European Research on Mobile Emission Sources

Transport Emissions Research in Australia

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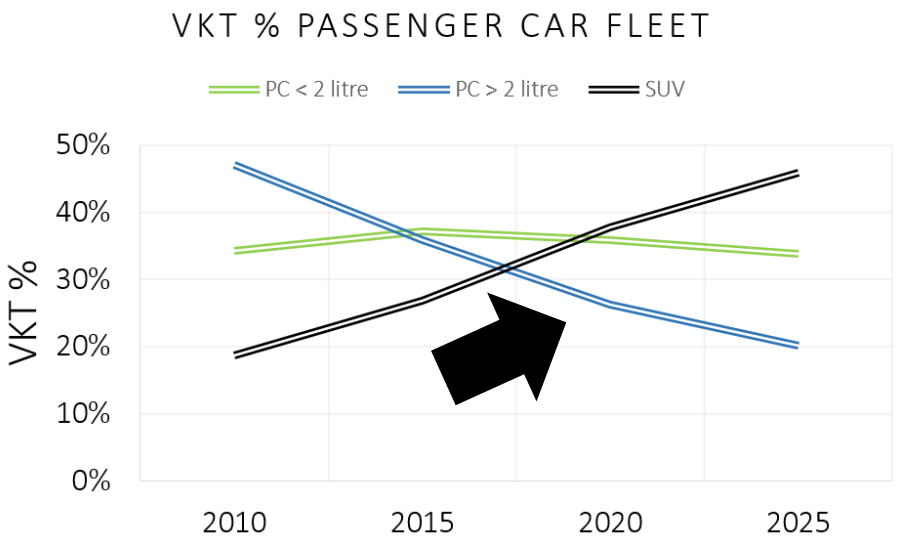
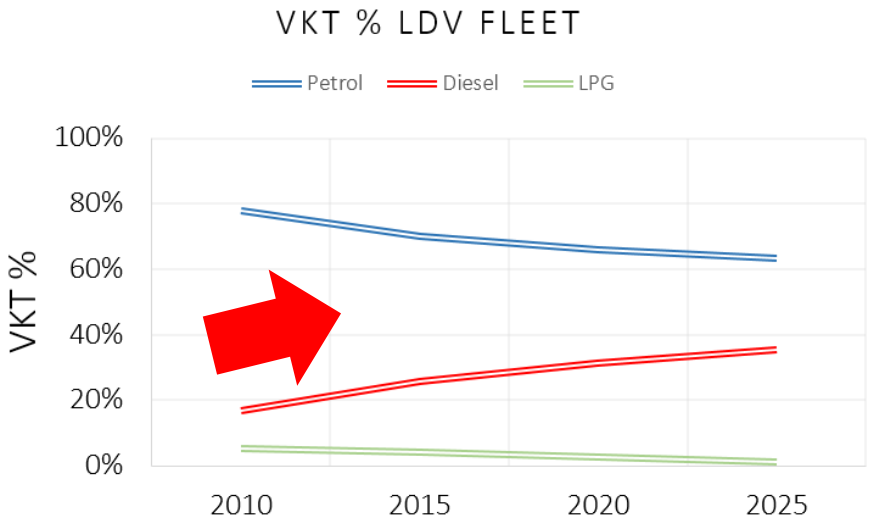
Queensland Government

Australian (LD) Fleet

Transport Energy Emission Research

- About 18 million LD vehicles
- ‘Large cars with large engines and automatic transmission’.
- Majority of cars > 2 litres engine capacity
- ‘Dieselisation’ of LD fleet





Vehicle Emission Models in Australia







- COPERT AUSTRALIA (Emisia – DES)
  - 226 vehicle classes
  - Different vehicle classification (SUVs, vehicle class definitions)
  - 16 organisations purchased software license
  - Emission inventory (tonnes)
    - Government (state/national) MVEI
    - Toll company: CO_2 MVEI
  - Emission factors (g/km)
    - Air quality consultants (local air quality assessments)
    - University (research)
- PΔP vehicle emission simulator (Transport Energy/Emission Research)
  - 73 vehicle classes
  - 1 Hz energy, fuel and emission simulation
  - Power and power-change hybrid model (physical/statistical)

Multi-Instrumented Vehicle Emission Model Validation

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- All validation methods have their strength and weaknesses ⇒ best approach is to use different approaches.

- 2015-2017 **tunnel study**

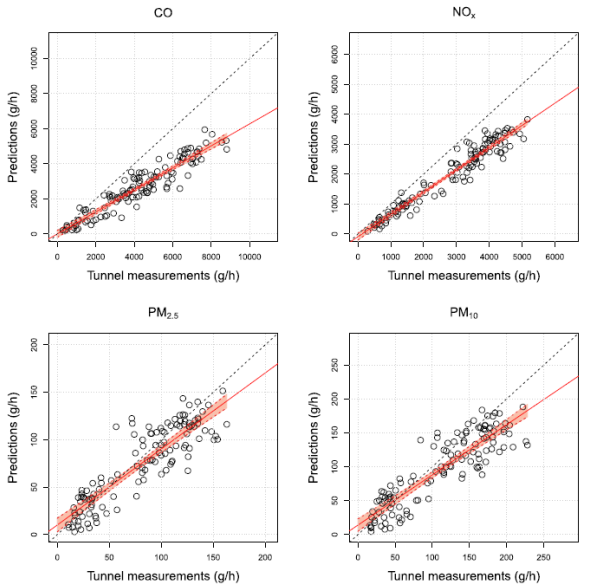
- 2018-2019 **remote sensing**
  + **dyno**
  + **on-road air quality monitoring** study

Tunnel study


Atmospheric Environment

A tunnel study to validate motor vehicle emission prediction software in Australia

- COPERT Australia + PΔP validation
- Prediction errors:
  - PM within 20%
  - NO_x and CO within 40%
- However… HCs large uncertainty…
  - VOCs ~ factor of 5 underestimation
  - PAHs ~ factor of 7 overestimation
  - different speciation of compounds



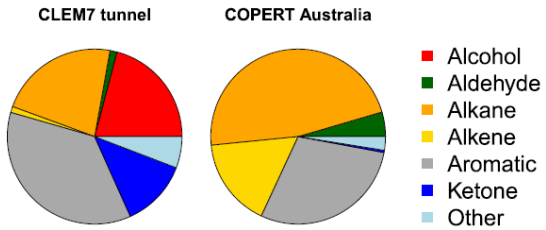


Fig. 9. Proportion of VOCs in fleet emission factors by VOC class as observed in the tunnel ("CLEM7 tunnel") and the complete VOC profile as predicted with COPERT Australia ("COPERT Australia").

RSD + On-Road Air Quality - 3 sites

URBAN

8% HDV, 30 km/h, 600 veh/h, +2.7°

COMMERCIAL

23% HDV, 35 km/h, 200 veh/h, +0.4°

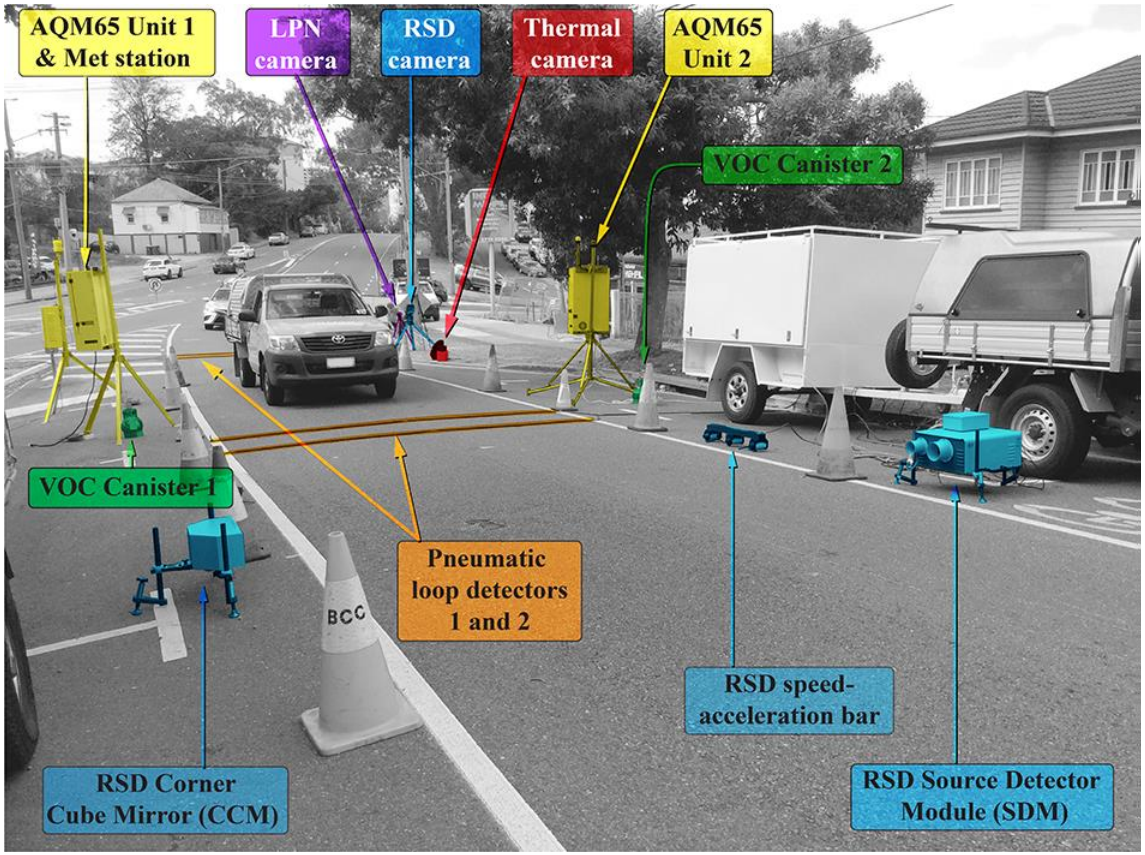
Represent different types of adjoining land use / fleet mix / driving behaviour

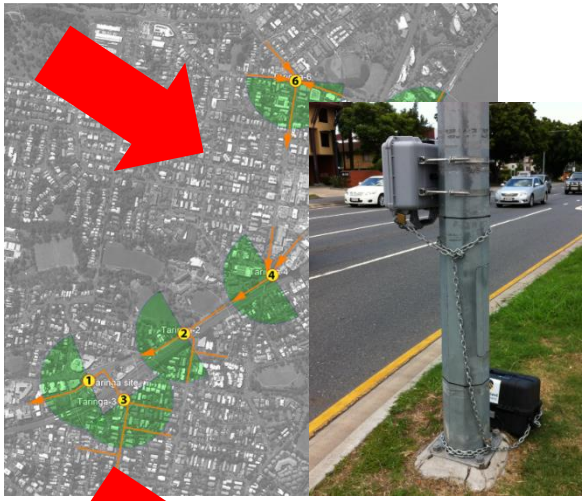
FREEWAY ON-RAMP

9% HDV, 40 km/h, 500 veh/h, +3.0°

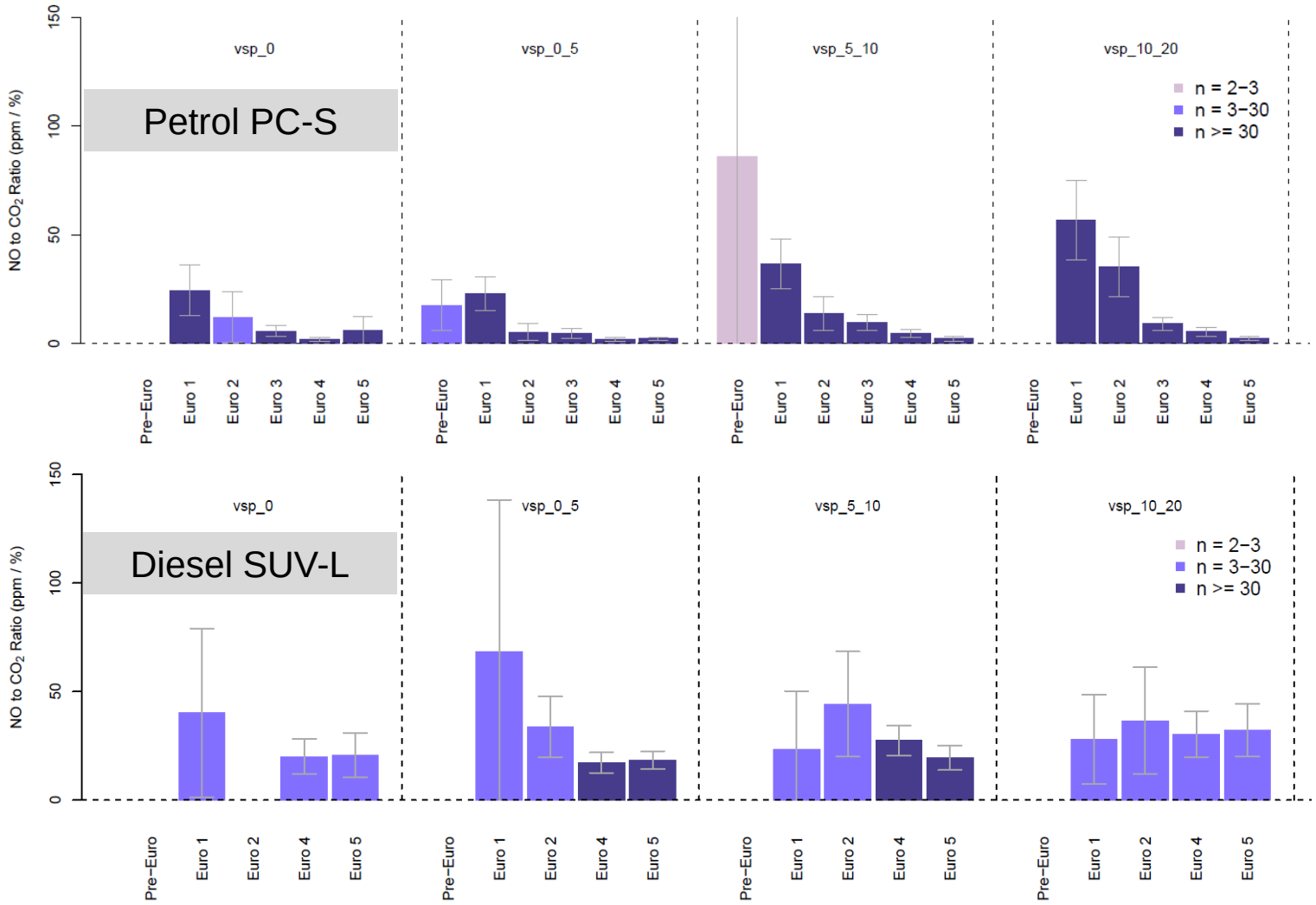
Equipment

Equipment	Site		
	Urban	Freeway	Commercial
Accuscan RSD4600	×	×	×
Reconyx MS7 Microfire	×	×	×
Noptic Thermal Camera	×	×	×
Pneumatic Loop Detectors	×	×	
Bluetooth MAC address units	×	×	
AQM65, Summa Canisters, Met Station	×		
Dynamometer			×





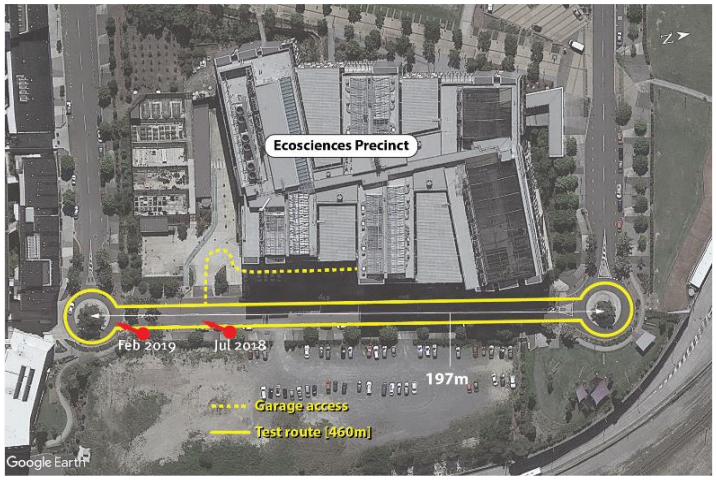
RSD data analysis – evidence of stabilizing NO_x diesel

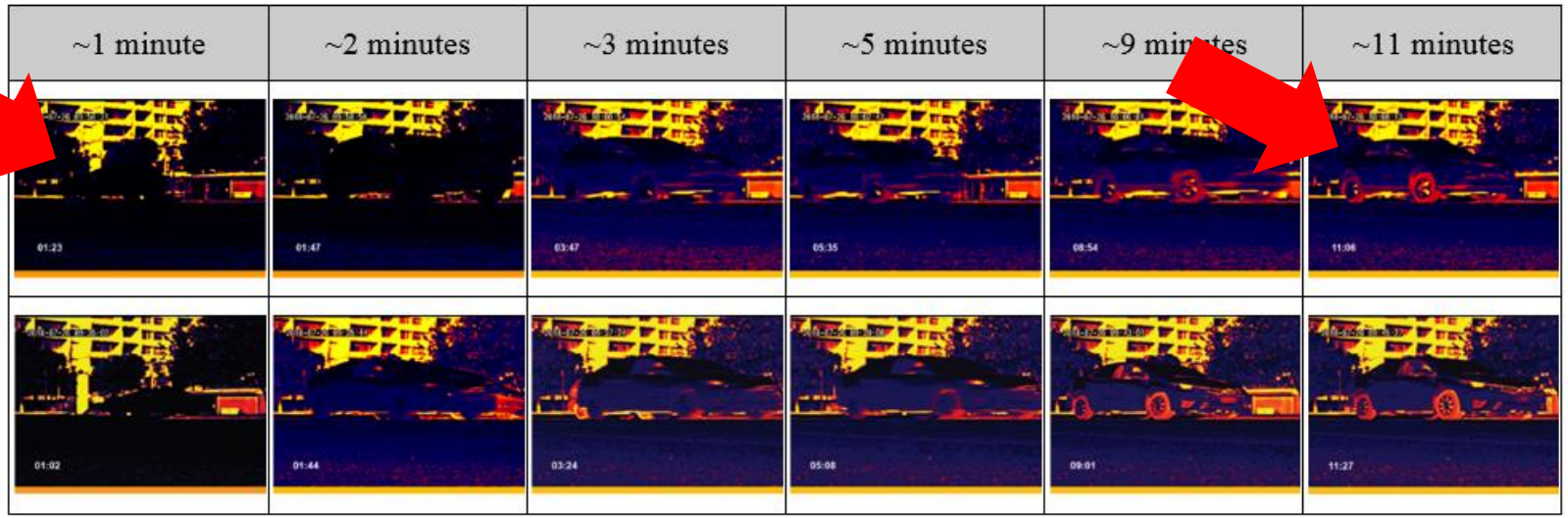


Note: increase NO_2 diesel LDVs not measured

Cold start detection - Method C

- Thermal IR imaging.
- Test loop, 3 vehicles (2P,1D), idling + moving vehicles.
- Vehicle = dark ~ first 1-2 minutes.
- Conclusion: cold start conditions have a distinctive thermal IR signature: exhaust + tyres/brakes + road reflection.
- → extract thermal images for 'vehicles of interest'.





Thermal profiling of ‘vehicles of interest’

HOT

8% outliers are in cold start mode

COLD

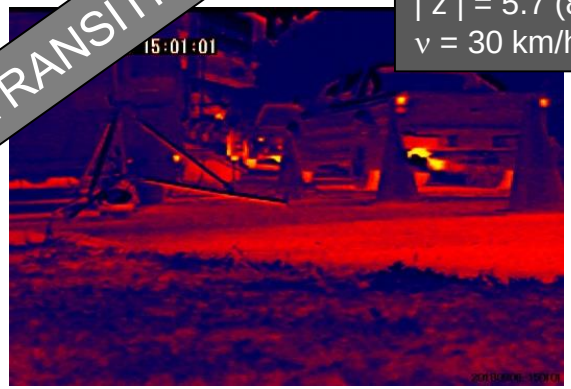
Diesel LCV E5
Macgregor (> 100 km)
CO/CO2 = 0.04 ppm/% (rank 5)
| z | = 6.8 (11 outliers, n = 870)
ν = 32 km/h, a = +0.8 m/s^2

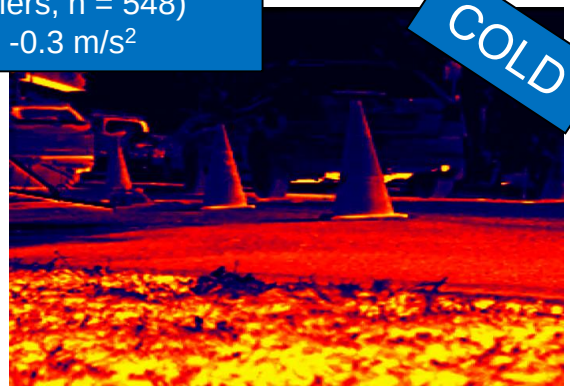
Diesel LCV E5
Macgregor (5 km)
CO/CO2 = 0.11 %/% (rank 1)
| z | = 13.5 (11 outliers, n = 870)
ν = 19 km/h, a = +1.3 m/s^2

TRANSITION

Diesel LCV E4
Taringa (< 2 km)
CO/CO2 = 0.06 %/% (rank 3)
| z | = 5.7 (8 outliers, n = 470)
ν = 30 km/h, a = +0.2 m/s^2

Petrol PC-M E4
Taringa (same suburb)
HC/CO2 = 65.4 ppm/% (rank 4)
| z | = 4.3 (4 outliers, n = 548)
ν = 13 km/h, a = -0.3 m/s^2





COLD

On-road air quality vs Tunnel

- On-road speciated VOC:

→ large discrepancies with current vehicle emission factors,

→ confirming the results from an earlier tunnel study.

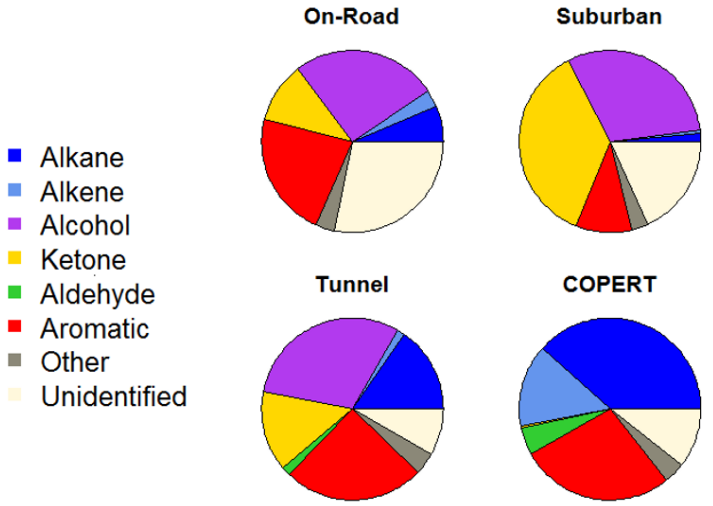
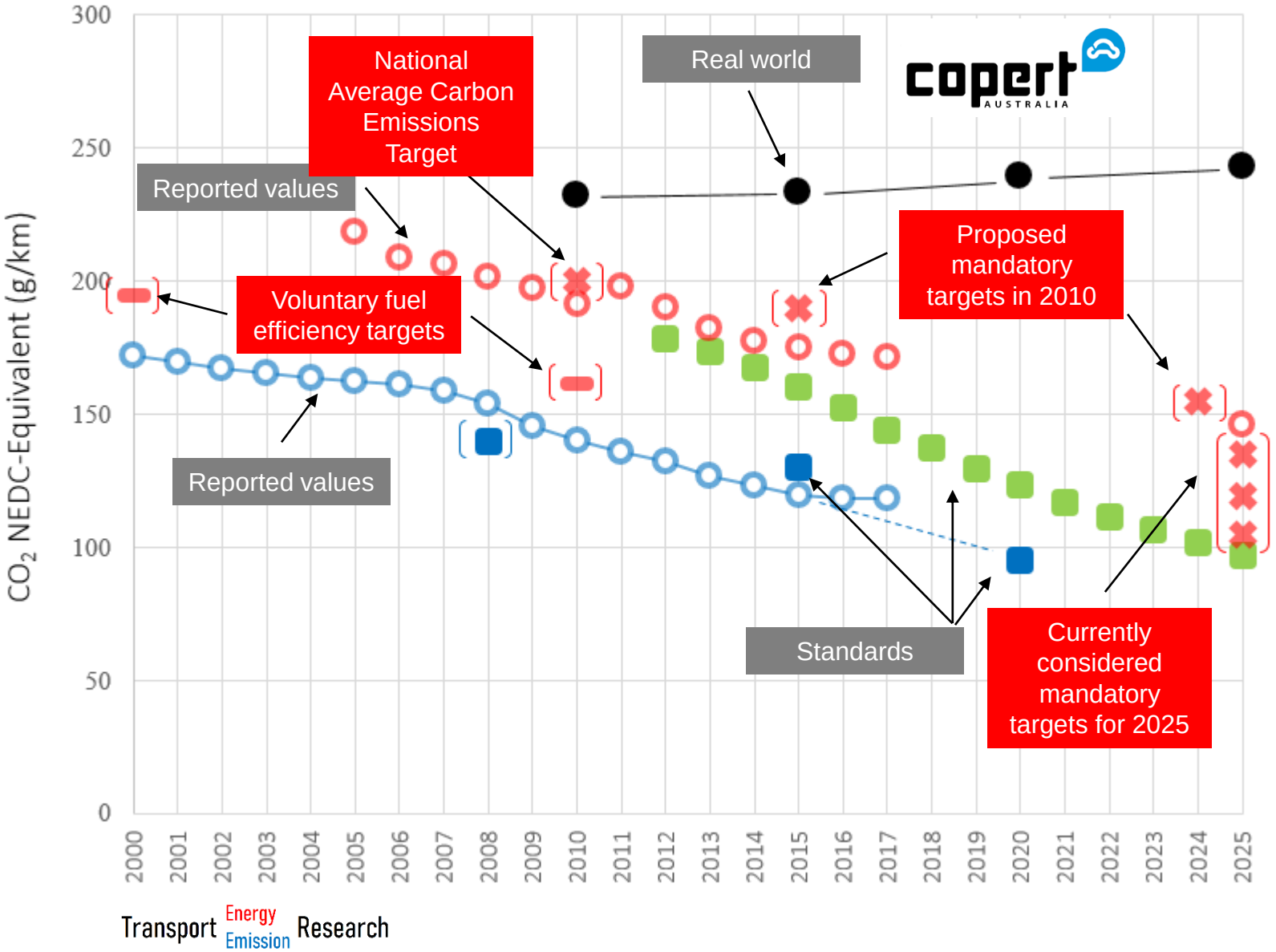


Table 3 – Selected VOCs in ppbv (mean values ± standard error).

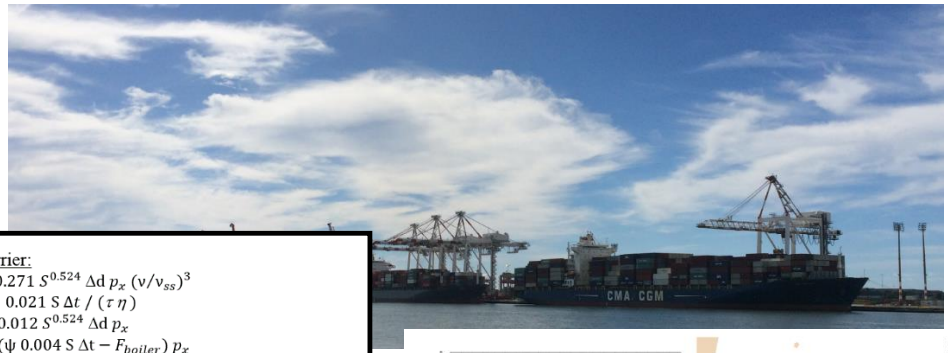
Speciated VOC	Tunnel (Smit et al., 2017)	On-road (This study)	Suburban (This Study)
Ethanol	36.0 (±7.3)	10.1 (±1.5)	20.5 (±9.4)
Acetone	16.8 (±0.7)	4.1 (±0.5)	23.5 (±10.4)
Toluene	9.3 (±0.5)	4.9 (±0.8)	2.5 (±2.0)
Xylene (m-& p-)	6.6 (±1.7)	1.7 (±0.4)	1.3 (±1.0)
Isopentane	6.4 (±0.5)	-	-
Pentane	5.2 (±0.6)	-	-
Benzene	4.4 (±0.6)	1.3 (±0.2)	0.5 (±0.2)
Methylene-chloride	3.2 (±2.6)	-	0.7 (±0.5)
Naphthalene	2.3 (±0.4)	0.6 (±0.0)	0.9 (±0.3)
Hexane	2.1 (±0.4)	1.7 (±0.3)	0.8 (±0.5)
1,2,4-Trimethylbenzene	2.0 (±0.7)	0.4 (±0.1)	0.5 (±0.2)
Acrolein	1.9 (±0.2)	-	-

CO_2 vehicle emissions legislation in Australia



Australian ship fuel/emission model

- High resolution (minute, AIS)
- Entire fleet prediction, but simulates individual ships
- Parameterised fuel/emission model
- Developed ship energy balance calibration method



Bulk Carrier:

$F_{ME,x} = 0.271\ S^{0.524}\ \Delta d\ p_x\ (v/v_{ss})^3$

$F_{boiler} = 0.021\ S\ \Delta t\ /\ (\tau\ \eta)$

$F_{AE1,x} = 0.012\ S^{0.524}\ \Delta d\ p_x$

$F_{AE2,x} = (\psi\ 0.004\ S\ \Delta t - F_{boiler})\ p_x$

where $\psi = 3.262\ (\tau\ \eta\ 0.004\ S\ \Delta t)^{-0.345}$

Cruise ship:

$F_{ME,x} = 0.257\ S^{0.613}\ \Delta d\ p_x\ (v/v_{ss})^3$

$F_{boiler} = 0.014\ P\ \Delta t\ /\ (\tau\ \eta)$

$F_{AE,x} = 4\ P\ \Delta t\ p_x/\ (\tau\ \eta), \ldots\ for\ P \leq 2000$

$F_{AE,x} = \left(22 - 2.3\ LN(P)\right)\ P\ \Delta t\ p_x/\ (\tau\ \eta), \ldots for\ P > 2000$

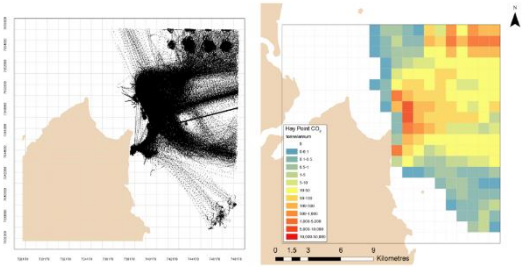
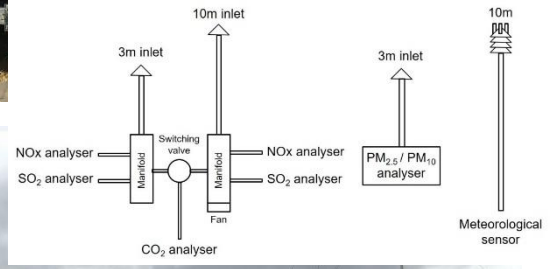
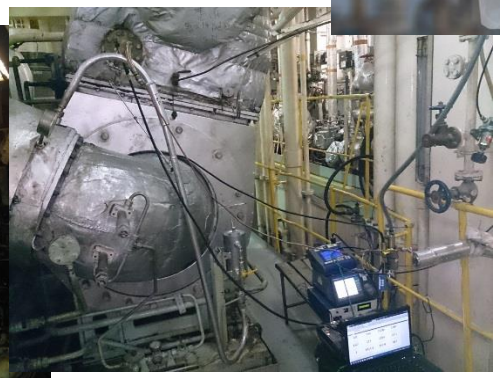


Figure 27. Hay Point – AIS data visualisation and gridded CO_2 emissions.

Next steps – validation in Australia

- Air monitoring program
  May 2019- May 2020
- On-board emission measurement (2015) – two CSL ships on their journeys (~ 30,000 GT)
- Drone sampling/measurement – moving and stationary ships
- Fuel use surveys





Papers available on request…
Collaboration always welcome…