Euro 5 Effect Study Update

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Introduction

Euro 5 Effect Study

The Effect Study

should confirm the measures in the Euro 5 (2020) package:

Requirements in:
Regulation EU No. 168/2013

Supplemented by:
Regulation EU No. 134/2014

Environmental and Propulsion unit Performance Requirements for type approval of Euro 5 vehicles

and should also assess:

Feasibility of further elements (post-Euro 5):
off-cycle emission testing, in-service verification, particle number

Euro 5 Effect Study

Regulation EU No 168/2013

Article 23 (4)

By 1 January 2016, the Commission shall carry out a ***comprehensive environmental effects study****. The study shall evaluate the air quality and the share of pollutants contributed by L-category vehicles and shall cover the requirements of test types I, III, IV, V, VII and VIII*

Article 23 (5)

Based on the findings referred to paragraph 4, the Commission shall by 31 December 2016 present to the ***European Parliament*** *and the Council a report*

Euro 5 Effect Study

Pre-Study (JRC)

Experimental Test Programme (Sep14-Jun15)

Effect Study (JRC)

Phase 1: Stocktaking and data mining, stakeholder consultation, literature survey, planning for phases 2 and 3 (Call for Tender).

Effect Study (Contractor + JRC supervision)

Phase 2: Experimental test programme, Cost/benefit analysis, Impact assessment

Phase 3: Validation programme, Report

Study - Phase 3
Contractor to be appointed

Validation Programme and Final Report

- **Completion of Final Report**

  September 2016

- **Commission to report to Parliament**

  December 2016

Euro 5 Effect Study

European Commission

Background

i) Asymmetric pollution by L-cat vehicles: small fleet, large contribution (urban THC, CO, PM).
ii) In off-cycle mode (hence in real-driving), tailpipe emissions and/or fuel consumption may significantly differ from type-approval.
iii) Vehicle speed profile poorly correlates with engine load.

Scope

The vehicle should be clean and energy efficient at each feasible operation point under the max torque curve.

Emission abatement technology which is neutral wrt to vehicles and test types (ratio part-load area vs feasible operation range).

Method

Engine load variable (e.g., engine torque, CO_2 mass emissions, etc.)

→ **quality, quantity and dynamics** of emission sampling used to compare part-load sampling conditions among various test types and vehicle types.

Euro 5 Effect Study

Sufficient and comprehensive assessment of tailpipe emissions in the part-load area

Quality

Distribution of emission sampling within the specified part-load area of testing (engine load Vs engine speed). Indicators:

- Covered part-load area: scatter area defined by engine speed and engine load compared to maximum torque area.
- Drive-ability: driver violations in the emission laboratory test cycle (actual vs desired vehicle speed).

Quantity

Intensity of part-load area sampling.

Dynamics

Statistics on the slope of "jumps" between the various engine speed and engine load matrix points.

Update

Pre-Study (JRC)

Pre-Study & Phase 1 (JRC)

Timeline	Feb 2015	Mar 2015	Apr-May 2015	July 2015	September 2015
Pre-study	On-going	Tests completed	Additional tests	Analysis	Results
Data mining	Analysis	Analysis	End	--	Results
Public Survey	--	Launch	Open	End	Results
Literature	On-going	Draft	End	--	Results
Call for Tender	Draft	Draft	End (Tech Spec)	Open	Target to appoint Contractor

Pre-Study - Experimental

Tested Vehicles: > 170 roller bench tests

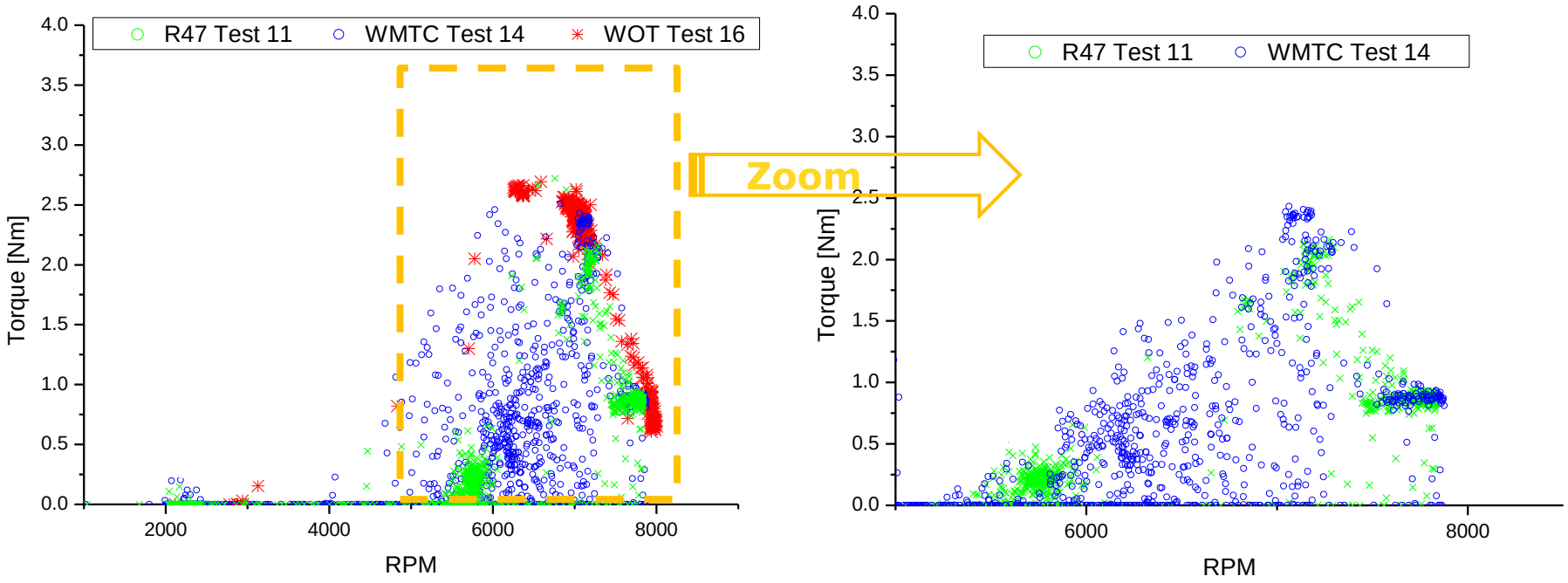
Vehicle	Cat	Stroke	Displacement [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
1	L1e-B	4	50	Carburetor 2-way-cat	≈3	2500	2010	2
2	L1e-B 25 km/h	4	50	Carburetor 2-way-cat	≈3	2000	2012	2
3	L1e-B	2	50	Carburetor 2-way-cat	≈2	2500	2010	2
4	L1e-B	2	50	Carburetor 2-way-cat Manual trans.	≈3	5000	2008	2
5	L1e-B 25 km/h	4	50	Carburetor 2-way-cat	≈3	3000	2012	2

Pre-Study - Experimental

Vehicle	Cat	Stroke	Displacement [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
6	L3e-A1	4	125	E.I. 2-way-cat	8	>2000	2010	3
7	L3e-A2	4	300	E.I. 2-way-cat	16	3000	2012	3
8	L3e-A2	4	400	I.E. 2-way-cat	24	27000	2013	3
9	L3e-A3	4	900	I.E. 2-way-cat	100	15000	2006	2
10	L3e-A3	4	700	Manual trans.	50	26000	2008	3
11	L5e-B	4	400	Manual trans.	12	5000	2010	2
12	L7e-A1	4	500	I.E. 2-way-cat	14	500	2014	2

L1e-B

High Speed Moped (45 km/h) with CVT - R47 and WMTC cycles

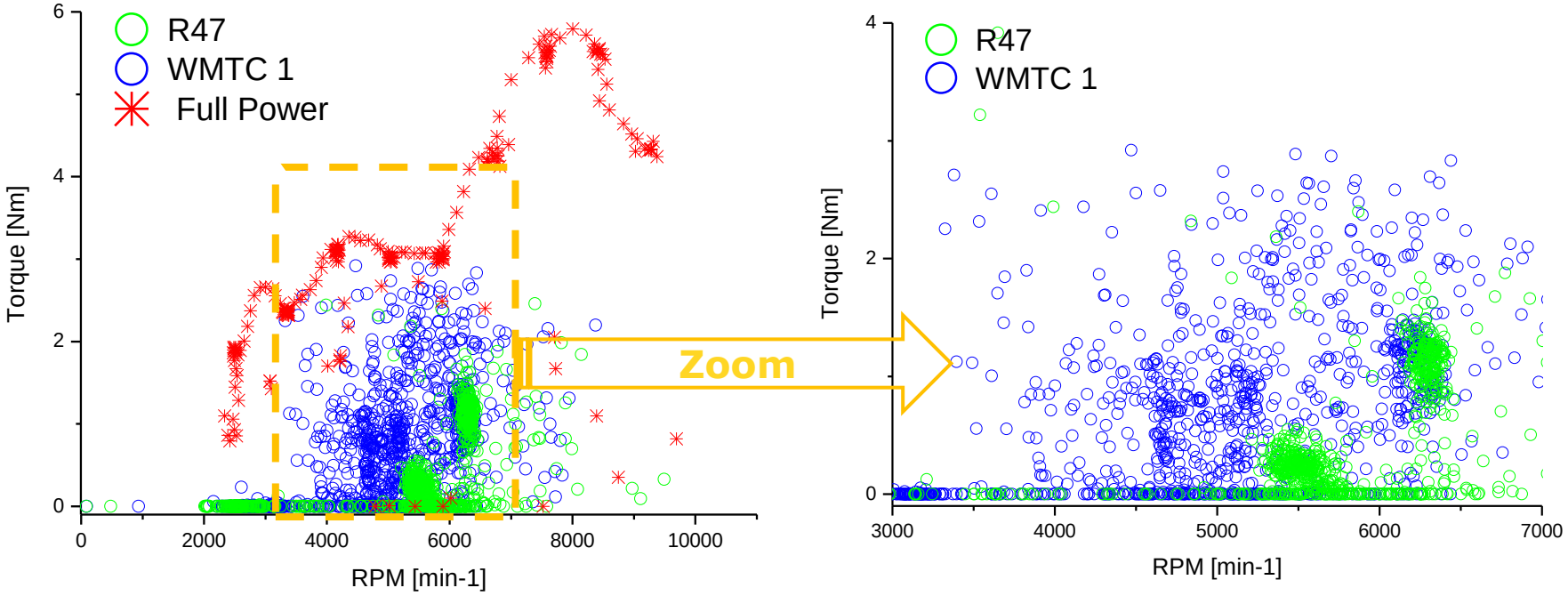


Larger area covered by WMTC → maximized sampling in the part-load area

Relatively little empty area between WOT Test and WMTC/R47 cycles

L1e-B

High Speed Moped (45 km/h) with manual transmission

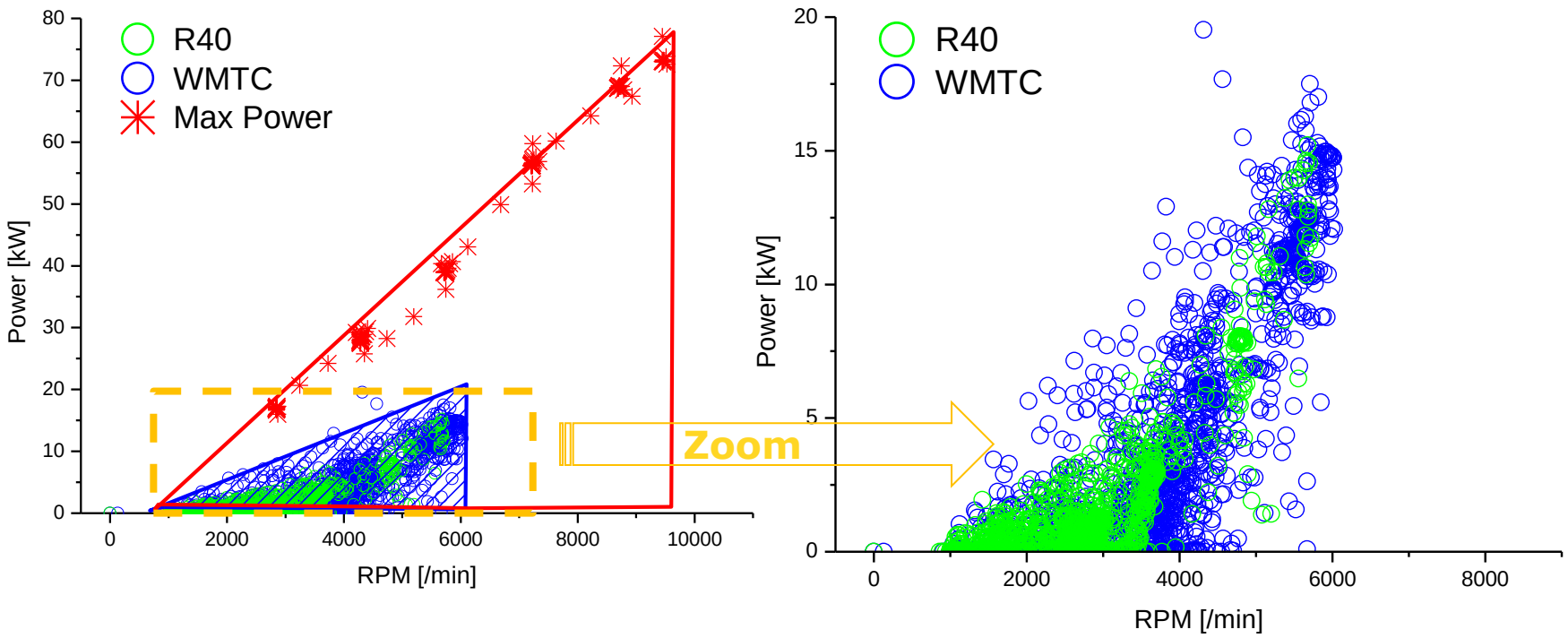


Larger area covered by WMTC → maximized sampling in the part-load area

Considerable empty, unsampled area between WOT Test and WMTC/R47

L3e-A3

High Performance Motorcycle with manual transmission

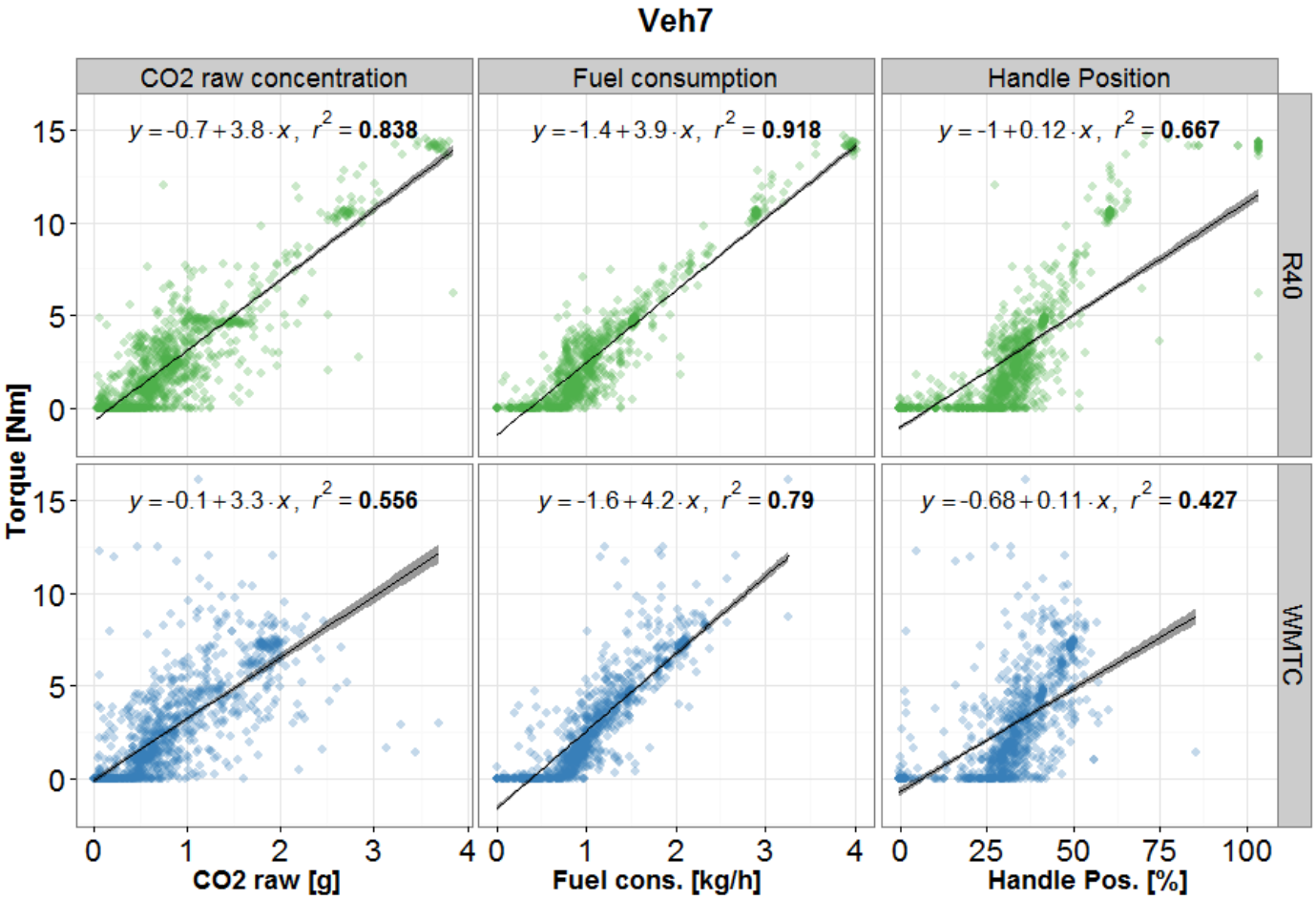


Larger area covered by WMTC → maximized sampling in the part-load area

Considerable empty, unsampled area between WOT Test and WMTC/R47

Pre-Study - Experimental

Example of correlation plots



Update

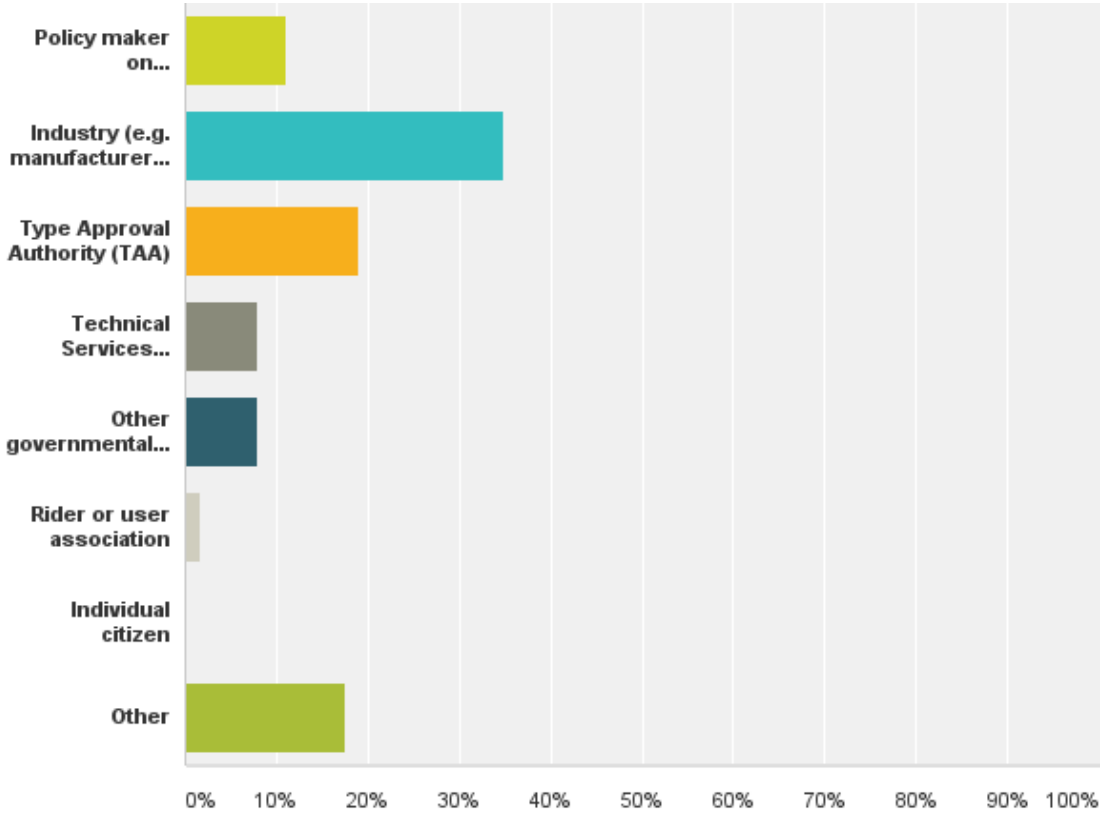
Phase 1 (JRC)

Stakeholder Consultation

Survey: public, open May-July 2015

Scope: gather opinions across the **EU and internationally** on the **EURO 5 ENVIRONMENTAL STEP FOR L-CATEGORY VEHICLES**

Parameter	Number
Recipients	1213
Responded	101



Stakeholder Consultation

Market increase L-cat (5 years), not homogeneously for sub-cat:
L1, L3 ↗
L5, L6, L7 ↔
L4 ↔ ↘

Pros Euro 5 will Reduce pollutant (96%), Protect public health (63%), Increase energy efficiency (50%).

Cons 87.5% increased production costs, 48% technical challenges, and 44% vehicle prices increase

Stakeholder Consultation

European Commission

Type I – tailpipe emission tests after cold start

WMTC is moderately representative of L-cat driving, the lack of knowledge dominates.

Technically feasible to comply with **Euro 5 limits** for THC, NOx, CO using existing technologies.

Respondents have a lack of knowledge on whether the **PM (and PN)** limit can be met. They think **DPF and GPF** will be involved, and that this is a potential problem for the L-cat.

Estimated Cost increase (by respondents)
min €101-200 for L1e and L2e
med
max €201-300 for L7e B and L7e-C

Ethanol in fuel is expected to affect Test IV - evaporative emission test - and leading to canister deterioration.

Stakeholder Consultation

European Commission

Type III – Emissions of Crankcase Gases

Unburnt crankcase gas emissions are considered a threat to human health and environment, but there is **uncertainty** whether crankcase emissions are higher than tailpipe emissions.

In addition, there is a general **lack of knowledge** on whether inefficient operating crankcase systems have a damaging effect on engine life and whether the verification method for the crankcase ventilation system is appropriate and beneficial.
Slightly preferred the vacuum than the overpressure method.

Type IV Evaporative Emissions

There is a general **lack of knowledge** on whether the fuel permeation test and lower SHED test limit are appropriate for L-category vehicles or whether Euro 5 SHED test complaint vehicles need and additional/ modified hardware.

Stakeholder Consultation

Type V - Durability of Pollution Control Devices

There is a general lack of knowledge on the most appropriate type-approval durability test, whether AMA cycle should be phased-out and whether an increase in distance accumulation for L3e –A motorcycle is justified.

Type VII Energy Efficiency Test

A range of technologies have the potential to improve fuel efficiency of L-category vehicles (e.g. alternative fuels, battery technology, gas recirculation, intelligent transmission).

Stakeholder Consultation

Functional on-board diagnostics and Type VIII environmental On-Board Diagnostic test

OBD is seen as providing better diagnostic quality information to the **repair**, enhance functional **safety** requirements and reduce repair costs to users.

However, there may be **increased vehicle costs for consumers**, longer vehicle development and production and increased research and development efforts.

Stakeholder Consultation

Off-Cycle Emissions

It is generally considered that future off-cycle emission requirements **should prevent the optimisation** of the environmental performance of the vehicle to pass only the test type approval.

Chassis dynamometer tests might be also used to obtain off-cycle information.

OCE not needed for limited speed/power vehicles (those for which the WOT curve is close to the WMTC).

Stakeholder Consultation

The Environmental Effect study should provide further analysis and clarifications on the following questions:

Does the WTMC represent real-world conditions for L-category vehicles? (The question does not resemble the Effect Study approach: quantity and quality of sampling in the load-speed area w.r.t. an assumed part-load area)

Can L-category vehicles adapted for technical progress meet the PM and PN limits?

How significant are crankcase emissions?

What is the most appropriate durability test and is the mathematical method using assumed deterioration factors an appropriate approach to assess durability of pollutant control devices at type-approval?

What is the impact of alternative fuels, OBD stage II, standard battery package and an HC limit on off-cycle emissions on L-category vehicles?

Update

Phase 2
(Contractor +JRC supervision)

Study - Phase 2
Contractor to be appointed

Call for Tender is closed and offers under evaluation

- **Task 1**

Experimental assessment and verification programme of measures within the Euro 5 Environmental Step as for *Art.23 (4) and (5), Reg.168/2013*

(different Test types + cost/benefit)

- **Task 2**

Research and assessment of further elements as for *Recital 12* of *Reg.168/2013*

(e.g., off-cycle emission testing, in-service verification, expand PN limits)

Study - Phase 2 (Contractor)

Timeline	July 2015	Sept 2015	Jun 2016	Jul 2016
Experimental Programme: Test type I to VIII	Test fleet	Tests JRC (for contractor)	Tests Contractor	End
Off-cycle	JRC Tests	--	Tests Contractor	End
In-service conformity	--	--	Tests Contractor	End
PN study	JRC Tests	--	Tests Contractor	End

This is beyond euro 5

Study - Phase 2 (Contractor)

Task 1.1.1.: Assessment Type I - **Tailpipe emissions test after cold start**
Sub-task 2.1.1.1: Assessment of the **applicability of the WMTC** (Worldwide harmonized Motorcycle Testing Cycle) to all the L-category vehicle types.
Sub-task 1.1.1.2: Assessment of the appropriateness of the **Euro 5 tailpipe emission limits** (Annex VI(A) of Reg. 168/2013)
Sub-task 1.1.1.3: Assessment of the separate **NMHC limit**
Sub-task 1.1.1.4: Assessment of **the impact of ethanol** in the reference fuel on the test type I results
Task 1.1.2: Assessment Type II – Tailpipe emissions at (increased) idle and free acceleration
Task 1.1.3: Assessment Type III – Emissions of **crankcase gases**
Task 1.1.4: Assessment Type IV – **Evaporative emissions test**
Sub-task 1.1.4.1: Assessment of evaporative emission test procedures set out in Annex V to Regulation (EU) No 134/2014, in particular the permeation and SHED test procedures
Sub-task 1.1.4.2: Investigation of the cost effectiveness of a 25% lower Euro 5 evaporative emission limit compared to the Euro 4 limit for vehicles subject to the SHED test
Sub-task 1.1.4.3: Investigation of the impact of fuel quality on the evolution of fuel permeation rate over time as well as the ageing effects of the carbon canister
Sub-task 1.1.5.1: Validation of **distance accumulation cycle (SRC-LeCV)**
Sub-task 1.1.5.2: Validation of assigned Deterioration Factors and useful life values
Task 1.1.6: Assessment Type VII – Energy efficiency tests (CO2 emissions, fuel/energy consumption and electric range measurements)
Task 1.1.7: Assessment functional on-board diagnostics requirements and Type VIII – OBD environmental tests + background information
Sub-task 1.1.7.1 - On-board diagnostic requirements – expansion functionality **OBD stage I to OBD stage II** – relevance for effective and efficient vehicle repair
Sub-task 1.1.7.2: Type VIII test - assessment of the OBD emission thresholds (OTLs) set out in the table laid down in Annex VI(B2) to Regulation (EU) No 168/2013
Sub-task 1.1.7.3 - On-board diagnostic requirements – assessment of the cumulative cost effectiveness of sub-tasks 1.7.1. and 1.7.2. and technical feasibility of supplemental OBD stage II

Task 2: Research and assessment of further elements listed in recital 12 of Regulation (EU) No 168/2013 **(beyond the Euro 5 step**)
Task 2.2.1: Off-cycle emissions testing
Sub-task 2.2.1.1. Experimental test programme on technical feasibility **off-cycle emission requirements**
Sub-task 2.2.2.2.Benefit / cost ratio range and cost effectiveness analysis off-cycle emission requirements
Task 2.2.2: In-service conformity verification testing
Task 2.2.3: Assessment of the need to expand the **PM limit** scope to other vehicle categories than those already subject in the Euro 5 step and introduction of a **PN limit**

Update

Phase 2, Additional features

Phase 2 – Particle Number

Particle number (PN) method

Solid particles that do not evaporate at 350°C with diameters above 23 nm.

Rationale

There is no significant sub-23 nm fraction for these technologies

Chronology

2009 PN for European diesel passenger cars

2013 PN for heavy duty engines

2014 PN for gasoline direct injection passenger cars

L-category (beyond Euro 5)

- The portion of solid particles not counted with the current PN method
- Artefacts below 23 nm due to the large amount of semi-volatile material

Phase 2 – Particle Number

2015-24-2512
Published 09/06/2015

doi:10.4271/2015-24-2512
saeeng.saejournals.org

Particle Emission Measurements from L-Category Vehicles

Barouch Giechaskiel, Alessandro Zardini, and Giorgio Martini
Joint Research Centre, EC

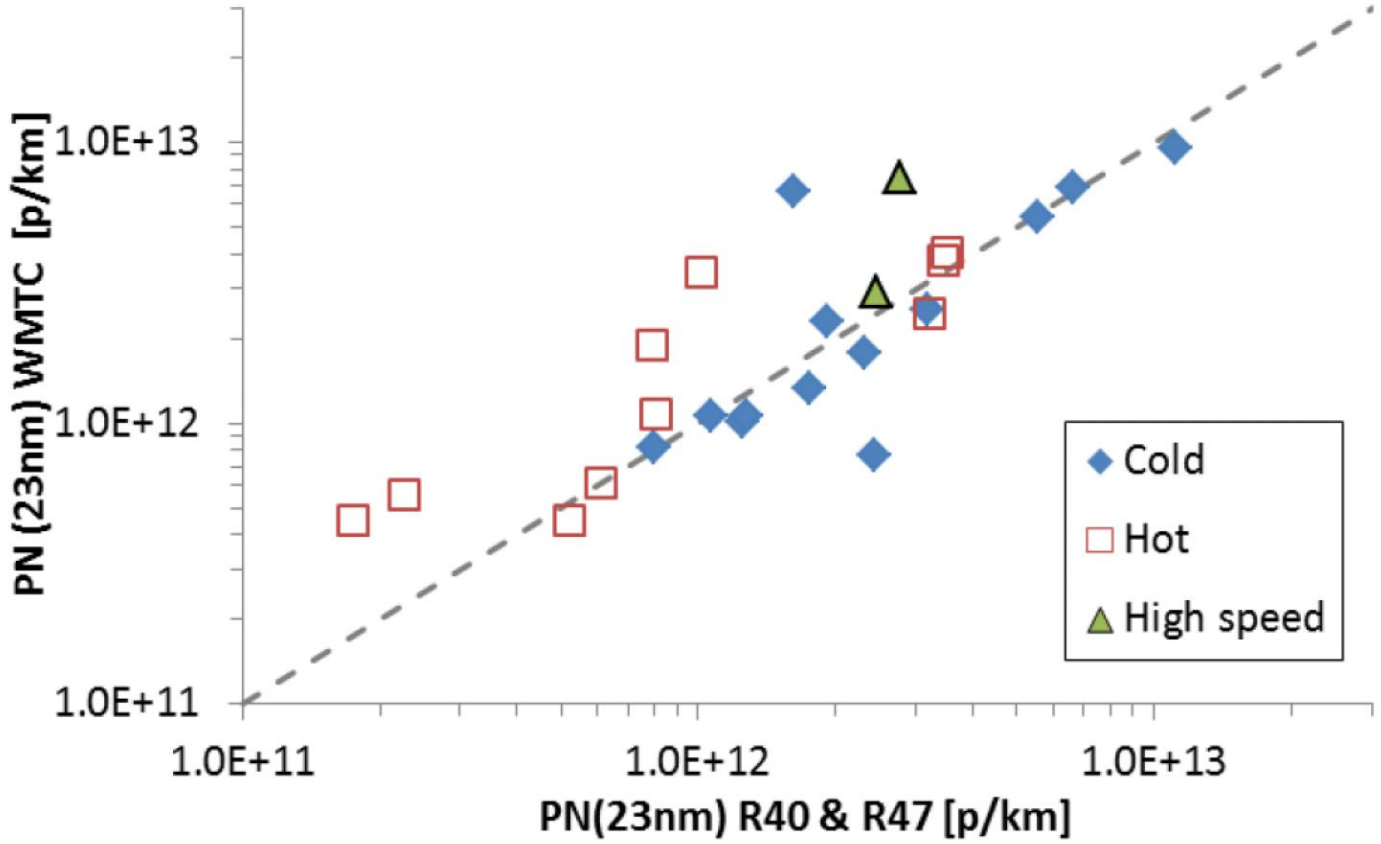
Fleet
5 mopeds, 9 motorcycles, 2 tricycles (one diesel) and 1 quad

Method
PN legislation compliant systems with counters >23nm and >10nm

Additional
Catalytic strippers, counters >3nm, particle sizers

Phase 2 – Particle Number

WMTC vs older cycles



Ensemble graph with all available data and vehicles for particles size >23nm (*Giechaskiel et al. 2015, SAE*)

Phase 2 – Particle Number

Artifacts Particles formation <23nm and <10nm at high load

Tailpipe vs Dilution Tunnel: >23nm 10-20%, <23nm up to 50%

PN levels

Vehicle	PN Level / $6x10^{11}$ p/km (limit for cars)
Mopeds	3-20
Motorcycles	2-4
Quad	12
Tricycle	3

WMTC vs older cycles: good correlation (same order of magnitude)

PMP: up to 70% non-counted particles (up to 40% for cars)

Compromise: PMP with 10nm cutoff

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