Development of a chassis dynamometer testing facility

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Talk agenda: 21st century challenges + solutions

Challenge: managing the transition to net zero transport emissions

Solutions: Bioenergy is the one of the pillars of transport sector decarbonisation

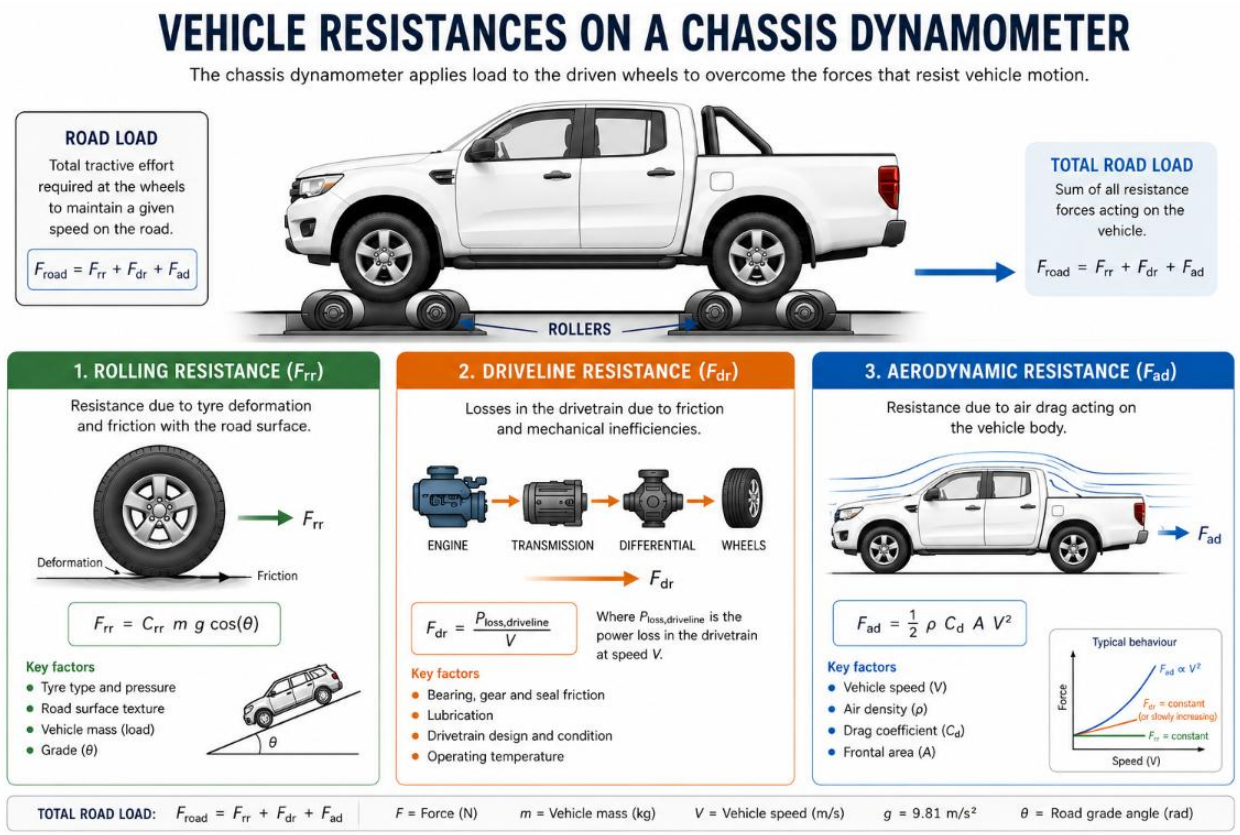
Part I (Testing Facility Development): The following Australian Design Rule (ADR) scope has been approved for **UTS** and **Swinburne University of Technology** (**contact:** Prof. Hadi Ghaderi)

This testing facility has been approved to test for a partial standard in relation to:

- ADR 79/05 — Emission Control for Light Vehicles
- ADR 80/04 — Emission Control for Heavy Vehicles
- ADR 81/03 — Fuel and Energy Consumption Labelling for Light Vehicles
- ADR 111/00 — Advanced Emission Control for Light Vehicles
- ADR 112/00 — Control of Real Driving Emissions for Light Vehicles

Part II: Presentation of some renewable diesel testing results

Equipment required for energy/emission testing?



Requirement #1: Chassis Dynamometer

- A power measurement technique for simulating road load in the laboratory

Image source: https://chatgpt.com/s/m_6a7c4ccd890481918e53d1a7e0e07fba (After three prompts)

Chassis dynamometer technical specifications

Chassis dynamometer technical specifications

Manufacturer/model	MAHA/MSR 500/2 four-wheel drive
Brake configuration	1 eddy current brake per axle
Motor configuration	1 electric motor per axle
Roller diameter (mm)	504
Track width (min/max; mm)	700/2,200
Axle load (kg)	2,500
Maximum speed (km/h)	300
Motor power (kW)	2 × 22
Front/rear wheel power static/dynamic (kW)	260/1,000
Tractive force (N)	7,000

- Road load adaption in accordance with SAE J2264 (2023) possible
- 4 quadrant dynamometer operation possible
- **Multiple drive cycles possible:**

- NEDC, WLTP, CUEDC, IM240, FTP, etc

Society of Automotive Engineers (SAE) International. (2023). SAE J2264 – Chassis Dynamometer Simulation of Road Load Using Coastdown Techniques, Warrendale, pp 1–25.

Portable Emissions Measurement System (PEMS)

Requirement #2: Access to a commercial PEMS

	Description	Serial no./ID	Measurement capability
1	AVL 493 Gas PEMS iX	521	CO_2, CO, NO_2, NO, C_3H_8, CH_4, O_2 at 10 Hz.
2	AVL 496 PN PEMS HD	206	Solid particle number (solid PN) concentration with a 23 nm cut-point at 10 Hz.
3	EFM 2.5 Inch Flow Tube	403	Exhaust gas flow rate, temperature and differential pressure.
4	AVL 495 EFM BOX	530	The EFM Control Box houses the transducers for the EFM flow tube and the calculation unit for processing results.
5	AVL M.O.V.E System Control	651	Monitors all devices within the PEM system and stores data.
6	AVL Concerto		Concerto which is a powerful post-processing software solution for PEMS testing data.

Mini-PEMS development

Requirement #3 [SUT]: A mini-Portable Emissions Measurement System (mini-PEMS)

	Description	Serial no./ID	Measurement capability
1	AVL Concerto		Concerto which is a powerful post-processing software solution for PEMS testing data.
2	ECM Gas Sensors	1937, 3949, 06-10T	CO_2, CO, NO, O_2, AFR, PM, PN.
3	ECM Weather Station	386	RH, Ambient Temperature, Barometric Pressure.
4	HC Gas sensor	X-am8000	C_3H_8, CH_4.
5	Systec PEMS EFM 5.0 Inch Flow Tube	TF4B2P23460001	Exhaust gas flow rate, temperature and differential pressure.
6	CSS cloud enabled datalogger	CANedge 2 (multiple dataloggers usable)	Monitors all devices within the PEM system, GNSS/IMU systems, stores data and sends to a cloud platform.

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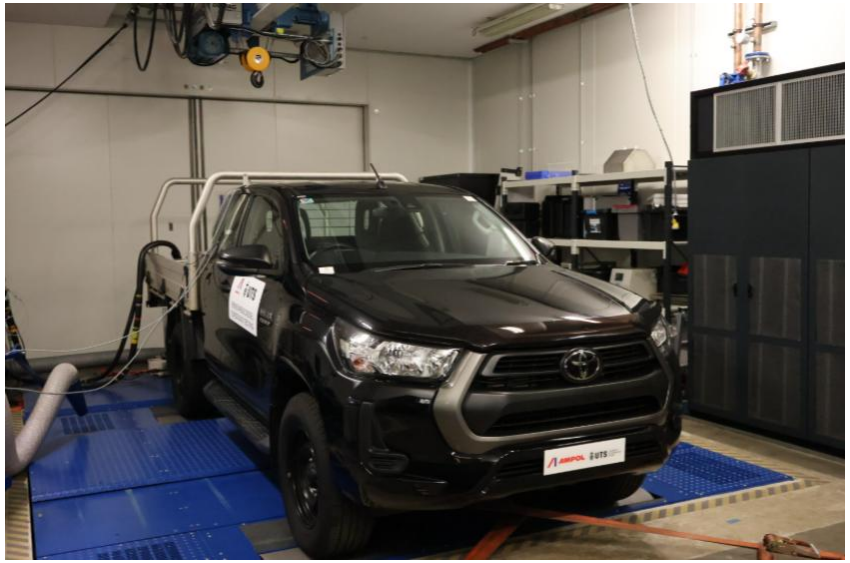
Test Vehicle Specifications

Vehicle Model	Toyota Hilux
Type Approval Emissions Limit	**Euro 5b**
License Plate Number	Unregistered vehicle
Make	Toyota
Model	Hilux
Model (engine block plate)	GUN126R-CTTSXQ3
Engine type (engine block plate)	1GD-FTV
Variant	SR Auto 4×4
Transmission Type	Automatic
Country of Manufacture	Japan
Fuel Type	**Diesel**
Gross Vehicle Mass (GVM)	3050 kg
Reference Mass ADR 79/04 clause 2.2	2050 kg
Kerb Weight	1950 kg
Actual Test Weight	2170 kg
Engine oil specification	SAE 0W-20
Engine Performance	
Rated engine power	150 kW @ 3000–3400 rpm
Maximum Torque	500 Nm @ 1600–280 rpm
Engine Specifications	
Engine Capacity	2.8 litres
Number of Cylinders	4
Aspiration	Turbocharged
Engine Type	Diesel
Cylinder Configuration	In-line
Bore × Stroke (mm)	92 × 103.6
Vehicle Specifications	
Fuel Tank Capacity	80 L
Fuel Tank Material	Plastic (Polyethylene)
Transmission Type	Automatic
Number of Gears	6
Wheels Driven	2 (driven as rear wheel drive)
Emission Control Technology	**DPF (Catalysed) + EGR**
Oil grade	ACEA C2



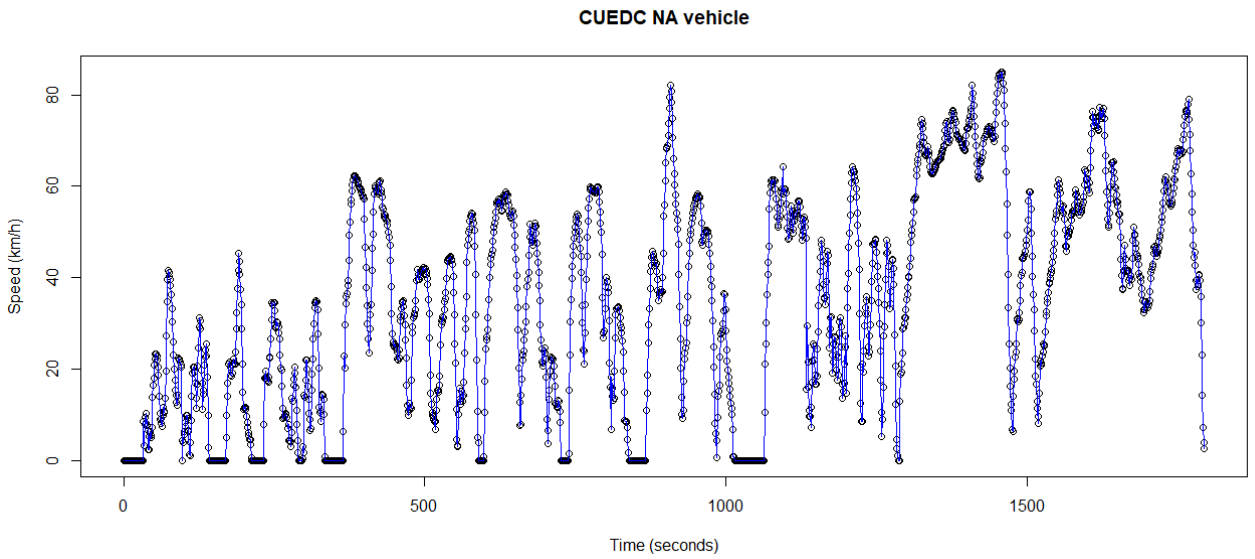
Source: A. Lidfors Lindqvist

Most crucial features:

- Euro 5b diesel, catalysed DPF + Exhaust Gas Recirculation (EGR) as aftertreatment

Drive cycle for testing

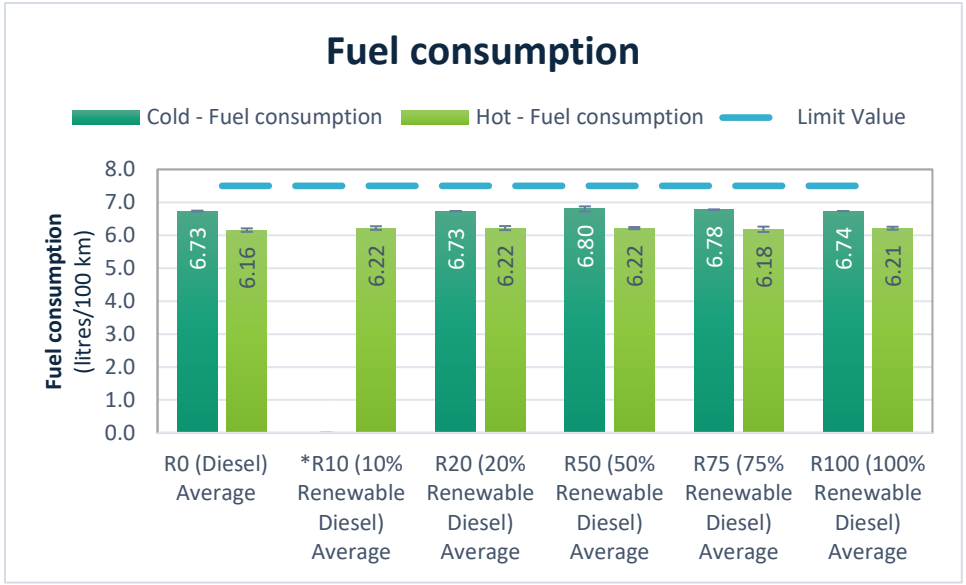
- **CUEDC** = Composite Urban Emissions Drive Cycle
- Developed by the NSW Environmental Protection Authority (EPA)



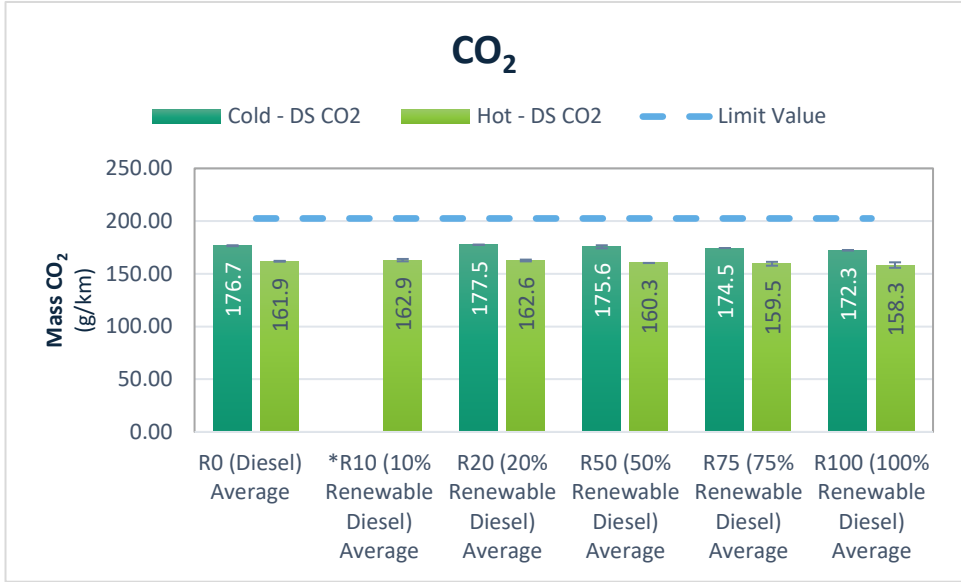
Dynamic Parameter	Value
Maximum speed (km/h)	85.0
Average speed (km/h)	35.1
Maximum acceleration (m/s^2)	3.18
Minimum acceleration (m/s^2)	-5.13

- NEDC (maximum acceleration) = 1.042 m/s^2
- WLTC (maximum acceleration) = 1.667 m/s^2
- Driver aggression important to consider

Renewable diesel: results #1



Green Vehicle Guide suggests 7.5 litres/100 km

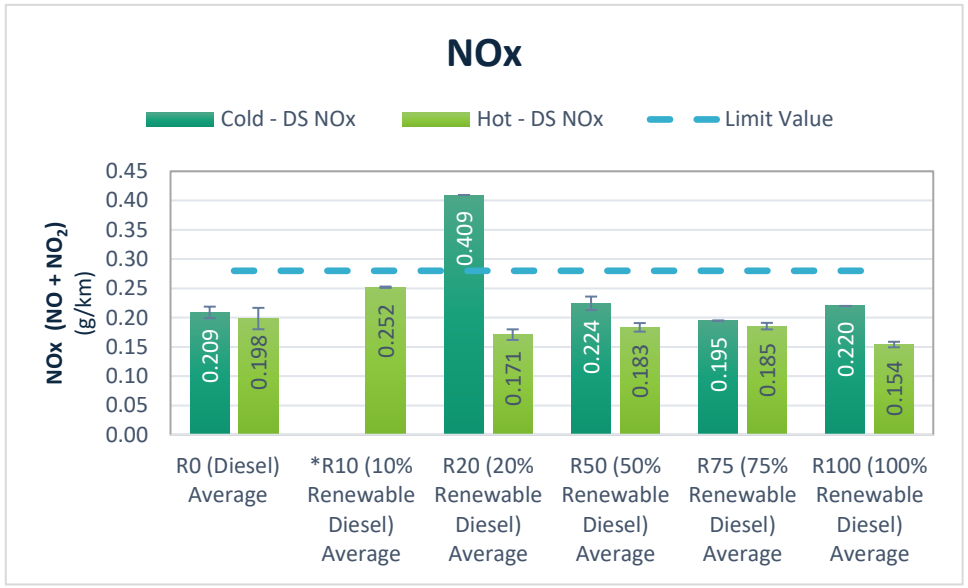


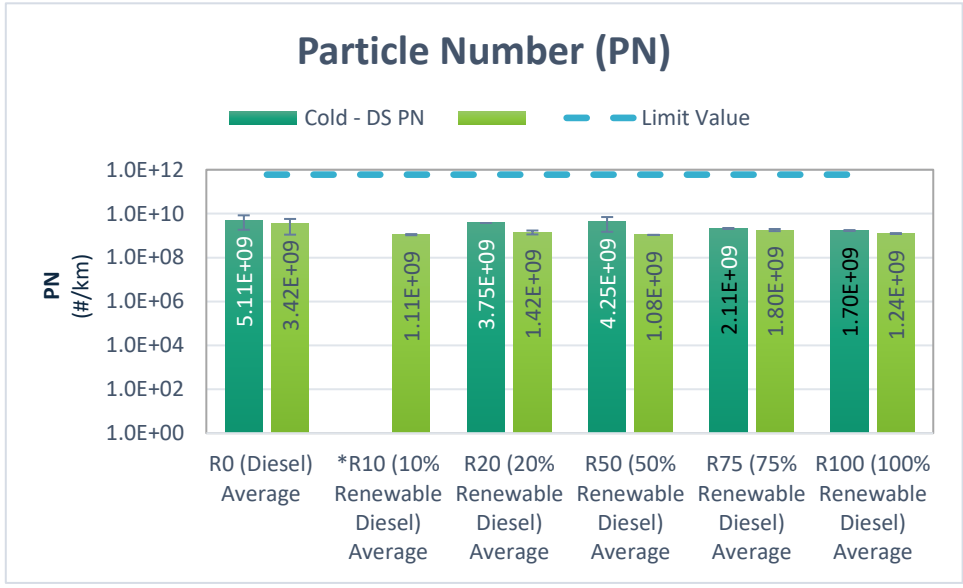
Green Vehicle Guide 202.5 g CO_2/km

1 litre diesel ≈ 2.7 kg CO_2

Sources: https://www.greenvehicleguide.gov.au/Vehicle/ViewMatchingVariants?vehicleDisplayId=30630

Renewable diesel: results #2





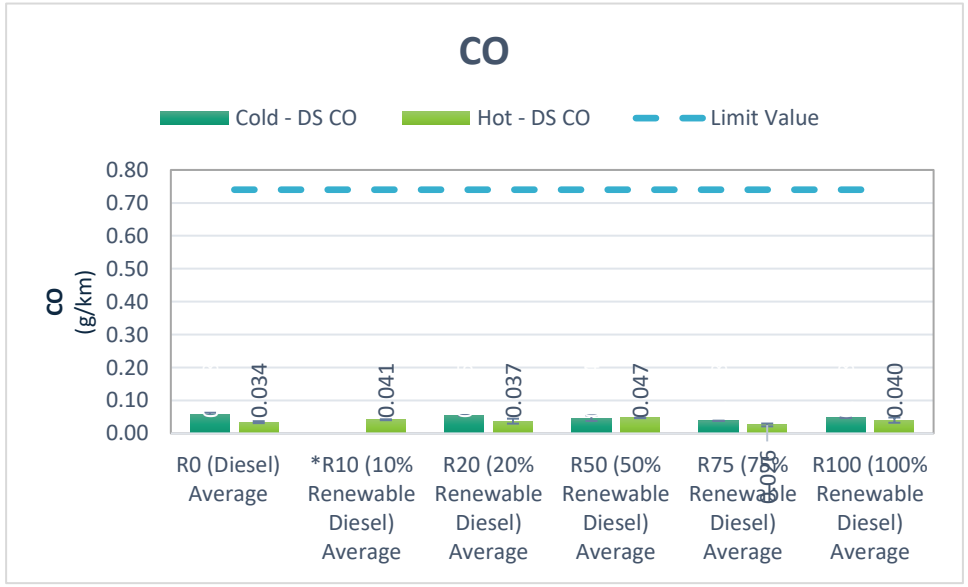
The Euro 5b type approval emission limit for NOx is 0.28 g/km

The Euro 5b type approval emission limit for PN is 6.0×10^{11} #/km

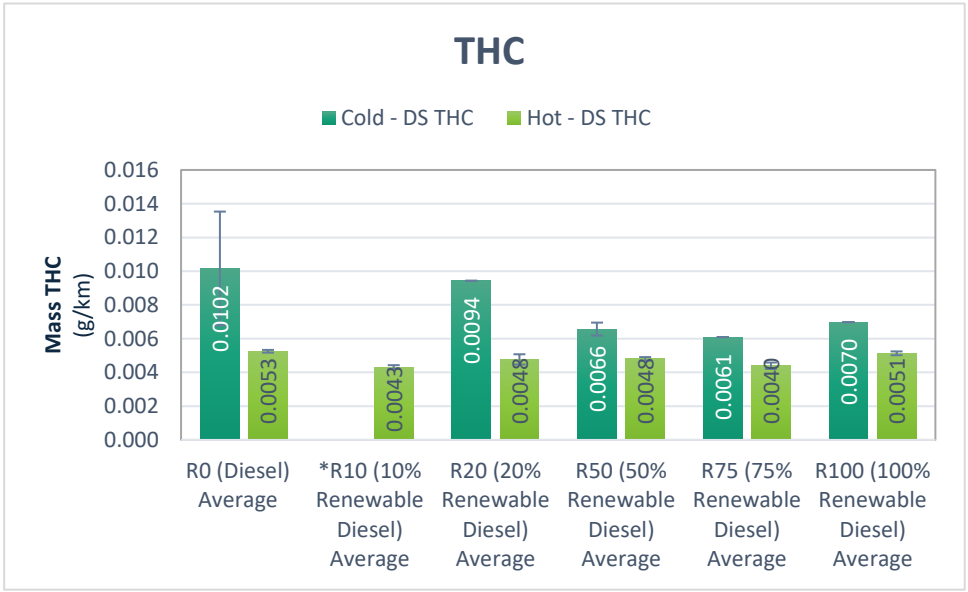
NO_2/NOx ratios range from 0.39 (diesel) to 0.68 R100 (100% renewable diesel)

Somewhere between 1.5–1.8 million Euro 5 diesel utes in Australia

Renewable diesel: results #3



The Euro 5b type approval emission limit for CO is 0.74 g/km



The Euro 5b type approval emission limit for NMHCs + NOx PN is 0.35 g/km

CH_4/THC ratio between 62–92%

Results synthesis: future work

Australian Government
Department of Climate Change, Energy, the Environment and Water

Australian National Greenhouse Accounts Factors

For individuals and organisations estimating greenhouse gas emissions

2025

For transport greenhouse gases:

CO_2 emission factors agree within a few percent

CH_4 emission factors are too low by a factor of 3–5

N_2O emissions factors …

Assumed NO_2/NOx ratio too low by a factor of 2

DPF regenerations expected every 250–300 km

We observed DPF regenerations every 50–222 km (**mean:** 130.1 km)

Explanations:

- Back pressure from PEMS?
- EGR valve activation?
- Fuel chemistry effects?

Technically, the Testing Facility Approval means …

ADR 79/05 (Euro 6d) – In Service Conformity (ISC) Testing

- Appendix A, Annex 4, Clause 5.3

ADR 80/04 (Euro 6) – Vehicle Emissions Testing with Portable Emissions Measurement System (PEMS)

- Annex 8, Appendix 1

ADR 81/03 – Calculation of NEDC CO_2 emissions for ICE and self-charging hybrids

- Annex B, Clause 3

ADR 111/00 – Type 1 Conformity of Production Tests (uses WLTP)

- Appendix 1, Type 1 test, Annex B6 Type 1 test, Annex B6 Appendix 1

ADR 112/00 – Vehicle Emissions Testing with Portable Emissions Measurement (on-road measurements)

- Appendix A, Annex 4

Next steps…

Student projects:

- Non-exhaust particulate matter
- Hybrid/Electric vehicle testing
- Further work on alternative fuels

On-road testing:

- Dual fuel (hydrogen + diesel) trucks

Collaborations welcome!

Thanks – contact details

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