Reviewing Aspects of the Engine Fuel Specs Regs 2011
Air Quality Impacts of Petrol Sulphur Reductions

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Summary

The Ministry of Business, Innovation and Employment (**MBIE**) is responsible for the administration of the Engine Fuels Specifications Regulations 2011 (**Regulations**). The Regulations need to be reviewed every three to four years to remain current with technology developments. The tightening of fuels specifications over the last 13 years has reduced harmful emissions from vehicles and enabled the uptake of the newest and cleanest vehicle technologies.

In the current review, MBIE is investigating, *inter alia,* a potential reduction in sulphur limits for petrol from the current maximum of 50ppm to 10ppm.

Emission Impossible Ltd was engaged to assess the potential air quality benefits of reducing petrol sulphur to 10ppm in a series of stepwise reductions starting 1 July 2016 versus retaining the current limit of 50ppm sulphur petrol indefinitely.

Using a damage cost approach, we found that opting for a reduced sulphur limit would return air quality-related benefits over the period of 2015 to 2030 of:

- $517 million (NZ$2014) with no discount rate applied
- $401 million (NZ$2014) at a discount rate of 3%
- $275 million (NZ$2014) at a discount rate of 8%

The assumptions and methodology followed to arrive at these figures are summarised in the next section of this report. The detailed workings are contained in two separate Excel spreadsheets:

- ***VEPM_scoping_final*** which outlines the year by year vehicle fleet compositions for the basecase and the scenario modelled that were used as **input** in the Vehicle Emissions Prediction Model (**VEPM**) to calculate the emissions
- ***Model_Petrol Fuel S Analysis_final*** which takes the emissions **output** from VEPM, multiples it by the activity data (the vehicle kilometres travelled) and damage costs to arrive at the overall air quality impacts

Methodology and key assumptions

The key assumptions used in the assessment of air quality impacts are as follows:

Scenarios evaluated

Two scenarios were evaluated covering the following proposed changes in petrol sulphur content:

- **Basecase** - 50ppm sulphur petrol from 1 July 2015 indefinitely.
- **Scenario A**:
  - 50ppm sulphur petrol from 1 July 2015
  - 30ppm sulphur petrol from 1 July 2016
  - 10ppm sulphur petrol from 1 July 2017 indefinitely out to 2030

Although current fuel quality monitoring data show that **actual** petrol sulphur content is well below the specified limits, all modelling was based on the assumption that the maximum limits would apply in reality (because potentially they could).

Time frames

Modelling was undertaken from 2015 year by year until 2030.

Although the fuel specification changes were signalled for mid-year, the modelling was undertaken on a **calendar** year basis, with any differences assumed to be minor.

Pollutants

Emissions of the following pollutants were estimated using the Vehicle Emissions Prediction Model (**VEPM**):

- Carbon monoxide (**CO**) *but no damage cost data were available*
- Carbon dioxide (**CO_2**)
- Volatile organic compounds (**VOCs**)
- Oxides of nitrogen (**NO_X**)
- Particulate matter less than 2.5µm or 10µm (**$PM_{2.5}$** or **PM_{10}**)

VEPM is a speed dependent model developed by the NZ Transport Agency and Auckland Council to predict emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions (NZTA 2012). It is populated with actual fleet data provided by the Ministry of Transport (**MoT**) with predictions out to 2040 based on MoT's vehicle fleet projections.

Oxides of sulphur (**SO_X**) were **not modelled** as they are not estimated in VEPM. Also all **particulate matter emissions were modelled together as PM_{10}**. Vehicle exhaust emissions are essentially $PM_{2.5}$ but vehicle brake and tyre wear include coarser PM_{10}.

Fleet composition, activity and performance

The **fleet composition** for each year from 2015 to 2030 was assumed to be the default national fleets shown in VEPM. These fleet compositions are based on the **proportion** of vehicle kilometres travelled (**VKT**) not on the **number** of vehicles because VKT is more representative of vehicle activity.

VEPM was run for an **average speed** of 42 km/hour because this aligns the VEPM predicted petrol use to MBIE actual petrol use (using 2013 annual statistics).

The latest actual total travel for the NZ fleet was from 2013 at 40.41 billion kilometres travelled (MoT 2014). **Future VKT** figures for 2014 to 2030 were estimated using an average **growth rate of 1.12% per annum** taken from projections developed in the Vehicle Fleet Emissions Model (MoT 2015).

Fleet performance

The key assumptions for fleet performance depend on the impact fuel sulphur levels have on emissions performance. Petrol sulphur hinders the ability of catalysts to function at their optimum level. New technologies cannot realise their full emissions benefits if sulphur levels are too high and older technologies can perform better if sulphur levels are reduced.

For **newer vehicles**, all Euro 5 or better petrol vehicles were assumed to perform at Euro 4 until 10ppm sulphur fuel was available.

For **existing vehicles going from 50ppm sulphur petrol to 10pppm sulphur petrol**, two references in particular – USEPA 2014 and EU 2001 – had the most robust and comprehensive data quantifying the likely emissions improvements. From these references, the following emissions reductions were assumed:

- 10% improvement in CO for Euro 1/Jap 00 to Euro 4/Jap 05 (USEPA 2014, EU 2001)
- 3% improvement in CO_2 for Euro 4/Jap 05 only (EU 2001)
- 10% improvement in VOCs for Euro 1/Jap 00 to Euro 4/Jap 05 (USEPA 2014, EU 2001)
- 10% improvement in NO_X for Euro 1/Jap 00 to Euro 4/Jap 05 (USEPA 2014, EU 2001)

No appreciable improvement was reported in the literature **for PM emissions** of existing vehicles with a reduction in petrol sulphur levels. Therefore the PM emissions performance of existing (Euro 4 or earlier) petrol vehicles was left unchanged in the modelling.

The emissions modelling for Scenario A assumed **half of the above improvements** for the initial step of going from **50ppm sulphur petrol to 30ppm sulphur petrol** in 2016.

Air quality benefits (damage costs)

The bulk of the air quality benefits from reducing vehicle emissions are in terms of health benefits. Of the pollutants, PM_{10} is of the most concern as it has no safe threshold below which effects do not occur and its effects range in severity from restricted activity days (days where people exposed are not able to undertake their normal activities) through to increased medication use, increased hospitalisations and, in the worst case, premature death.

However, vehicle emissions comprise many other pollutants which can also have separate and additive impacts, such as NO_X (irreversible lung damage in children), VOCs (precursors of photochemical smog formation) and CO_2 (a greenhouse gas).

Air pollution health effects have been estimated previously in New Zealand as part of the Health and Air Pollution in New Zealand (HAPINZ) study. This work found that the social costs associated with vehicle-related air pollution alone amounts to $935 million per annum (Kuschel *et al.* 2012). However, this work was based on 2006 Census data, only included effects associated with PM_{10} and the health impacts were monetised in NZ$2010.

Although the HAPINZ methodology provides a **comprehensive picture of exposure** to air pollution across New Zealand, a full update was not possible or warranted in the time available for the assessment of potential changes in petrol sulphur levels. HAPINZ relies on detailed information on pollutant **concentrations** to predict health outcomes which are then monetised to get total social costs.

Internationally, jurisdictions have increasingly adopted **damage cost methodologies** as a means to evaluate the effectiveness of national emissions reductions strategies (eg policies and incentives). Damage cost methodologies utilise average damage costs per tonne of pollutant so that **emissions** can be used to get total social costs.

In our assessment, internationally reported damage costs were used to scale updated HAPINZ figures to arrive at New Zealand damage costs per tonne of pollutant emitted as follows:

1. Updated HAPINZ figures (for Auckland based on 2013 Census data) were used to derive an updated social cost per tonne for PM_{10} (Nunns 2015). This figure was then revised to reflect the latest OECD recommendation that PM morbidity from transport air pollution is 10% of the mortality costs (OECD 2014). This resulted in a revised figure of $439k per tonne of PM_{10} (based on NZ$2014) versus $399k used by Nunns (2015).
2. The HAPINZ study is based on valuing PM_{10} costs in terms of a Value of Statistical Life (**VoSL**) to reflect premature deaths. However, many international air pollution assessments are based on Value of Life Year (**VoLY**) which is typically in the order of $1/5^{th}$ to $1/10^{th}$ of the VoSL (Concawe 2006, PAE Holmes 2013), depending on whether the VoSL has been derived for road safety or environmental risks. This means the NZ VoLY-based PM_{10} damage cost would be NZ$88k per tonne, as the NZ VoSL is based on road safety risks.
3. Looking at the review of reported damage costs, the international costs per tonne of PM_{10} (eg NZ$106k from PAE Holmes 2013) were close to the approximated NZ VoLY figure of NZ$88k. The PAE Holmes figures were developed for NSW Environment Protection Authority and seemed the most reasonable to use as they applied to cities with comparable population densities to urban environments in New Zealand.
4. Assuming the NZ PM_{10} VoLY approach was valid, damage costs per tonne for NO_X and VOCs were then developed based on the ratios reported in PAE Holmes (2013) to arrive at the following:
   - PM_{10} – NZ$88k per tonne
   - NO_X – NZ$14.1k per tonne
   - VOCs – NZ$3.6k per tonne
5. The damage cost for CO_2 was assumed to be NZ$3.40 per tonne (based on the average cost of an emissions unit in 2014).

Emissions and cost calculations

The steps involved in deriving the total emissions predicted for each scenario and the associated air quality impacts were as follows:

1. VEPM was run for each year from 2015 to 2030 to establish the "default" national fleet profiles in terms of %VKT.
2. For years where the **petrol sulphur content was greater than 10ppm**, the VEPM fleet profiles were "corrected" assuming all Euro 5 or better could only perform at Euro 4.

This meant that the %VKT in Euro 4 increased whilst the %VKT in Euro 5 or better were set to zero etc.

3. For years where the **petrol sulphur content was 10ppm**, all Euro 5 or better were left as VEPM predicted but the emission factors for Euro 4/Jap 05 and earlier vehicles were "corrected" to reflect the emission performance improvements outlined in the earlier section on Fleet Performance (ie 10% improvement for NO_X).
4. For years where the **petrol sulphur content was 30ppm**, the VEPM fleet profiles were "corrected" assuming all Euro 5 or better could only perform at Euro 4 but the emission factors for Euro 4/Jap 05 and earlier vehicles were "corrected" to reflect half of the emission performance improvements outlined in the earlier section on Fleet Performance (ie 5% improvement for NO_X).
5. VEPM was then run with the corrected fleet profiles/emission factors to arrive at fleet weighted emission factors (g/km) for CO, CO_2, VOC, NO_X and PM_{10}.

The fleet profiles and fleet weighted emission factors for each year assessed for the two scenarios are shown in detail in ***VEPM_scoping_final.***

6. The fleet weighted emission factors (g/km) were then multiplied by the VKT projections (km) for each year to arrive at total emissions (in kilotonnes) for each assessment year.
7. These figures in turn were then multiplied by the damage costs per tonne in NZ$2014 to get costs for each assessment year.
8. Discount rates of 3% and 8% were then applied to determine the overall NZ$2014 present value of the total "damages" for the Scenario A versus the Basescase. A discount rate of 3% is the Government's social rate of time preference whilst 8% is Treasury's default applied to regulatory proposals.
9. The cumulative differences in emissions and present values were also calculated.

The VKT projections, emissions and benefits comparisons for each year assessed for the two scenarios are shown in detail in ***Model_Petrol Fuel S Analysis_final.***

Results

Based on the modelling, Scenario A (transitioning towards 10ppm sulphur petrol from 1 July 2016) will save:

- 184 kilotonnes of CO
- 7,688 kilotonnes of CO_2
- 22.5 kilotonnes of VOCs
- 26.8 kilotonnes of NO_X
- 0.353 kilotonnes of PM_{10}

between 2015 and 2030 versus the Basecase (50ppm sulphur petrol indefinitely).

Using a damage cost approach, we found that opting for a reduced sulphur limit would return air quality-related benefits over the period of 2015 to 2030 of:

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