challenges

Challenges remain across all the transport models investigated in this work in adequately addressing several important considerations for improving mode shift. For example, the contribution of land use and urban planning is very rarely addressed in any level of detail or at a spatial resolution useful for policy makers looking to increase mode shift at a local level. Models also often omit the use of biofuels and disruptive technologies e.g. autonomous vehicles, from their results.

The transport models reviewed were often very complex, especially the scenarios-based models that attempt to give insight into the future. The complexity means including public transport or active mode shifts will take a concerted effort to ensure correct data is used to underpin the modelling of mode shift for mobility.

Developing ways that allow stakeholders to access results aimed at active mode shift are needed to show the potential of biofuel, urban planning, rapid transit schemes or other approaches alongside technology changes including EV introduction. Efforts to document and explain assumptions and relationships between key variables in plain English would be a positive step forward.

5.2.3 Addressing modal shift in models

To be more effective in estimating mode shift changes and associated emissions reductions at 2030 and 2050, models would need to address the following:

- The contribution of urban planning and the spatial elements of transportation interventions e.g. transport oriented corridors;
- Inclusion of variables to measure changes in public transport and active transport provision and uptake;
- The limitations with underlying data, for example feedback during interviews suggested there are important limitations in the sampling of active transport modes in the Household Travel Survey. Many model owners also discussed a lack or inconsistency of quality data at a regional level;
- Greater transparency in the development of scenarios used in models. If the process for developing scenarios was clarified this may improve the ability of models to include scenarios aimed specifically at addressing active mode shift;
- Scenarios need to develop and apply a 2050 lens and allow further analysis of 2030 and 2050 GHG emissions goals. Feedback during the project included several comments that the scenarios included in current models are often unambitious and fell short of shedding light on options for reducing emissions in line with stated goals;
- Commonly held assumptions about the economic and business case of public transport or active transport in NZ, may need to be challenged. For example, a few model owners suggested they believe the economics do not stack up for public transport, and so it wasn't worth considering in detail in their models;

- Models that are used for policy interventions should have a long-term plan for development, if possible. Such a plan should set up a schedule for the updates needed for supporting sub-models and databases;
- Transport forecasts should be updated on a regular cycle but not necessarily always on a policy neutral basis, as this often has the effect of limiting the detailed investigation of the active transport modes or disruptive technologies and often leads to a focus on business as usual.

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