Real-World Testing of NZ Vehicles – Fuel use and Exhaust emissions

CASANZ TSIG and TEKH-EG
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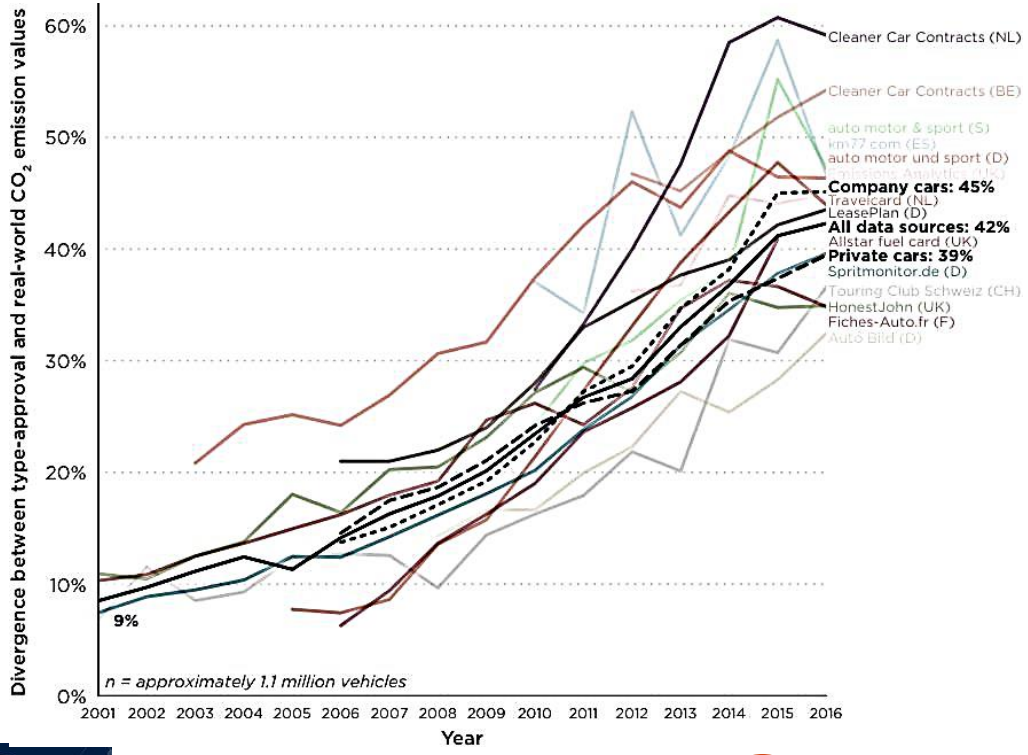
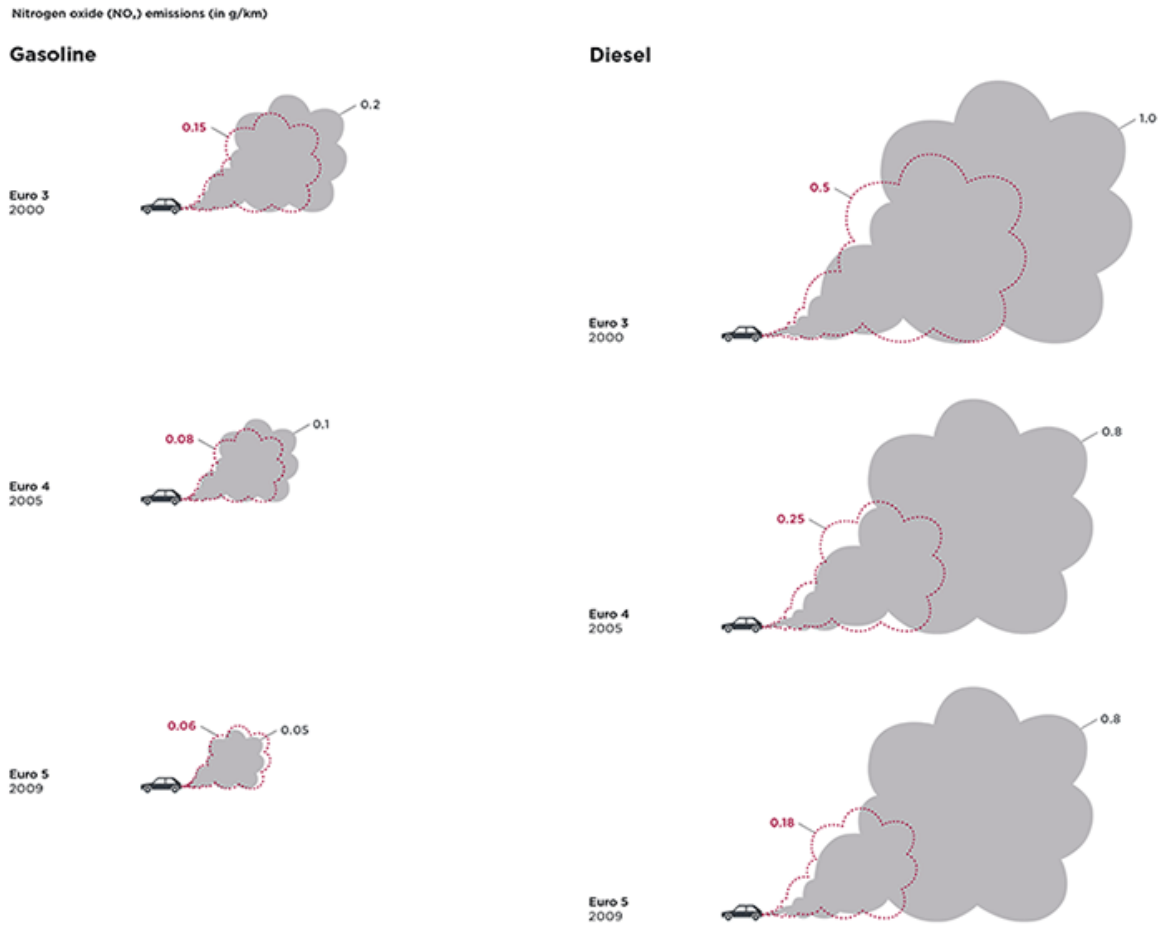
Quick recap: what did we do?

Research purpose

To improve understanding of real-world fuel consumption and real-world emissions from the New Zealand fleet



Real-world vs type approval CO_2



Real-world
vs
type approval
NO_X

Research objectives

- Develop an on-road testing **methodology**
- Carry out real world **testing** on a range of representative vehicles including 26 light duty and 6 heavy duty
  - Includes PM_{10}, NO, NO_2, CO_2 and fuel consumption
- Investigate the **reasons** for differences between expected results and actual findings
- Develop **factors** for later incorporation into VEPM where appropriate

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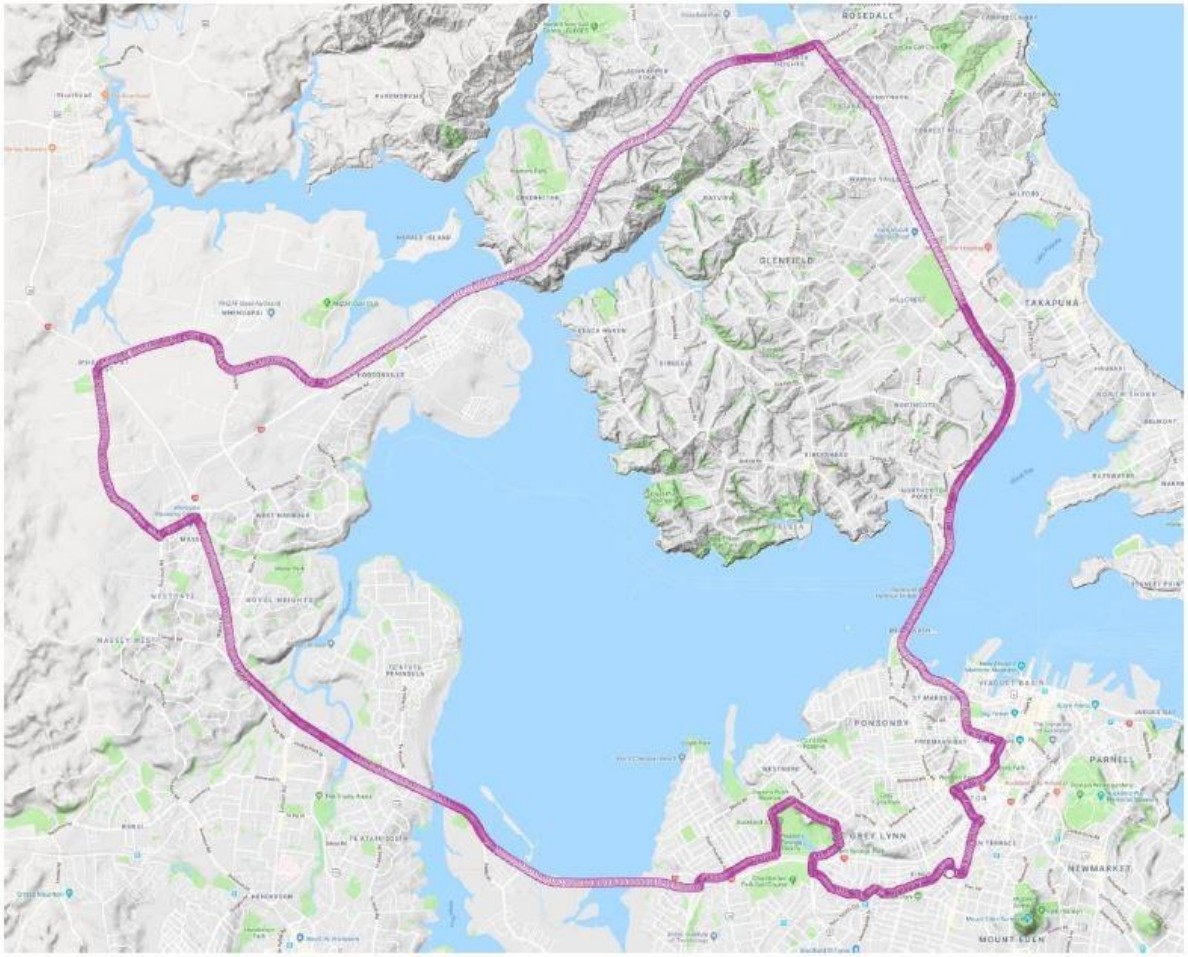
Test route

Designed to include:

- Mix of urban + rural + motorway
- Mix of gradients



Testing

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Emissions testing to provide data from vehicles in NZ

Following the Volkswagen emissions scandal, it's hard to know the levels of pollution your car is emitting Source: 1 NEWS

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NEW ZEALAND

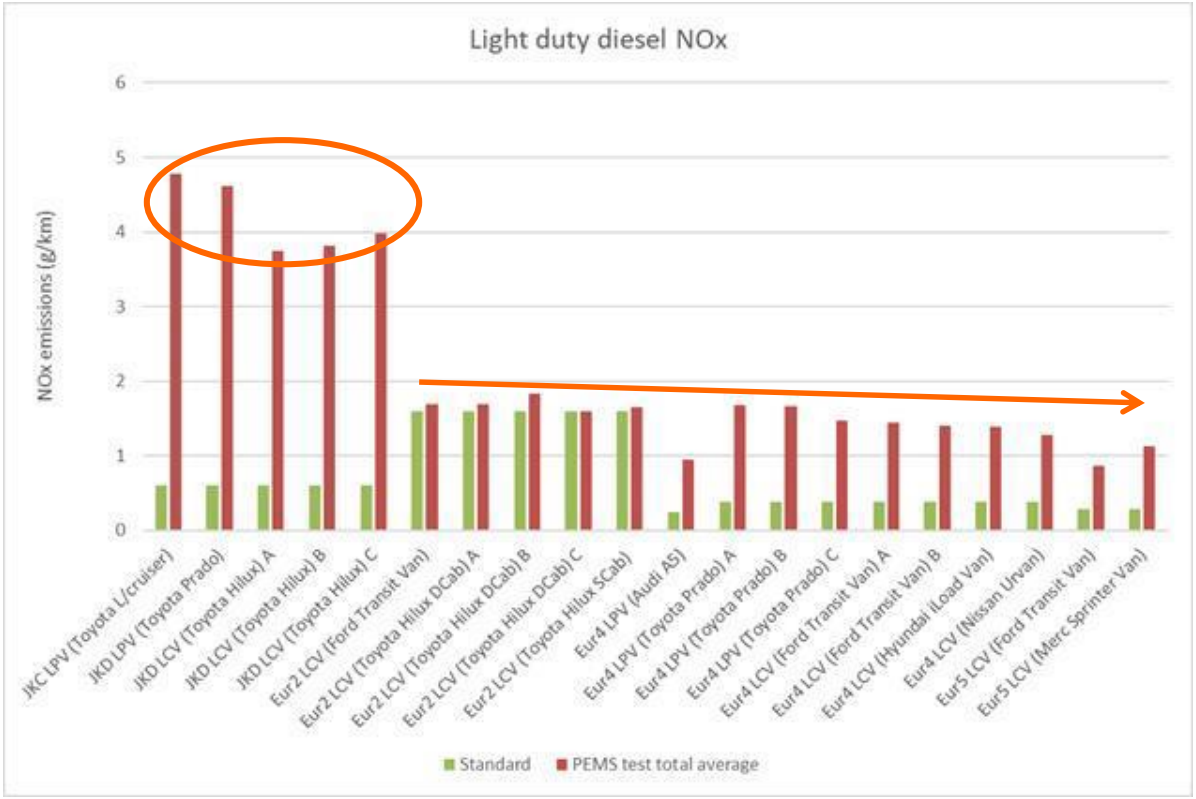
A New Zealand study is putting 34 different cars, trucks and vans through emissions testing, aiming to glean more accurate data than is currently available form overseas.

Twenty-eight types of car and six models of truck are being tested in a $300,000 research project funded by the New Zealand Transport Agency.

What did we find?

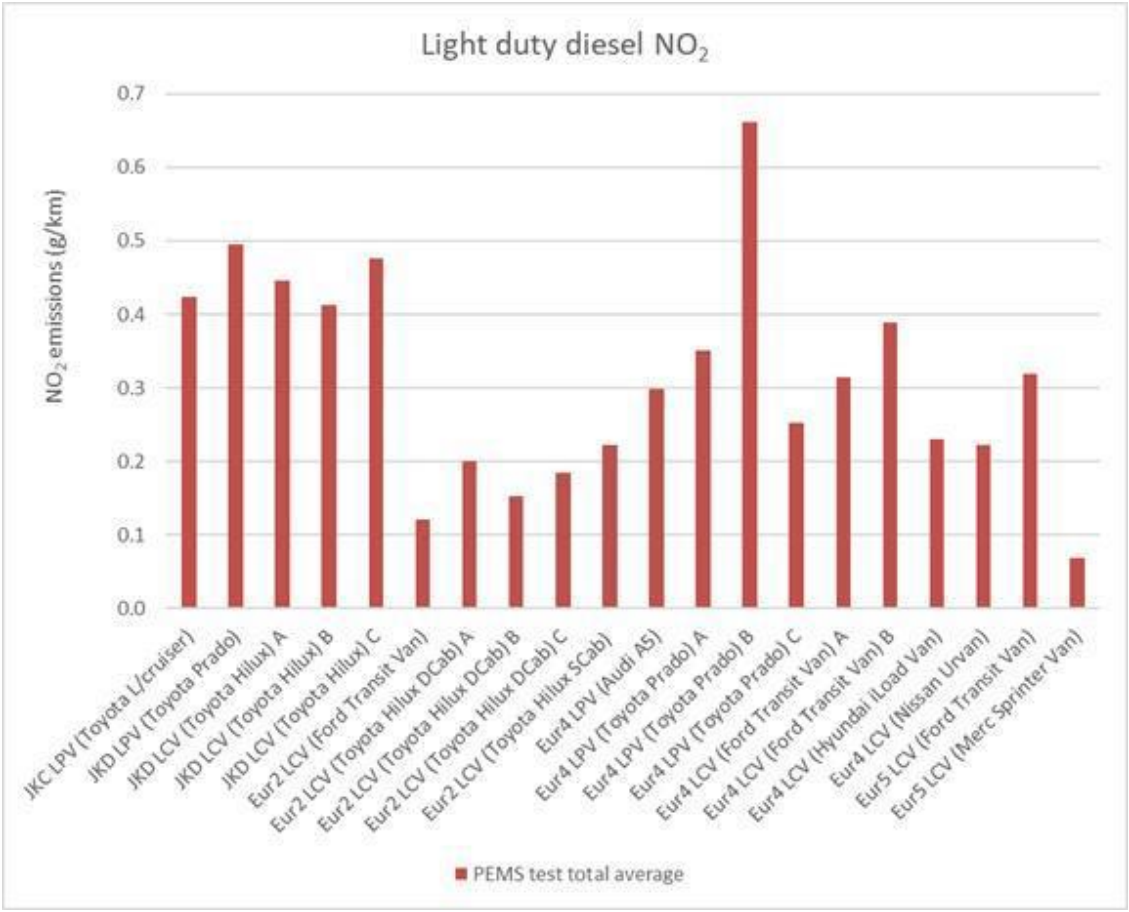
Real-world NO_x versus standards

Real-world 4.6 times **higher** on average than stds (2-~8x)



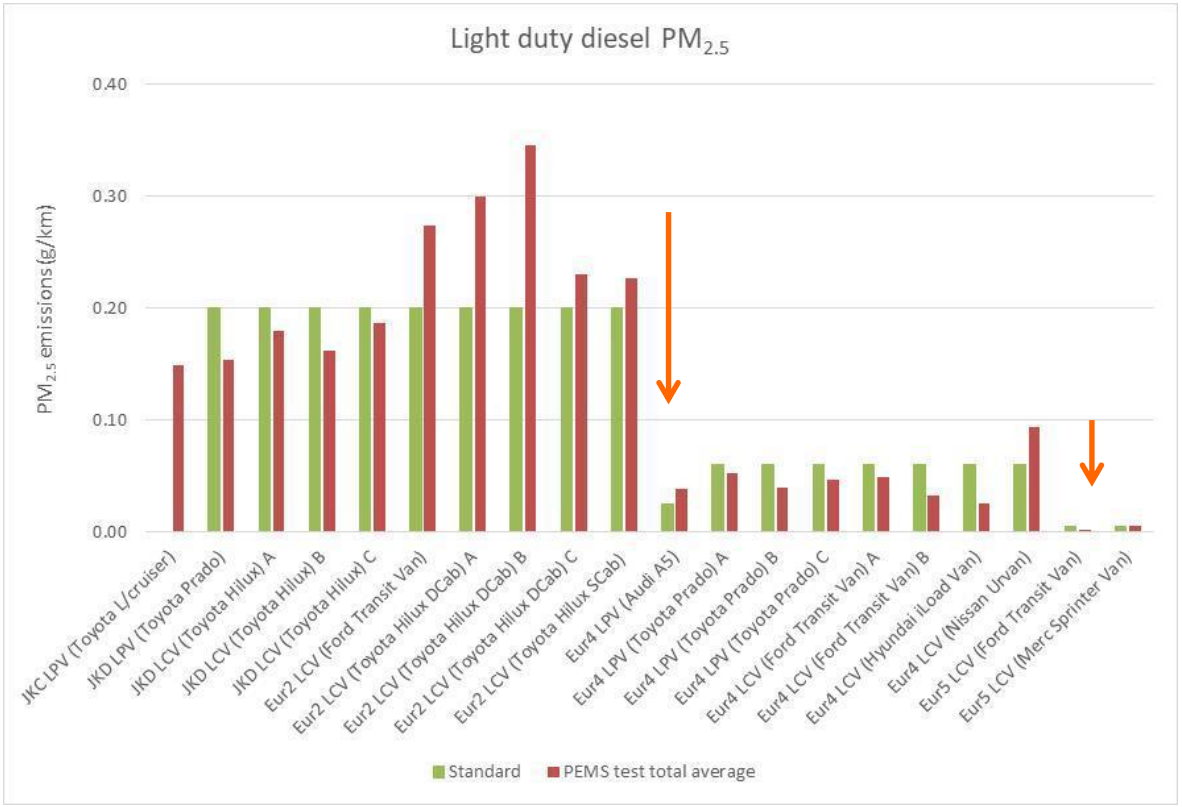
Real-world NO_2 emissions

There are no regulated stds for NO_2 for any fuel/duty

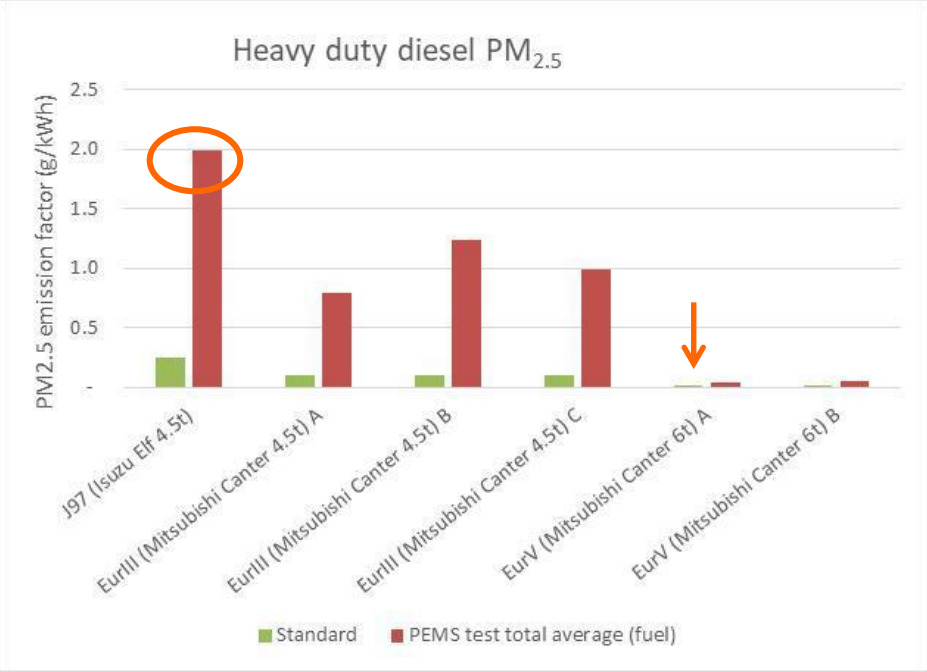


Real-world $PM_{2.5}$ versus standards

Real-world typically **same** on average than stds (0.5-1.5x)



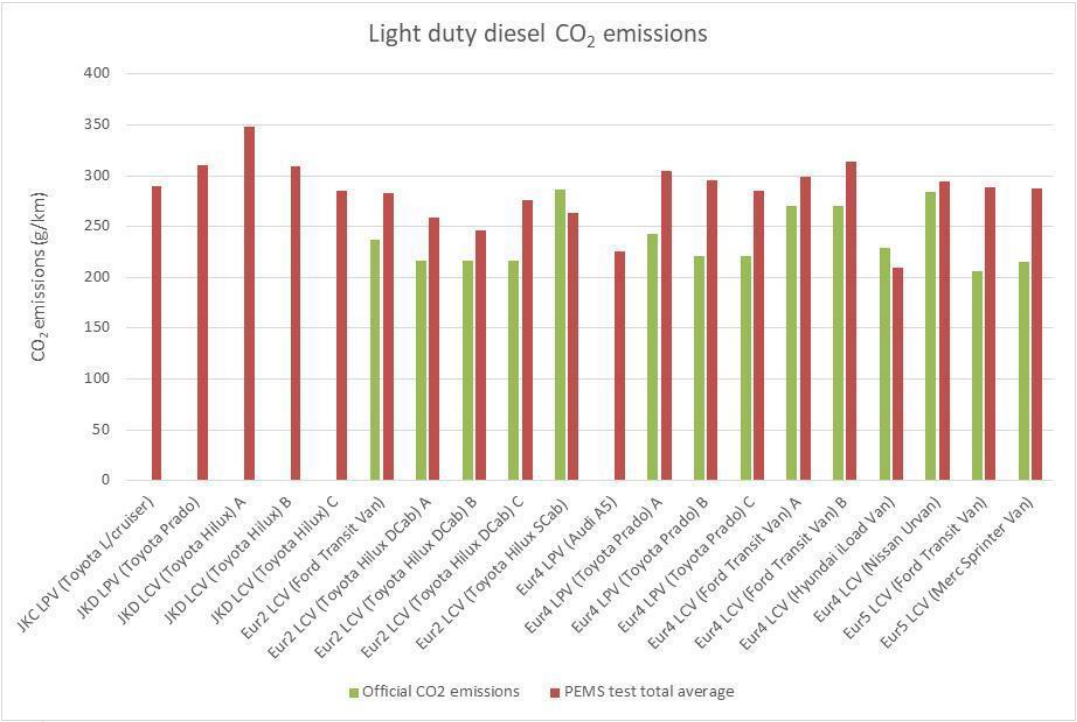
Real-world $PM_{2.5}$ versus standards

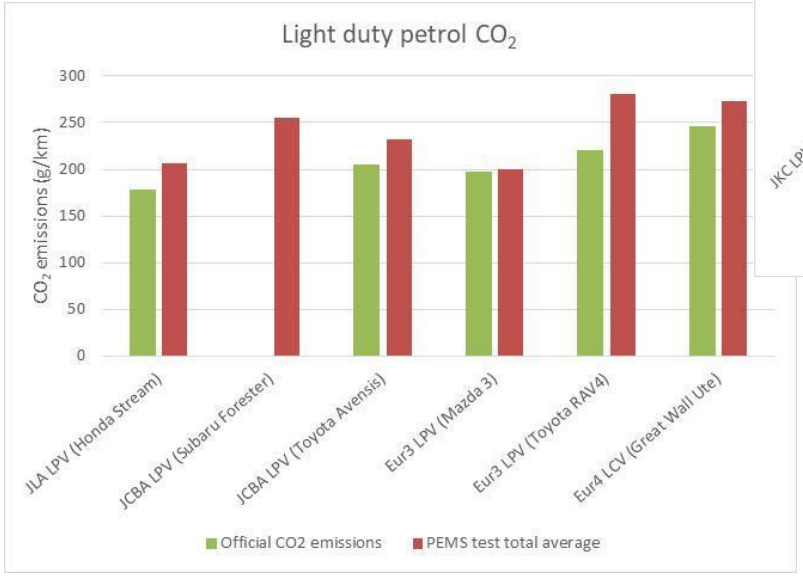


- Note heavy diesel PEMS $PM_{2.5}$ results in g/kWh are **indicative** only (based on fuel use, energy content & 45% engine efficiency)

Real-world CO_2 versus type-approval

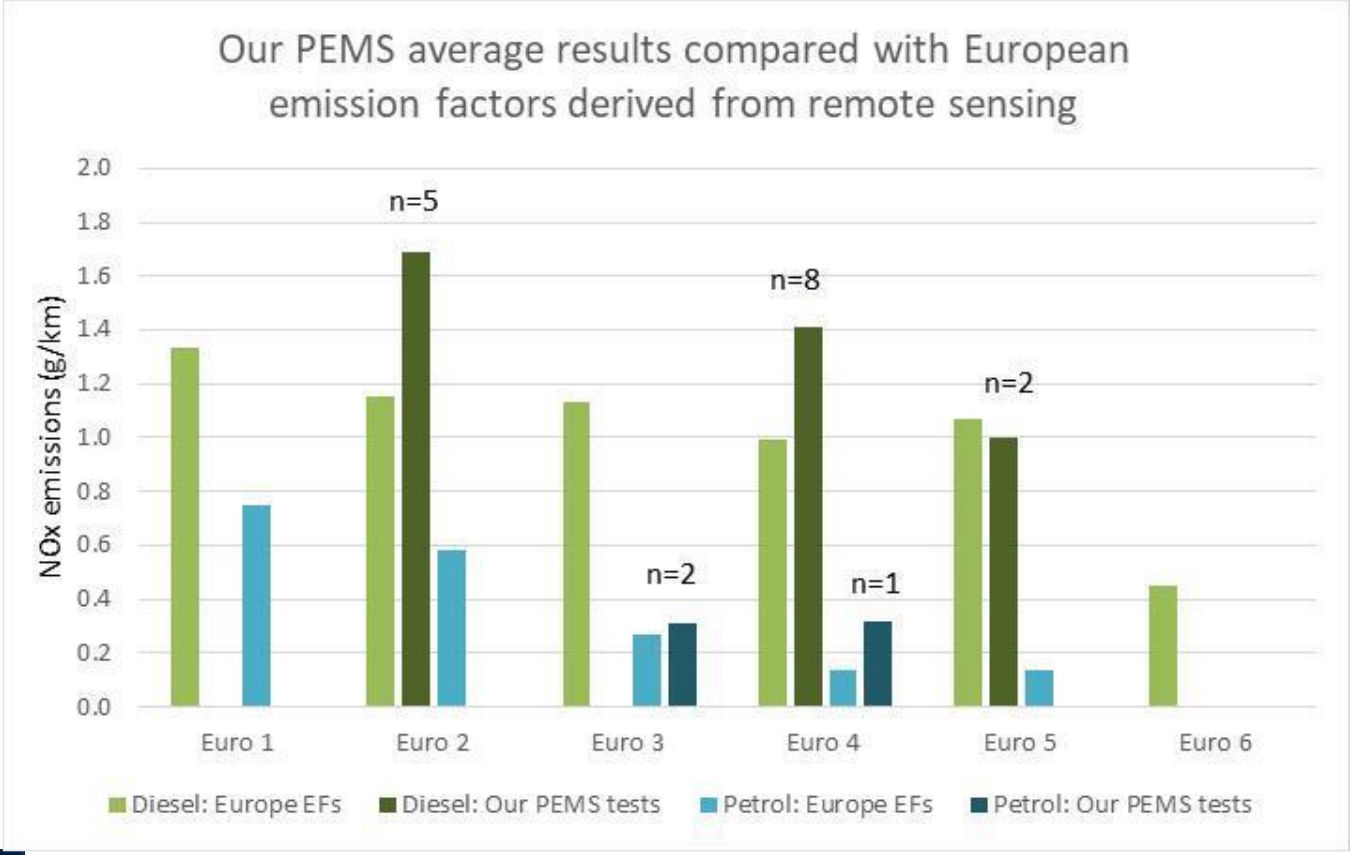
Real-world **17% higher** on average than type-approval





Comparison with Europe

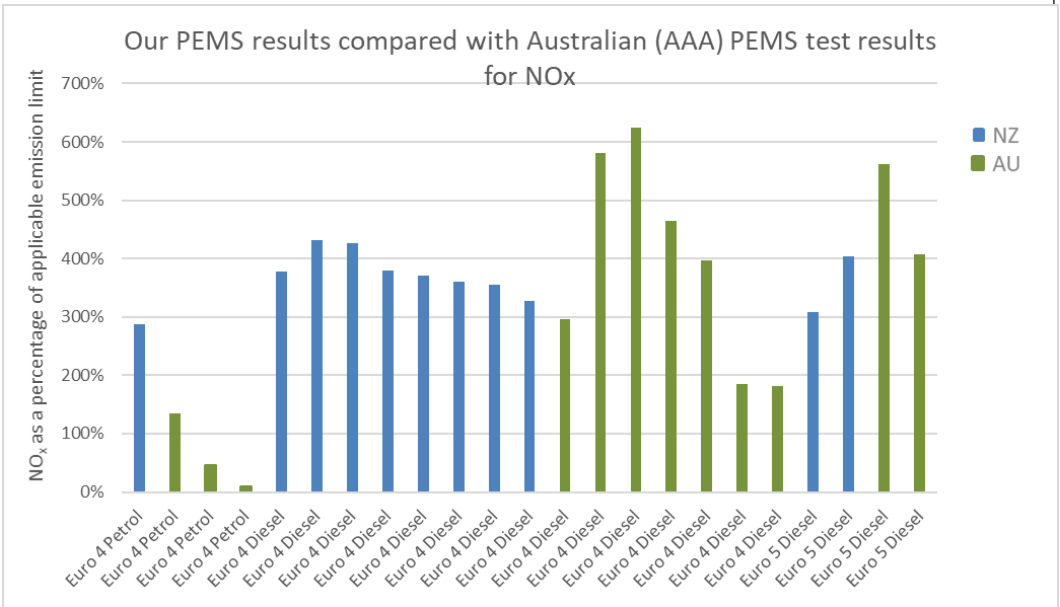
Our results **agree reasonably well**, considering small number of our tests (shown by 'n' below)

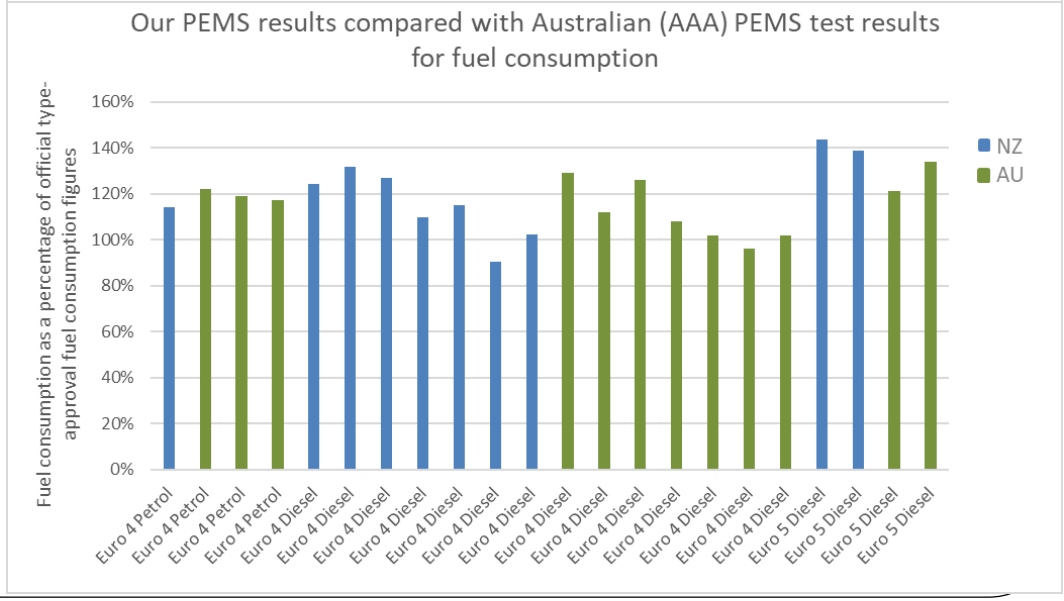


Comparison with Australian PEMS

Our results **remarkably similar**

- Australia had greater variety in NO_X maybe due to greater diversity of test vehicles(?)





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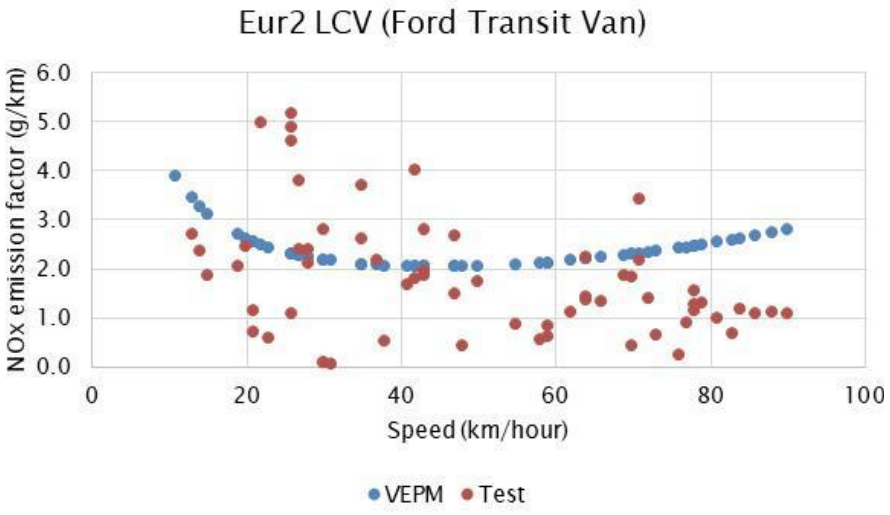
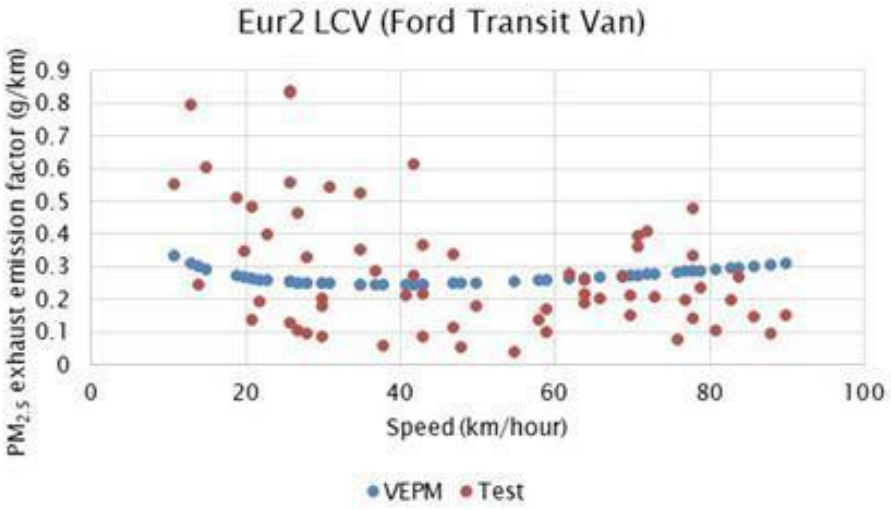
Comparison with VEPM

- Each vehicle compared with VEPM predictions
- Raises some questions and recommendations for further work

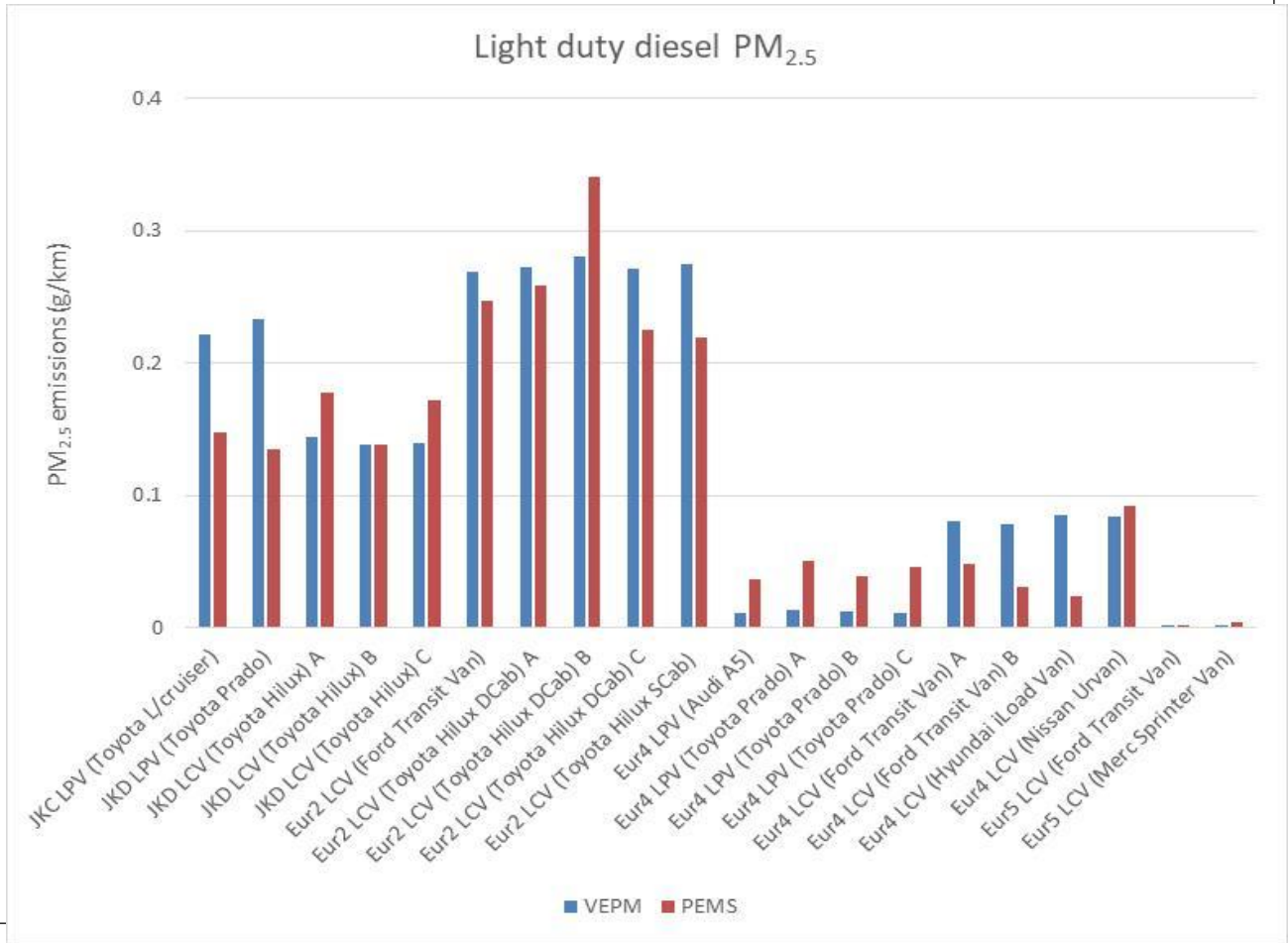




Comparison with VEPM

In general:

- European emission factors applicable in NZ
- Emission factors represent real world emissions



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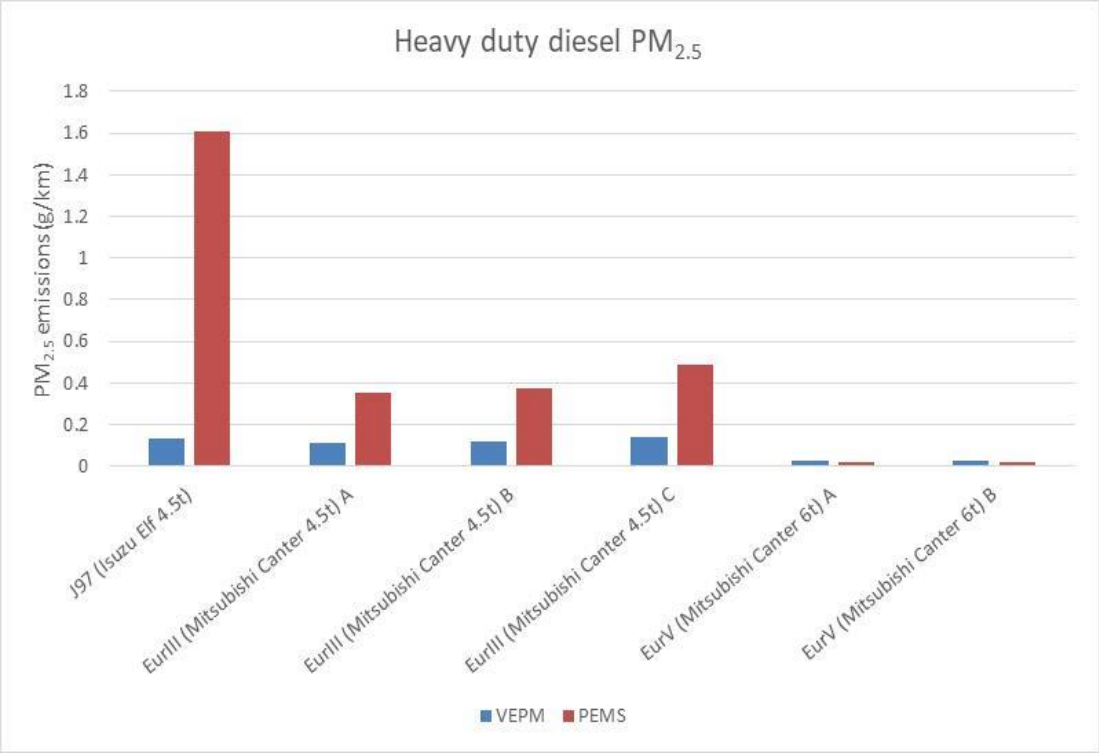
Key recommendations

- Investigate heavy duty PM



Key recommendations

- Use RSD and PEMS data to investigate emission factors for unique features of NZ fleet (e.g. Japanese and older vehicles)

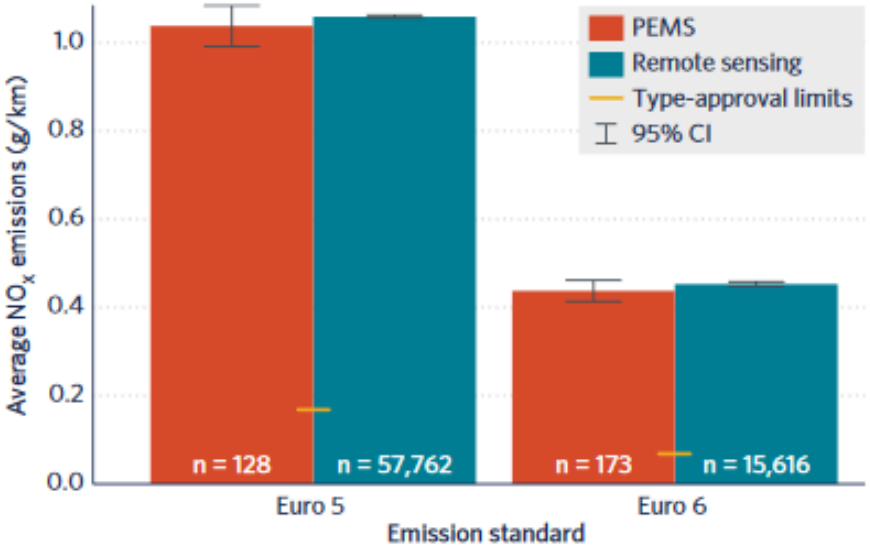


Figure 9: Average diesel NO_x emissions (g/km) measured from emissions testing campaigns with PEMS and calculated from remote sensing data. (Corrected on 6/6/2018 to fix Y axis incorrectly labeled as g/kg)

European TRUE initiative recommends method which has found good agreement between PEMS and RSD

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Thank you!

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Light duty petrol test vehicles (6)

- YOM from 2002 to 2014, engine size from ~1.7l to 2.4l
- All with TWC, all 91P except Great Wall ute (95P)
- All in VEPM as LPV except Great Wall ute (LCV)

Vehicle ID	Make and model	Engine size (cc)	Fuel[a]	GVM[b] (kg)	Emission standard	NO_x limit	PM[c] limit	Official[d] CO_2	Exhaust treatment[e]	VEPM class[f]
Light duty petrol						(g/km)	(g/km)	(g/km)		
JLA LPV (Honda Stream)	2002 Honda Stream	1660	91P	1725	J00 (JLA)	0.04	---g	178	TWC	LPV
JCBA LPV (Subaru Forester)	2006 Subaru Forester	1990	91P	1695	J05 (JCBA)	0.025	---g	204	TWC	LPV
JCBA LPV (Toyota Avensis)	2005 Toyota Avensis	1990	91P	1755	J05 (JCBA)	0.025	---g	n/a	TWC	LPV
Eur3 LPV (Mazda 3)	2006 Mazda 3	1998	91P	1655	Euro 3	0.15	---g	197	TWC	LPV
Eur3 LPV (Toyota RAV4)	2010 Toyota RAV4	2362	91P	2100	Euro 3	0.15	---g	220	TWC	LPV
Eur4 LCV (Great Wall Ute)	2014 Great Wall V240 Ute	2378	95P	2660	Euro 4	0.11	---g	245	TWC	LCV

Light duty diesel test vehicles (20)

- YOM from 1996 to 2016, engine size from ~2.1l to 4.2l
- All with EGR but only Euro 5 vans with DPFs
- All classified in VEPM as LCV except Prado/L'cruisers (LPV)

Vehicle ID	Make and model	Engine size (cc)	Fuel[a]	GVM[b] (kg)	Emission standard	NO_x limit	PM[c] limit	Official[d] CO_2	Exhaust treatment[e]	VEPM class[f]
Light duty diesel						(g/km)	(g/km)	(g/km)		
JKC LPV (Toyota L/cruiser)	1996 Toyota Landcruiser	4163	D	3350	J92 (JKC)	0.60	---[g]	n/a	EGR	LPV
JKD LPV (Toyota Prado)	1997 Toyota Prado	2982	D	2185	J95 (JKD)	0.60	0.20	n/a	EGR	LPV
JKD LCV (Toyota Hilux) A	1996 Toyota Hilux	2982	D	2185	J95 (JKD)	0.60	0.20	n/a	EGR	LCV
JKD LCV (Toyota Hilux) B	1996 Toyota Hilux	2982	D	2185	J95 (JKD)	0.60	0.20	n/a	EGR	LCV
JKD LCV (Toyota Hilux) C	1997 Toyota Hilux	2982	D	2185	J95 (JKD)	0.60	0.20	n/a	EGR	LCV
Eur2 LCV (Ford Transit Van)	2005 Ford Transit Van	2402	D	3490	Euro 2	1.60[h]	0.20	237	EGR	LCV
Eur2 LCV (Toyota Hilux DCab) A	2005 Toyota Hilux Double Cab	2982	D	2780	Euro 2	1.60[h]	0.20	216	EGR	LCV
Eur2 LCV (Toyota Hilux DCab) B	2006 Toyota Hilux Double Cab	2982	D	2780	Euro 2	1.60[h]	0.20	216	EGR	LCV
Eur2 LCV (Toyota Hilux DCab) C	2008 Toyota Hilux Double Cab	2982	D	2780	Euro 2	1.60[h]	0.20	216	EGR	LCV
Eur2 LCV (Toyota Hilux SCab)	2004 Toyota Hilux Single Cab	2986	D	2730	Euro 2	1.60[h]	0.20	287	EGR	LCV
Eur4 LPV (Audi A5)	2012 Audi A5	2967	D	2010	Euro 4	0.25	0.025	n/a	EGR	LPV
Eur4 LPV (Toyota Prado) A	2008 Toyota Prado	2982	D	2900	Euro 4	0.39[i]	0.060[i]	242	EGR	LPV
Eur4 LPV (Toyota Prado) B	2009 Toyota Prado	2982	D	2990	Euro 4	0.39[i]	0.060[i]	221	EGR	LPV
Eur4 LPV (Toyota Prado) C	2010 Toyota Prado	2982	D	2990	Euro 4	0.39[i]	0.060[i]	221	EGR	LPV
Eur4 LCV (Ford Transit Van) A	2011 Ford Transit Van	2399	D	3490	Euro 4	0.39	0.060	270	EGR	LCV
Eur4 LCV (Ford Transit Van) B	2011 Ford Transit Van	2399	D	3490	Euro 4	0.39	0.060	270	EGR	LCV
Eur4 LCV (Hyundai iLoad Van)	2014 Hyundai iLoad Van	2477	D	3160	Euro 4	0.39	0.060	229	EGR	LCV
Eur4 LCV (Nissan Urvan)	2008 Nissan Urvan	2953	D	3100	Euro 4	0.39	0.060	284	EGR	LCV
Eur5 LCV (Ford Transit Van)	2012 Ford Transit Van	2198	D	3490	Euro 5	0.28	0.005	206	EGR, DPF	LCV
Eur5 LCV (Merc Sprinter Van)	2016 Mercedes Sprinter Van	2143	D	3490	Euro 5	0.28	0.005	215	EGR, DPF	LCV

Heavy duty diesel test vehicles (6)

- YOM from 1998 to 2013, only one Jap-used truck (J97)
- GVMs from 4.5t to 6.0t, engine size from ~3.0l to 4.3l
- All with EGR but only Euro V trucks with DPFs
- All classified in VEPM as HCV

Vehicle ID	Make and model	Engine size (cc)	Fuel[a]	GVM[b] (kg)	Emission standard	NO_x limit	PM[c] limit	Official[d] CO_2	Exhaust treatment[e]	VEPM class[f]
Heavy duty diesel						(g/kWh)	(g/kWh)	(g/km)		
J97 (Isuzu Elf 4.5t)	1998 Isuzu Elf 4.5t	4330	D	4500	J97	4.5	0.25	n/a	EGR	HCV
EurIII (Mitsubishi Canter 4.5t) A	2007 Mitsubishi Canter Furn Van 4.5t	3907	D	4495	Euro III	5.0	0.10	n/a	EGR	HCV
EurIII (Mitsubishi Canter 4.5t) B	2007 Mitsubishi Canter Furn Van 4.5t	3907	D	4495	Euro III	5.0	0.10	n/a	EGR	HCV
EurIII (Mitsubishi Canter 4.5t) C	2007 Mitsubishi Canter Furn Van 4.5t	3907	D	4495	Euro III	5.0	0.10	n/a	EGR	HCV
EurV (Mitsubishi Canter 6t) A	2012 Mitsubishi Canter Tipper 6t	2998	D	5995	Euro V	2.0	0.02	n/a	EGR, DPF	HCV
EurV (Mitsubishi Canter 6t) B	2013 Mitsubishi Canter Tipper 6t	2998	D	5995	Euro V	2.0	0.02	n/a	EGR, DPF	HCV

Comparison with VEPM - overall

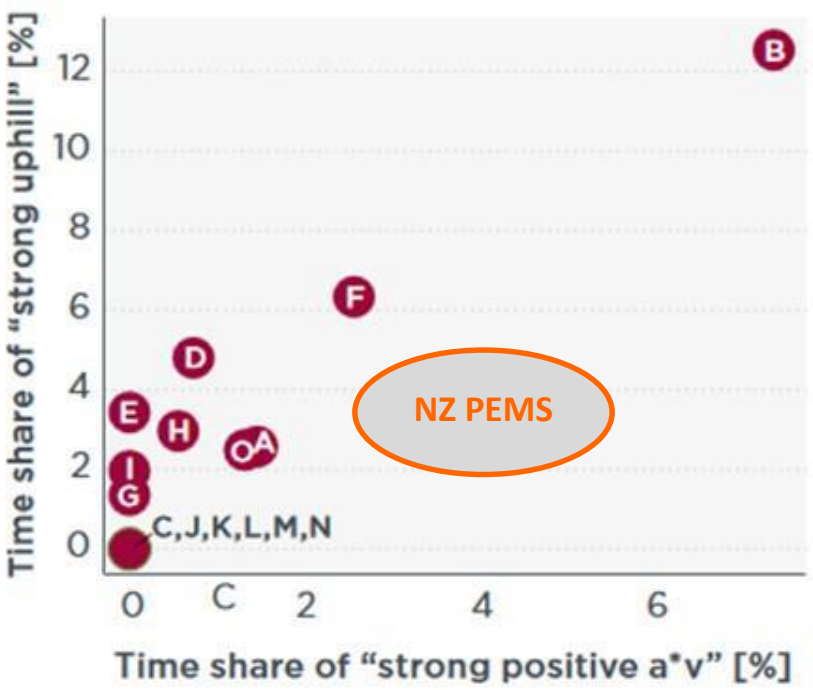
Average only – treat with caution

Vehicle category	VEPM emission factor / PEMS emission factor			
	NO_x	NO_2	$PM_{2.5}$	CO_2
Light duty petrol	45% ✗	43% ✗	77% ✓	85% ✓
Light duty diesel	60% ✗	86% ~	108% ✓	92% ✓
Heavy duty diesel	51% ✗	51% ✗	19% ✗	104% ✓

Effect of route characteristics

Same route used for all of our PEMS tests

ICCT meta analysis of PEMS



Our PEMS results

- 'strong **uphill**' (gradient ≥4%)
  ~3% on average (1.9%-4.9%)
- 'strong **positive**' (a*v ≥9.2W/kg)
  ~4% on average (0.9%-6.5%)

Overall our route has typical amount of hilly but more dynamic driving than overseas studies

Emission factors at low speed/idle

Real-world emissions at **idle and at low speeds** are typically **similar to** emissions at **10km/h** (on a g/s basis)

- Note 10km/h is the minimum valid speed setting in VEPM