Transport Outlook Vehicle Fleet Emissions Model

(Version 2)

Short name

'VFEM2' or 'Fleet Model'

Purpose of the model

This model projects the makeup of the future vehicle fleet and their travel, energy (fuel and electricity) use and greenhouse gas (GHG) emissions.

Software used

☐ **Excel**

☐ **Tableau**

☑ **SAS**

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1. At a high-level, what does this model do?

This model projects the makeup of future vehicle fleets and their kilometres travelled, energy (fuel and electricity) use and greenhouse gas (GHG) emissions.

The original version of Ministry of Transport's Vehicle Fleet Emissions Model (VFEM) was a spreadsheet model. We have revised the model to enhance its performance. The current version, referred to as VFEM2, is operated on the SAS platform. VFEM2 consists of a number of SAS files and needs to read a number of huge datasets. It is therefore not easily used by external people. We recommend that those interested contact the Ministry of Transport for possible arrangements.

The model estimates data for historic years (since 2001) and projected years (up to 2040). The data is broken out by:

- vehicle type;
- vehicle age;
- NZ new or used import;
- engine size bracket (light vehicles) or gross vehicle mass bracket (trucks and buses);
- fuel type.

The data produced includes:

- number of vehicles
- vehicle travel (vehicle kilometres travelled);
- fuel use;
- GHG emissions.

The vehicle types and fuel types included in the model are described in Tables 1 and 2 below.

Table 1: Vehicle types and sizes in VFEM

Code	Vehicle type	Size bands				
1	Cars and SUVS	0-1299cc	1300-1599cc	1600-1999cc	2000-2999cc	3000+cc
2	Vans and utes	0-1299cc	1300-1599cc	1600-1999cc	2000-2999cc	3000+cc
3	Shared use cars and SUVs	0-1299cc	1300-1599cc	1600-1999cc	2000-2999cc	3000+cc
4	Shared use vans and utes	0-1299cc	1300-1599cc	1600-1999cc	2000-2999cc	3000+cc
5	Mopeds and motorcycles	<60cc	60+cc			
6	Light trucks	<5000kg	<7500kg	<10000kg		
7	Heavy trucks	`	<25000kg	<30000kg	30000+kg	
8	Buses	<7500kg	<12000kg	12000+kg		

Table 2: Fuel types in VFEM

Fuel type for vehicles	Code
Petrol	1
Diesel	2
Petrol hybrid	3
Diesel hybrid	4
Electric	5
Petrol plugin hybrid – fuel and electricity	6
Diesel plugin hybrid – fuel and electricity	7
LPG/CNG	8
Other	9

2. Where do I find the model results?

After VFEM completes calculations for all five scenarios, a summary file is produced (VFEM run20170719_Adj_ghg&fuel_FY.xlsx). On the "Total_CO2" sheet of the summary, one can find total GHG emissions (CO2-e), GHG emissions per capita, GHG emissions per vehicle kilometre travelled, and GHG emissions per vehicle in each projection year for all scenarios. The "Five_Scenarios_data" sheet contains detailed results. Users can do more customised analyses on the data (for example, by using the Pivot Table tool).

3. What are the inputs to this model and where do they come from?

There are many inputs to VFEM 2. The structure of the key data files is presented in the Appendix:

- historic fleet mix
- historic vehicle annual travel by vehicle type, size, age, fuel type/engine technology
- historic scrappage breakdown
- historic registration new/used import breakdown
- historic registration vehicle age breakdown
- energy (fuel and electricity) use per 100km travelled by vehicle type, size, manufacturing year and fuel type/engine technology. There are energy factors for every year from 1980 to 2040
- future vehicle registration mixes - by vehicle type, size, fuel type/engine technology entering the fleet each year up to 2040 (see Section 4 below)
- future fleet size generated by the separately-documented VKT/Vehicle Numbers Model
- future fleet travel generated by the VKT/Vehicle Numbers Model
- Future and historic amounts of CO2 produced for each kilowatt hour of electricity used. These factors drop over time, as our electricity generation becomes more sustainable.

The first five data inputs, including the historic fleet mix and vehicle travel data, are obtained from analysis of the Motor Vehicle Register (MVR) database, which is administered by the NZ Transport Agency. The data on future and historic amounts of CO2 produced for each kilowatt hour of electricity used are provided by the Ministry of Business, Innovation and Employment. Energy

factors for different vehicle categories are obtained in a research project conducted by Emission Impossible[1].

4. How does this model derive its results?

VFEM2 is essentially a calculator and similar to an average emission factor model.

To project vehicle fleet mix in future years, it uses the historic vehicle fleet mix as the base data, for example, those for the fleet years from 2001 to 2015. The process works through each projection year to 2040, starting with the most recent, to determine the size and makeup of the future vehicle fleets. The steps the model goes through for each projection year are as follows:

- use the recent levels of vehicle scrappage (the last three years' averages, e.g. 2013-2015 averages for the 2016 projection year) to work out how many existing vehicles survive to the next modelled (projection) year
- use VKT/Vehicle Numbers Model projected vehicle numbers by type (cars/SUVs, vans/utes, shared cars, shared van/utes, motorcycles, trucks, buses) to work out how many vehicles of each type need to be registered into the fleet in the next projection year; the vehicles surviving scrappage plus the new registrations must match the projected vehicle numbers from the VKT/Vehicle Numbers Model
- use the new/used import average mix in the last three years (e.g. the average for 2013-15 for the 2016 projection year) to split the new registrations that are needed into new and used imports
- use the exogenously-specified fleet feed-in mixes to determine the mix of vehicles that will be newly registered by their characteristics (age, fuel type, engine size, new/used). There is a different feed in mix for each year from 2016 to 2040. These mixes have been specified by the model developers and are shown in the file Vehicle feedin v12; note that there are different tabs for the different scenarios. Except for the fuel type, future feed-in mixes largely follow the 2013-2015 feed-in mix. However, as discussed in the main *Transport Outlook: Future State* document, the number of electric and plug-in hybrid vehicles in the mix increases over time

Using a similar procedure to that followed for the mix of vehicles, VFEM2 also takes as input the projected annual travel values from MOT's VKT/Vehicle Numbers Model and splits them across the fleet using the historic travel patterns (based on last three years' averages). It then works out the amount of liquid fuel and electricity required for each specific vehicle category in each specific year using the following formula:

Energy use = Energy factor (energy use / vehicle-km) × Vehicle travel (vehicle-km in a year)

[1] Metcalf J. and Sridhar S. (2016), Real world energy use projections for VFEM; Report prepared for Ministry of Transport.

Appendix: Vehicle Fleet Emissions Model (Version 2) – Structure of Key Data Files

Vehicle types	Size bands(*)	Fuel types	New/ used	Vehicle age	Projected and historic years	Data value	Cells
8	5	9	2	31	40	4	3571200
1. cars and SUVs	5 CC bands	1 conventional petrol		Current year	2001-2040	Vehicles	
2. vans and Utes	5 CC bands	2 conventional diesel		plus the 30		Total travel	
3. shared ownership - cars	5 CC bands	3 hybrid petrol		Before		Scaled travel (**)	
4. shared ownership - vans	5 CC bands	4 hybrid diesel				Fuel used	
5. motorcycles	2 CC bands	5 LPG/CNG					
6. light trucks (*)	3 GVM bands	6 plugin hybrid - petrol			CO2 and fuel used worked out during		
7. heavy trucks (*)	4 GVM bands	7 plugin diesel hybrid - diesel			reporting steps		
8. buses	3 GVM bands	8 battery electric			Fuel used=fuel factor*scaled travel>		
		9 hydrogen fuel Cell/ wild card			CO2 is a linear function of fuel used		

(*) light truck GVM bands are :
1. < 5000
2. < 7500
3. < 10000

heavy truck GVM bands are :
1. < 20000 (incorporates the old < 15000)
2. < 25000
3. < 30000
4. >= 30000

(**) travel is scaled to match the results of the VKT/Vehicle Numbers model

Fuel factors in energy/vehicle kilometre travelled					
From the consultation with EECA, MBIE, MfE and NZTA					
Vehicle types	Size bands	Fuel types	New/ used	History years	Cells
8	5	11	2	71	51120
Cars and SUVs	5 CC bands	1. Conventional Gasoline		1970-2040	
Vans and Utes	5 CC bands	2. Conventional Diesel			
Shared ownership - cars	5 CC bands	3. Hybrid Gasoline			
Shared ownership - vans	5 CC bands	4. Hybrid Diesel			
Motorcycles	2 CC bands	5. LPG/CNG			
Light trucks	3 GVM bands	6. Plug-In Hybrid - Petrol			
Heavy trucks	4 GVM bands	7. Plug-In Hybrid - Diesel			
Buses	3 GVM bands	8. Battery Electric			
		9. Hydrogen Fuel Cell/Wild card			
		10. Plugin petrol hybrid - electricity			

		11. Plugin diesel hybrid - electricity			

Scrappage history (2001-2015) in number of vehicles						
Vehicle types	Size bands	Fuel types	New/ used	Vehicle age	2001-14	Cells
8	5	2	2	31	14	69440
Cars and SUVs	5 CC bands	Conventional Gasoline		Current year		
Vans and Utes	5 CC bands	Conventional Diesel		plus the 30		
Shared ownership - cars	5 CC bands			before		
Shared ownership - vans	5 CC bands					
Motorcycles	2 CC bands					
Light trucks	3 GVM bands					
Heavy trucks	4 GVM bands					
Bus	3 GVM bands					

Ongoing scrappage factors in percent – these are based on an average of actual 2013 to 2015 values for the first projection year (2016) and rolling averages of the prior three years thereafter					
Vehicle types	Size bands	Fuel types	New/ used	Vehicle age	Cells
8	5	2	2	31	4960
Cars and SUVs	5 CC bands	Conventional Gasoline		Current year	
Vans and Utes	5 CC bands	Conventional Diesel		plus the 30	
Shared ownership - cars	5 CC bands			before	
Shared ownership - vans	5 CC bands				
Motorcycles	2 CC bands				
Light trucks	3 GVM bands				
Heavy trucks	4 GVM bands				
Bus	3 GVM bands				

Registration history (2001-2015) in number of vehicles						
Vehicle types	Size bands	Fuel types	New/ used	Vehicle age when first registered	2001-14	Cells
8	5	9	2	31	14	312480
Cars and SUVs	5 CC bands	Conventional Gasoline		Current year		
Vans and Utes	5 CC bands	Conventional Diesel		plus the 30		
Shared ownership - cars	5 CC bands	Hybrid Gasoline		before		
Shared ownership - vans	5 CC bands	Hybrid Diesel				
Motorcycles	2 CC bands	LPG/CNG				
Light trucks	3 GVM bands	Plug-In Hybrid - Petrol				
Heavy trucks	4 GVM bands	Plug-In Hybrid - Diesel				
Bus	3 GVM bands	Battery Electric				
		Hydrogen Fuel Cell/Wild card				