Where do Euro 6 cars stand?

Nick Molden

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Agenda

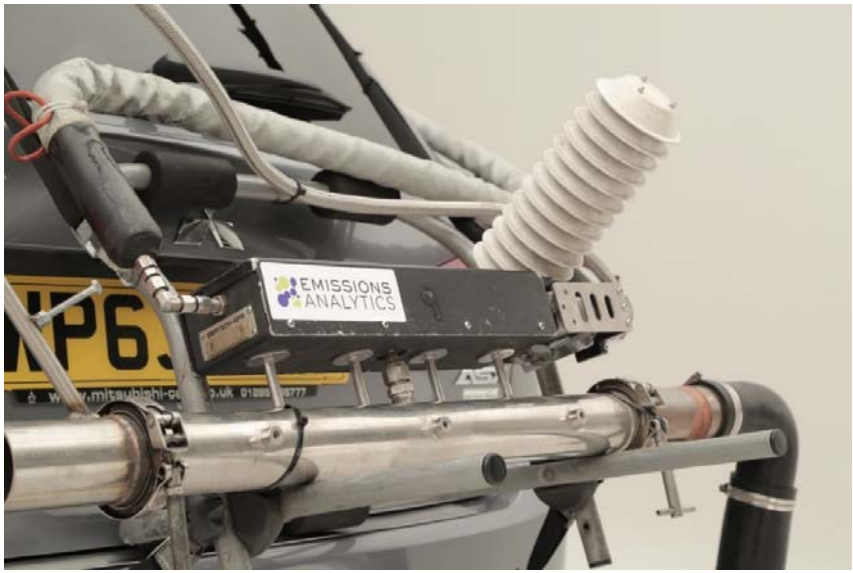
- Background and credentials
- Performance tracking programme
- Comparison to Real Driving Emissions
- Latest trends in NOx
- Context of fuel economy
- Data inventory and benchmarking
- Next steps

Emissions Analytics' credentials

- Founded in 2011
- Headquartered in Winchester, with operations in London and Los Angeles
- 10 employees, currently expanding in EU
- Specialist in PEMS testing and data analysis
- Over 900 vehicles tested
- RDE-compatible testing conducted since 2011
- Expert in cycle design and testing strategies to meet multiple and complex objectives
- Works with OEMs, Tier 1 suppliers, fuel and chemical companies, regulators, consultancies, consumer media

Benefits of PEMS

- Real on-road testing using PEMS is a powerful research method
- Authentic and cost effective
- Works on all vehicle types
- No permanent vehicle modification required
- Flexible location
- High rate of data acquisition – 1 Hertz
- Precision approaching laboratory levels



Equipment (1)

- SEMTECH-DS and Ecostar-FEM
- Portable Emissions Measurement System connects to tailpipe
  - Captures emissions for CO_2, CO, NO, NO_2, total hydrocarbons
  - At 1 Hertz
- Air temperature, pressure, humidity
- GPS for speed and altitude
- Engine data via CANBUS
- Fuel economy derived via carbon balance
- Ecostar weighs approximately 50kg including auxiliary batteries

Equipment (2)

- Pegasor Mi2
- Real-time tailpipe concentrations
- No filter papers
- Particle mass and number
- Sub-23nm particles

- Flexible, economic, real-world data collection

PERFORMANCE TRACKING PROGRAMME

Objectives

- On-going, real-time performance monitoring programme
- Air quality, greenhouse gases, fuel economy
- Independent
- Authentic: production vehicles, public highway
- Create feedback loop into better engineering, regulation and purchase decisions
- To ensure beneficial outcomes are achieved

Activity

- 200-250 passenger cars tested per year in EU
  - Similar in US
- Testing primarily in London, but flexible location
- New, commercially available vehicles
- Typically 2,000km+ on odometer
- Fixed weight addition
- Proprietary route based on typical driving
- 2.5-3 hour test

- New programme for light commercial underway

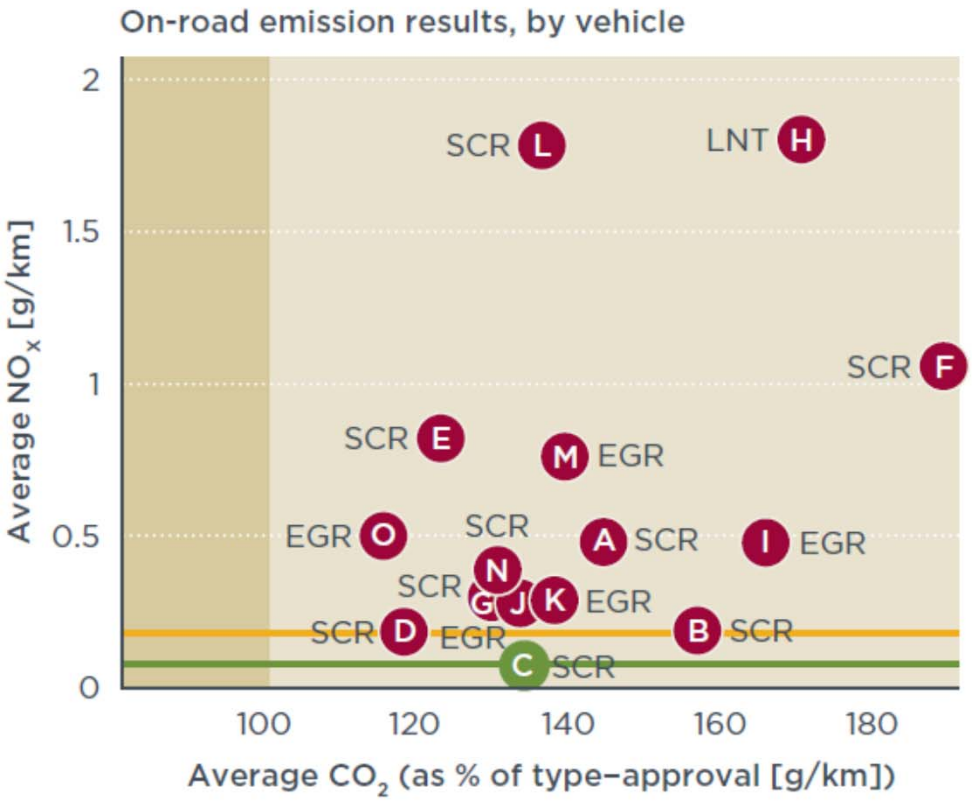
COMPARISON TO RDE

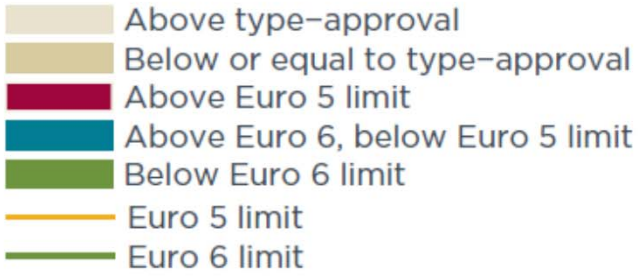
Comparison with RDE

- Many similarities, some differences
  - RDE before RDE…
  - RDE-compatible
- Test ~50% longer in time
  - Economies of scale
- Town/rural/motorway defined by continuous route-segments
- Range of driving modes tested, but avoiding extended conditions
- Prescribed weight addition
- Separation of cold start and DPF regeneration
- Controlled use of air conditioning, no other auxiliary systems
- Maximum speed 110km/h

LATEST NO_x TRENDS

ICCT report





15 test vehicles in total (6 manufacturers), with different NO_x control technologies:
- 10 selective catalytic reduction (SCR)
- 4 exhaust gas recirculation (EGR)
- 1 lean NO_x trap (LNT)

Average Euro 6 NO_x conformity factors (ratio of on-road emissions to legal limits):
- all cars: 7.1
- best performer (Vehicle C, SCR): 1.0
- bad performer (Vehicle H, LNT): 24.3
- worst performer (Vehicle L, SCR): 25.4

Euro 6 latest trends

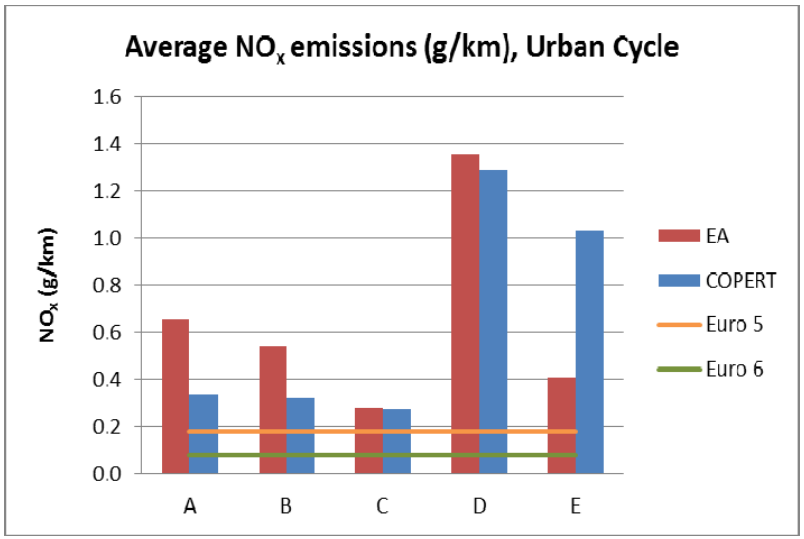
- Early Euro 6 passenger cars exceeded regulatory levels by 7.1 times – ICCT
- Early evidence of gap closing, especially towards end of 2014
- Further analysis required
- Best performers meet standard
- SCR dominant solution
- Spread reducing, but still wide

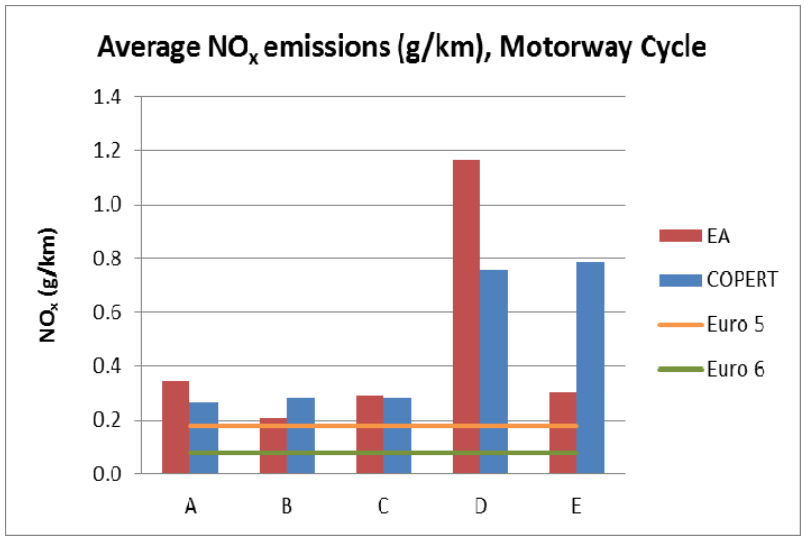
COPERT study

- Joint project with Imperial College London
- February 2015
- 5 Euro 5/6 passenger cars
- Detailed comparison with COPERT v4.10 and v4.11 models
- To assess effectiveness for policy and planning
- Euro 5 to Euro 6 performance compared to regulated levels
- Analysis of fraction of NO_x and NO_2

COPERT results – NO_x

- COPERT better on average, but lacks resolution for road and model type
- Euro 6 significantly lower on average than Euro 5
- High inter-model NO_x variability
- All vehicles above regulated level in both urban and extra-urban



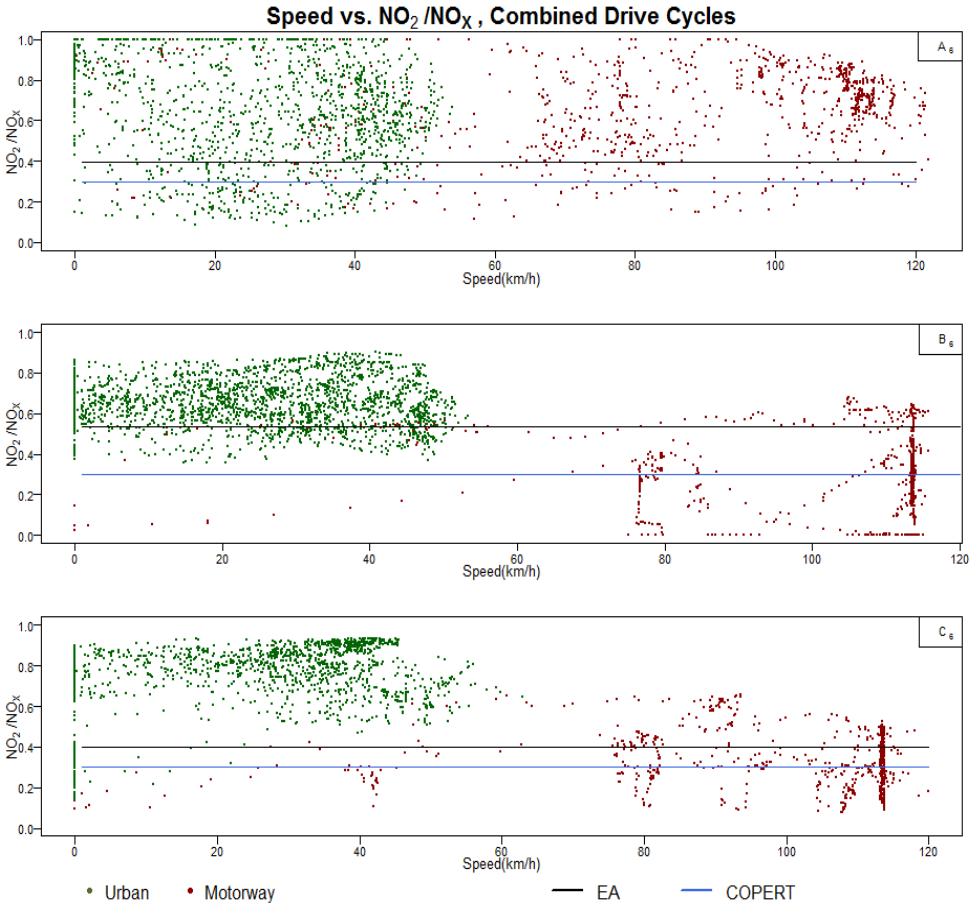


Euro 6: A, B, C

Euro 5: D, E

COPERT results – NO_2

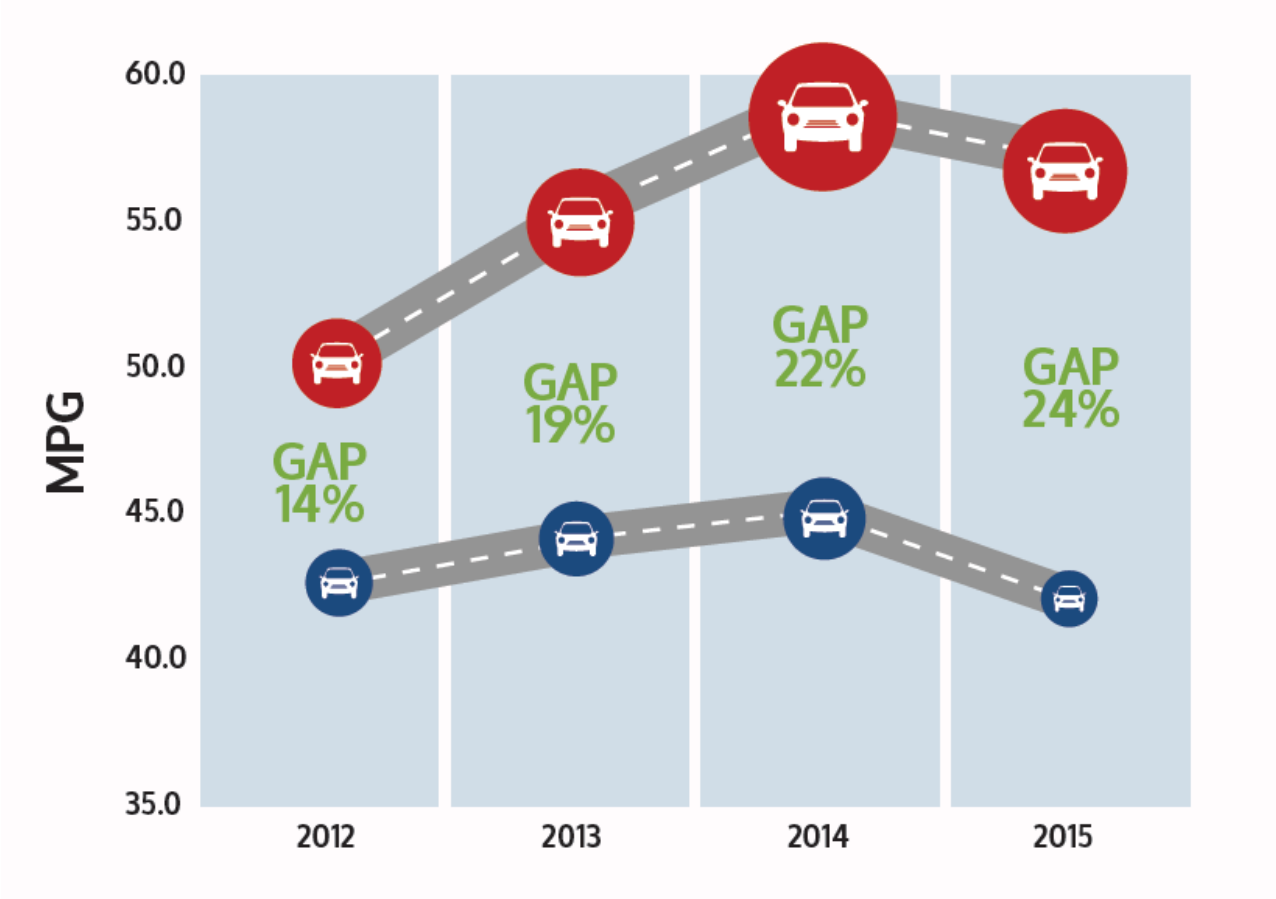
- No consistent relationship between fNO_2 ratio and speed
- Variance between different models
- COPERT consistently underestimates primary NO_2 emissions in urban areas where public exposure is greatest
- Implies high primary fraction of NO_2 in urban areas, up to ~90%
- COPERT v4.11 assumes a ratio of 30% for Euro 6 diesel cars
- Danger of meeting NO_x target but not solving air quality problem



FUEL ECONOMY CONTEXT

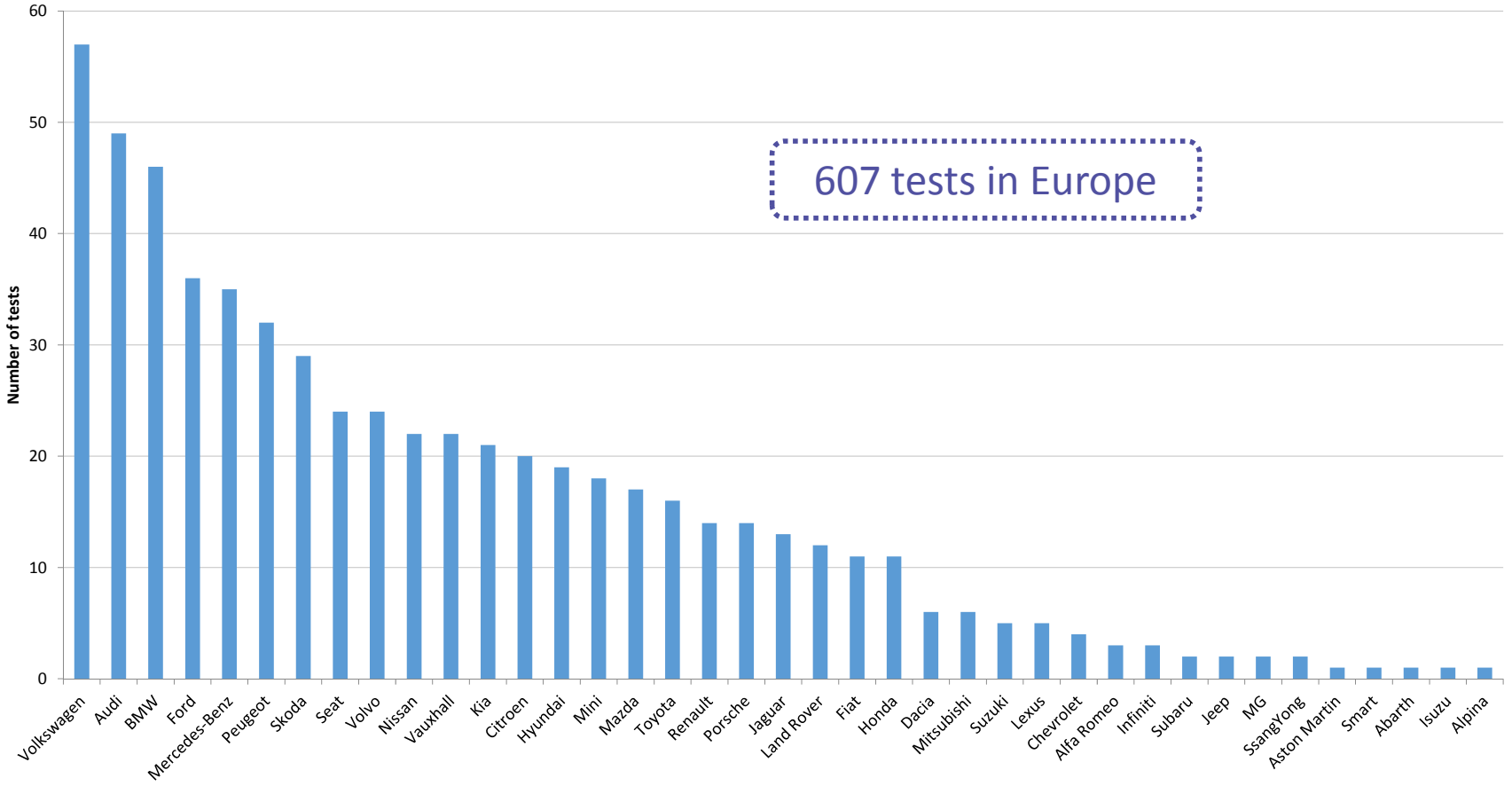
Trends in fuel economy

- Gap between real-world and NEDC grows
- Combustion, after-treatment and thermal management strategies introduces trade-offs between NO_x and CO_2
- Early evidence of a potential problem
- Although some mix effect with limited MY2015 sample



DATA INVENTORY AND BENCHMARKING

By manufacturer



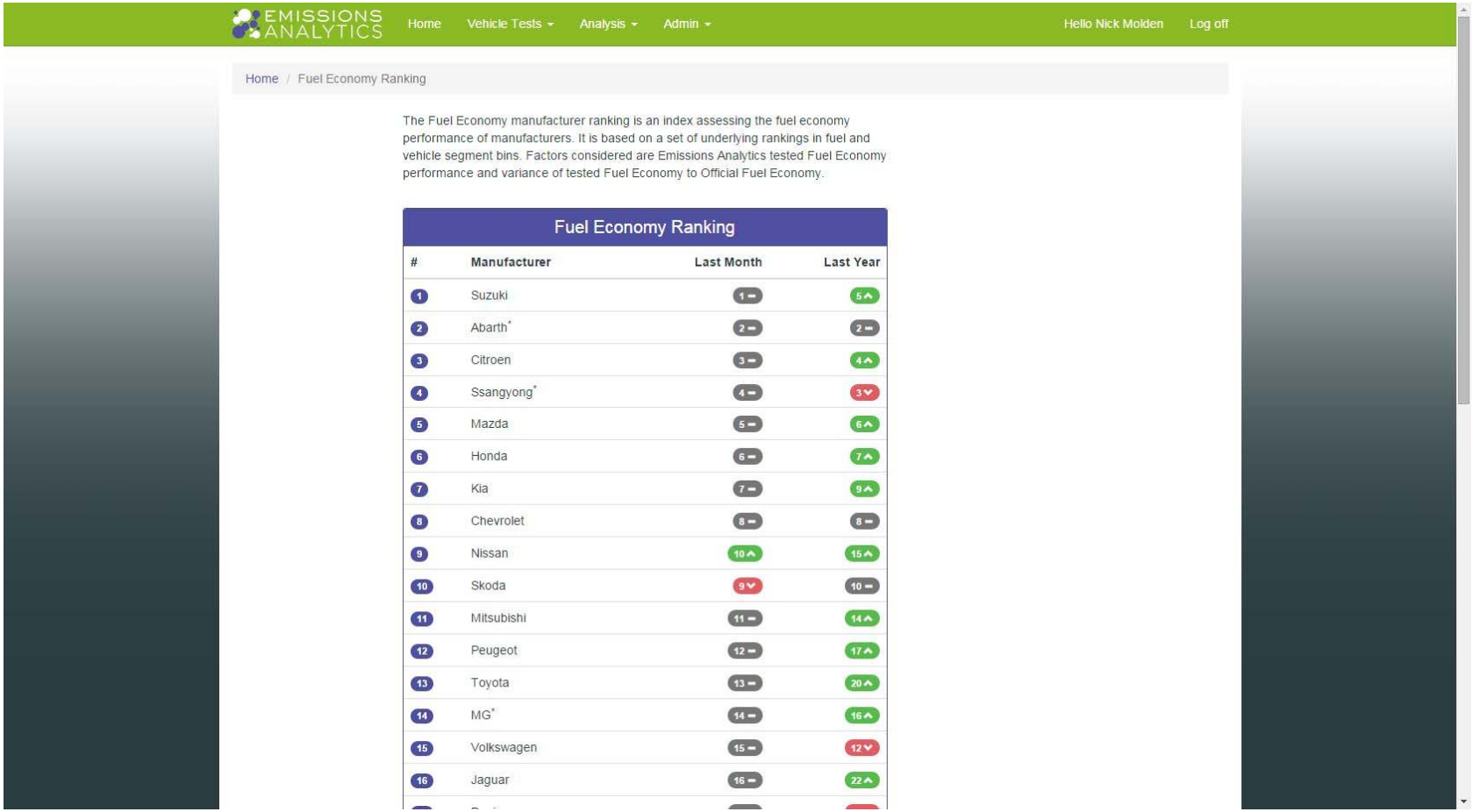
Engine, powertrain, Euro stage

Model Year	Diesel	Petrol	Total
2011	17	13	**30**
2012	105	71	**176**
2013	103	73	**176**
2014	113	84	**197**
2015	20	8	**28**
Total	**358**	**249**	**607**

Engine size class (litres)	Diesel	Petrol	Total
0-1	0	8	**8**
1-2	128	165	**293**
2-3	183	46	**229**
3-4	44	18	**62**
4-5	3	7	**10**
5+	0	5	**5**
Total	**358**	**249**	**607**

Euro Stage	Diesel	Petrol	Total
Euro 5	307	214	**521**
Euro 6	51	35	**86**
Total	**358**	**249**	**607**

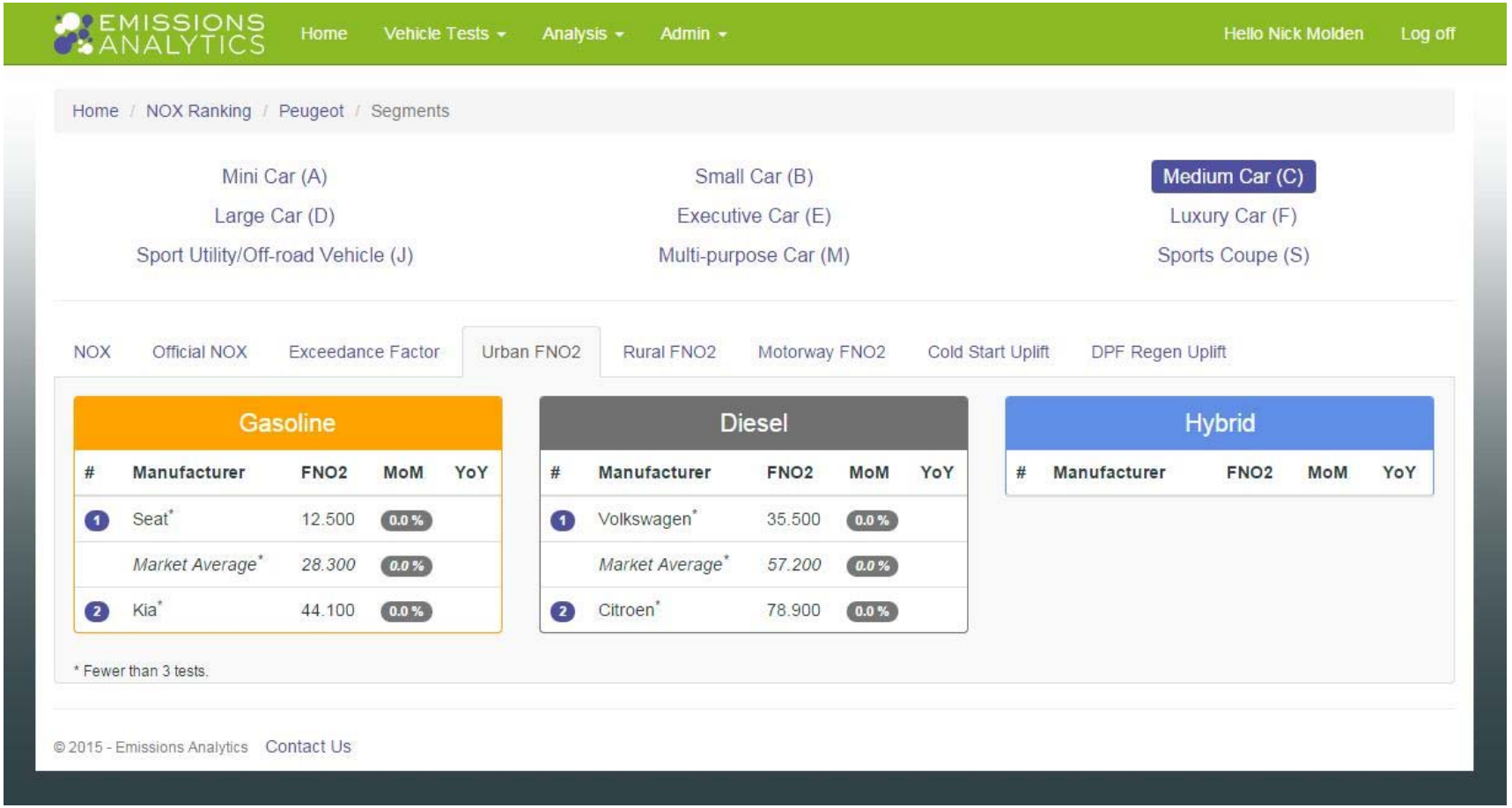
OEM league table



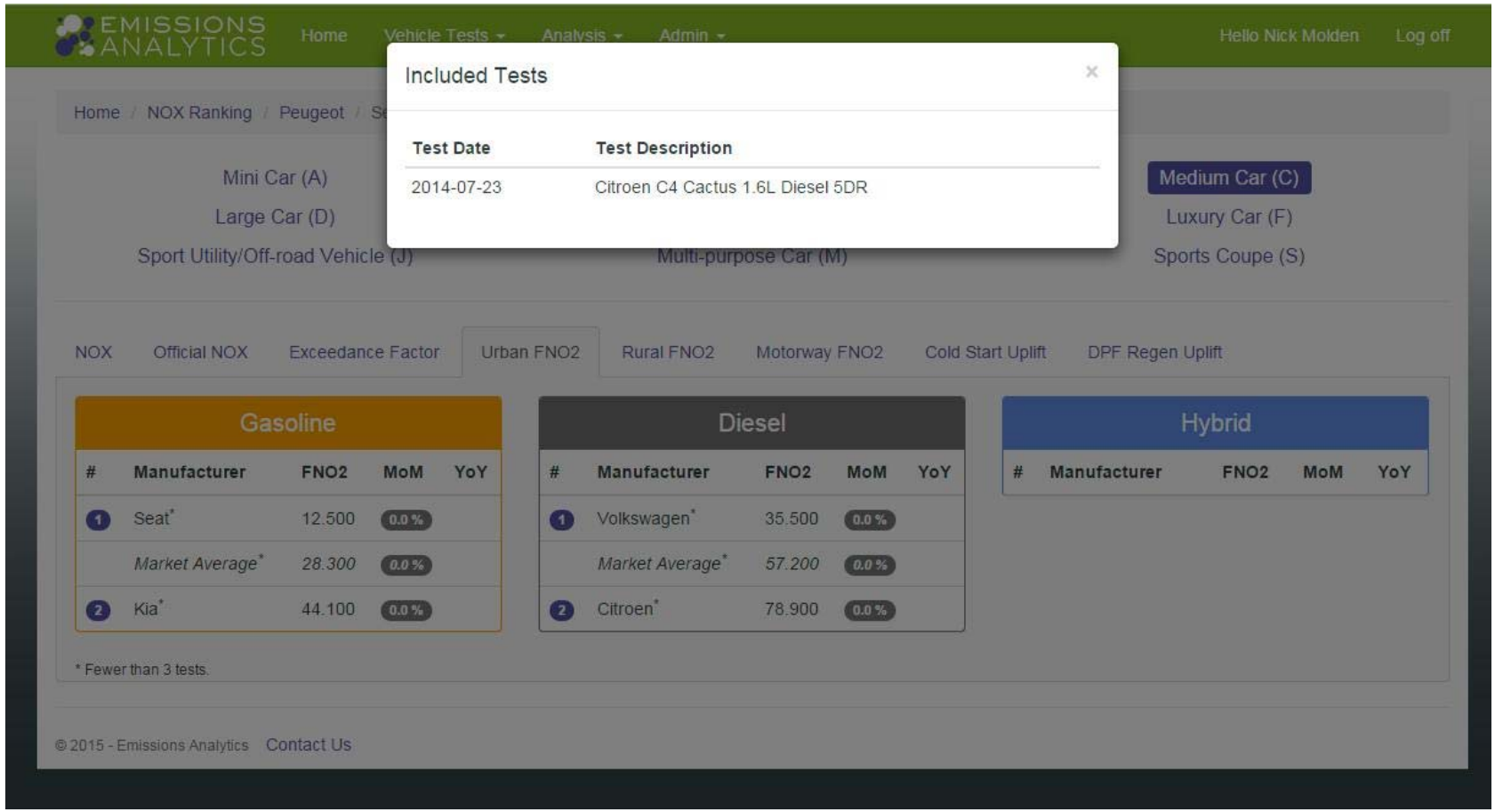
Fuel Economy Ranking

#	Manufacturer	Last Month	Last Year
1	Suzuki	1 –	5 ▲
2	Abarth*	2 –	2 –
3	Citroen	3 –	4 ▲
4	Ssangyong*	4 –	3 ▼
5	Mazda	5 –	6 ▲
6	Honda	6 –	7 ▲
7	Kia	7 –	9 ▲
8	Chevrolet	8 –	8 –
9	Nissan	10 ▲	15 ▲
10	Skoda	9 ▼	10 –
11	Mitsubishi	11 –	14 ▲
12	Peugeot	12 –	17 ▲
13	Toyota	13 –	20 ▲
14	MG*	14 –	16 ▲
15	Volkswagen	15 –	12 ▼
16	Jaguar	16 –	22 ▲

Segment/fuel ranking



Drill-down to individual datasets



Next steps

- Track performance of latest Euro 6 diesels for NO_x
- Together with fuel economy and other technologies such as GDI
- Expand and develop scope of performance tracking programmes
  - More vehicles
  - Additional driving modes
  - Other emission types
- Make analysis available via live benchmarking product
- Provide data and expertise to support third part analysis

Nick Molden, Chief Executive Officer
nick@emissionsanalytics.com
+44 (0) 20 7193 0489
+44 (0) 7765 105902