VEPM 5.3
Vehicle Emission Prediction Model update:
Technical report

Prepared for
NZ Transport Agency
April 2017
Authors: Jayne Metcalfe, Surekha Sridhar
Organisation: Emission Impossible Ltd
Date: April 2017
Peer reviewer: Shanju Xie, Auckland Council

Recommended Citation:


Acknowledgements

Funding for this update of VEPM was provided by NZ Transport Agency, Ministry for the Environment and Auckland Council. The authors would like to thank Stuart Badger (Ministry of Transport) for providing updated fleet and country of origin data, and Shanju Xie (Auckland Council) for his peer review.
Executive summary

The NZ Transport Agency commissioned an update of key assumptions and emission factors in Vehicle Emission Prediction Model (VEPM), which was last updated in 2012 (EFRU, 2012). These include:

- Updating the fleet
- Incorporating nitrogen dioxide (NO₂) in VEPM
- Updating emission standards that are assumed for vehicles entering the fleet
- Updating country of origin assumptions
- Updating emission factors for Euro 5, 6 and V
- Adding EURO VI emission standards

The vehicle fleet was updated based on updated vehicle kilometres travelled (VKT) data from the Vehicle Fleet Emission Model (VFEM) provided by Ministry of Transport. VFEM data up to 2014 is based on analysis of historical fleet and travel data as reported in the Annual Fleet Statistics 2014 (MoT, 2014).

Projected default fleet weighted emission factors in VEPM 5.3 are slightly lower than VEPM 5.1 after 2030 due to:

- Changes in Ministry of Transport vehicle fleet projections; and
- The incorporation of Euro VI and V emission factors for heavy duty vehicles (HDVs).

However, in general, the fleet weighted emission factors from the updated VEPM 5.3 are similar to VEPM 5.1.
Contents

Executive summary........................................................................................................................................i

1.0 Introduction........................................................................................................................................1

1.1 Background and scope .........................................................................................................................1

1.2 Purpose and scope of this report ........................................................................................................1

2.0 Method ...............................................................................................................................................2

2.1 Vehicle fleet .......................................................................................................................................2

2.1.1 Updated vehicle fleet ..................................................................................................................3

2.1.2 Overall fleet breakdown .............................................................................................................3

2.1.3 Detailed fleet breakdown ............................................................................................................5

2.2 Incorporating NO\textsubscript{2} in VEPM ..........................................................................................6

2.3 Emission standards and country of origin ..........................................................................................7

2.4 Emission standards date of introduction .........................................................................................8

2.5 Emission factors ...............................................................................................................................10

2.5.1 Heavy vehicle weight categories .............................................................................................12

3.0 VEPM 5.1 versus VEPM 5.3 ..............................................................................................................12

3.1 Effect on fleet weighted emission factors .........................................................................................12

3.1.1 Discussion of the fleet weighted emission factor comparison ..................................................15

3.2 Light duty diesel NO\textsubscript{x} emission factors ............................................................................16

3.3 NO\textsubscript{2} emission factors ...........................................................................................................17

4.0 Future updates ....................................................................................................................................18

5.0 Conclusions .......................................................................................................................................18

References ..................................................................................................................................................20
1.0 Introduction

1.1 Background and scope

The Vehicle Emissions Prediction Model (VEPM) was developed by the NZ Transport Agency (hereafter referred to as the Transport Agency) and Auckland Council to predict emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions. The model provides estimates suitable for air quality assessments and regional emissions inventories.

VEPM requires a detailed breakdown of kilometres travelled by the fleet. Fleet weighted emission factors are calculated by multiplying the emissions factors in g/km for each vehicle class by the proportion of kilometres travelled by that class for any given year.

The Transport Agency commissioned Emission Impossible Ltd to update key assumptions and emission factors in VEPM, which was last updated in 2012. These include:

- Updating the fleet
- Incorporating nitrogen dioxide (NO$_2$) in VEPM
- Updating emission standards that are assumed for vehicles entering the fleet
- Updating country of origin assumptions
- Updating emission factors for Euro 5, 6 and V
- Adding Euro VI emission standards

1.2 Purpose and scope of this report

This technical report:

- Provides details of the vehicle fleet update
- Describes the incorporation of NO$_2$ in VEPM 5.3
- Describes the update to emission standards and country of origin assumptions, and
- Summarises the differences in fleet weighted emission factors between VEPM 5.1 and VEPM 5.3.

Further information and technical reports relating to development of the Vehicle Emission Prediction Model are available on the Transport Agency’s Highways Information Portal website.

---

1 Vehicle emissions prediction model (VEPM) version 5.1, Energy and Fuels Research Unit, Auckland University (2012)
2.0 Method

2.1 Vehicle fleet

Fleet weighted emissions are calculated in VEPM by multiplying the emissions factors in g/km for each vehicle category by the proportion of vehicle kilometres travelled (VKT) by that category for a defined year.

The vehicle categories include:

**Light duty vehicles (LDVs)**
- Cars
  - Petrol cars (<1.4L, 1.4L to 2L, and >2L)
  - Diesel cars (<2L and > 2L)
  - Hybrid cars
  - Plug in hybrid cars
  - Electric cars (brake and tyre wear emissions only)

**Light commercial vehicles (LCVs)**
- Petrol LCVs
- Diesel LCVs
- Hybrid, plug in hybrid and electric LCVs are assumed to have equivalent emissions to hybrid, plugin hybrid and electric cars

**Heavy duty vehicles (HDVs)**
- Buses
  - All buses are assumed to have equivalent emissions to HCVs in VEPM

**Heavy commercial vehicles (HCVs)**
- Diesel HCVs
- Broken down by gross vehicle weight

These categories are further broken down by:
- year of manufacture
- whether the vehicle was sold new in New Zealand or a used import
- country of origin

Vehicle kilometres travelled (VKT) and country of origin data is used in VEPM to calculate the proportions of VKT travelled for each vehicle category.
2.1.1 Updated vehicle fleet

Updated VKT data from the Vehicle Fleet Emission Model (VFEM) was provided by Ministry of Transport (MoT) for all years from 2001 to 2040 broken down by:

- vehicle type,
- fuel type,
- engine capacity,
- year of manufacture,
- and whether the vehicle was sold new in New Zealand or was a used import.

VFEM data up to 2015 is based on analysis of historical fleet and travel data as reported in the Annual Fleet Statistics 2014 (MoT, 2014). It should be noted that, the default fleet data (% VKT for each vehicle category) provided for this update (VEPM 5.3) is different to the default fleet data provided for VEPM 5.1 due to changes in the Ministry of Transport’s analysis methodology (MoT, 2016). This includes historical VKT data from 2001 onwards.

2.1.2 Overall fleet breakdown

The overall composition of the default fleets in VEPM 5.1 and the updated VEPM 5.3 are shown in Table 1 and Table 2 respectively.

There are differences in the projected fleet compositions. For example, diesel cars account for 24% of VKT by 2040 in the VEPM 5.1 projection and only 7% of VKT in the updated projection in VEPM 5.3.

Figure 1 and Figure 2 show the overall proportions of light duty petrol, light duty diesel, light duty hybrid & electric and heavy duty diesel vehicles. The trends for these categories are similar from VEPM 5.1 and VEPM 5.3, except that VEPM 5.3 has a lower proportion of VKT from light duty diesel vehicles in future years. For example, in 2040:

- VEPM 5.3 has a lower proportion of VKT from light duty diesel vehicles at 23% compared with 34% in VEPM 5.1
- VEPM 5.3 has a slightly higher proportion of VKT from heavy duty diesel vehicles at 8.6% compared with 7.7% in VEPM 5.1
- VEPM 5.3 has a similar proportion of VKT from light hybrid and electric vehicles at 26% compared with 28% in VEPM 5.1
Table 1: Default fleet (% VKT by vehicle class) in VEPM 5.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Light Duty Vehicles &lt;3.5tonnes</th>
<th>Diesel HCV &gt;3.5tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car petrol</td>
<td>Car diesel</td>
</tr>
<tr>
<td>2001</td>
<td>72.9%</td>
<td>7.0%</td>
</tr>
<tr>
<td>2005</td>
<td>71.3%</td>
<td>8.1%</td>
</tr>
<tr>
<td>2010</td>
<td>70.4%</td>
<td>7.7%</td>
</tr>
<tr>
<td>2015</td>
<td>68.8%</td>
<td>8.0%</td>
</tr>
<tr>
<td>2020</td>
<td>63.6%</td>
<td>11.0%</td>
</tr>
<tr>
<td>2025</td>
<td>55.7%</td>
<td>15.9%</td>
</tr>
<tr>
<td>2030</td>
<td>46.0%</td>
<td>21.4%</td>
</tr>
<tr>
<td>2035</td>
<td>37.6%</td>
<td>24.3%</td>
</tr>
<tr>
<td>2040</td>
<td>29.7%</td>
<td>24.5%</td>
</tr>
</tbody>
</table>

Table 2: Updated default fleet (% VKT by vehicle class) in VEPM 5.3

<table>
<thead>
<tr>
<th>Year</th>
<th>Light Duty Vehicles &lt;3.5tonnes</th>
<th>Diesel HCV &gt;3.5tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car petrol</td>
<td>Car diesel</td>
</tr>
<tr>
<td>2001</td>
<td>72.3%</td>
<td>7.0%</td>
</tr>
<tr>
<td>2005</td>
<td>70.9%</td>
<td>8.0%</td>
</tr>
<tr>
<td>2010</td>
<td>70.1%</td>
<td>7.6%</td>
</tr>
<tr>
<td>2015</td>
<td>67.5%</td>
<td>7.8%</td>
</tr>
<tr>
<td>2020</td>
<td>63.1%</td>
<td>8.0%</td>
</tr>
<tr>
<td>2025</td>
<td>55.5%</td>
<td>8.8%</td>
</tr>
<tr>
<td>2030</td>
<td>50.3%</td>
<td>8.4%</td>
</tr>
<tr>
<td>2035</td>
<td>44.9%</td>
<td>7.7%</td>
</tr>
<tr>
<td>2040</td>
<td>41.4%</td>
<td>7.0%</td>
</tr>
</tbody>
</table>
Figure 1: Default fleet (% VKT by vehicle class) in VEPM 5.1

Figure 2: Updated default fleet (% VKT by vehicle class) in VEPM 5.3

2.1.3 Detailed fleet breakdown

As well as changes in the overall fleet breakdown described in the previous section, there are changes at the detailed level:

- MoT fleet calculation method
  MoT have changed the methods in VFEM for determining when vehicles leave the fleet (as described in MoT, 2014, Appendix B).

- Actual fleet profile compared with projections
In addition to changes in the calculation method, there will be changes in the actual measured fleet compared with projections. VEPM 5.1 fleet data was based on analysis of historical fleet and travel data up to 2010. VEPM 5.3 fleet data is based on analysis of historical fleet and travel data up to 2014.

The overall effect of these changes on the average age of the light duty fleet is shown in Figure 3. The key reasons for the difference in average fleet age are:

- The average light duty fleet age up to 2014 is slightly higher in the updated VEPM 5.3 fleet due to the changed fleet calculation method (MoT, 2014).
- The average light duty fleet age from 2015 onwards is lower in the updated VEPM 5.3 because the trend of reduced vehicle registrations and consequent ageing of the fleet has stabilised since the VEPM 5.1 projections were provided in 2010.

![Figure 3: Average age of the light duty vehicle fleet in VEPM 5.1 and VEPM 5.3](image)

**2.2 Incorporating NO₂ in VEPM**

VEPM 5.1 had emissions from nitrogen oxides (NOx) but did not include NO₂ either directly or as a proportion of NOx. Research recommended the inclusion of NO₂ (due to the higher toxicity of NO₂ compared to NO) in VEPM as a valuable first step in improving understanding of NO₂ trends (Metcalfe et al. 2013).

The EMEP/EEA Air pollutant emission inventory guidebook 2016 (EEA, 2016a) includes factors for the proportion of NO₂ in NOx (f-NO₂) according to vehicle type, fuel used and the Euro emission standard (EEA, 2016a).

These factors are shown in Tables 3, 4 and 5, and are directly compatible with VEPM.
Table 3: Fraction of NO$_2$ emitted by petrol cars and light duty vehicles (LDVs) (EEA, 2016a)

<table>
<thead>
<tr>
<th>Emission</th>
<th>f-NO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-EURO</td>
<td>0.04</td>
</tr>
<tr>
<td>Euro 1</td>
<td>0.04</td>
</tr>
<tr>
<td>Euro 2</td>
<td>0.04</td>
</tr>
<tr>
<td>Euro 3</td>
<td>0.03</td>
</tr>
<tr>
<td>Euro 4</td>
<td>0.03</td>
</tr>
<tr>
<td>Euro 5</td>
<td>0.03</td>
</tr>
<tr>
<td>Euro 6</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 4: Fraction of NO$_2$ emitted by diesel cars and LDVs (EEA, 2016a)

<table>
<thead>
<tr>
<th>Emission</th>
<th>f-NO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-EURO</td>
<td>0.15</td>
</tr>
<tr>
<td>Euro 1</td>
<td>0.13</td>
</tr>
<tr>
<td>Euro 2</td>
<td>0.13</td>
</tr>
<tr>
<td>Euro 3</td>
<td>0.27</td>
</tr>
<tr>
<td>Euro 3 with DPF*</td>
<td>0.51</td>
</tr>
<tr>
<td>Euro 4</td>
<td>0.46</td>
</tr>
<tr>
<td>Euro 5</td>
<td>0.33</td>
</tr>
<tr>
<td>Euro 6</td>
<td>0.30</td>
</tr>
</tbody>
</table>

* Not used in VEPM 5.3

Table 5: Fraction of NO$_2$ emitted by diesel (HDVs) and buses (EEA, 2016a)

<table>
<thead>
<tr>
<th>Emission</th>
<th>f-NO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-EURO</td>
<td>0.11</td>
</tr>
<tr>
<td>Euro I</td>
<td>0.11</td>
</tr>
<tr>
<td>Euro II</td>
<td>0.11</td>
</tr>
<tr>
<td>Euro III</td>
<td>0.14</td>
</tr>
<tr>
<td>Euro IV</td>
<td>0.10</td>
</tr>
<tr>
<td>Euro V</td>
<td>0.12</td>
</tr>
<tr>
<td>Euro VI</td>
<td>0.08</td>
</tr>
<tr>
<td>Euro III + CRT*</td>
<td>0.35</td>
</tr>
</tbody>
</table>

* Not used in VEPM 5.3

2.3 Emission standards and country of origin

In VEPM 5.1 it was assumed that vehicles manufactured in Japan are manufactured to Japanese standards and vehicles manufactured in Europe are manufactured to European Standards. Previous research has suggested that it may be more correct to assign the
emission standard based on country of first registration, because vehicles should be manufactured to the emission standard of the country where they are sold (Metcalfe et al., 2013).

Ministry of Transport emission data (Figure 4) now clearly shows that the majority of new vehicles are manufactured to European standards.

![NZ new petrol emissions regime](image)

**Figure 4**: Emission standards of new petrol vehicle imports (MoT, 2016 – Figure 3a)

The New Zealand requirements are different for new and existing vehicle models and for different countries of origin. Country of origin assumptions have therefore been updated in VEPM 5.3 as follows:

- vehicles manufactured in Europe are manufactured to European standards
- vehicles manufactured in Japan and first sold in New Zealand are manufactured to European standards
- used imported vehicle from Japan are manufactured to Japanese standards until 2010
- from 2010 onwards it is assumed that new and used Japanese vehicles are manufactured to European standards because the emission standards are similar (this is the same as the assumption in VEPM 5.1)

### 2.4 Emission standards date of introduction

In VEPM 5.1 it is assumed that all vehicles meet the emission standard that was in force in the country of origin at the time of manufacture. However, since the original development of VEPM, New Zealand has promulgated emission standards. These standards are delayed compared with international requirements. As shown in Table 6 and 7, there is a three to five year delay between the introduction of emission standards in Europe and the introduction of these standards in New Zealand.
Table 6: Light duty emission standard introduction dates for Europe and New Zealand

<table>
<thead>
<tr>
<th></th>
<th>Europe (^3)</th>
<th>New Zealand (^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light duty</td>
<td>Light duty petrol</td>
</tr>
<tr>
<td>New models</td>
<td></td>
<td>New models</td>
</tr>
<tr>
<td>All models</td>
<td></td>
<td>All models</td>
</tr>
<tr>
<td>Euro 1</td>
<td>Jul-92</td>
<td>Jan-93</td>
</tr>
<tr>
<td>Euro 2</td>
<td>Jan-96</td>
<td>Jan-97</td>
</tr>
<tr>
<td>Euro 3</td>
<td>Jan-00</td>
<td>Jan-01</td>
</tr>
<tr>
<td>Euro 4</td>
<td>Jan-05</td>
<td>Jan-06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro 5</td>
<td>Sep-09</td>
<td>Jan-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Heavy duty diesel emission standard introduction dates for Europe and New Zealand

<table>
<thead>
<tr>
<th></th>
<th>Europe (^5)</th>
<th>New Zealand (^4)</th>
<th>New Zealand (^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New models</td>
<td>All models</td>
</tr>
<tr>
<td>New models</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro I</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro II</td>
<td>Oct-96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro III</td>
<td>Jan-00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro IV</td>
<td>Oct-05</td>
<td>Jan-08</td>
<td>Jan-09</td>
</tr>
<tr>
<td>Euro V</td>
<td>Oct-08</td>
<td>Jan-12</td>
<td>Jan-12</td>
</tr>
<tr>
<td>Euro VI</td>
<td>Jan-13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Ministry of Transport recently published emission standard data for new and used vehicle imports. Figure 4 shows data for new light duty petrol vehicles, indicates that a substantial proportion of new vehicle registrations are in advance of New Zealand requirements, and are compliant with the emission standards in force in Europe. However, the data also suggests that a substantial proportion of new vehicle registrations did not meet Euro 4 requirements even after 2009 when this became compulsory for all new vehicles in New Zealand. We have discussed this with Ministry of Transport staff\(^6\) and have concluded that, for the purpose of modelling it is valid to assume that 100% of vehicles comply with dates specified in New Zealand legislation. This assumption is conservative. Figure 4 shows that 50% of new vehicle imports for light duty petrol vehicles were compliant with Euro 5 by 2016.

---


\(^6\) Personal communication, Iain McGlinchy, December 2016.
The date of introduction of emission standards in VEPM has been updated based on the following assumptions:

- It is assumed that all New Zealand new vehicles are manufactured to European emission standards
- For emission standards that are specified in New Zealand legislation, it is assumed that 100% of new vehicles comply with the European emission standard required by New Zealand legislation at the year of manufacture
- For emission standards which are not specified in New Zealand legislation (Euro 1, 2, 3 and 6), a four to five year delay is assumed for compliance with European emission standards in New Zealand.

The emission standards assumed in VEPM for new vehicles by year of manufacture are summarised in Table 8 and Table 9.

Table 8: Assumed date of introduction of Euro emissions standards in VEPM 5.3 for light duty vehicles

<table>
<thead>
<tr>
<th>Europe</th>
<th>Assumed date of introduction in VEPM for new vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All models</td>
</tr>
<tr>
<td>Euro 1</td>
<td>Jan-93</td>
</tr>
<tr>
<td>Euro 2</td>
<td>Jan-96</td>
</tr>
<tr>
<td>Euro 3</td>
<td>Jan-01</td>
</tr>
<tr>
<td>Euro 4</td>
<td>Jan-06</td>
</tr>
<tr>
<td>Euro 5</td>
<td>Jan-11</td>
</tr>
<tr>
<td>Euro 6</td>
<td>Sep-15</td>
</tr>
</tbody>
</table>

Table 9: Assumed date of introduction of Euro emissions standards in VEPM 5.3 for heavy duty vehicles

<table>
<thead>
<tr>
<th>Europe</th>
<th>Assumed date for NZ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New models</td>
</tr>
<tr>
<td>Euro I</td>
<td>92</td>
</tr>
<tr>
<td>Euro II</td>
<td>Oct-96</td>
</tr>
<tr>
<td>Euro III</td>
<td>Jan-00</td>
</tr>
<tr>
<td>Euro IV</td>
<td>Oct-05</td>
</tr>
<tr>
<td>Euro V</td>
<td>Oct-08</td>
</tr>
<tr>
<td>Euro VI</td>
<td>Jan-13</td>
</tr>
</tbody>
</table>

2.5 Emission factors

As described in previous technical reports (EFRU, 2011), emission factors in VEPM 5.1 were based primarily on:

- emission factors from the UK National Atmospheric Emissions Inventory (NAEI) database for light duty vehicles from 2009, and
- emission factors from COPERT4 for heavy duty vehicles
The UK database has been updated a number of times since 2009 (DEFRA, 2016). Emission factors in the UK database for NOx, PM and HC are now based on the COPERT model. Therefore, light duty emission factors in this version of VEPM have been updated based on emission factors from the COPERT model.

Emission factors are therefore updated in VEPM 5.3. This involves the replacement of:

- emission factor equations for all pollutants, for all Euro 5, Euro 6 and Euro V vehicles.

And the addition of:

- Euro VI (heavy duty) emission factors (which is not currently included in VEPM)

The updated emission factors are the latest available COPERT factors from the European Environment Agency (EEA) as at December 2016 \(^7\)\(^8\).

---

\(^7\) Light duty Euro 5 and Euro 6 emission factors are from EEA (2016B). *EMEP/EEA Air pollutant emission inventory guidebook 2016 – Update Dec. 2016.*

2.5.1 Heavy vehicle weight categories

Emission factors for Euro V and VI (heavy duty) vehicles have been updated from the EMEP/EEA Air pollutant emission inventory guidebook 2016 (EEA, 2016a). This includes a more detailed breakdown of heavy vehicles with many more weight classes and a division by vehicle type. As heavy duty vehicles are not divided by vehicle type in the MoT fleet data, the factors for rigid trucks were applied to all heavy vehicles.

Table 10: Heavy vehicle weight categories

<table>
<thead>
<tr>
<th>EMEP/EEA</th>
<th>Fleet Data</th>
<th>Classes in VEPM 5.3 (COPERT class used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;7.5t</td>
<td>3.5 – 5t</td>
<td>3.5 – 7.5t (&lt;7.5t) – includes buses 3.5 – 7.5t</td>
</tr>
<tr>
<td>7.5 – 12t</td>
<td>5 – 7.5t</td>
<td>7.5 – 12t (7.5 – 12t) – includes buses 7.5 – 12t</td>
</tr>
<tr>
<td>12 – 14t</td>
<td>7.5 – 10t</td>
<td>12 – 15t (12 – 14t) – includes buses 12t</td>
</tr>
<tr>
<td>14 – 20t</td>
<td>10 – 12t</td>
<td>15 – 20t (14 – 20t)</td>
</tr>
<tr>
<td>20 – 26t</td>
<td>12 – 15t</td>
<td>20 – 25t (20 – 26t)</td>
</tr>
<tr>
<td>26 – 28t</td>
<td>15 – 20t</td>
<td>25 – 30t (26 – 28t)</td>
</tr>
<tr>
<td>28 – 32t</td>
<td>20 – 25t</td>
<td>&gt;30t (&gt;32t)</td>
</tr>
<tr>
<td>&gt;32t</td>
<td>25 – 30t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30t</td>
<td></td>
</tr>
</tbody>
</table>

The EMEP/EEA Air pollutant emission inventory guidebook 2016 provides separate emission factors for exhaust gas recirculation (EGR) and selective catalytic reduction (SCR) HDV Euro V vehicles. For European Member States, it is estimated that approximately 75% of Euro V heavy duty vehicles are equipped with SCR, the rest being equipped with EGR. There is no specific data for New Zealand, therefore the same assumption has been made for this update and incorporated into VEPM 5.3.

3.0 VEPM 5.1 versus VEPM 5.3

This section briefly describes the differences between VEPM 5.1 and the updated VEPM 5.3.

3.1 Effect on fleet weighted emission factors

This section discusses the effect of changes in the assumptions on fleet weighted emission factors. Figures 6 to 10 show fleet weighted emission factors for carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NOx), PM2.5 and fuel consumption from VEPM5.1 and from each stage of the technical update:

Stage 1: updated fleet

Stage 2: Stage 1 + country of origin and date of emission standard implementation

---

9 EEA (2016b), page 79
Stage 3 (VEPM 5.3): Stage 2+ updated emission factors for Euro 5, 6, and V, and the addition of Euro VI.

Figure 6: Comparison of CO emission factors from VEPM 5.1 and VEPM 5.3

Figure 7: Comparison of VOC emission factors from VEPM 5.1 and VEPM 5.3
Figure 8: Comparison of NOx emission factors from VEPM 5.1 and VEPM 5.3

Figure 9: Comparison of PM$_{2.5}$ emission factors from VEPM 5.1 and VEPM 5.3
3.1.1 Discussion of the fleet weighted emission factor comparison

Figures 6 to 10 show that:

**Stage 1:**
Updating the fleet made little difference to the fleet weighted emission factors compared with VEPM 5.1.

**Stage 2:**
Modified country of origin and emission factor date of introduction assumptions made fleet weighted emission factors of NOx, VOC and PM$_{2.5}$ higher up to 2030. This difference in fleet weighted emissions factors is due to assumed differences in emission rates and the implementation dates of Japanese and European emission standards, more specifically:

- Compared with VEPM 5.1, the updated VEPM 5.3 has a lower proportion of vehicles manufactured to Japanese standards due to changes in country of origin assumptions.
- Compared with VEPM 5.1, the date of implementation of European emission standards is delayed.

The difference compared with VEPM 5.1 becomes less significant over time because:

- It is assumed in VEPM that Japanese and European vehicles manufactured from 2010 onwards have equivalent emissions (so the country of origin assumptions have no effect on vehicles manufactured after 2010), and
- The effect of delayed emission standard implementation dates becomes insignificant over time. Euro 6 and Euro VI are first introduced from 2020 in VEPM 5.3 and from...
2015 in VEP M5.1. After the introduction of Euro 6 and Euro VI standards (from 2015 in VEP M5.1 and from 2020 in VEP M 5.3) there are no further emission reductions assumed in VEP, so emission reductions stabilise.

Stage 3:

Changing the assumptions and updating emission factors for Euro 5, 6 LDVs and Euro VI HDVs made little difference to fleet weighted emission factors until 2030 when the emission factors for NOx, VOC and PM$_{2.5}$ fall below the emission factors in VEP M 5.1.

The reduction in fleet weighted emissions from 2030 compared to VEP M 5.1 is due to the addition of Euro VI emission factors for HDVs, which are much lower than Euro V emission factors, especially for NOx (as shown in Figure 6).

### 3.2 Light duty diesel NOx emission factors

Recent research has found that on road emissions of NOx from light duty diesel vehicles are substantially higher than previously expected. The findings of this research are taken into account in the latest European emission factors$^{10}$. These updated factors for Euro 5 and Euro 6 vehicles have been incorporated into VEP M 5.3. The difference in NOx emission factors for light duty diesel vehicles is significant as shown in Figure 11.

![Diesel car NOx emission factors @50km/hour](Figure 11: Diesel car emission factors from VEP M 5.3 and VEP M 5.1 (50 km/hr) for NOx by emissions standard.)

As discussed previously (in Section 3.1), fleet weighted NOx emission factors are not significantly different as a result of these updated emission factors. This is because:

- light duty diesel vehicles represent a relatively small proportion of the fleet, and

---

$^{10}$ Why diesel NOx emission factors (EF’s) have changed in COPERT for light duty vehicles (LDVs). Emisia advice note September 2016.
http://emisia.com/sites/default/files/Why_new_diesel_NOx_EF.pdf
• as discussed in Section 2.1.1, the proportion of light duty diesel vehicles is lower in VEPM 5.3 compared with VEPM 5.1.

3.3 NO₂ emission factors

The VEPM update includes emission factors for NO₂, which were not previously available in VEPM. Figure 12 shows the emission factors for NO₂ versus the emission factors for NOx, as well as the percentage reduction in emission factors for every 10 year interval.

![Figure 12: Emission factors for NO₂ versus NOx, with the percentage change at 10 year intervals.](image)

Figure 12 shows that the estimated percentage reduction in NOx emissions between 2001 and 2020 is much higher than the estimated percentage reduction in NO₂ emissions over the same time period. This is because:

• The fraction of NO₂ in NOx emissions from light duty diesel vehicles increased with the introduction of Euro 3 and Euro 4 vehicles (as shown in Table 4), and
• The proportion of diesel vehicles in the fleet increases between 2001 and 2020 as shown in Table 2. Diesel vehicles have a higher fraction of NO₂ in NOx emissions compared with petrol vehicles (as shown in Tables 3, 4 and 5)

The inclusion of NO₂ emission factors in VEPM will provide information to help understand trends in ambient NOx and NO₂.
4.0 Future updates

The methodology for this update of VEPM has been peer reviewed by Pacific Environment Limited\(^{11}\). This review identified a number of additional updates or modifications to VEPM that may be considered in future versions. These include:

- The current update incorporates the latest emission factors for Euro 5 and 6 light duty and Euro V and VI heavy duty vehicles. In future, for general consistency and ease of updating it would be preferable to make all European emission factors consistent with the latest version of COPERT. If possible adjustment factors and equivalencies for Japanese vehicles should also be recalculated to be consistent with COPERT.
- Inclusion of additional vehicle technologies (e.g. plug in petrol hybrids, diesel hybrids and gasoline direct injection (GDI) vehicles) and emission control devices based (e.g. DPF, SCR, EGR).
- There is scope for inclusion of unregulated pollutants in VEPM.
- COPERT Australia could potentially be used to fill some gaps in VEPM including SUVs and Australian imports.
- COPERT Australia approach to estimating cold start emissions could be considered.

In general, it is recommended that VEPM should be updated whenever COPERT is updated. The detailed fleet profile should also be updated regularly.

5.0 Conclusions

VEPM is now based on recent fleet information and projections from Ministry of Transport, as well as the latest emission factors from Europe.

The key conclusions from this update of VEPM were:

- Updating the vehicle fleet resulted in minor differences to fleet weighted emission factors;
- Changes to the country of origin assumptions and the implementation dates of European emission standards resulted in higher fleet weighted average emission factors compared with VEPM 5.1 up to 2030, however the difference becomes less significant over time;
- Updating the emission factors for Euro 5, 6 and V, and including Euro VI saw little impact on the overall emission factors until 2030, after which fleet weighted emission factors are lower due to the inclusion of Euro VI to the fleet.

The inclusion of NO\textsubscript{2} emission factors in VEPM will provide valuable information for evaluation of vehicle emission trends.
References


