

User guide: Traffic Model Emissions Tool

Calculating emissions from traffic model outputs

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The Traffic Model Emissions Tool has been developed by Beca for Waka Kotahi NZ Transport Agency for calculating emissions from transport model outputs.

It can be used to estimate the changes in vehicle emissions¹ associated with a proposed transport project or a transport policy intervention.

The tool includes basic instructions for users; this guide provides further background information to aid understanding of the methodology used.

The tool is available for download from the Waka Kotahi website.

[Traffic Model Emissions Tool](#)

1 Introduction

The Traffic Model Emissions Tool applies emission rates sourced from the Vehicle Emission Prediction Model (VEPM), to “link and turn” (intersection) output data from a traffic model. Although developed for outputs from traffic models developed in SATURN software, its use of link and turn data means it is readily applicable to other model systems.

The method adopted in the tool is to apply emissions rates to each link in a traffic model, based on the average traffic speed on that link. The tool makes use of both link and turn (intersection) data from the traffic model to determine the average speed of each link (that is, the average link speed includes intersection delays at the end of the link).

The tool allows flexibility in what user classes are available in the project traffic model (allowing for up to 12 model user classes) which are then classified as “total vehicles” or as one of three vehicle types (light vehicles, heavy vehicles or buses). Models with only a single, combined user class are accommodated by using fleet-average VEPM emission rates.

2 VEPM data

The emission rates are sourced by undertaking a bulk-run of VEPM to output emission rates by vehicle class in the model year for speeds from 10 km/hr to 110 km/hr in 1km/hr increments (the speed range in the VEPM is currently set to a minimum of 10km/hr and a maximum of 110km/hr). Note that if the specified speed in VEPM is outside the valid range for the vehicle type or group, VEPM will calculate emission rates for the closest valid speed. The VEPM outputs are then copied and formatted to the Traffic Model Emissions Tool which matches the emission rates to the speeds for each vehicle class (light, heavy and bus vehicle classes).

The key variables in the emission rates in most assessments will be assessment year, vehicle speed and vehicle type. Other influences of emission rates include road gradients, average trip length, ambient temperature, and heavy vehicles load. The practitioner should consider if default values for these input assumptions in VEPM are appropriate for the assessment of enabled vehicle emissions in the study area,

¹ VEPM predicts emissions of the following contaminants: carbon monoxide (CO), carbon dioxide equivalent (CO₂-e), volatile organic compound (VOC), oxides of nitrogen (NO_x), nitrogen dioxide (NO₂), exhaust particulate matter (PM_{2.5}-e), and particulate matter from brake and tyre wear (PM_{B&T}).

and if not, modifications to the default values should be appropriately justified and documented. In the case of gradients, the available options in VEPM are 0%, +/-2%, +/-4% and +/-6%². Roads in the study area should be categorised by road gradient according to these options, and the appropriate emissions rates should be extracted from VEPM and applied in the tool.

3 Traffic model data

3.1 Data format

The tool requires data to be supplied from the traffic model in the following format for each link and turn:

- A-node (prefixed with a 'C' if centroid connector)
- B-node (prefixed with a 'C' if centroid connector)
- C-node if a turn, otherwise blank
- Link distance (m)
- Travel time (s)
- Blank (this field is not used but could include capacity)
- Total demand flow in vehicles or Passenger-Car Equivalents (PCUs)
- Demand flows by user class, in vehicles or Passenger-Car Equivalents (PCUs)

Other traffic model software output files can be readily adapted to match this format.

As listed above, total demand flow is a required input (in addition to flows by user class). The tool is set up to accommodate an adjustment to flows by user class to match total demand flows (which may be required for Saturn models using PassQ files).

Traffic models will typically have two or more user classes and the tool is set up to accommodate between 1 and 12 user classes. Models with only a single, combined user class are accommodated by using VEPM fleet-average rates. In such circumstances, the total demand flow column (Column G) should be repeated in Column H for the correct functioning of the tool.

3.2 Flow units

The units of flow (PCUs or vehicles) will depend on the user classes used in the traffic model, and the corresponding PCU-factor is set in the tool (in the 'Summary' tab).

Traffic models such as SATURN can export traffic flows as either demand or actual (arrival) flows. For assessment of enabled emissions from vehicles, demand flows should be used to ensure partially completed trips are accounted for.

3.3 Centroid connectors

It is recommended that travel data on zone centroid connectors are exported and included in the VEPM assessment. While zone centroids don't represent real roads, they do represent real travel (typically on local streets/driveways not included in the modelled network). Additionally, where models have multiple centroid connectors, different network options can alter the choice of connector used, as part of calculating least-cost paths. Omitting the centroid travel will arbitrarily omit such relevant changes in overall system travel.

3.4 Demand changes

Both road capacity and alternative-mode projects are likely to alter travel patterns, either by induced-traffic or mode-shift effects. It can be important to capture such effects as the VEPM results are influenced by:

² If roads in the study area are above +/-6%, then further research on factors to apply to the available VEPM emissions rates would be required.

- changes in the quantum of vehicle travel, as typically reflected in origin-destination matrices
- changes in vehicle kilometres travelled (VKT) due to changes in the routes taken through the network
- changes in congestion, and hence emission rates per kilometre
- changes in the forecast future vehicle fleet, as reflected in the average emission rates for future years estimated by VEPM

Some of these effects influence emissions in opposite directions, and the congestion influence means that changes in emissions are not always directly proportional to changes in VKT. Sufficiently precise network models and demand-responses are therefore recommended to be used in such analysis.

4 Spreadsheet

4.1 Process

The spreadsheet includes an 'Instructions' tab which outlines the step-by-step procedure of applying VEPM to each set of traffic model outputs.

The basic process for each set of traffic model data (being defined by the model year, peak and scenario³) is as follows:

1. The tool determines if each row of traffic model data represents a link (SEG), a turn (TURN), or a centroid connector (CONN).
2. Vehicle kilometres travelled (VKT) are calculated by multiplying the demand flows by the link distance
3. The tool uses total flow to calculate volume-weighted average turn time for each user class.
4. The average speed for each approach link is then calculated by including the link time and the volume-weighted average turn time. The average speed for each user class is thereby identical.
5. An emission rate (in g/km) and the rate of fuel consumption (L/100 km) is then calculated based on the average speed. Emissions are assessed for carbon monoxide (CO), carbon dioxide equivalent (CO₂-e), volatile organic compound (VOC), oxides of nitrogen (NO_x), nitrogen dioxide (NO₂), exhaust particulate matter (PM_{2.5-E}), and particulate matter from brake and tyre wear (PM_{B&T}).
6. The actual emissions are then calculated by multiplying the rate (in g/km) by the VKT. Likewise, fuel consumption (FC) is calculated by multiplying the rate (L/100 km) by the VKT.
7. The total emissions and total fuel consumption are summed across all links in the model extent.
8. The total emission outputs and total fuel consumption are summarised in the 'Summary tab'. Note the conversion of the units from grams to tonnes for emissions outputs and from L to 1000 L for fuel consumption outputs.
9. A summary by vehicle type is presented in the scenario tab.

4.2 Appropriateness of the tool and checks

Detailed checks on the process are recommended, such as:

1. Are the flow units, distance units, and travel time units correct and consistent between the traffic model outputs and the spreadsheet?
2. Are the flow units consistent between the Total demand flow column and the Flows by user class columns?
3. Are the emission rate lookup tables appropriate to the scenario/year being evaluated?
4. Have the calculation formulas in each tab of the tool been extended to cover all rows of input data?
5. Has each tab correctly selected the correct user class (or classes) and emission lookup table?

³ If variable road gradients in the study area are being accounted for, link gradient would be an additional category by which the traffic model data would need to be grouped.

6. Does the total VKT from the tool match that in the traffic model?
7. Validation of selected links is recommended by manually applying the VEPM emissions rate to that individual link.

Additionally, where feasible the predicted changes in link emissions should be viewed graphically to check the appropriateness of results. That is, viewing each link spatially either by a GIS-type interface or re-importing the links back into the traffic model is recommended.

4.3 Version control

This note refers to Version 2.3 of the spreadsheet tool. A version-control table is included in the 'Instructions' tab and should be used if any changes are made to the tool. It is recommended that any major structural changes result in an increase in the integer number (e.g. Version 3.0) while minor changes are reflected in updates to the decimal place (e.g. version 2.3).

The significant updates incorporated in this version 2.3 of the tool are summarised as follows:

- Providing a summary table for traffic modelling methodology and assumptions.
- Introducing a new category for buses.
- Providing nitrous oxide (N₂O) emission factors.
- Replacing carbon dioxide (CO₂) with carbon dioxide equivalent (CO₂-e) emission factors.
- Introducing 'macro' runs that allow for more efficient spreadsheet operation when dealing with larger data sets.

Further information

- [Traffic Model Emissions Tool](#)
- [Transport model development guidelines](#)
- [Vehicle Emissions Prediction Model](#)
- Contact the Waka Kotahi Environment and Sustainability team, email environment@nzta.govt.nz