Queen St contains highest levels of black carbon in NZ

Downtown Auckland appears to be serving as a basin for air pollution, including high levels of potentially deadly black carbon.

“...traffic volumes are declining in the central city, leading scientists to believe the rise in black carbon must be down to other factors – most likely old diesel engines”.

New research indicates black carbon levels in Auckland’s downtown area is three times higher than Canadian cities and twice as high as major North American, European and United Kingdom centres. Photo: 123RF
Determining the impact of gross emitting vehicles

6 December 2018
Project Objective

To determine the impact that gross emitting vehicles (GEVs) have on emissions of harmful pollutants and of carbon dioxide from the vehicle fleet.

Stage 1: Method Development – today’s presentation.

- Harmful pollutants
- CO$_2$

Hold point meeting: Should we progress to Stage 2?

Stage 2: Assessing the impacts of GEVs.
What is gross emitter?

The total emissions from the on-road fleet are dominated by a small number of vehicles with very high emissions known as “gross emitters”.

ROADSIDE MEASUREMENTS OF EXHAUST EMISSIONS

The diagram shows the distribution of exhaust emissions with NO (ppm) on the y-axis and years (2003 to 2015) on the x-axis. It indicates that 95% of emissions fall within the 5% to 95% range, 50% within the 25% to 75% range, and the mean and median values are also highlighted.
What is gross emitter?

ROADSIDE MEASUREMENTS OF EXHAUST EMISSIONS
What do we know about GEVs? (1)

- The most polluting 10% vehicles are responsible around 50% of the total emissions.
- The cleanest 50% vehicles are responsible for less than 10% of total emissions.
- The impact of GEVs has been increasing over time.
What do we know about GEVs? (2)

Fuel type:
- Petrol vehicles, 96% of gross emitters of CO, HC and NO
- Diesel vehicles disproportionate number of particulate GEVs

Year of manufacture
- Older vehicles are much more likely to be gross emitters
- A few new vehicles are gross emitters

Mileage. High km:
- **Petrol** vehicles have **significantly higher** emissions than low km vehicles
- **Diesel** vehicles have **slightly higher** emissions of HC, NO and PM than low km vehicles
Gross Emitters in the 2015 RSD data set – CO
GEVs in the 2015 RSD data set – CO
Key Questions for Stage 1 of this Study

Can we use the RSD data to calculate the:

- Impact of emissions from GEVs?
- Benefit of replacing GEVs with Typical Emitting Vehicles (TEVs)
  - Part 1 – Harmful emissions
  - Part 2 – CO$_2$ emissions
Method Part 1: Calculating Emissions of Harmful Pollutants using RSD and other data.

Roadside exhaust measurement. *(RSD data)*

Chemistry

Emission factor *(g/kg fuel)*

Fuel consumption

Distance Travelled:

Emission factor *(g/km)*

Total emissions *(g)*
Stage 1: Method Development – Proof of Concept.

- Data inputs are typical values, not specific to any one vehicle.
- Results are indicative.
- Full analysis will use vehicle specific data for many vehicles.
- The results will be aggregated to provide emissions for the monitored fleet.
Prelim Result – 1. Annual Impact of a Gross Emitting Vehicle

Data inputs.

- CO = 2 % (RSD)
- CO emission factor = 17 g/km.
- 5,000 km year (MVR 2018-2015)
Prelim Result – 2. Annual CO emissions of a Typical Emitting Vehicle

Data inputs

- CO = 0.023 % (RSD)
- CO emission factor = 0.2 g/km.
- 10,000 km year (MVR 2018-2015)
Prelim Result – 3. Net Benefit of replacing a GEV with a TEV.
Key Questions for Stage 2: Auckland 2015 monitored Fleet

• How long do GEVs remain in the fleet? – Registration still current?
• How far have GEVs travelled since 2015?
• What is the impact of replacing GEVs with TEVs within the 2015 monitored fleet?
Key Questions for Stage 2: National Fleet

• How many GEVs are there **likely** to be in the national fleet?
• Is there a regional variation in the occurrence of GEVs?
• What is the national/regional benefit of replacing GEVs?
• What percentage of GEVs should/could be replaced?
Method Part 2: Calculating GEV Emissions of CO$_2$ using RSD and other data.

RSD measures the ratios of:

- CO/CO$_2$
- HC/CO$_2$
- NO/CO$_2$

No data direct on CO$_2$ emissions.

Challenge!

Utilise the RSD data to estimate the impact of GEVs on CO$_2$ emissions.
General approach

• CO and HC emissions are useful indicators of engine efficiency.
• Use CO and HC emissions to estimate the amount of additional fuel used by gross emitters.
• Calculate increase in CO$_2$ emissions from additional fuel use.
Concept for calculating CO$_2$ emissions

Inefficient engine. Wasted energy

Increased CO$_2$ Emissions

Additional fuel to meet engine energy demand.

Annual CO emissions (kg)

Typical Emitting vehicle

Gross Emitting Vehicle
Impact of CO gross emitter on CO$_2$ Emissions

- 156 kg CO$_2$
- 84 kg of CO
- 380 MJ of energy
- 51 kg of additional petrol

Typical Emitting Vehicle

Gross Emitting Vehicle
Benefit of replacing CO GEVs for CO$_2$ Emissions

1995 Toyota Corolla

2005 Toyota Corolla

Gross emitter

Typical emitter

Net reduction 31 g CO$_2$/km or 16%.
Limitations and Logistics – CO$_2$ gross emitters

• HC and CO emissions are easily controlled by catalytic converters
  • Some engine inefficacy will not be detected by the RSD.

• Assessing the combined impact of CO and HC emissions.

• Possibly use a top down approach.
Conclusions: Stage 1 Method Development

Harmful pollutants and CO$_2$ Emissions -

- RSD and supporting information can be used to calculate real world:
  - Emissions from GEVs
  - Benefit of removing GEVs from the vehicle fleet

Preliminary Results show the potential benefits of replacing GEVs with TEVs are:

- Very large reductions of emissions of CO
- Non-trivial reduction of emissions of CO$_2$
Next step in the project:

Hold point meeting -
Progress to Stage 2?

Those Gross Emitters are GROSS!
Thank you!
Questions?