REPORT N°: 18/07795-2

APPLICANT : Euro NCAP
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SUBJECT : Validation tests of the Green NCAP pilot program

CONCLUSION : This last step of the pilot program allowed to consolidate the feasibility of the procedures and processes established by the Green NCAP technical working group, to build a first database of results publishable, and to continue the development of the rating process.

MONTLHÉRY, 01/02/2019

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ABREVIATIONS

AT	Automatic Transmission
RRT	Round Robin Test
WLTC	Worldwide harmonized Light duty Test Cycle
WLTP	Worldwide harmonized Light duty Test Procedure
RDE	Real Driving Emissions
PEMS	Portable Emissions Measurement System
EFM	Exhaust flow meter
GSI	Gear Shift Indicator
FTP	Federal Test Procedure
OBD	On-Board Diagnostics
CO_2	Carbon dioxide
CO	Carbon monoxide
NO_X	Nitrogen oxides
PN	Particulate number
THC	Total hydrocarbons
4WD	Four Wheel Drive
BAB130	ADAC Motorway laboratory test cycle
DPF	Diesel Particulate Filter
TA	Type-Approval
CoC	Certificate of Conformity
ICE	Internal Combustion Engine
RCB	REESS Charging Balance
TtW	Tank-to-Wheel

EXECUTIVE SUMMARY

The Green NCAP technical working group was set up by Euro NCAP to build up a test procedure matrix that would assess the vehicles' environmental performance. Overall objectives of an independent Green NCAP program are to provide comprehensive but simplified rating information to the consumer and provide detailed technical information and test results to experts, e.g. for product improvement or own analysis. This ambitious project of the Euro NCAP steps in a period when exhaust emissions have been the centre of attention in the media and when at the same time the emissions regulations are undergoing deep modifications. In order to launch the project, the Green NCAP technical working group decided to set up a pilot test program which was ran between May 2017 and September 2018. It was split into four phases: initial test procedure development (May – November 2017), verification testing (December 2017 – April 2018) subdivided in a first verification test series (December 2017 – April 2018) and Round Robin verification tests (March 2018 - July 2018) and as a last step a validation test phase closed the program (June – October 2018).

This report deals with the validation phase, which the main objective was to consolidate the procedures and processes established by the Green NCAP technical working group, taking into account the feedback from the first verification test program and the round robin test program performed previously.
The second objective was to build a first database of publishable results, to see how vehicles react to the test procedure and to finalise the rating approach. For that purpose, the tests were performed on twelve different vehicles mostly Euro 6d temp compliant in eight different laboratories across Europe. The participating laboratories have all been part of the round robin test and showed ability for be accredited by Euro NCAP.

As the first verification was slightly late on schedule, the validation eventually started in conjunction with the last round robin tests. The test procedures that were used for this last phase of the pilot program were nevertheless direct output from the verification phase.
The validation phase timeliness was impacted by the availability of the test vehicles: to meet the ambition of delivering publishable results, the group set itself a priority to test relevant vehicles for the coming market, that is Euro 6d temp, but which were not all easily available in the time frame.
Despite this key issue, in the end, the validation phase was carried out in a shorter time period than the first verification phase. Indeed, on the one hand, the withdrawal of tests deemed to be irrelevant or redundant after the verification phase made it possible to reduce the global duration required for testing each vehicle from 15-20 effective days during the first verification phase, down to 10-15 effective days during the validation phase (not including data post-processing). On the other hand, the constant follow-up and exchanges that occurred between the members of the group allowed addressing immediately any submitted concern.

The group selected seven Euro6d-temp vehicles representative of high market shares, of representative engine type and latest technologies available in Europe. The other five vehicles were Euro-b vehicles from which two were pure electric vehicles, two were the round robin test vehicles and the last one chosen in replacement of an unavailable Euro6d temp vehicle.

The consolidation of the test procedures was built out of the feedback of laboratories which identified new issues and ongoing thinking within the working group, which led to an adaptation of the existing procedures to the adopted test procedures applicable for the fully fledge program:

- For instance, maximum power torque engine load test including emissions measurement, which is a pillar of the Green NCAP program, had too high thermal constraints preventing tests to be run in laboratories as initially foreseen, without risking any damage of the equipment; an alternative equivalent method was developed, testing directly on the road with PEMS.
- As Green NCAP is willing to have a technology neutral approach, a major step was to harmonize the expression of the energy consumption between all the powertrain technologies, in order to rate the fossil fuel consumption and the electrical energy consumption based on a common parameter.
- The results of the tests carried out in laboratories were more representative (that is closer to open road testing) thanks to taking into account the rolling resistance parameters from the CoC document of the test vehicles. The parameters resulting from the WLTP flat-rate calculation showed to be overly restrictive during the first verification phase.
- Finally, the group focused on the simplification of the data post-processing aiming at reducing the time needed for this step. In order to do so, significant improvements on harmonization of the submission of data, as well as the rationalization of the templates were made.

The pilot program has achieved its fundamental objective of building up a first batch of results to launch the Green NCAP program. A database composed of test results, comments and feedbacks from laboratories, as well a specific rating scores per vehicle, is consolidated and available. Information from which will be extracted the information to be published at a date to be defined.
The rating is based on two different indices: the "Clean Air Index" assessing pollutant emissions and the "Energy Efficiency Index" assessing energy consumption, the minimum score being taken as the overall rating (maximum of 5 stars). The two pure electric vehicles scored 5 stars, the Euro6d temp vehicles scored between 1 and 4 stars, and all three Euro6b vehicles scored 0 star.

The consolidation of the results on the first batch of vehicles already highlighted trends and possible room for vehicle emission improvements:
As far as pollutant emissions are concerned, a clear distribution in the "Clean Air Index" between Euro6d temp and Euro6b vehicles proves that there has been a significant step towards greener cars taken by manufacturers thanks to the adoption of RDE and WLTP regulations in type approval. The very low sensitivity to the test conditions of most of Euro6d temp vehicles during the laboratory and PEMS tests conditions, enhance a robust engine management of those vehicles. The Euro6d temp vehicles comply with the Euro6 regulatory limits on all the WLTC tests whatever the test conditions, which is not the case for Euro6b vehicles.
Some well-known issues such as enrichment for vehicles equipped with MPi technology (post-fuel injection) nevertheless remain, as excessive CO emissions are recorded for Euro6b as well as Euro6d temp vehicles for heavy conditions tests. In a similar manner downsized engine vehicles tend to see their emissions increased when tested in heavy conditions, unlike high displacement engine vehicles that were able to absorb heavy conditions without any significant increase of energy consumption or pollutant emissions
Furthermore, the Green NCAP procedures focused on the various driving modes aiming at incentivising the OEMs to include eco modes and in a second step to educate consumers to the benefits of eco driving on their energy consumption and pollutant emissions. Vehicles equipped with an eco mode (or sensitive to eco driving) had their rating improved due to a decrease of their CO_2 emissions: between -2% and -10% for laboratory tests, and between -4% and -16% during for PEMS tests. On the contrary, vehicles equipped with a sport mode (or simply sensitive to sporty driving) were disadvantaged in the rating by the increase of their CO_2 emissions: between +2% and +12% during laboratory tests, and between +5% and +45% during PEMS tests.

The output of this final phase of the pilot program encompasses also recommendations for future optimisation of the Green NCAP fully fledge program procedures.

- To withdraw the FTP75 test deemed redundant with the combination of other tests
- To reduce to the minimum possible time the post-processing phase by further simplification of the template and further harmonisation between the laboratories. This approach would lead to the reachable target of 2 to 5 days post-processing time compared to 3 to 10 days presently.
- To improve the quality and reliability of the results, the procedures should tend to limit the use of results coming from the OBD signals, and to favour using of the measured data.
- Finally, a fundamental line of work, is the review of the robustness PEMS test method to assess efficiently all types of powertrains in a relevant and equitable manner.

Overall, the pilot program has reached its objectives and succeeded in setting up a complete testing and rating process to incentivise greener cars in no more than 20 months' time. The Green NCAP program now enters in its Phase 1 with a fully-fledged program and intends to continue to improve the test procedures and assess the issues compiled in the road map such as driving resistance, cold test, new pollutants etc.

1 INTRODUCTION

In 2017 Euro NCAP decided to start with a pilot program to assess a car's environmental performance based on similar principles and mechanisms as used in its 20-year's successful safety program. In this 1.5-year pilot program consumer organisations, some governments and highly professional test lab organisations collaborated to establish an independent test program. The target of the program was to set-up a system in which comprehensive and objective tests were translated into a simple consumer rating. For this purpose, common test procedures were developed, often based on world-wide accepted regulatory tests but custom-tailored to the needs of Green NCAP. The basis and reference for the Green NCAP test program assessment and rating were still largely emission laboratory tests. Emphasis was also put on real-world verification testing. Robustness testing was included, both for lab and real-world testing to cover assessment gaps.

Objective and comprehensive information based on scientifically sound test methods, condensed in a simple rating, will be provided to the consumer. Pollutant and greenhouse gas emissions as well as a vehicle's energy efficiency and driving range are part of the assessment and rating system. To obtain a good rating for their products manufacturers shall offer the best possible technology as standard in all segments and countries, protecting the environment and saving cost for the consumer. The Green NCAP program will spark competition and target an upward spiral of the environmental performance of vehicles at lowest cost for the environment, society and the individual consumer.

The pilot program was run between May 2017 and September 2018. It was split into three phases: initial test procedure development (May – November 2017), verification testing (December 2017 – April 2018) subdivided in a first verification test series (December 2017 – April 2018) and Round Robin verification tests (March 2018 - July 2018). Finally, a validation test phase followed (June – October 2018).

This report deals with the validation phase, which the main objective was to consolidate the procedures and processes established by the Green NCAP technical working group, taking into account the feedback from the first verification test program and the round robin test program performed previously.
The second objective was to build a first database of publishable results, to see how vehicles react to the test procedure and to finalize the rating approach. For that purpose, the tests were performed on twelve different vehicles mostly Euro 6d temp compliant in eight different laboratories across Europe. The participating laboratories have all been part of the round robin test and showed an ability to be accredited by Euro NCAP.

The validation phase was to be a foundation of the fully-fledged program.

2 OBJECTIVES

This report addresses the Green NCAP validation phase for which the objectives were:

- To consolidate the feasibility of the procedures and processes established by the Green NCAP technical working group, taking into account the feedback from the first verification test program and the round robin verification test program performed in a previous stage.

- To build a first database of publishable results, to see how vehicles react to the test procedure and to develop a rating process. For that purpose, the tests were performed on twelve different vehicles in eight different laboratories across Europe. The selection process of the different proposed tests were used to optimise the test matrix and sequence, laboratory working load and economical aspects.

3 LIST OF PARTICIPANTS

Each Green NCAP participant designated a laboratory to carry out the testing of one vehicle in the first verification test phase and committed to sponsor testing of one vehicle. However, due to the ambitious timing some participants were not in the position to sponsor a vehicle in the first verification phase; their contributions were postponed to the validation phase. All eight participating and designated laboratories were involved in the round robin verification test phase.

GNCAP member(s)	Associated test laboratory
ACI-CSI	CSI (and BRC)
ADAC	ADAC
Applus, IDIADA Proving Ground	Applus, IDIADA Proving Ground
TNO	TNO (and Horiba)
FIA Region I	ADAC
ÖAMTC / IFA Uni Vienna	IFA Uni Vienna
TCS / EMPA	TCS / EMPA
UTAC	UTAC
BASt	ADAC
ICRT	ADAC
UK DfT	MIRA

Table 1- Participants List

- Specific organisation of some laboratories:
    - CSI: CSI laboratory was in charge of PEMS tests, and subcontracted chassis dynamometer tests to its partner BRC.
    - TCS & EMPA: the TCS laboratory was in charge of PEMS real-world tests, and EMPA laboratory was in charge of chassis dynamometer tests.

4 GLOBAL OVERVIEW OF THE TESTING SCHEDULE

The validation test series was performed between July 2018 and October 2018.

Name	Begin date	End date	Duration
Euro NCAP Board and HLSG meetings	28/06/16	23/10/19	867
Green NCAP technical working group (GNT) meetings	09/05/17	10/12/20	938
Green NCAP Pilot program	09/05/17	31/12/18	430
Test protocol and score development phase	09/05/17	14/12/17	158
Laboratory accreditation process	17/08/17	13/09/18	281
Pilot program test phase 1, test protocol first verification	27/11/17	04/05/18	115
Round Robin test lab verification tests	05/02/18	27/07/18	125
Development communication Green NCAP to stakeholders	25/04/18	31/12/18	179
Pilot program test phase 2, final validation	07/05/18	19/10/18	120
Decision Euro NCAP Board full Green NCAP program	23/10/18	24/10/18	2
Submission final validation report to TWG, all vehicles + comments Board on preliminary version	31/10/18	31/10/18	0
Adoption final validation report by TWG, submission to Board	05/11/18	05/11/18	0
Adoption Board final validation report	05/11/18	05/11/18	0
Green NCAP full program	24/10/18	02/01/32	3,443

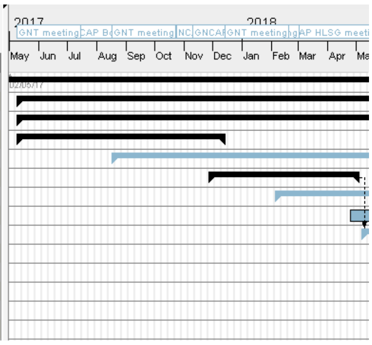

Table 2- Overall test schedule of Green NCAP pilot program

Name	Begin date	End date	Durati...
Euro NCAP Board meetings	28/06/16	22/10/19	866
Green NCAP technical working group (GNT) meetings	09/05/17	12/07/19	569
Pilot program	09/05/17	28/09/18	364
Test protocol and score development phase	09/05/17	14/12/17	158
Laboratory accreditation process	17/08/17	13/09/18	281
Pilot program test phase 1, test protocol first verification	27/11/17	04/05/18	115
Round Robin test lab verification tests	05/02/18	20/07/18	120
Pilot program test phase 2, final validation	07/05/18	28/09/18	105
Update test protocols	07/05/18	29/06/18	40
Test program	02/07/18	14/08/18	32
Collect test results	10/07/18	14/08/18	26
Final validation report phase 1	10/07/18	27/07/18	14
Final validation report phase 2	20/08/18	28/09/18	30
Development communication Green NCAP to stakeholders	25/05/18	31/12/18	157
Green NCAP full program	24/10/18	29/12/34	4,223
Phase 1	24/10/18	30/05/19	157
Phase 2 Green Vehicle Index (GVI) program	03/06/19	31/12/20	414
Phase 3	01/01/21	31/12/29	2,347
Phase 4 Life Cycle based assessments	03/01/33	29/12/34	520

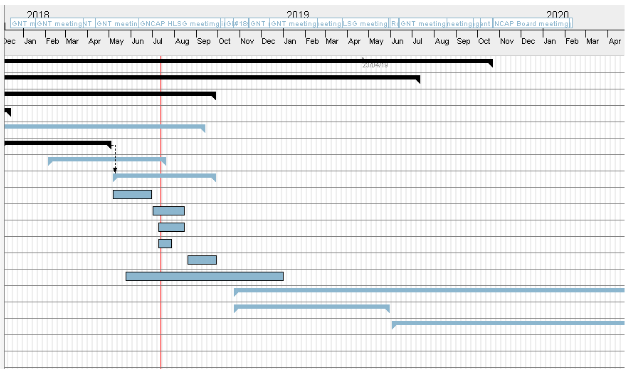

Table 3 – Validation phase Testing Schedule

5 TEST PROGRAM OF THE VALIDATION TEST SERIES

The test program of the validation test series was discussed and agreed in the Green NCAP technical working group. The sequence and test conditions of the validation phase are based on experiences built from the first verification test series. Changes were made to the following:

- The test sequence was regarded as too long (4 working weeks) and some tests were considered less relevant or redundant
  - ⇨ Those tests hereunder were discarded from the test matrix:
    - WLTC warm start with standard payload & standard driving mode. This test has been reintroduced into the proposal for the future full program.
    - US06 warm start with standard payload & standard driving mode
    - PEMS warm start with standard payload & standard driving mode in urban area
    - PEMS cold, second test to access repeatability
    - PEMS cold, light payload
    - Driveability propulsion unit performance (max power & torque),the only remaining measurement from this test was the maximum engine load curve mapping
- The test conditions on chassis dynamometer at +10°C was too constraining regarding the capability of test cells and soaking area
  - ⇨ Tests were eventually performed at the ambient temperature of +14°C

5.1 Summary of the test program for the validation phase

The test program was the compilation of the output of six Green NCAP task forces dedicated to:

(1) Overall test procedure
(2) Tailpipe pollutant emission tests - Emission laboratory tests (chassis dynamometer tests)
(3) Real world driving tests (PEMS tests)
(4) Emission robustness tests (both laboratory and real-world tests)
(5) Max engine load curve mapping test
(6) Rating Task Force

5.1.1 Summary of tests and test conditions overview

Type of test		Test ID	Payload	Soaking T° before test	Oil T° before test	Warmup method	Test cell / outside T°	Method/Driving	Tolerance display	Stop&start function	Climatisation
LAB	WLTC	Coast down (dyno setting)	Standard	+14°C	+14°C	-	+14°C	Fixed-run	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_warm_precon	Standard	-	no recommandation	-	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_cold_default_mode	Standard	+14°C	+14°C	-	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_warm_eco_mode (if available)	Standard	-	> 80°C	5min stab at 80km/h	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_warm_sport_mode (if available)	Standard	-	> 80°C	5min stab at 80km/h	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	WLTC	Coast down max payload (dyno setting). Could be performed at the end of coast down standard	High	+14°C	+14°C	-	+14°C	Fixed-run method	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_warm_max_payload_def_mode	High	-	> 80°C	5min stab at 80km/h	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	WLTC	WLTC_cold_default_mode_rep + PEMS correlation	Standard	+14°C	+14°C	-	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	US-BAB	FTP72_precon	Standard	-	no recommandation	-	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	US-BAB	FTP75_cold_default_mode	Standard	+14°C	+14°C	-	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	US-BAB	BAB_default	Standard	-	> 80°C	5min stab at 80km/h	+14°C	GSI	Yes	Active	Active (+23°C)
LAB	PERFO	Full load curve	Standard	-	> 80°C	5min stab at 80km/h	+14°C	-	-	-	-
ROAD	PEMS	PEMS_Correlation	Standard	-	no recommandation	-	[-7°C;+35°C]	GSI	-	Active	no recommandation
ROAD	PEMS	RDE_Regular	Standard	Inside (23°C) (8h-36h)	+23°C	-	[-7°C;+35°C]	GSI + Standard driving	-	Active	Active (+23°C)
ROAD	PEMS	PEMS_Stand_Cold_Eco	Standard	Inside	Depending on soaking T°	-	[-7°C;+35°C]	Eco driving	-	Active	No
ROAD	PEMS	PEMS_Heavy_Warm	High (90% of Max)	-	> 80°C	Driving on road/track recommanded	[-7°C;+35°C]	Sport driving	-	No	Active (+23°C)

Table 4- Validation phase test conditions

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5.1.2 Test conditions

5.1.2.1 Test temperature (soaking, test cell, engine oil & coolant):

Tests were performed at 14°C in the test cell. As one as the lessons learned from the verification phase, 10 °C proved too constraining for the laboratories organisation, it was therefore agreed to raise the ambient (soaking) temperature to 14°C during validation testing.

For cold start tests, the vehicles were soaked for a period greater than 6 hours into a soaking area or directly into the test cell. The purpose of the soaking is to start the test with engine oil and coolant temperatures of 14°C +/-3°C. The warm start tests were performed after a warm-up run on the chassis dynamometer with an oil temperature target greater than 80°C.

- PEMS+ testing

In the PEMS+ protocol the real-world tests aimed to be performed under 'normal' and 'extended conditions' as defined in the Euro 6 Regulation[1] [-7°C; +35°C]. Considering the validation test period (summer), the average outside temperature turned out to be +21°C within a range of +12°C; +35°C.

The cold start PEMS+ tests were carried out after a soaking period in an indoor soaking area. The purpose of the soaking is to start the test with an engine oil temperature of 23°C +/-3°C to increase test robustness. The emissions generated, whilst the engine oil temperature was recorded below 70°C, were included in the test results.

The warm start tests were preceded by a warm-up run on the road with targeting an oil temperature greater than 80°C.

5.1.2.2 Payload definition for this program

For the chassis dynamometer test:

- A **standard payload** stands for the combination of a test mass and road load coefficients calculated according to the formulas in paragraph 5.1.2.8
- A **high payload** stands for the combination of a test mass set to the maximum laden mass and the road load coefficients adapted accordingly.

For the PEMS test:

- A **standard payload** stands for the real mass of the vehicle with a fully filled fuel tank, including the driver and the PEMS+ test equipment.
- A **high payload** stands for the standard payload with an additional mass as close as possible to 90% of the maximum permissible mass of the vehicle.

⇨ The summary table of the vehicle test masses is available in paragraph 6.4.

5.1.2.3 Chassis dynamometer setting

Except IFA, which is equipped with a mechanical bench of an older generation (a new bench is planned for 2019), all of the laboratories used the WLTP method from the Euro 6 1151/2017 European regulation.

5.1.2.4 Air conditioning

The chassis dynamometer tests were performed with the air conditioning on.
For the PEMS+ tests, the air conditioning was activated during the heavy tests, but deactivated during eco tests.
For the regular PEMS+ test, the activation or deactivation depended on the drivers need when vehicles were with manual controlled system and automatic activation for vehicles equipped with that option (according to the normal conditions as RDE, no more recommendation were made).

5.1.2.5 Driving mode:

All the laboratories tests were performed using the test vehicle Gear Shift Indicator (GSI) prescriptions.

The majority of the PEMS tests were also conducted using the GSI, exception made of two types of PEMS tests which were carried out with specific gearshift prescriptions. That is::

- For the PEMS tests on Eco mode: shifting to higher gear at a very low engine speed and high engine load target (2000rpm)
- For the PEMS tests in Sport mode: shifting to higher gear at a high engine load & engine speed target (3500rpm)

5.1.2.6 Road load parameters

For the validation phase, the test mass and the road load parameters were directly obtained from the Certificate of Conformity of the tested vehicles (CoC).

Concerning the five Euro 6b vehicles, the road load parameters used were calculated from the coast down results extracted from the CoC of the vehicle determined according to the UN Regulation No 83 procedure and corrected with the WLTP test mass.

5.1.2.7 Definition of test mass & inertia

- **Standard payload :**

Test Mass = UM + $OM_{repr.}$ + 100 kg +0,15* (LM-RM)

$$\text{Inertia} = \begin{cases} \text{TM} + 0.5 \cdot (0.03 \cdot \text{RM}) \ [\text{Applicable for 4WD in following mode}] \\ \text{TM} \quad [\text{Applicable for 4WD}] \end{cases}$$

Where:

UM: unladen mass (kerb weight)
$OM_{repr.}$: mass of vehicle options (representative)
LM: laden mass (gross vehicle weight)
RM: Reference Mass = UM + OM + 100 kg (100 kg for driver and luggage)
TM: Test Mass
0,15: payload factor for M1 vehicles

- **High payload :**

Test Mass = LM

$$\text{Inertia} = \begin{cases} \text{TM} + 0.5 \cdot (0.03 \cdot \text{RM}) \ [\text{Applicable for 4WD in following mode}] \\ \text{TM} \quad [\text{Applicable for 4WD}] \end{cases}$$

Where:

LM: Laden mass (gross vehicle weight)
TM: Test Mass

5.1.2.8 Definition road load coefficients for High payload tests

$$\begin{cases} F_{2,max} = F_{2,std} \\ F_{1,max} = F_{1,std} \\ F_{0,max} = F_{0,std} \cdot \dfrac{\text{Test Mass}_{max}}{\text{Test Mass}_{std}} \end{cases}$$

5.2 Detailed descriptions of the tests

5.2.1 Tests based on the WLTC

These tests procedures were based on the Euro 6 Regulation (EU) 1151/2017 using the WLTC_Class3b test cycle (figure 1) split in 4 phases with a total duration of 1800s a distance of 23.3 km and an average vehicle speed of 46.5 km/h, performed in various conditions:

Tests delivering emissions results:

- **WLTC_cold_default_mode:** Test performed with a standard payload at 14°C test cell and soak chamber temperature (start with engine oil and coolant temperature of 14°C to simulate cold engine start) and use of default driving mode.
- **WLTC_warm_eco_mode:** Test performed with a standard payload at 14°C test cell temperature after warm-up driving on the chassis dynamometer (start with an oil temperature > 80°C to simulate a warm start with subsequent warm engine driving) and with the eco mode activated if available on the vehicle.
- **WLTC_warm_sport_mode:** Test performed with a standard payload at 14°C test cell temperature after warm-up driving on the chassis dynamometer with an oil temperature > 80°C to simulate a warm start with subsequent warm engine driving) and with the sport mode activated if available on the vehicle.
- **WLTC_warm_max_payload_def_mode :** Test performed with a high payload at 14°C test cell temperature after warm-up driving on chassis dynamometer (start with an oil temperature > 80°C C to simulate a warm start with subsequent warm engine driving) and applying maximum payload / default mode

Test preparation steps:

- **Coast down (dynamometer setting):** Tests performed with standard set-up conditions at 14°C test cell temperature after a warm-up on the chassis dynamometer with one WLTC.
- **Coast down max payload (dyno setting). :** Test performed with heavy set-up conditions at 14°C after a warm-up on the chassis dynamometer with one WLTC.
- **WLTC_warm_precon:** WLTC prep test performed with standard set-up conditions at 14°C test cell temperature before the first WLTC test.

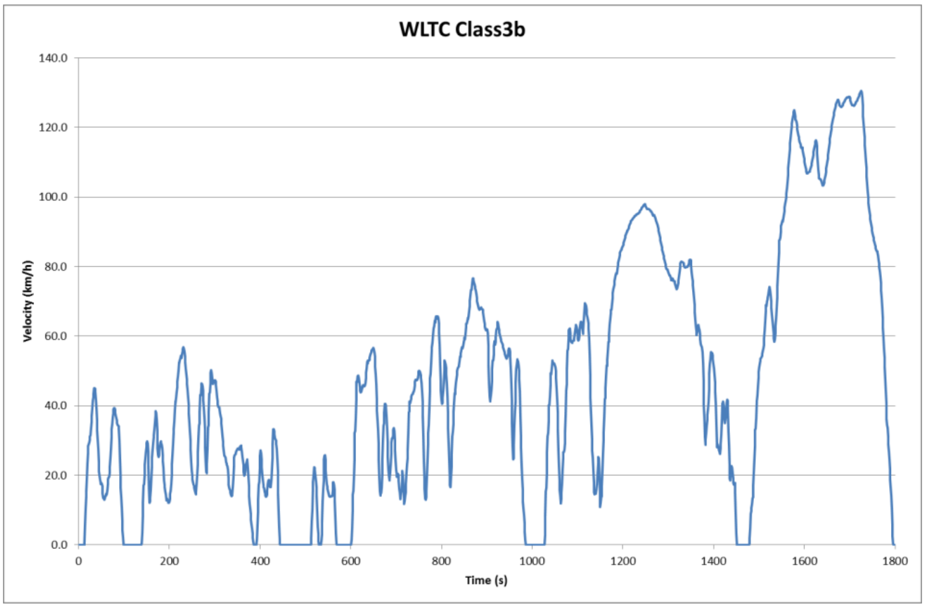


Figure 1- WLTC

5.2.2 Tests based on the FTP_75 cycle

All emission laboratory tests were carried out according to the Green NCAP specified WLTP+ procedure, which is mainly based on the regulatory requirements. For the US FTP75 test cycle only the vehicle speed profile over test time was used and combined with the WLTC+ test instructions. This test cycle was split into 3 phases with a total duration of 1874s, a distance of 17.8 km and an average speed of 34.1 km/h. This test cycle included a 600s hot soak period between phases 2 and 3 generating a warm start for phase 3.
Tests using the FTP75 cycle were performed with only one combination of test conditions:

Test delivering emissions results:

- **FTP75_cold_default_mode:** Test performed at 14°C test cell temperature with a standard payload after soaking at 14°C (start with an oil temperature and coolant temperature at 14°C). This test was performed without a specific dynamometer setting, but using the one from the WLTP. The cold start was followed by the FTP72 cycle (corresponding to the first phases of the FTP75 cycle), then a 600s soak, followed by a warm start and repeating the first stage of the FTP72 with a warm engine (figure 2).
- .

Test preparation steps:

- **FTP72_precon:** Test performed with standard set-up at 14°C test cell temperature before conducting the FTP75_Cold test. The FTP72 cycle corresponds to the first phases of the FTP75 cycle.

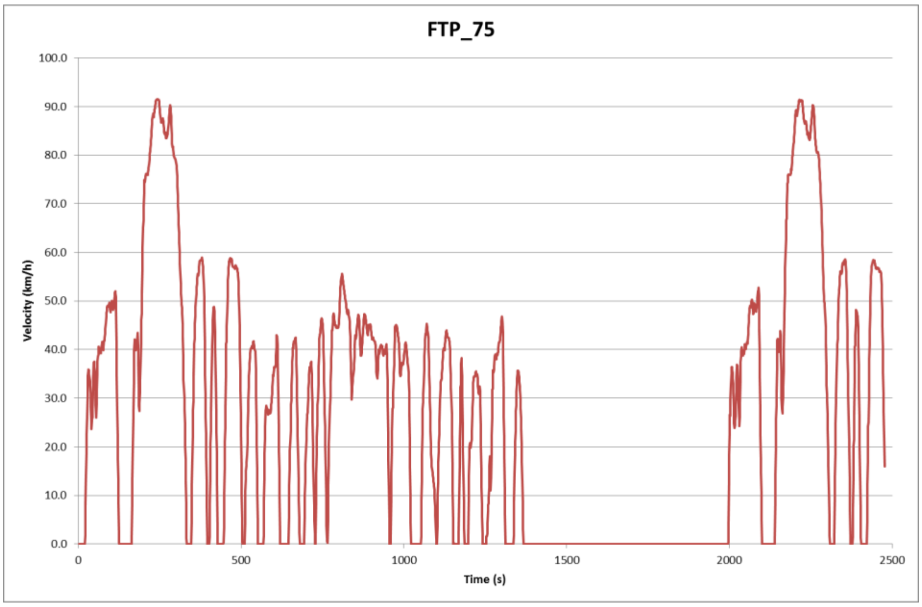


Figure 2- FTP75 cycle

5.2.3 Tests based on the BAB130

All emission laboratory tests were carried out according to the Green NCAP specified WLTP+ procedure instructions, which were largely based on the regulatory requirements. Therefore regarding the ADAC BAB130 Highway cycle test, only the vehicle speed profile was changed from the WLTP+ procedure. This test also includes a warm up period (figure 3).

Test delivering emissions results:

- **BAB_warm_default:** Test performed with a standard payload at 14°C test cell temperature after warm-up driving on the chassis dynamometer (warm with an oil temperature > 80°C).

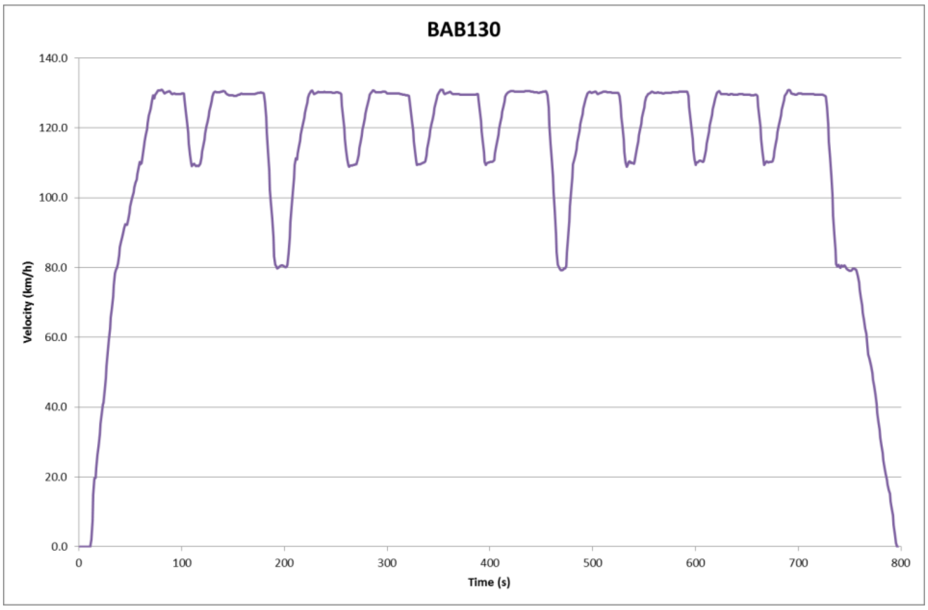


Figure 3- BAB130

5.2.4 PEMS+ test

The PEMS+ test procedure for the validation phase was based on the RDE regulation test methodology. This test was carried out on the open road and contained similar requirements compared to a regulatory RDE test:

- the route was split in 3 phases (urban/rural/motorway)
- the minimum distance per phase was 16km
- the trip duration is to be within 90min and 120min
- the accumulated distance split between the 3 phases was to be approximately 34%, 33% and 33%

In the PEMS + test program, the regular RDE test conditions were maintained for one of the three tests performed. The conditions of the other 2 tests were modified in order to cover a wider engine speed – engine load operation range.
Thus, one of the PEMS + tests was carried out under Eco type conditions (Eco driving, without air conditioning). The second was made under Heavy conditions (High payload, sport driving, with air conditioning).

The other main difference with the RDE regulatory test procedure concerned the post-processing of the results: in this program the emissions results were directly calculated from the raw measurements, unlike the regulatory procedure.

The figures below show an example of a test route.

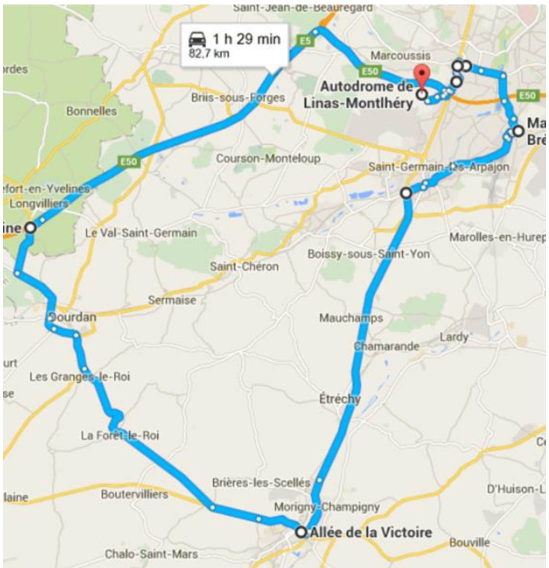


Figure 4- Overview of a test route (around UTAC facilities)

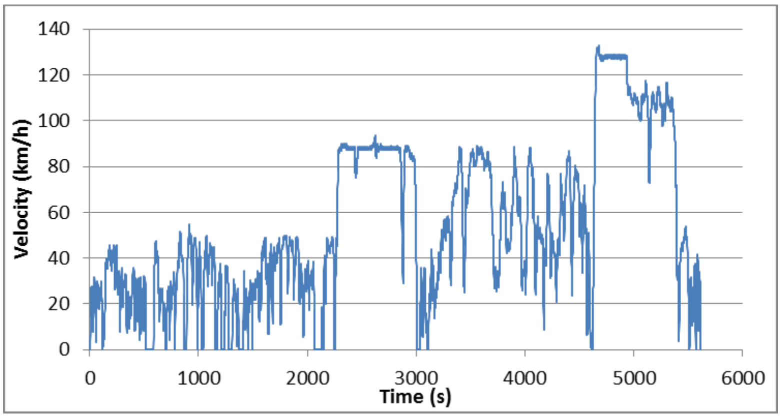


Figure 5- Vehicle speed curve of a possible PEMS route 'around UTAC facilities)

This PEMS test was performed in different conditions:

- **PEMS_Regular:** Test performed with a standard payload after a soaking at ~23°C (start with an oil and coolant temperature at ~23°C). This test was performed under the type approval test conditions.
- **PEMS_Stand_Cold_Eco:** Test performed with a standard payload and with eco-driving after a soaking at ~23°C (start with an oil and coolant temperature at ~23°C).
- **PEMS_Stand_Warm_Heavy:** Test performed with a high payload and with sport driving after a warm up on open road (start with an oil temperature > 80°C).

5.2.5 PEMS+ Correlation

Before the start of the PEMS+ test series, it was deemed necessary to validate the combination vehicle / PEMS equipment by a correlation test on the chassis dynamometer (**PEMS_Correlation**). The aim was to compare the results from the PEMS+ tests with reference values issued from the classic emissions test procedure on a chassis dynamometer and emission benches. The outputs checked were:

- The tailpipe emissions of CO_2, CO, NOx & PN and THC, if available
- The distance by comparing the velocity delivered by the OBD and the one from the chassis dynamometer
- The weather station regarding the ambient temperature, the barometric pressure and the relative humidity

5.2.6 Maximum engine load curve

One of the main objectives of the Green NCAP program was to significantly widen the scope of tested propulsion unit operating points.
The engine-speed & load sample matrix values shall be compared to the ones when sampling emissions on the chassis dynamometer or in the real-world tests.

Feedback from some of the labs during the first verification phase was that continuous high load engine operation challenged the gas analysis system too much, due to PEMS equipment exposure to potentially too high exhaust gas temperatures when performing the maximum engine load sweep test on the chassis dynamometer in accordance with the first draft test procedure GNT_propulsion_unit_performance_v2.
In order to propose an alternative solution, a new test methodology was developed for the validation phase tests, set-out in documents GNT_propulsion_unit_performance_v3 & GNT_CELV_v5, tests which were performed on-road or track with PEMS.

5.3 Final test program : input from the validation program (recommended to the BoD for the fully fledge program)

Green NCAP Program
Introductory Test Procedures

Laboratory	Robustness (Laboratory & Real-World)	PEMS (Real-World)	Maximum Engine Load Curve Mapping
Fuel / Energy efficiency, pollutant and GHG emissions*	**Fuel / Energy efficiency and pollutant emissions***	**Fuel / Energy efficiency, pollutant and GHG emissions***	**Maximum engine load versus engine speed test**
Approval test cycles under average ambient conditions (@ 14°C)	Custom-tailored tests with variations of vehicle settings, low and high engine load)	Custom-tailored approval driving tests under real-world ambient conditions	Custum-tailored sweep test to visualise maximum engine load operation and emissions sampling
❖ WLTC cold engine (2x)	❖ WLTC warm engine (regular) ❖ WLTC warm (eco mode) ❖ WLTC warm (sport mode) ❖ BAB130 Motorway ❖ PEMS+ warm Eco ❖ PEMS+ warm Heavy load	❖ PEMS+ cold engine (regular)	❖ Sweep test to log maximum engine load versus engine speed (fully depressed accelerator pedal)

**NB Fuel Efficiency: CO_2 Emissions, Fuel / Energy Consumption, (in future real-world Driving Range to be added)*

Figure 6 - Test matrix remaining after optimisation as a result of validation testing, recommended as the starting point for fully-fledged program

6 DESCRIPTION OF TEST VEHICLES & TEST FACILITIES

The list of vehicles included in the program was an output of the Green NCAP task force working on:
(4) Test vehicle selection procedure.

The group selected Euro6d-temp vehicles representative of high market shares, of representative engine type and latest technologies available in the EU. Green NCAP chose not to test hybrid vehicles, because of the complexity of the issue to be developed and the need of longer time than available to develop robust procedures. Nevertheless, as Green NCAP deemed it essential to point out that in the all engine technologies shall be in the scope of the Green NCAP program, a pure electric vehicle was included in the batch.

Two Euro 6b compliant vehicles were added to this list. These vehicles were already used for the first verification test series and in the Round Robin verification tests (RRT: VW Golf TDi & Ford Fiesta 1L GDI). Three other Euro 6b vehicles were also added to the list (Fiat Panda 0.9LTwinair & Hyundai Ioniq EV & BMW i3 EV).

For the validation test series, a total of 12 vehicles were selected:

- 7 petrol engine vehicles :
  - Ford Fiesta 1L GDi EcoBoost Euro6b . Tested by UTAC
  - Ford Fiesta 1L GDi EcoBoost Euro6d Temp. Tested by MIRA
  - Fiat Panda 0.9L Twinair. Tested by ACI-CSI
  - Mercedes A200 120 kW. Tested by IDIADA
  - Subaru Outback 2.5i. Tested by EMPA-TCS
  - Volvo XC40. Tested by ADAC
  - VW Up! GTI. Tested by ADAC
- 3 diesel engine vehicles :
  - Audi A7 TDI. Tested by ADAC
  - BMW X1d. Tested by MIRA
  - VW Golf 1.6L TDI Euro6b (RRT). Tested by ADAC
- 2 pure electric vehicle :
  - Hyundai Ioniq EV. Tested by IFA
  - BMW i3. Tested by IFA

6.1 Petrol Vehicles

Data	Type of data	Unit	Fiat Panda 0.9 TwinAir	Ford Fiesta 1.0 l EcoBoost Euro6b	Ford Fiesta 1.0 l EcoBoost Euro6d_temp	Mercedes A200 120kW Petrol
Make	Text	--	FCA	Ford EU	Ford EU	MERCEDES BENZ
Type/Variant/version	Text	--	Panda TwinAir	Ford Fiesta 1.0 T 100hp	Ford Fiesta 1.0 T 100hp	A200 120kW
Engine position	Text	--	Front	Front	Front	Front
Nr. of powered axles	Number	1 or 2	1 (Front)	1 (Front)	1 (Front)	1 (Front)
Mass in Running order	Number	kg	955	1115	1369	1375
Maximum laden mass	Number	kg	1420	1550	1675	1885
Combustion type	Text	--	Spark Ignition	Spark Ignition	Spark Ignition	Spark Ignition
Gas Post-treatment	Text	--	TWC	TWC	TWC/GPF	TWC/GPF
Fuel Type	Text	--	E10 reference fuel	E10 reference fuel	E10 reference fuel	E10 reference fuel
Cylinder Nr/Position	Number	--	2 in line	3 in line	3 in line	4 in line
Engine displacement	Number	cm^3	875	998	998	1333
Charging type	Text	--	Turbocharged	Turbocharged	Turbocharged	Turbocharged
Injection type	Text	--	MPI	GDI	GDI	GDI
Rated Power / rpm	Number	kW/rpm	62,5 / 5500	74 / 6000	92 / 6000	120 / 5500
Max Torque /rpm	Number	Nm/rpm	145 / 1900	174 / 1400÷4000	170	250 / 1620÷4000
Transmission type	Text	--	Manual	Manual	Manual	Automatic
n. of gears	Number	--	5	6	5	7
Tyre size	Text	--	175/65R14	195/55 R16 87V	205/45R17	225/45R18
Test Mass	Number	kg	1115	1317	1369	1500
F0	Number	N	89,8	70,5	137,6	100,2
F1	Number	N/km/h	0	0,0643	0,601	1,067
F2	Number	N/(km/h)^2	0,0393	0,0360	0,0330	0,0271
Vehicle mileage	Number	Km	4000	4500	3000	2850
Level comliance	Text	--	Euro 6b	Euro 6b	Euro 6d_temp	Euro 6d_temp
TA CO2 emissions	Numbers	g/km	99	97	136	143

Table 5 – Description of Petrol test vehicles (1/2)

Data	Type of data	Unit	Subaru Outback 2.5i	Volvo XC40	VW Up! GTI
Make	Text	--	Subaru	Volvo	Volkswagen
Type/Variant/version	Text	--	Outback 2.5i Luxury	XC40 T5 AWD	UP! GTI
Engine position	Text	--	Front	Front	Front
Nr. of powered axles	Number	1 or 2	2	2	1 (Front)
Mass in Running order	Number	kg	1620	1969	1070
Maximum laden mass	Number	kg	2100	2220	1400
Combustion type	Text	--	Spark Ignition	Spark Ignition	Spark Ignition
Gas Post-treatment	Text	--	TWC	TWC/GPF	TWC/GPF
Fuel Type	Text	--	CD : E10 reference PEMS : Fuel Market	E10 reference fuel	E10 reference fuel
Cylinder Nr/Position	Number	--	4 flat	4 in line	2 in line
Engine displacement	Number	cm^3	2498	1969	999
Charging type	Text	--	Atmospheric	Turbocharged	Turbocharged
Injection type	Text	--	MPI	GDI	GDI
Rated Power / rpm	Number	kW/rpm	129 / 5800	182 / 5500	85 / 5000
Max Torque /rpm	Number	Nm/rpm	235 / 4000	350 / 1800	200 / 2000
Transmission type	Text	--	CVT "Linartronic"	Automatic	Manual
n. of gears	Number	--	-	8	6
Tyre size	Text	--	225/60R18	235/55 R18	195/40 R17
Test Mass	Number	kg	1795	1889	1171
F0	Number	N	160,5	145,8	73,3
F1	Number	N/km/h	0,403	0,311	0,507
F2	Number	N/(km/h)^2	0,0381	0,0419	0,0323
Vehicle mileage	Number	Km	6500	4700	400
Level comliance	Text	--	Euro 6d_temp	Euro 6d_temp	Euro 6d_temp
TA CO2 emissions	Numbers	g/km	166	194	128

Table 6 - Description of Petrol test vehicles (2/2)

6.2 Diesel vehicles

Data	Type of data	Unit	VW Golf 1.6 TDI	Audi A7 TDI	BMW X1d
Make	Text	--	Volkswagen	Audi	BMW
Type/Variant/version	Text	--	Golf 1.6 TDI 110hp	A7 Sportback 50 TDI	X1 18d
Engine position	Text	--	Front	Front	Front
Nr. of powered axles	Number	1 or 2	1 (Front)	2	1 (Front)
Mass in Running order	Number	kg	1315	1955	1590
Maximum laden mass	Number	kg	1930	2535	2090
Combustion type	Text	--	Compression ignition	Compression ignition	Compression ignition
Gas Post-treatment	Text	--	SCR/DPF	SCR/DPF	SCR/LNT/DPF
Fuel Type	Text	--	B7 reference fuel	B7 reference fuel	B7 reference fuel
Cylinder Nr/Position	Number	--	4 in line	6 in V	4 in line
Engine displacement	Number	cm^3	1598	2967	2000
Charging type	Text	--	Turbocharged	Turbocharged	Turbocharged
Injection type	Text	--	CR	CR	CR
Rated Power / rpm	Number	kW/rpm	81 / 3200÷4000	210 / 3500	110
Max Torque /rpm	Number	Nm/rpm	250 / 1500÷3000	620 / 2250	350
Transmission type	Text	--	Manual	Automatic	Manual
n. of gears	Number	--	5	8	6
Tyre size	Text	--	225/45 R17	255/40 R20	225/55R17
Test Mass	Number	kg	1483	2216	1679
F0	Number	N	89,5	200,9	163,7
F1	Number	N/km/h	0,681	0,45	0,337
F2	Number	N/(km/h)^2	0,0292	0,0360	0,0343
Vehicle mileage	Number	Km	7500	5500	3400
Level comliance	Text	--	Euro 6b	Euro 6d_temp	Euro 6d_temp
TA CO2 emissions	Numbers	g/km	109	196	121

Table 7 - Description of diesel test vehicles

6.3 Pure Electric vehicles

Data	Type of data	Unit	Hyundai Ioniq EV	BMW i3
Make	Text	--	Hyundai	BMW
Type/Variant/version	Text	--	Ioniq EV	i3
Engine position	Text	--	Front	Rear
Nr. of powered axles	Number	1 or 2	1 (Front)	1 (Rear)
Mass in Running order	Number	kg	1475	1270
Maximum laden mass	Number	kg	1880	1620
Combustion type	Text	--	EV	EV
Gas Post-treatment	Text	--	-	-
Fuel Type	Text	--	-	-
Cylinder Nr/Position	Number	--	-	-
Engine displacement	Number	cm^3	-	-
Charging type	Text	--	-	-
Injection type	Text	--	-	-
Rated Power / rpm	Number	kW/rpm	88	75
Max Torque /rpm	Number	Nm/rpm	295	250
Transmission type	Text	--	-	-
n. of gears	Number	--	-	-
Tyre size	Text	--	205/55 R16	155/70 R19
Test Mass	Number	kg	1621	1344
F0	Number	N	109,1	102,9
F1	Number	N/km/h	0,3679	0,8553
F2	Number	N/(km/h)^2	0,0294	0,0280
Vehicle mileage	Number	Km	17400	25000
Level comliance	Text	--	Euro6b	Euro6b
TA CO2 emissions	Numbers	g/km	0	0

Table 8 - Description of pure electric test vehicles

6.4 Summary table of Vehicle Test Masses

		Laboratory Tests Mass		PEMS Tests Mass		
		Standard (kg)	Heavy (kg) (= max laden mass)	Standard (kg)	Heavy	
					Value (kg)	% / Max laden mass
Petrol	Ford Fiesta Gdi Euro6b	1317	1670	1320	1500	90%
	Ford Fiesta Gdi Euro6d_temp	1369	1675	1370	1513	90%
	Fiat Panda 0.9L Euro6b	1115	1455	1225	1413	97%
	Mercedes A200	1500	1885	1717	1762	93%
	Subaru Outback 2.5i	1795	2100	1795	2055	98%
	Volvo XC40	1889	2220	1889	2220	100%
	VW Up GTI	1171	1400	1200	1400	100%
Diesel	Audi A7 TDI	2216	2535	2216	2535	100%
	BMW X1d	1679	2090	1720	2042	98%
	VW Golf 1.6L TDI Euro6b	1483	1840	1490	1840	100%
EV	BMW i3	1344	1620	1295	1575	97%
	Hyundai Ioniq	1661	1880	1540	1820	97%

Table 9 Summary of test vehicle masses

6.5 Description of Laboratories Test Facilities

Each laboratory was equipped with a four wheel drive chassis dynamometer (4WD), and with gas analysers (PEMS & test cell) that complied with the requirements of the tests to be carried out. The laboratories respected the metrological verification process of their equipment.
The eight laboratories involved in the validation testing first passed successfully through the Round Robin verification test series and Green NCAP audit. A detailed description was made in the verification phase report.

7 TEST RESULTS

The emission results are summarised below for the 12 vehicles tested by the eight laboratories participating in the validation test series. This test series took place from July 2018 to October 2018.

The WLTC+ test with cold start and standard driving conditions was the test closest to the current type approval procedure.
For the first verification test series, the vehicle test mass and road load standard values were calculated with a worst-case approach due to the non-availability of representative road load settings. The verification results obtained were not relevant because they proved to be much higher than the PEMS results.
For the validation test series, the mass and road load values were obtained from the Certificate of Conformity (CoC) of the tested vehicles, which were the settings provided by the manufacturer on the basis of which the vehicles were approved.
The PEMS+ tests were performed under the same test requirement conditions as the first verification test series.

The gaps in the following graphs correspond to non-performed tests or analysis problems issues of the tests results.

Exception made of the vehicles from the verification phase (Golf & Fiesta both Euro6b) as well as the Fiat Panda and the Hyundai Ioniq EV, the selected vehicles were type approved according to Euro 6d Temp regulation and therefore were to comply with WLTP and with the RDE Regulation (EU) 2017/1151.

Regarding the regulated limits for diesel vehicles, the HC+NOx limit (170 mg/km) were split by the Green NCAP group into separate THC and NOx limit in order to have a common approach “by pollutant” for all vehicles (petrol & diesel).

7.1 NOx emissions

7.1.1 NOx emissions – WLTC tests:

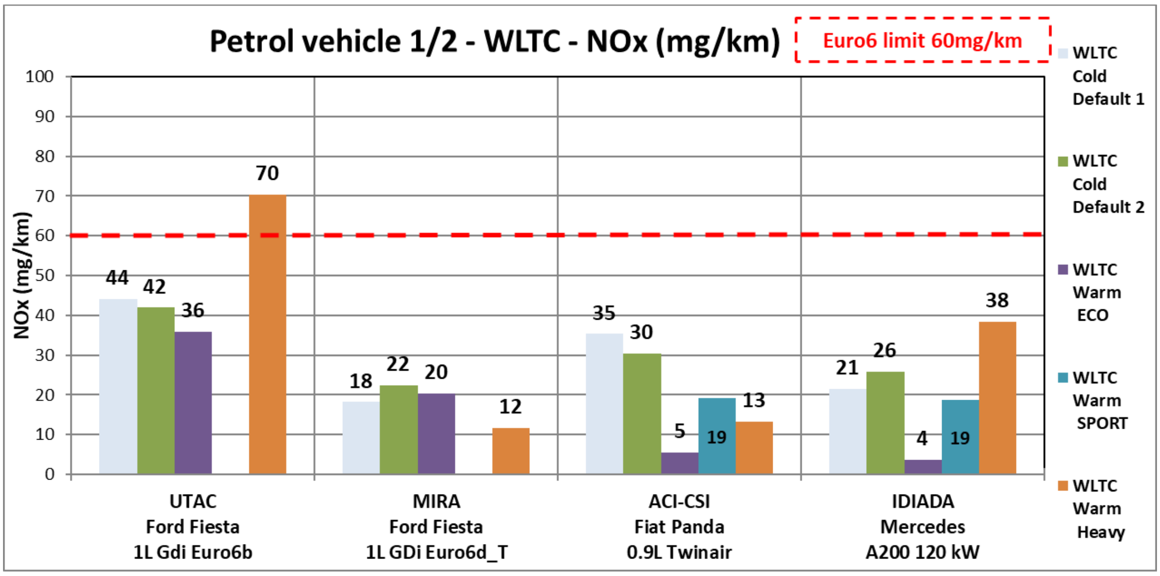


Figure 7 - NOx Emissions – WLTC tests – Petrol vehicles 1/2

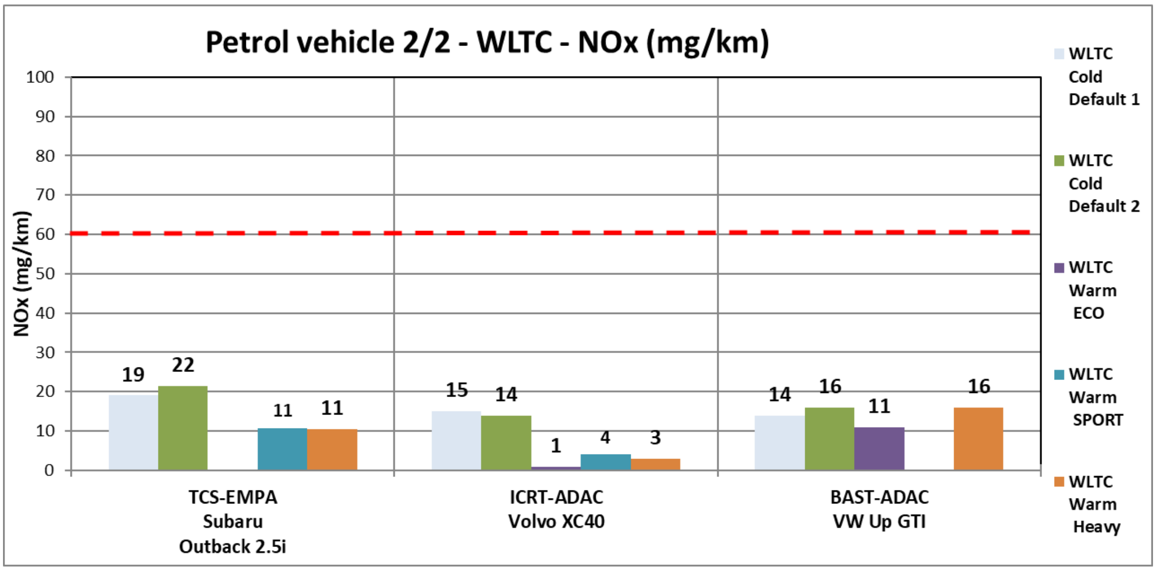


Figure 8 - NOx Emissions – WLTC tests – Petrol vehicles 2/2

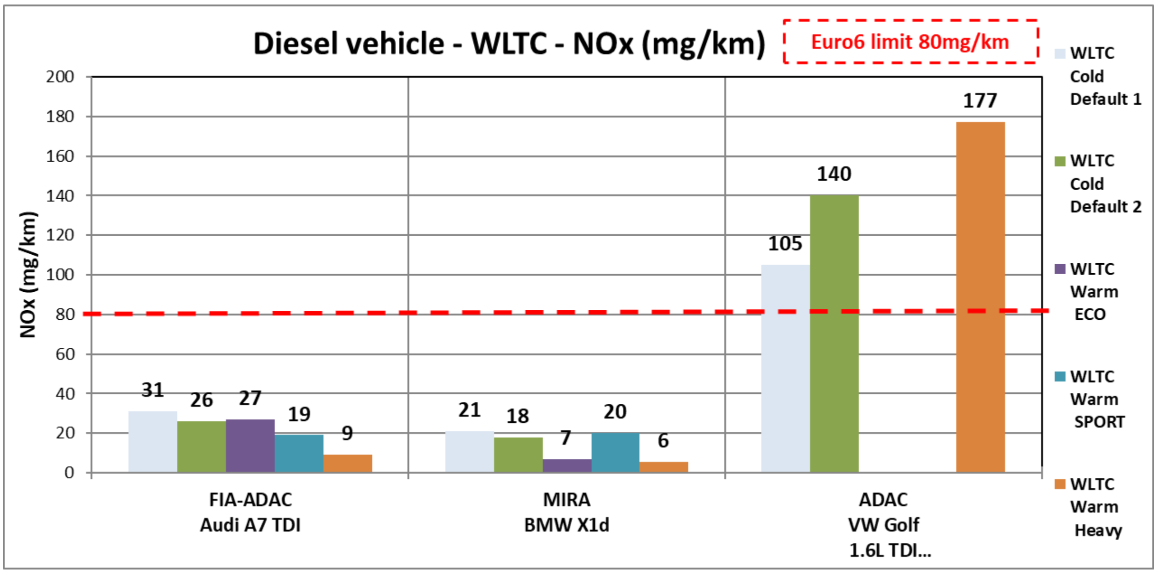


Figure 9 - NOx Emissions – WLTC tests – Diesel vehicles

With the exception of the the Golf TDI Euro6b and the Fiesta GDi Euro6b (on heavy conditions), all the vehicles had NOx emissions compliant with the Euro 6 limits.

The vehicles were impacted differently by the various test conditions:

Test conditions had a small impact on the emissions of the Audi A7 TDI, the BMW X1d and the VW UP! GTi, of which the emissions systematically complied with the Euro 6 limits. This seemed to indicate that these vehicles had a robust engine management system design and after treatment systems control.

For the other vehicles, the warm start had a significant impact on emissions; the NOx emissions were on average halved compared to the cold start results.
The sport mode seemed to have a significant impact for the Fiat Panda 0.9L and the Mercedes A200, where the emissions of NOx were multiplied with a factor 4 compared to the eco mode results.
This was less the case for the Subaru Outback 2.5i & the Volvo XC40, of which the emissions systematically complied with the Euro 6 NOx limits.

The warm start test with heavy load had a significant impact (significant increase of NOx emissions) on the Ford Fiesta Euro 6b, the Mercedes A200 and on the VW Golf Euro 6b.

The NOx emissions of the VW Golf 1.6L TDI were lower than the ones measured in the first verification phase ,but were higher than the Euro6 limits despite the decrease of road load parameters from calculated default to CoC values. The pollutants results were also dispersed between the 2 WLTC cold start tests, which was not the case for the CO_2 emissions.

7.1.2 NOx emissions – FTP75 & BAB130 tests:

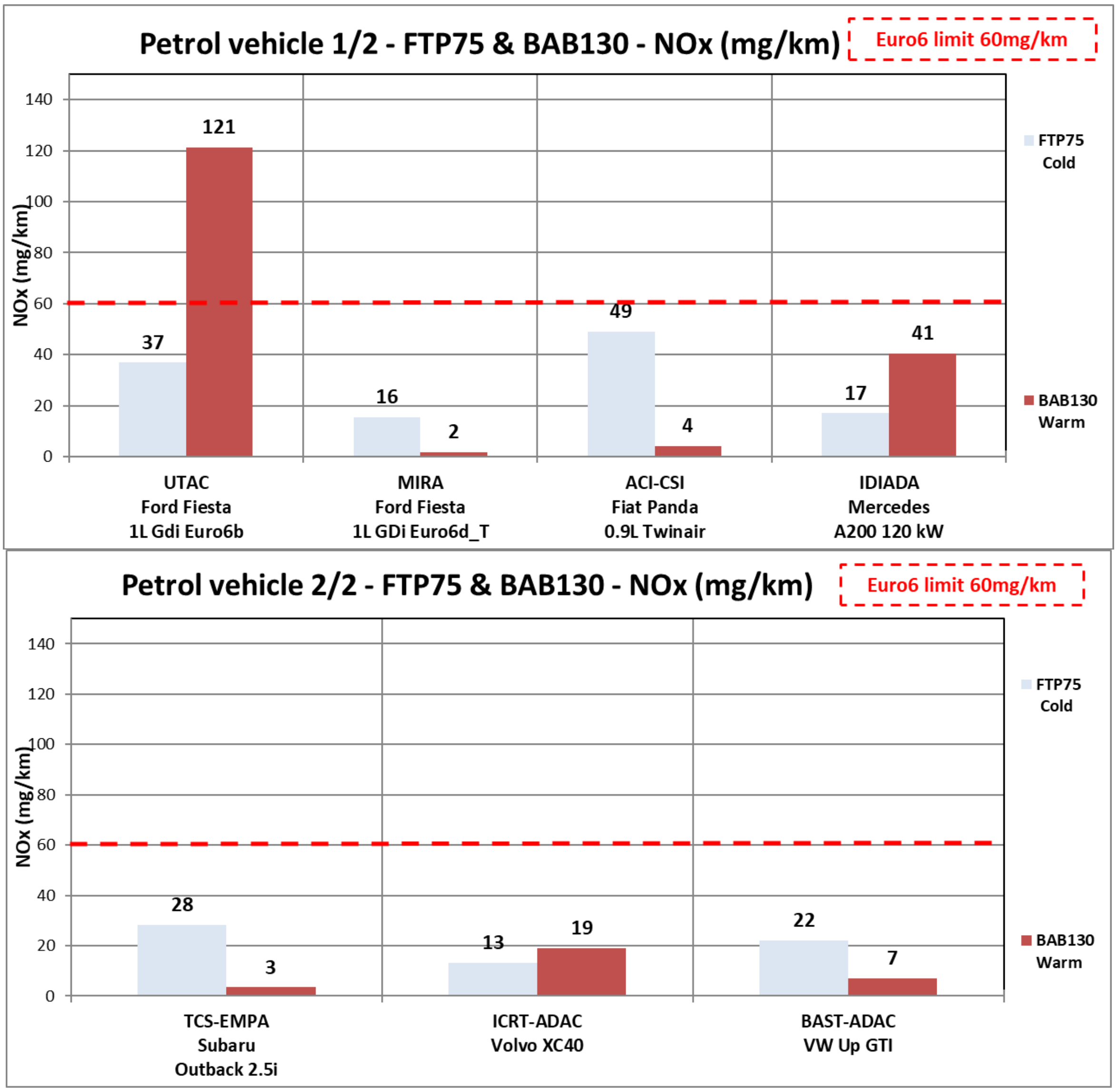


Figure 10 NOx Emissions – FTP75 & BAB130 tests – Petrol vehicles

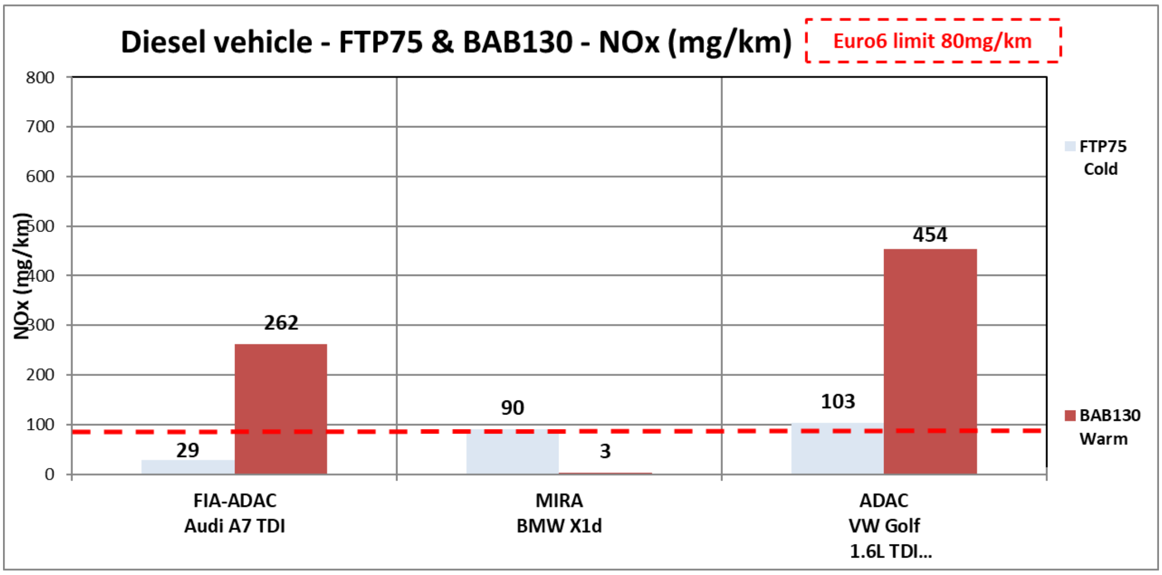


Figure 11 - NOx Emissions – FTP75 & BAB130 tests – Diesel vehicles

For the FTP75 tests, the NOx emissions were generally lower than the Euro 6 limit. With exception of VW Golf TDI Euro6b and BMW X1d Euro6d_temp which were close to the limit.
Except for the Ford Fiesta GDi Euro6b, the emissions of petrol vehicles remain below the limits, unlike the diesel vehicles and particularly the VW Golf TDI Euro6b of which the measurement values were high despite the decrease of road load parameters from calculated default, assumed in the first verification test series, to manufacturer declared CoC values selected for these validation tests.

Comparing results from FTP75 and WLTC tests showed that these cycles gave similar results. Therefore, deleting the FTP75 test cycle from the test matrix could be a possibility to simplify the final Green NCAP test procedure.

With respect to the BAB130 test, which forced the engine to operate under significantly higher engine load conditions, it could be observed that the limits were significantly exceeded in the cases of the Fiesta and VW Euro6b test vehicles, Only the Audi A7 results were high, all other Euro 6d Temp vehicles showed good performance, even under the challenging BAB130 engine load conditions.

7.1.3 NOx emissions – PEMS tests:

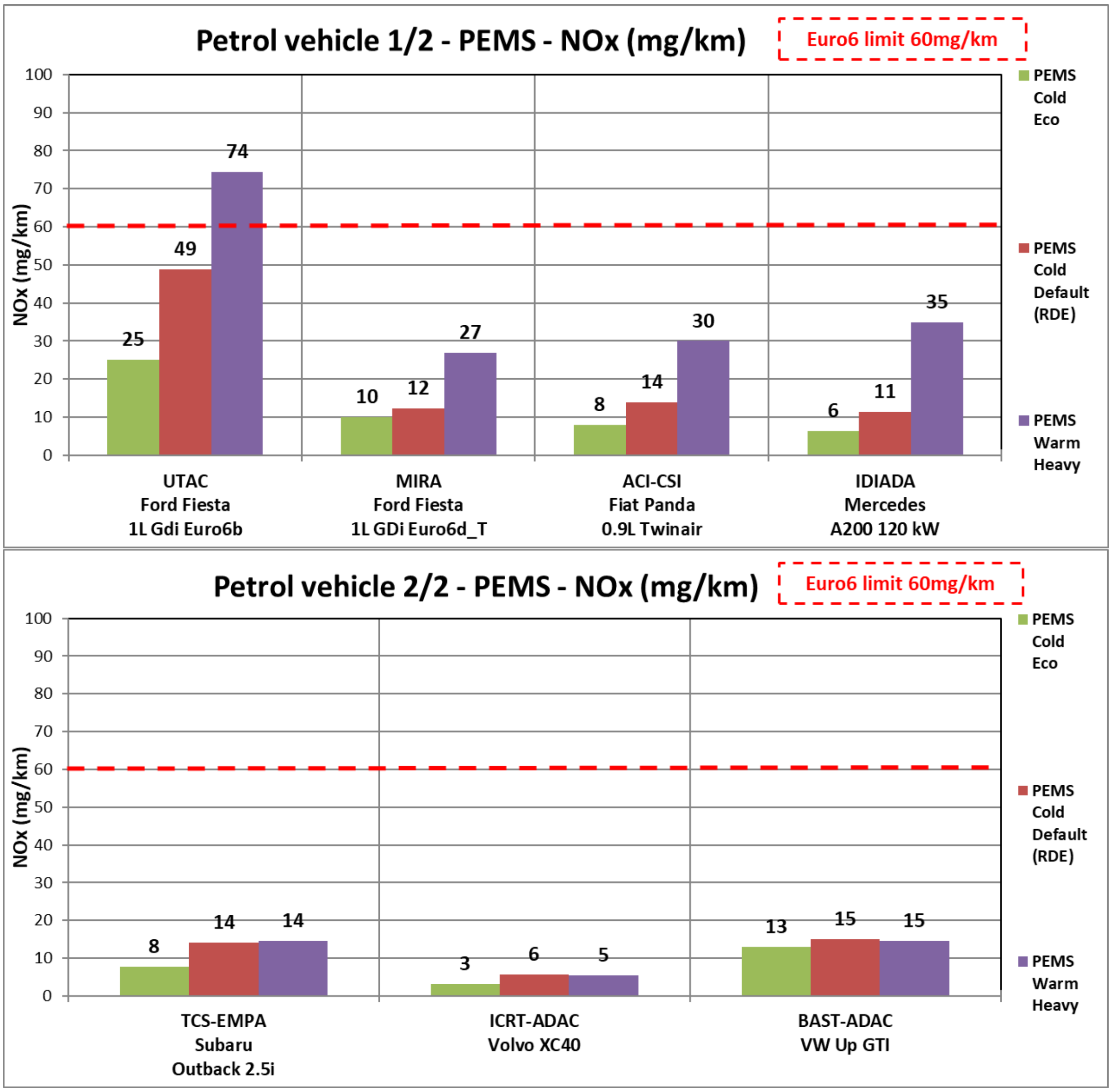


Figure 12 NOx Emissions – PEMS tests – Petrol vehicles

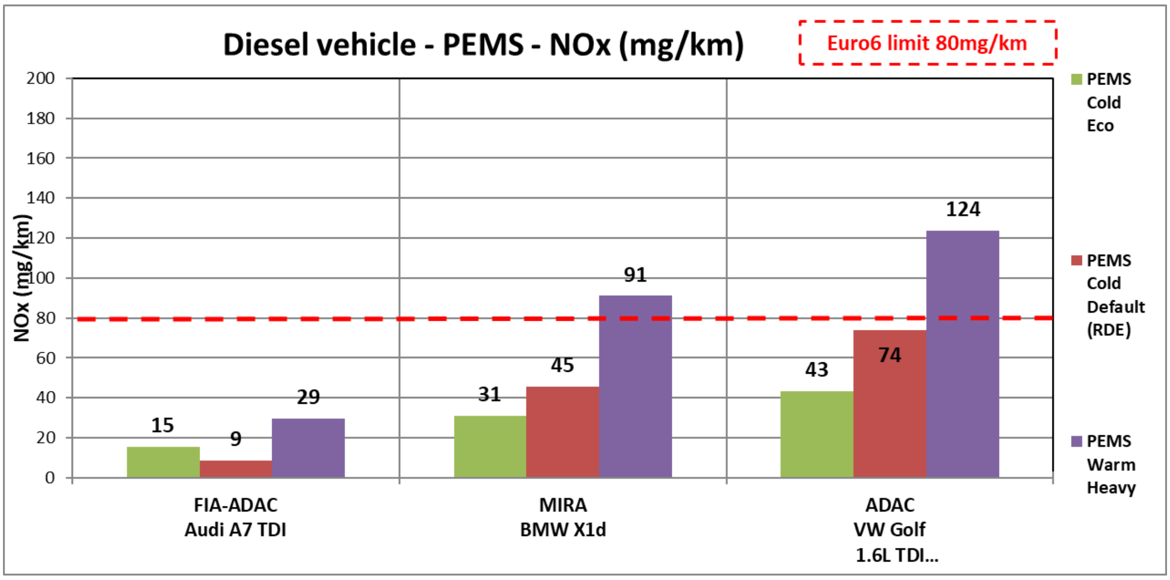


Figure 13 - NOx Emissions – PEMS tests – Diesel vehicles

With exception of two Euro6b vehicles (Ford Fiesta GDi and VW Golf TDI) and the BMW X1d, only under heavy load conditions for these three vehicles, the NOx emissions from all other vehicles tested were under the Euro 6 limit.
It could be noted that for a diesel vehicle the Audi A7 TDI had very low NOx emissions in the PEMS tests.
This was also the case for all Euro6d Temp compliant petrol vehicles.

Except for the Audi A7 TDI, the impact of the “eco mode” on NOx emissions was significant for all vehicles compared with standard driving mode (-37% in stable average compared to standard driving mode).

The influence of the heavy load test on NOx emissions was not obvious for all the vehicles. Only these 6 vehicles seemed to be impacted by such test conditions compared with default mode:

- Ford Fiesta 1L GDi Euro6b :+52%
- Fiat Panda 0.9L: +114%
- Mercedes A200 :+208%
- Audi A7 TDI :+246%
- BMW X1d : +100%
- VW Golf TDI Euro6b :+67%

7.2 PN emissions

For the first verification test series, the GDI vehicles' PN emissions did not comply with the Euro 6 limit and were much higher than diesel vehicle PN emissions owing to an efficient DPF fitted.
For the validation phase, the values of diesel vehicles remained low, and the petrol vehicles Euro 6d temp compliance and equipped with GPF proved to be more efficient.

7.2.1 PN Emissions - WLTC Tests:

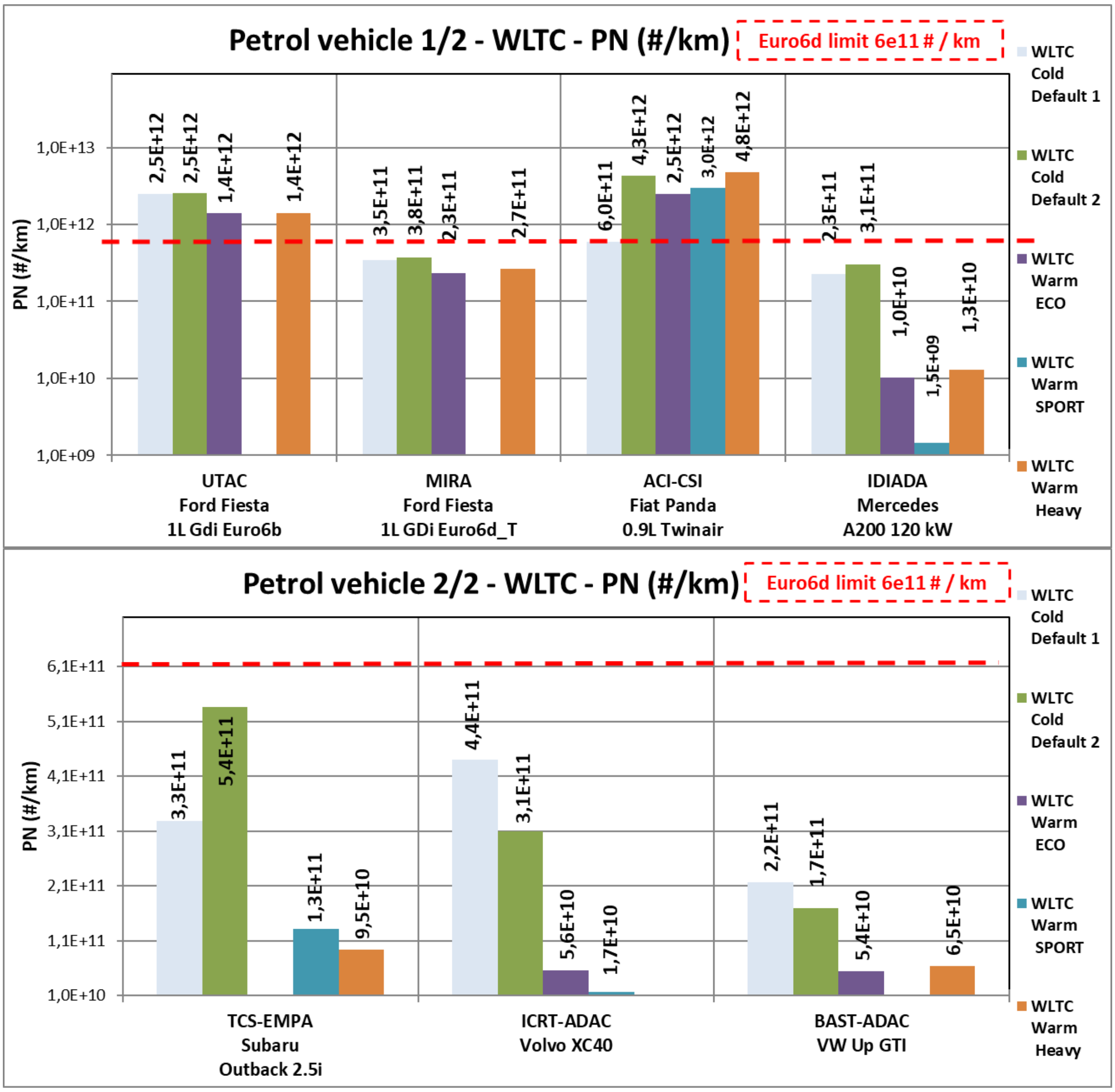


Figure 14 - PN Emissions – WLTC tests – Petrol vehicles

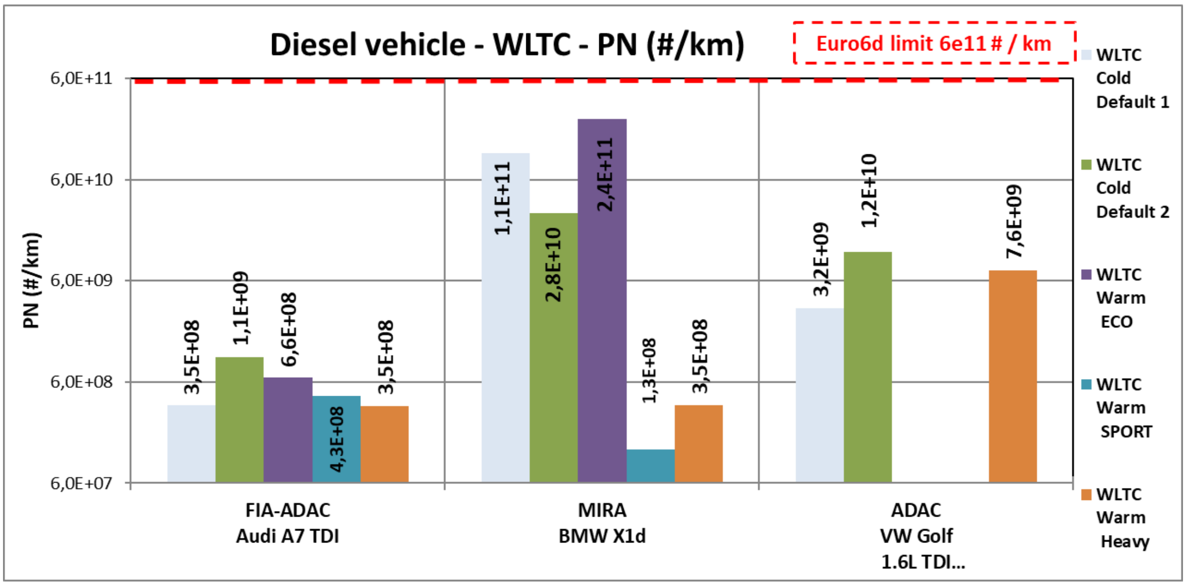


Figure 15 - PN Emissions – WLTC tests – Diesel vehicles

Except for the Ford Fiesta GDi Euro6b & the Fiat Panda 0.9L Euro 6b, all vehicles were compliant with the PN Euro 6d limit (6e11#/km).

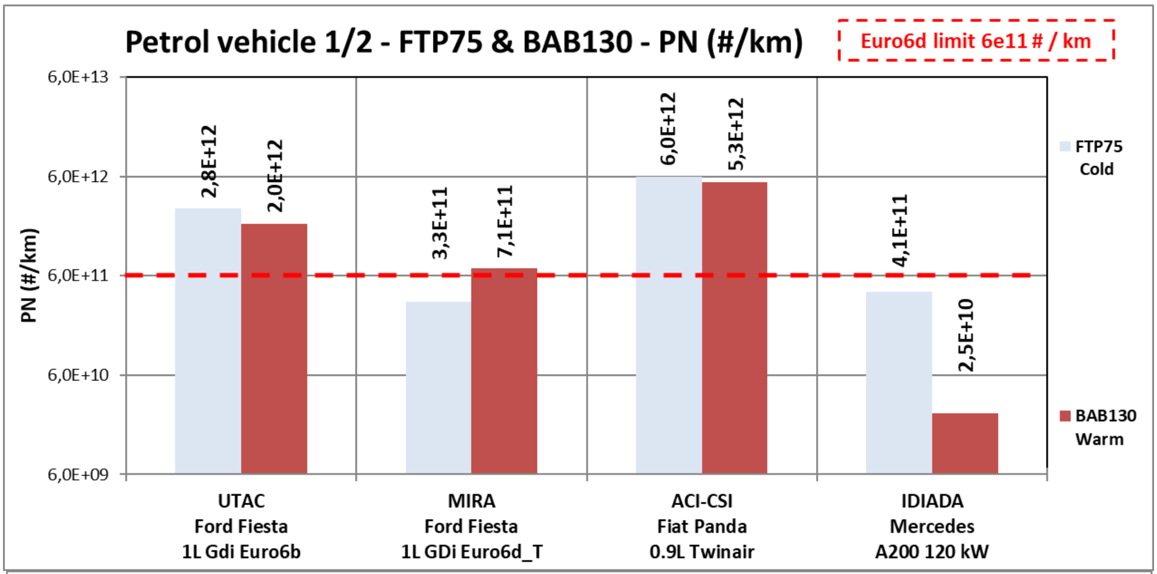
Some petrol vehicles were already equipped with a Gasoline Particulate Filter (example Mercedes A200 and Volvo XC40) and reached particularly low PN emissions level.

Regarding the impact of test conditions, the trend of PN emissions was similar to the one from NOx emissions of petrol vehicles. Except for the Ford Fiesta GDi Euro6b which was not sensitive to the heavy load, and the Panda 0.9L which was impacted by the heavy load, the PN results of all other vehicles were compliant with the Euro 6 limit under the different conditions tested.

The PN limit for vehicles equipped with port-injected petrol engines were not mandated in Euro6 (only direct injected engines (GDI) were in the scope of the limits), but the test values obtained on the Panda were high being close to Euro 6b limit for GDi (6e12#/km).

The gap between the two Ford Fiesta GDi vehicles showed the development work done to limit PN emissions in the Euro6d temp type.

7.2.2 PN Emissions – FTP75 & BAB130 Tests:



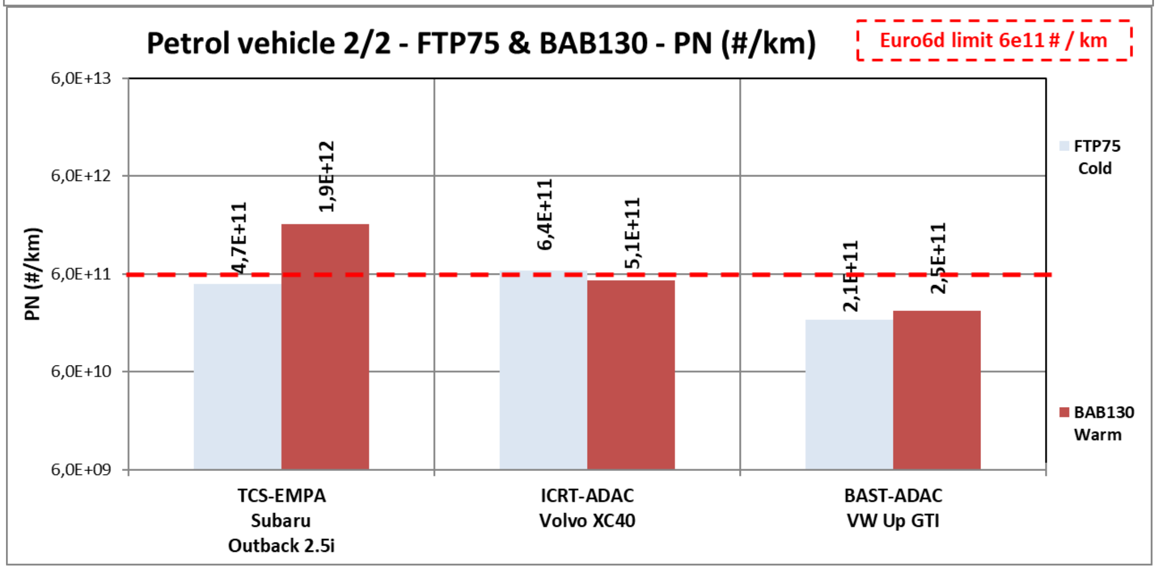


Figure 16 - PN Emissions – FTP75 & BAB130 tests – Petrol vehicles

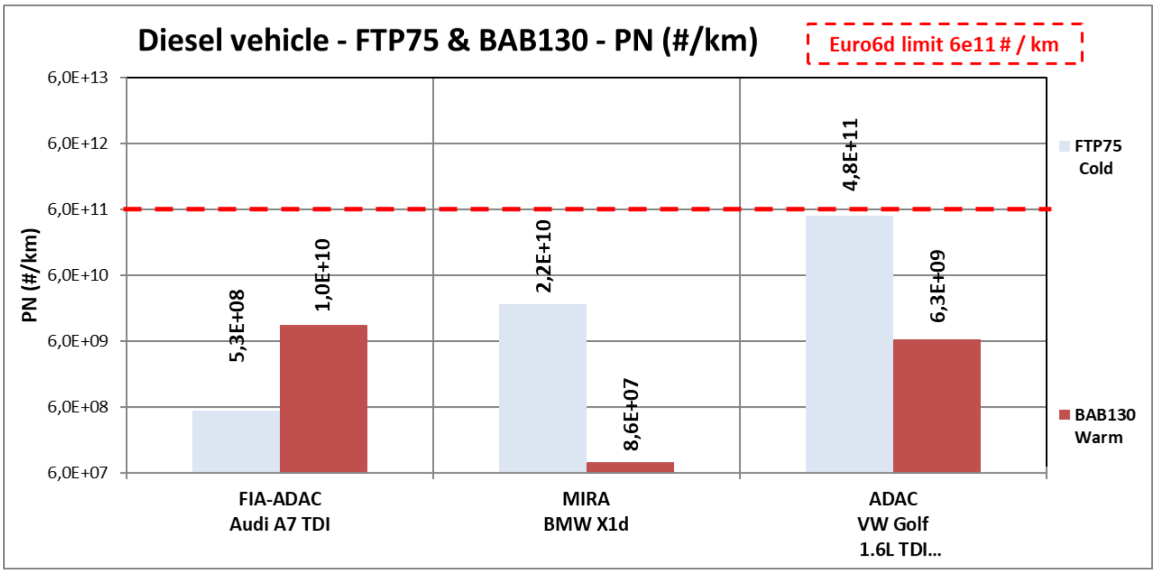


Figure 17 - PN Emissions – FTP75 & BAB130 tests – Diesel vehicles

With the exception of the Ford Fiesta GDi Euro6b & the Fiat Panda 0.9L, all the vehicles tested on the FTP75 cycle were compliant with or close to the Euro 6d limit (6e11#/km).
Except for the Fiat Panda 0.9L MPi Euro 6b & the VW Golf TDI Euro6b, the emission results from the other 9 test cars in the FTP75 cycle were similar to the ones in the WLTC cold start test.

The vehicles equipped with GPF (A200, XC40) again emitted particularly low particulate number levels during these 2 test cycles.

7.2.3 PN Emissions – PEMS Tests:

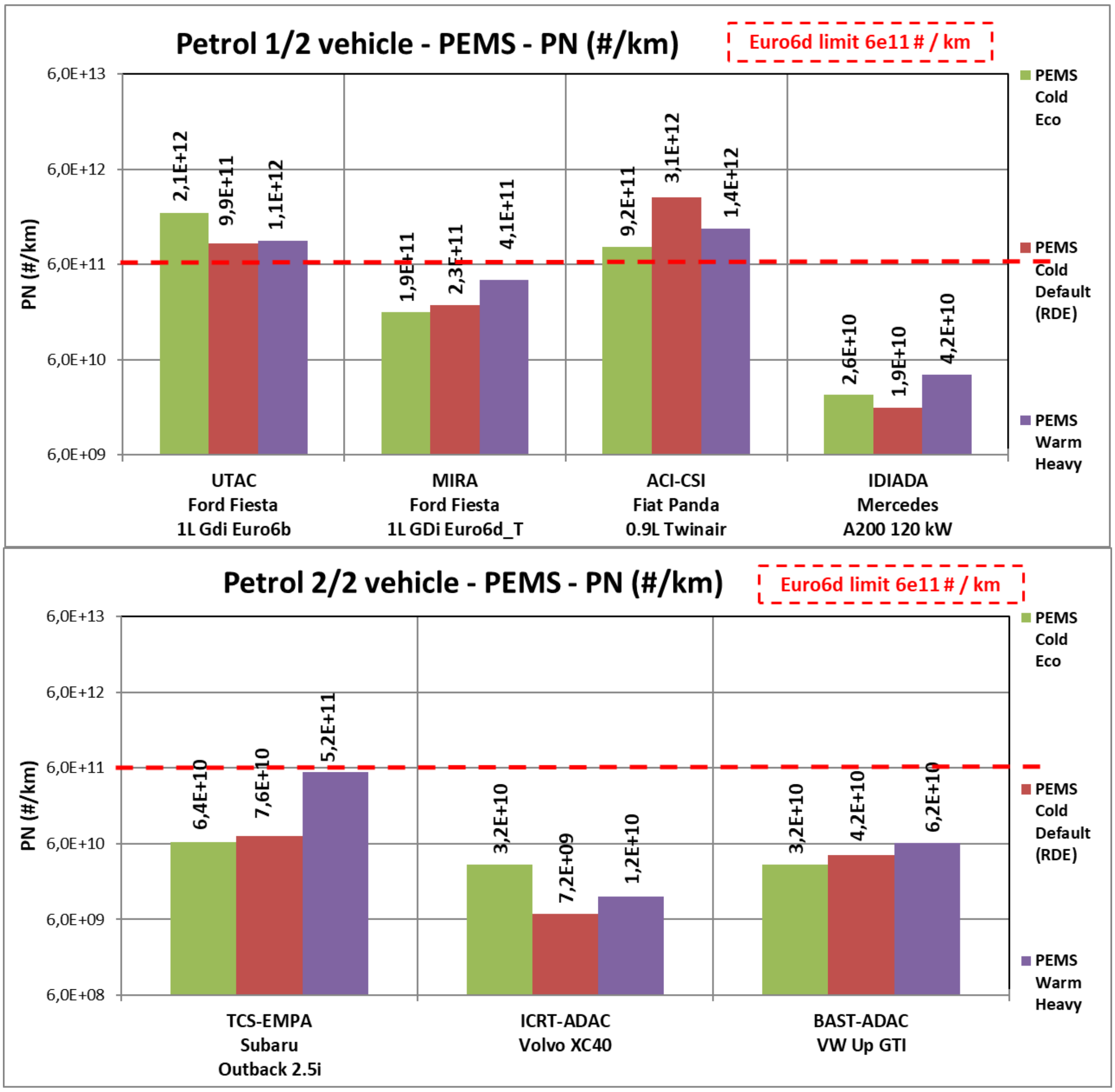


Figure 18 - PN Emissions – PEMS tests – Petrol vehicles

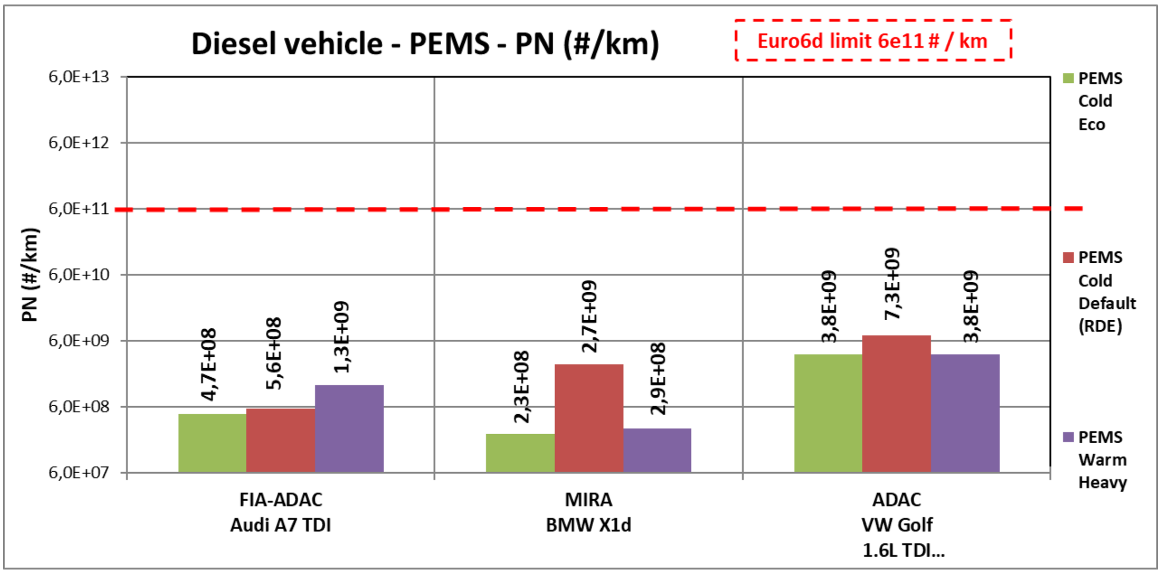


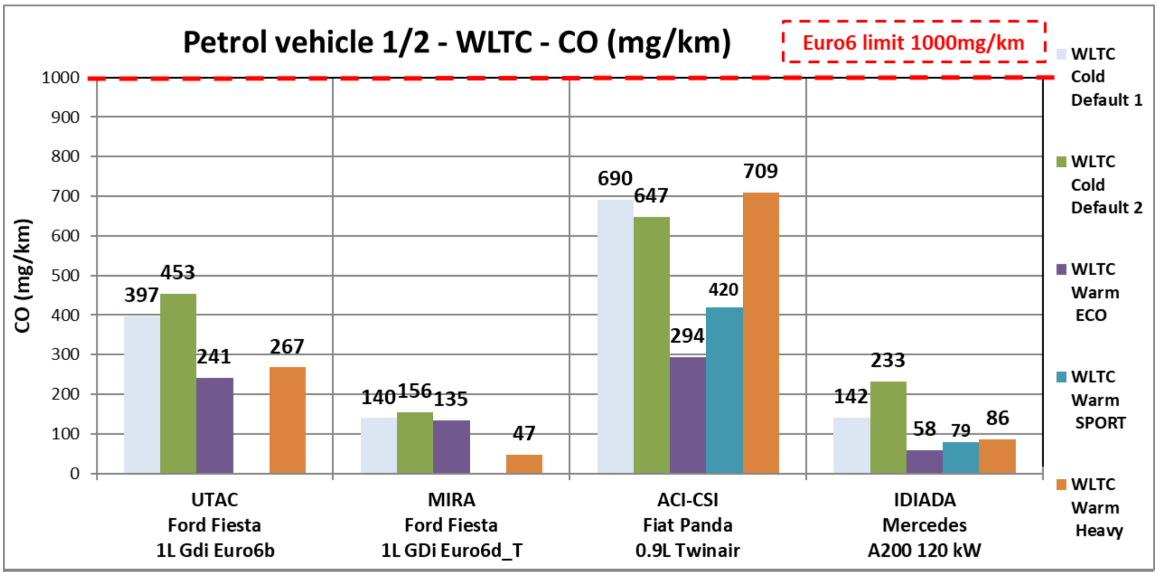
Figure 19 - PN Emissions – PN tests – Diesel vehicles

The same conclusions for PN emissions could be made for the real-world tests as for testing on the chassis dynamometer. Except for the Ford Fiesta GDi Euro6b & the Fiat Panda 0.9L, all test vehicles emitted particle number numbers at a low level, well under and compliant with the Euro 6d limit (6e11 # / km).

The test conditions (eco & heavy engine load) had a significant impact on the emissions of the Subaru Outback 2.5i.

7.3 CO emissions

7.3.1 CO Emissions – Petrol vehicles (all tests)



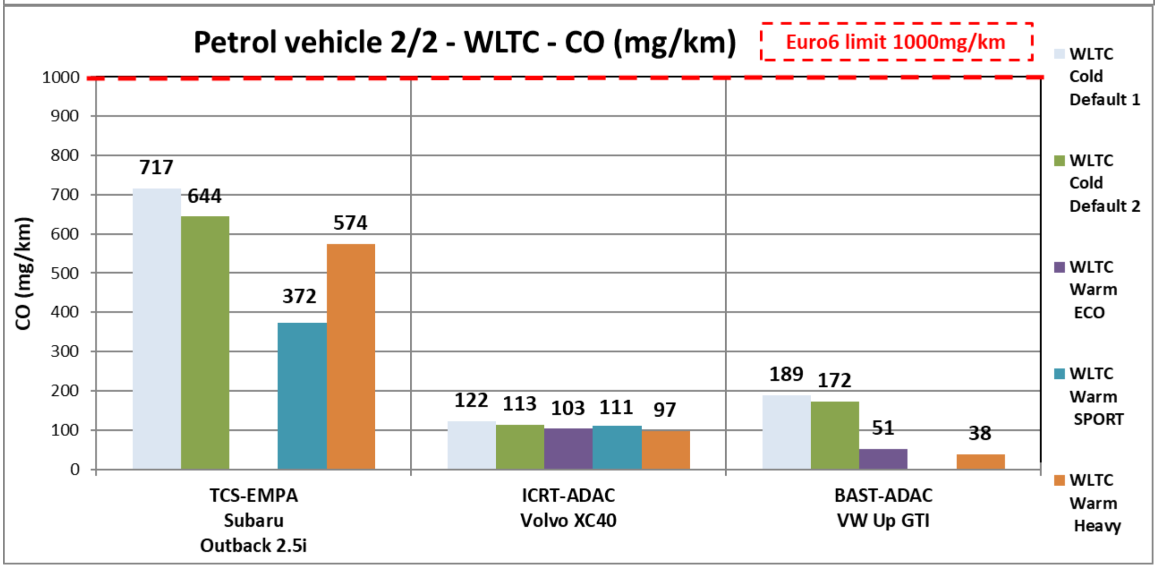


Figure 20 CO Emissions – WLTC – Petrol vehicles

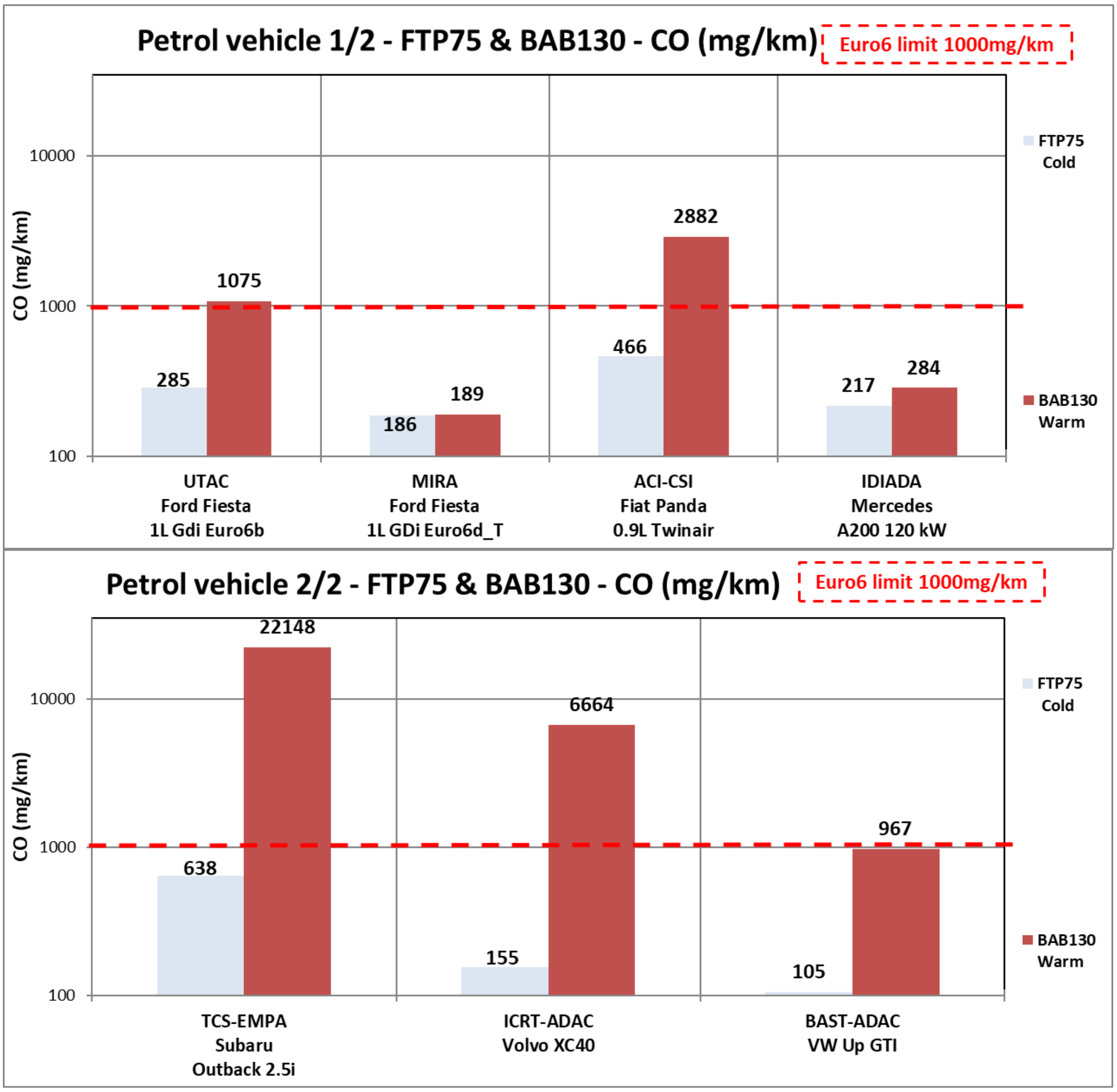


Figure 21 : CO Emissions – FTP75 & BAB130 – Petrol vehicles

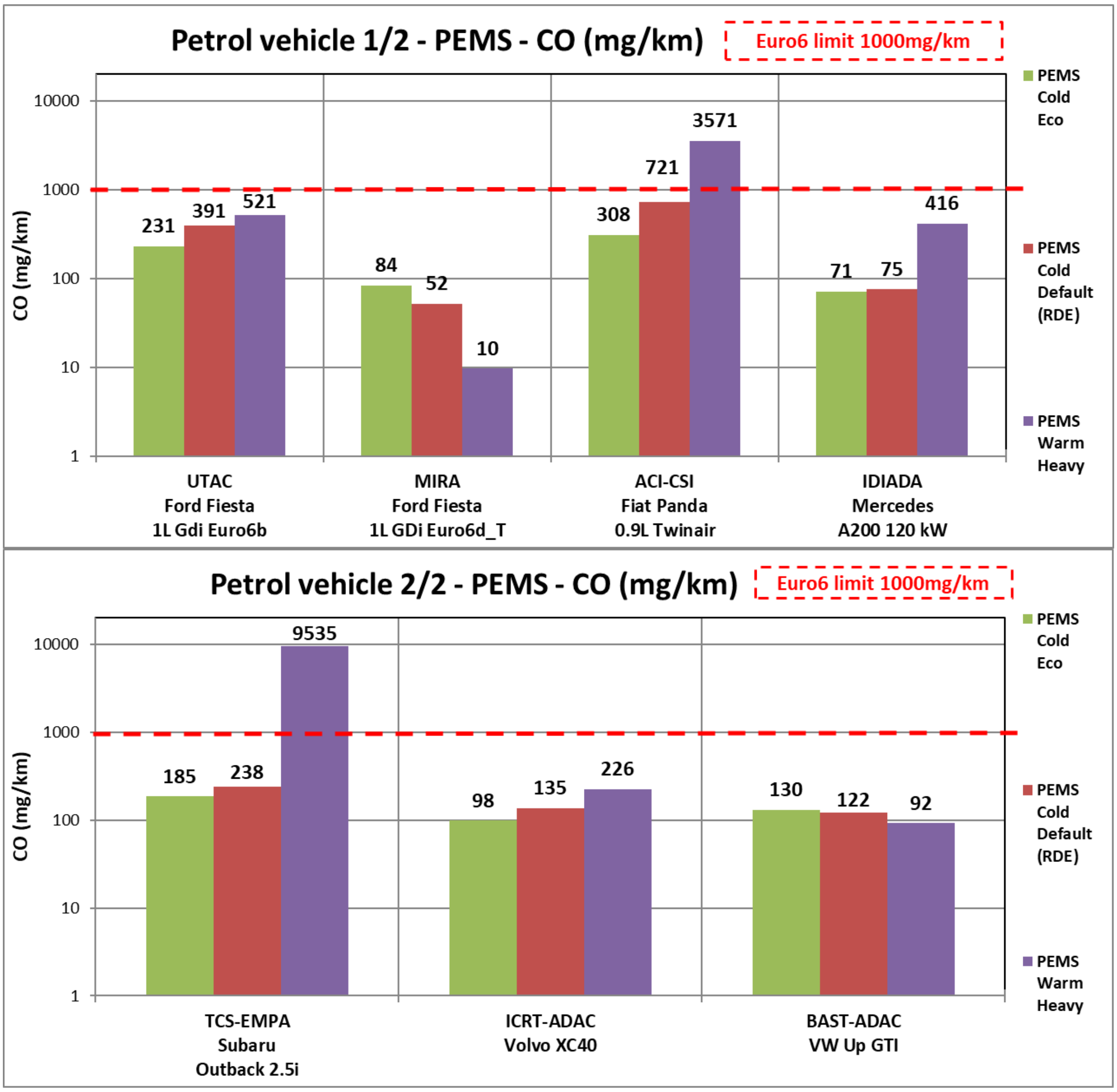


Figure 22 : CO Emissions – PEMS tests – Petrol vehicles

CO emissions were quite low on WLTC & FTP75 test cycle compared to the Euro 6 limits for most of the vehicles.
Only the Panda 0.9L and the Outback 2.5i were impacted by the PEMS heavy load test and the BAB130 robustness test cycle.
It was confirmed that these very high CO emissions were caused by air/fuel mixture enrichment at higher engine loads, especially in challenging robustness test cycles like the BAB130 lab test and the heavy load PEMS+ test.

The impact of the engine temperature at start (cold start / warm start) on the emissions was acceptable both in WLTC & PEMS tests.

7.3.2 CO Emissions – Diesel vehicle (all tests)

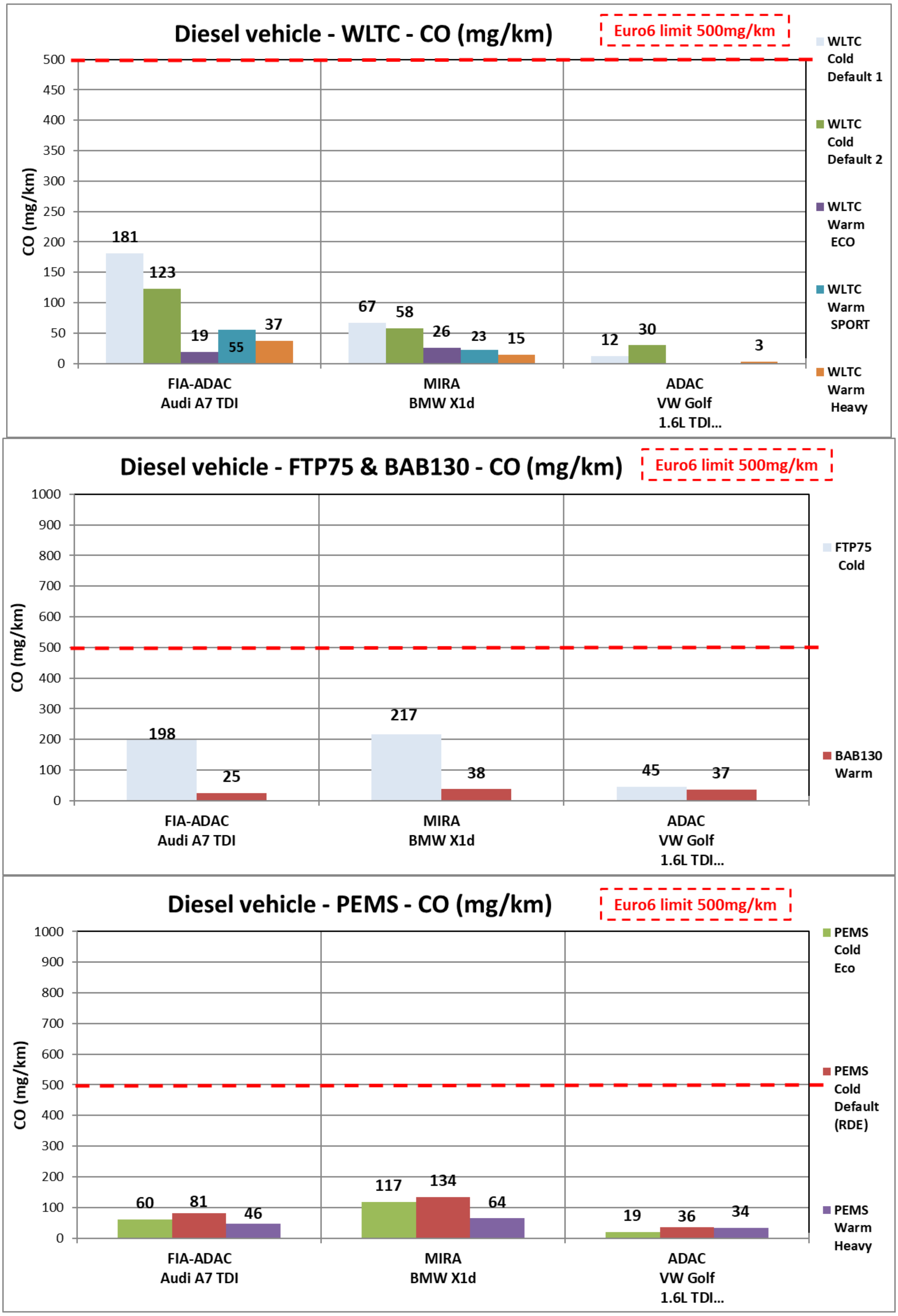
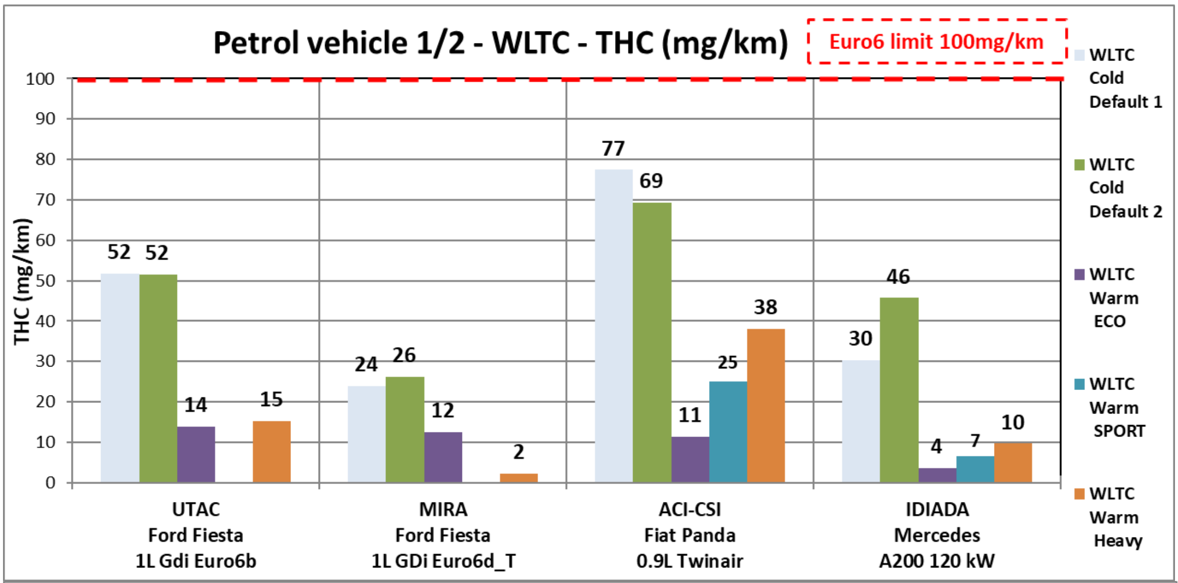


Figure 23 - CO Emissions – Diesel vehicles

The CO emissions of the Diesel vehicles were very low and significantly below the limit for all the vehicles and tests.

7.4 THC Emissions:

7.4.1 THC Emissions – Petrol vehicles (all tests)



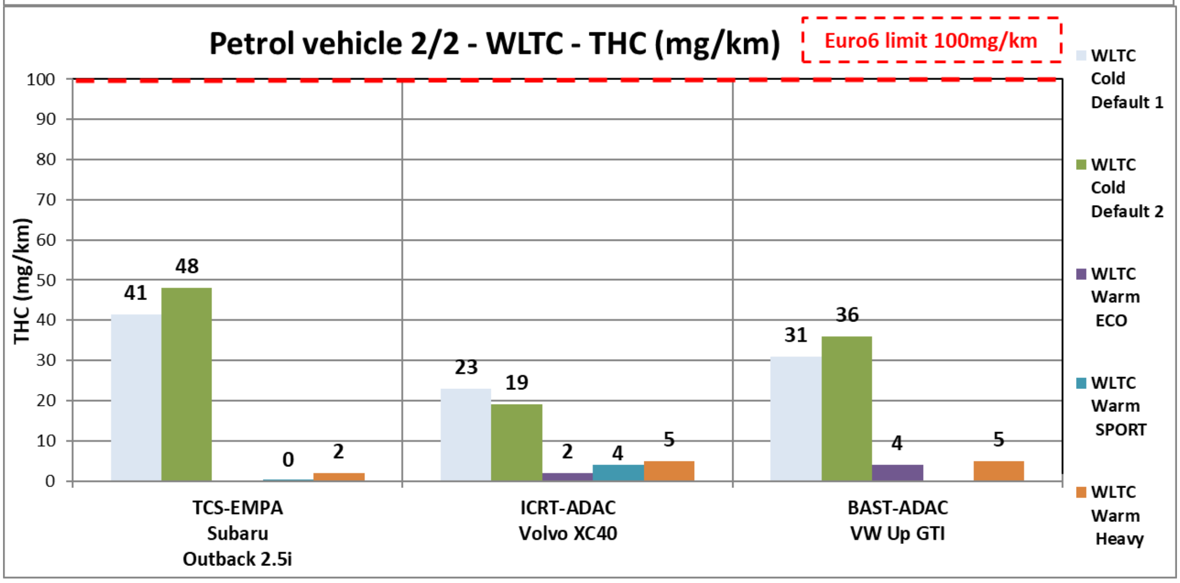


Figure 24 - THC Emissions – WLTC – Petrol vehicles

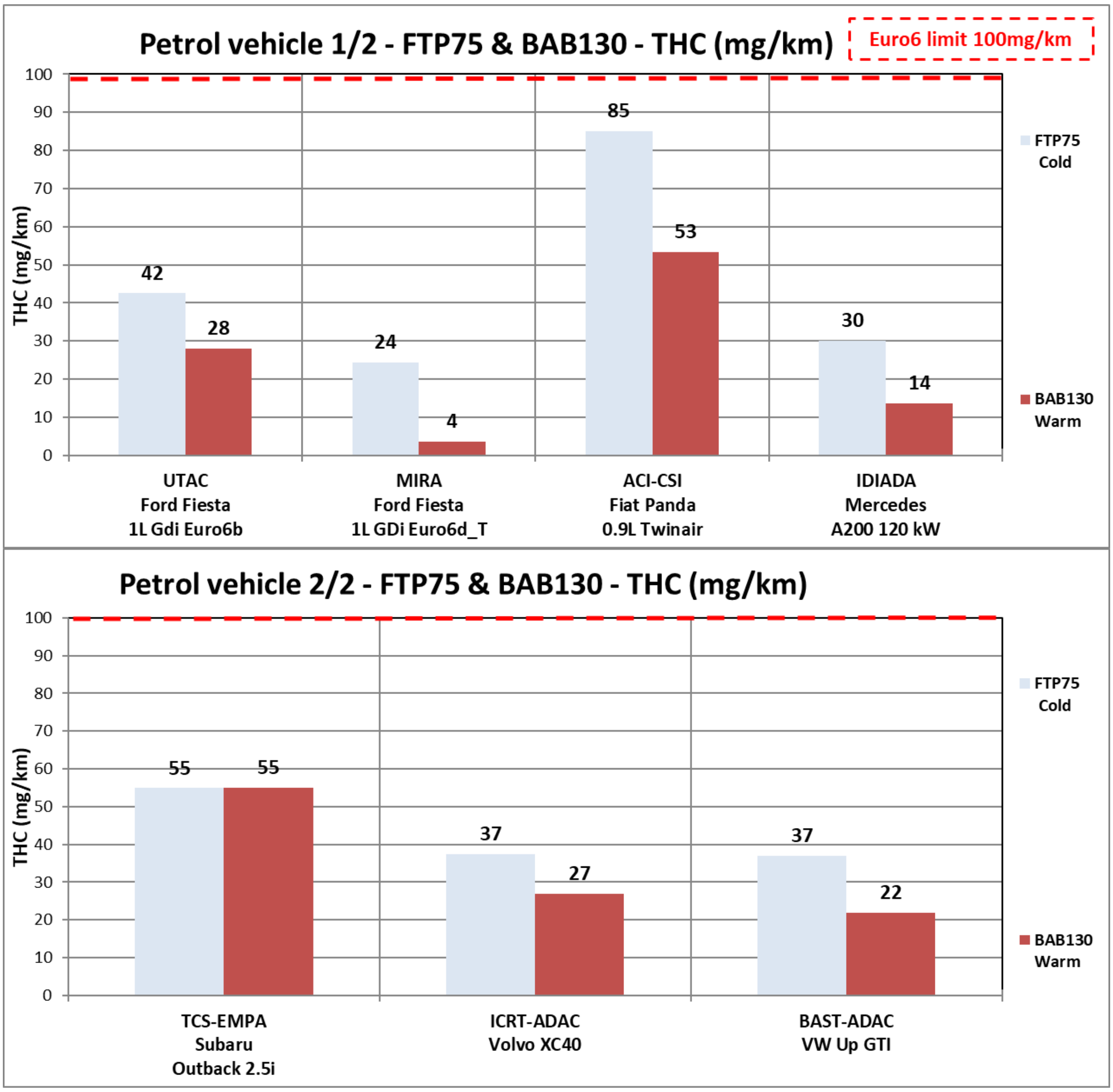


Figure 25 - THC Emissions – FTP75 & BAB130 – Petrol vehicles

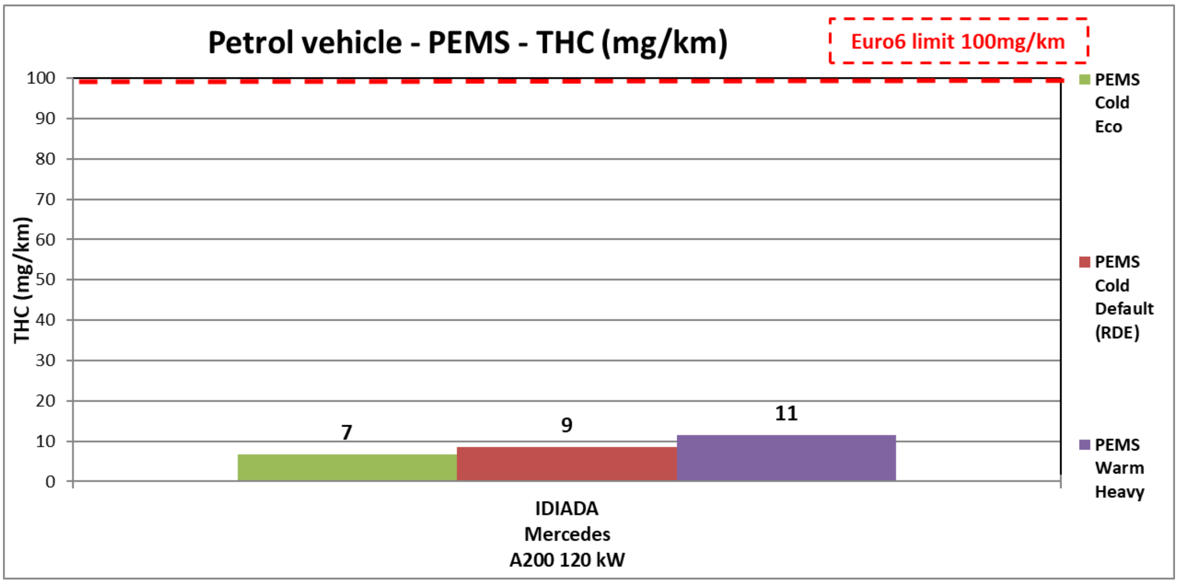


Figure 26 - THC Emissions – PEMS test – Mercedes A200 Petrol vehicle

Except the Fiat PANDA 0.9L, the THC emissions of the petrol vehicles were very low and significantly below the limit for all the vehicles and all the tests (including PEMS tests on the Mercedes A200).

7.4.2 THC Emissions – Diesel vehicles (all tests)

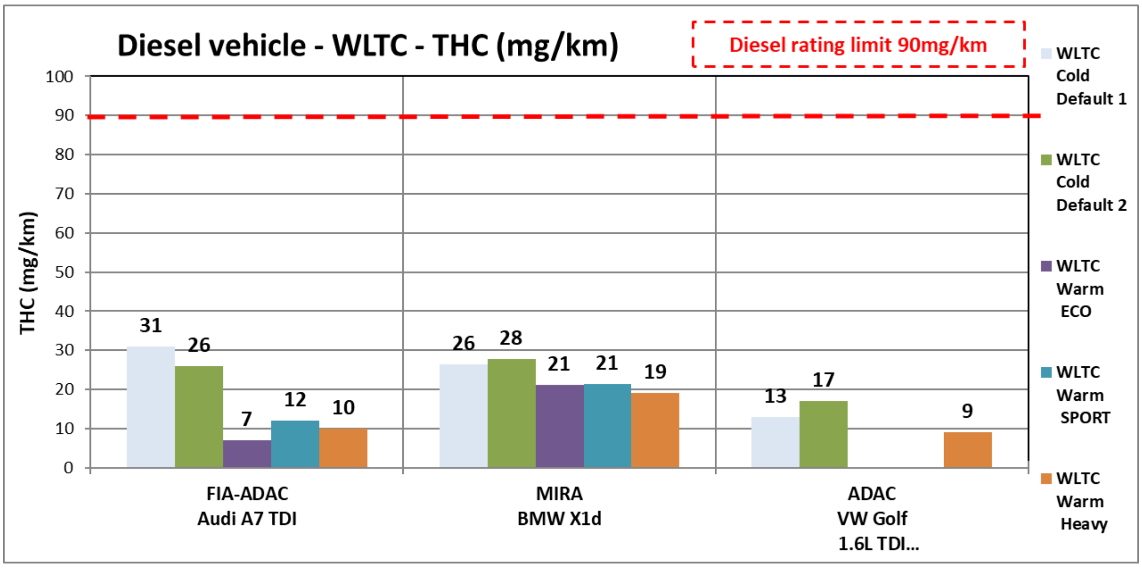


Figure 27 – THC Emissions – WLTC – Diesel vehicles

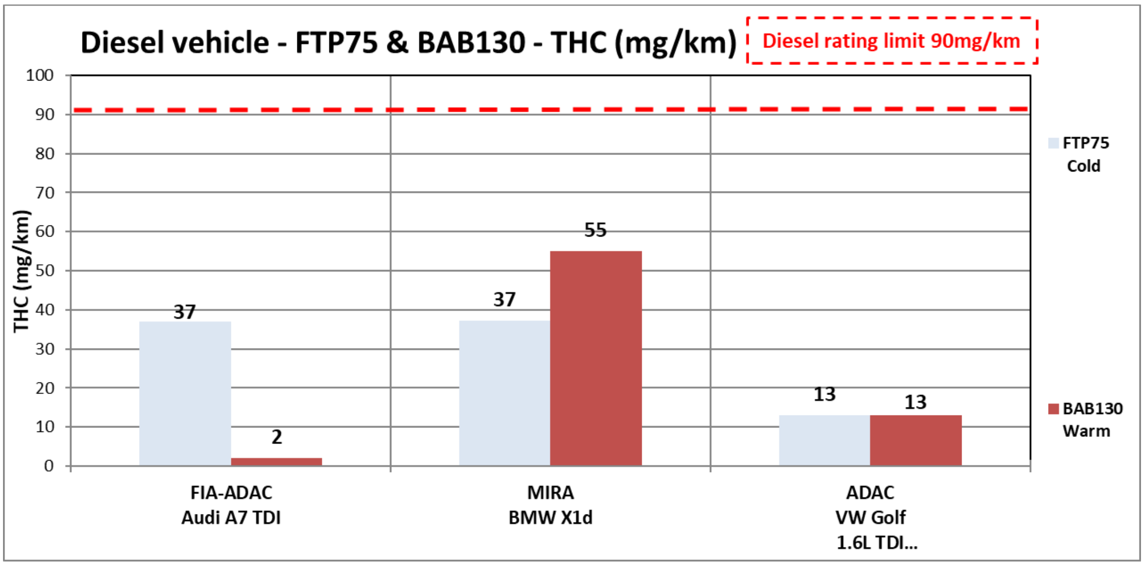


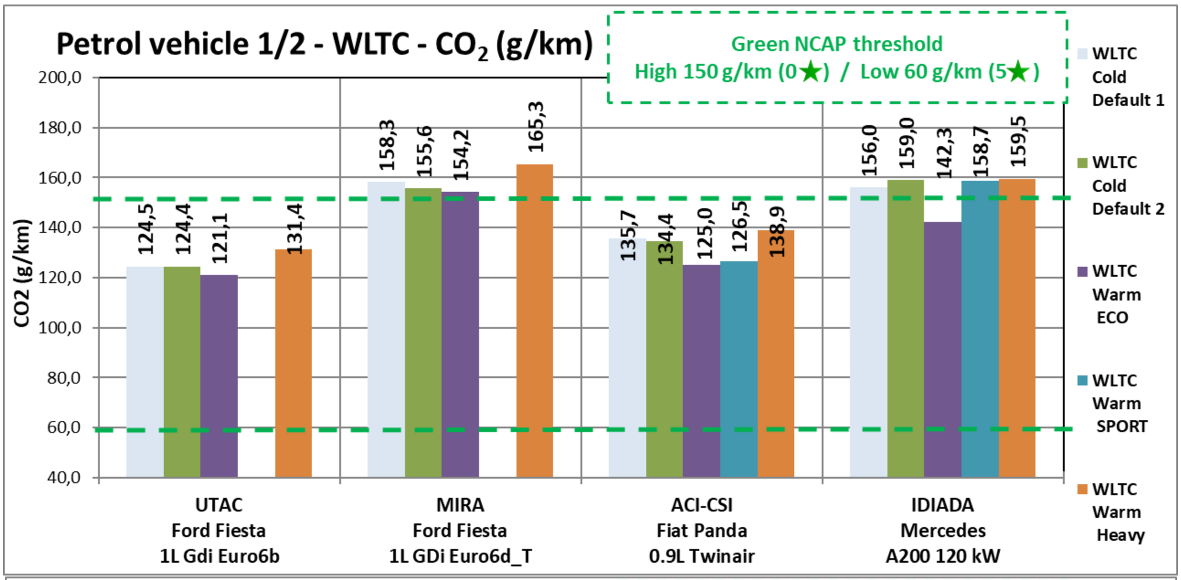
Figure 28 – THC Emissions – FTP75 & BAB130 – Diesel vehicles

The THC emissions of the diesel vehicles were very low and significantly under the Green NCAP rating limit for all the vehicles and tests.

7.5 CO2 Emissions

The Green NCAP scoring system is based on Tank-to-Wheel energy consumption. The CO_2 thresholds in the graphs below were derived from the actual fuel efficiency low and high thresholds.
Thus, the higher CO_2 threshold (150 g/km) is the 0-star equivalent threshold, and the lower CO_2 threshold (60 g/km) is the 5-star equivalent threshold.

7.5.1 CO2 Emissions – WLTC tests:



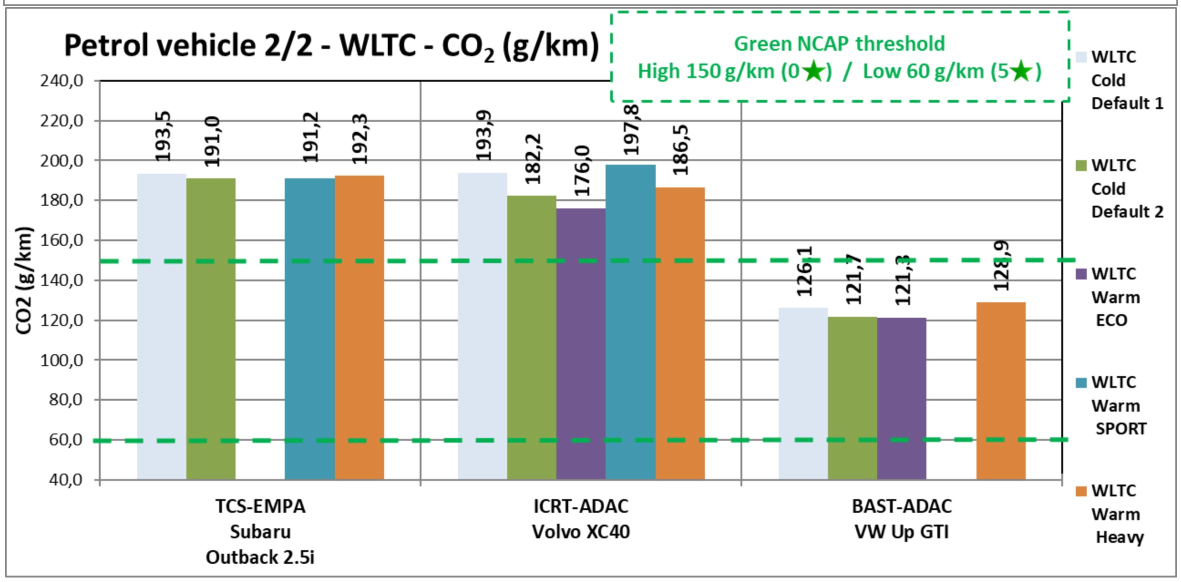


Figure 29 – CO_2 Emissions – WLTC tests – Petrol vehicles

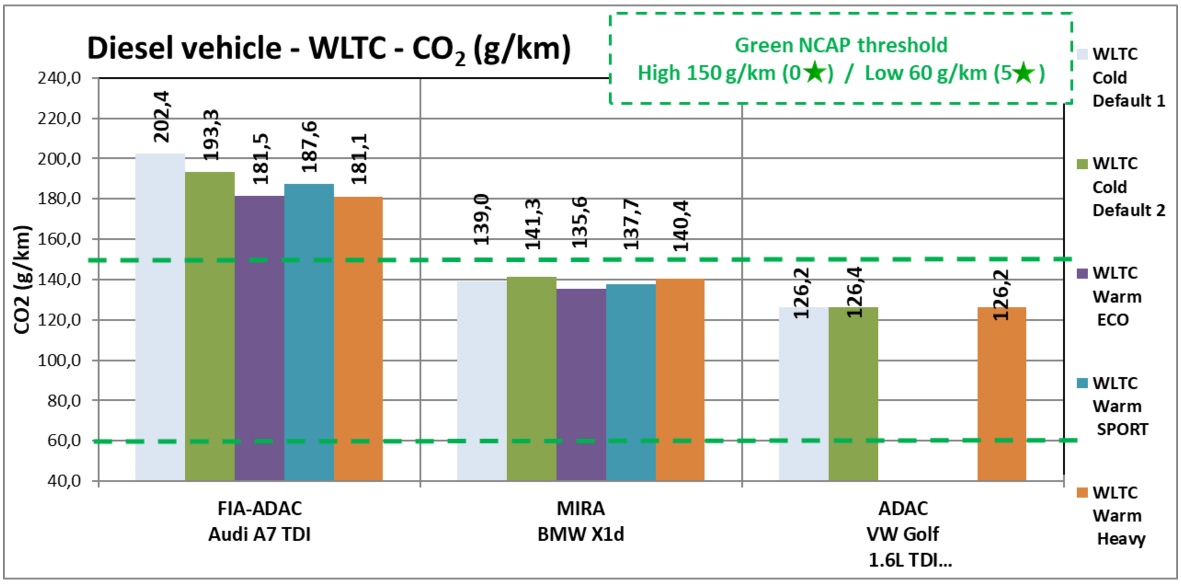


Figure 30 – CO_2 Emissions – WLTC tests – Diesel vehicles

The comparison warm/cold was masked by the impact of eco/sport mode & vice versa.

The impact of the eco mode was nevertheless significant for the vehicles equipped with this mode in comparison with the average value obtained with the standard driving mode in a WLTC test with cold start:

- Ford Fiesta 1L GDi Euro6b: -3%
- Ford Fiesta 1L GDi Euro6d_temp: -2%
- Fiat Panda 0.9L: -7%
- Mercedes A200 : -10%
- Volvo XC40 : -6%
- VW UP GTI : -2%
- Audi A7 TDI :-8%
- BMW X1d : -3%

The impact of the sport mode was significant for the vehicles equipped by this mode in comparison with the value obtained with the eco mode:

- Mercedes A200 : +12%
- Mercedes XC40 : +12%
- Audi A7 TDI : +3%
- BMW X1d : +2%

The impact of the sport mode was not significant for the Outback 2.5i despite this type of vehicle (sport).

The impact of heavy conditions was significant for the two versions of the Fiesta; 1L GDi Euro6b and Euro6d_temp (+ 6% and +5% in comparison with the average of value obtained with the standard driving mode and cold start) as well as the Fiat Panda 0.9L

Despite the feedback from the first verification phase, the dispersion of CO2 emissions of the two WLTC_cold_start stayed high for some vehicles (11g/km for the XC40, and 9g/km for the A7 TDI). Please see the analysis in paragraph 7.9.

The values measured in the WLTC_warm_heavy tests were low in comparison with WLTC_warm_eco test for the Audi A7. The finding is that this type of vehicle and engine (high power diesel) is able to take into account relatively large payload without impacting consumption.

7.5.2 CO2 Emissions – FTP75 & BAB130 tests:

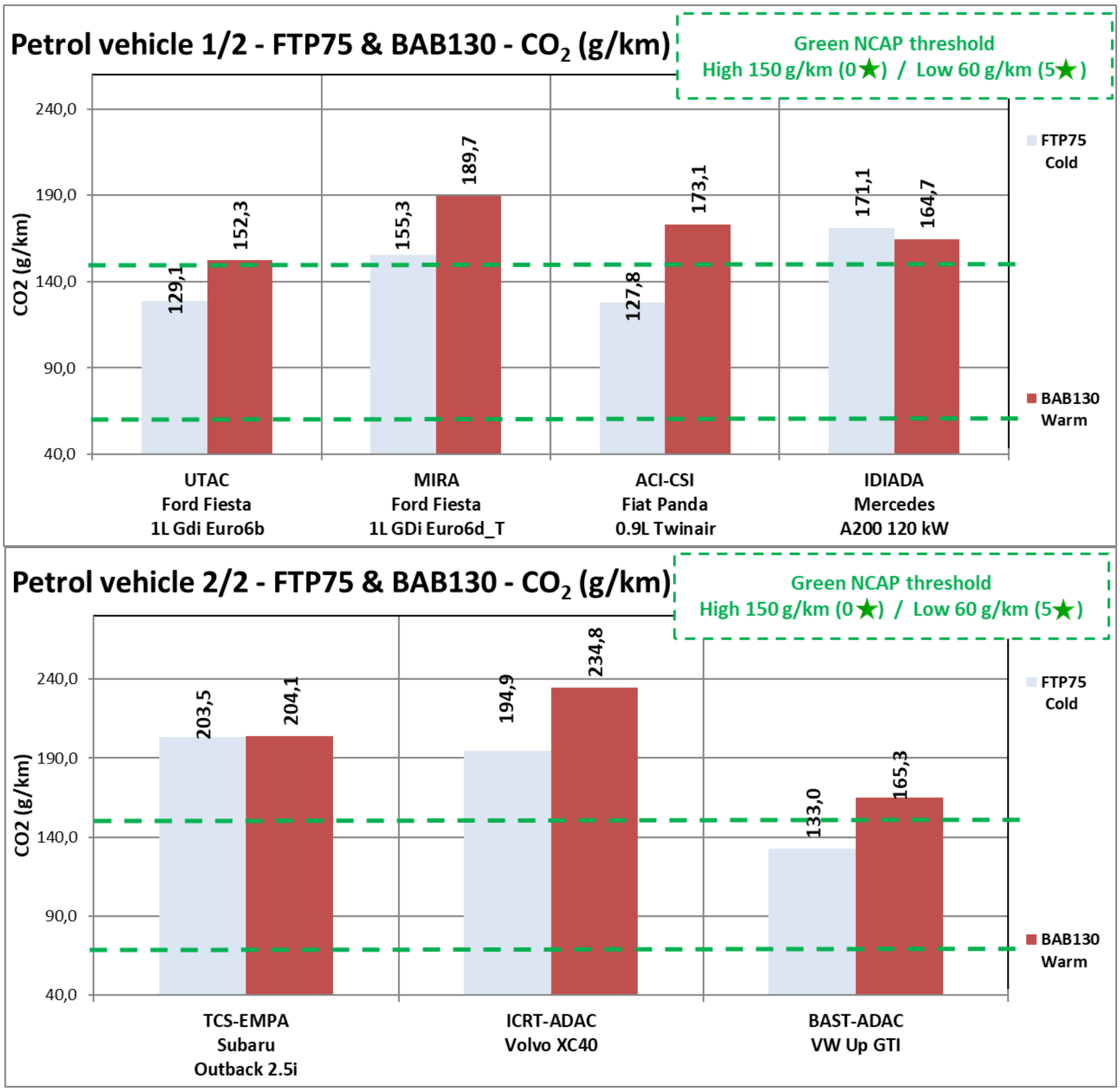


Figure 31 - CO_2 Emissions – FTP75 & BAB130 tests – Petrol vehicles

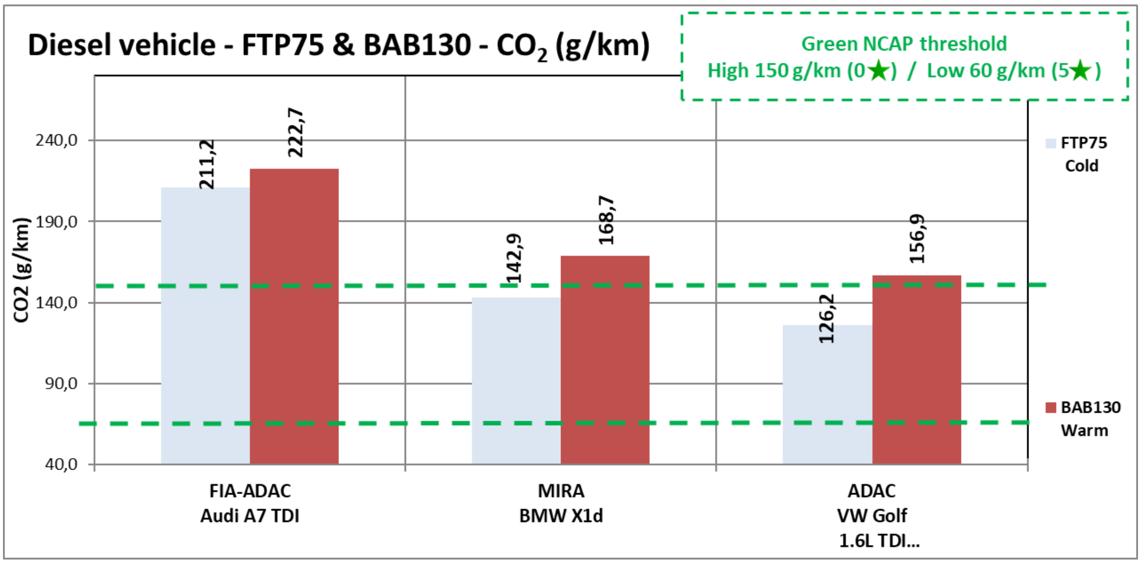


Figure 32- CO_2 Emissions – FTP75 & BAB130 – Diesel vehicles

The emissions on the FTP75 cycle were similar to those on the WLTC. The emissions on BAB130 were substantially higher than in other cycles. The summary of comparison with Green NCAP limits is available in the paragraph 7.5.4

7.5.3 CO2 Emissions – PEMS tests:

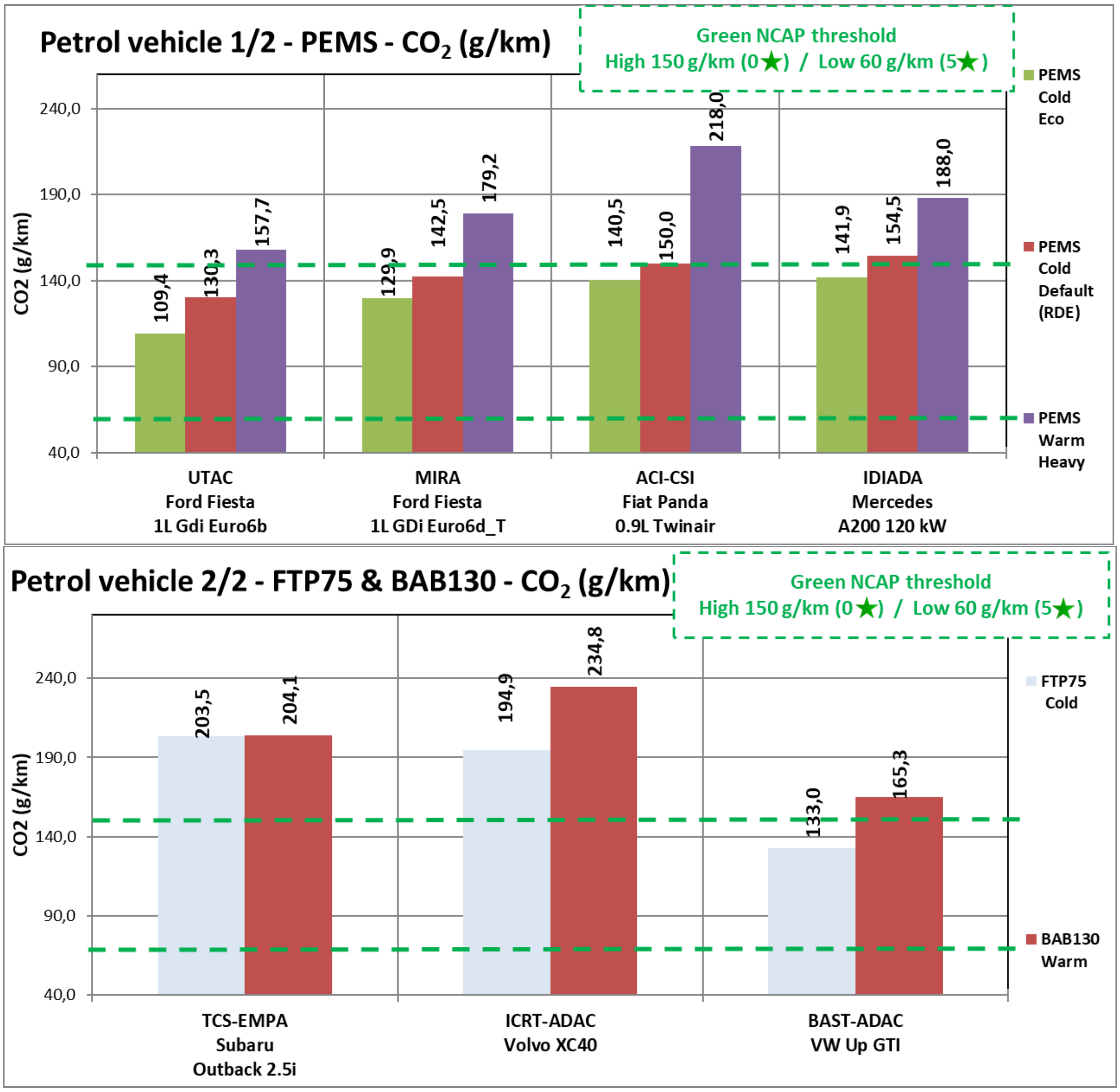


Figure 33 – CO_2 Emissions – PEMS tests – Petrol vehicles

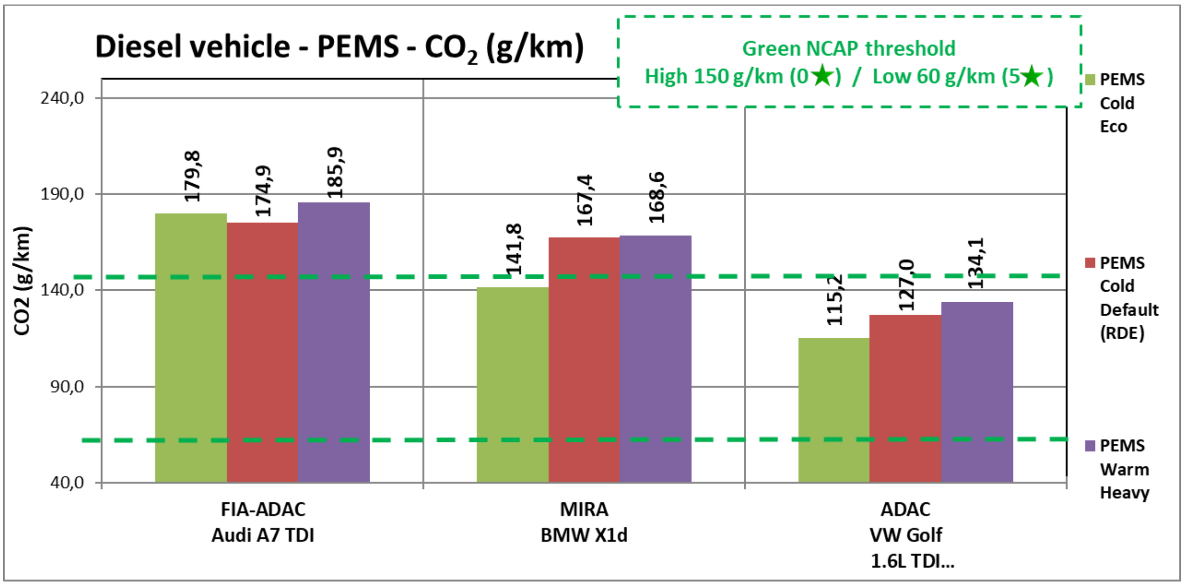


Figure 34 – CO_2 Emissions – PEMS tests – Diesel vehicles

The impact of the eco mode on the CO2 emission was significantly positive for most of the vehicles compared to the standard driving mode:

- Ford Fiesta 1L GDi Euro6b: -16%
- Ford Fiesta 1L GDi Euro6d_temp: -9%
- Fiat Panda 0.9L: -6%
- Mercedes A200 : -8%
- Subaru Outback 2.5i : -10%
- Volvo XC40 : -5%
- VW UP GTI : -4%
- VW Golf TDI Euo6b :-9%
- BMW X1d : -15%

Only the A7 TDI CO_2 emission was not impacted by eco mode

The impact of the heavy mode was important all the vehicles compared with the standard mode:

- Ford Fiesta 1L GDi Euro6b: +21%
- Ford Fiesta 1L GDi Euro6d_temp: +26%
- Fiat Panda 0.9L: +45%
- Mercedes A200 : +22%
- Subaru Outback 2.5i : +32%
- Volvo XC40 : +5%
- VW UP GTI : +10%
- Audi A7 TDI :+6%
- VW Golf TDI Euo6b :+6%

Only the BMW X1d CO_2 emission was not impacted by heavy conditions.

The combined effect of driving style (running engine at higher loads where specific energy consumption is higher for a combustion engine) and manufacturer applied fuelling strategies, like e.g. exhaust component protection or full -load power enrichment have a major impact on the test results. A specific analysis of the Fiat Panda and the Subaru Outback has been done in paragraph 7.10

The summary of comparison with Green NCAP limits was made available in the paragraph 7.5.4

7.6 Energy consumption results

In this section, the results from two pure electric vehicles, Hyundai Ioniq and BMW i3, have been included in the overall summary. Indeed, in the Green NCAP program, there was a will to integrate pure electric vehicles right from the first step to compare it to the ICE vehicles and to use it as benchmark in terms of TtW energy efficiency.
In order to compare the energy efficiency of these vehicles with the conventional ICE vehicles, it was necessary to convert the ICE vehicle fuel consumption (L/100km) in TtW energy consumption (kWh / 100km).
For that purpose, fuel specific conversion coefficients, developed by the Green NCAP working group, were used. These coefficients were determined according to the energy content of the fuel type. Fuels used for testing purposes both in the laboratory and under real-world conditions were the respective reference fuels.

Below are the conversion coefficients used for the study:

Petrol	EU6 cert (E10)	8.67
Diesel	Diesel (B7)	9.86

For the vehicle tested by EMPA-TCS, the conversion coefficients were adapted to the market fuel that was used for their PEMS tests.

The trend for energy consumption was the same as CO_2 for the ICE vehicles. The objective of the section was to evaluate the performance of the EV as a benchmark compared to the ICE vehicles. That's why only a few representative ICE vehicles were compared on the figures 35-36-37 below. All the results are available in the table 10 bellow.

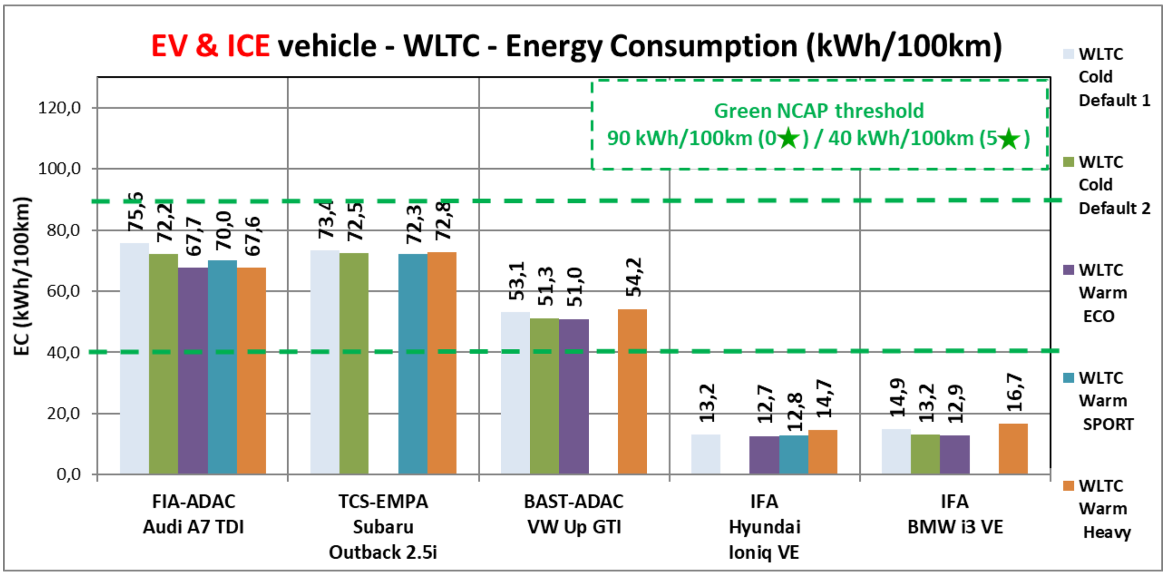


Figure 35 – Energy consumption – Example of Diesel/Petrol/PEV vehicles - WLTC

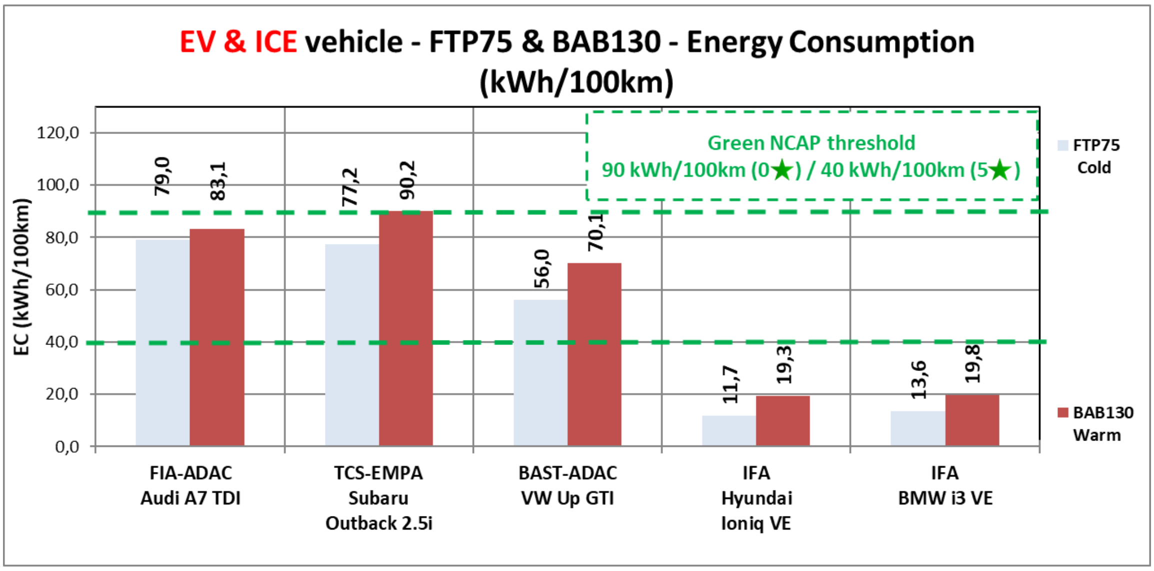


Figure 36 – Energy consumption – Example of Diesel/Petrol/PEV vehicles – FTP75 & BAB130

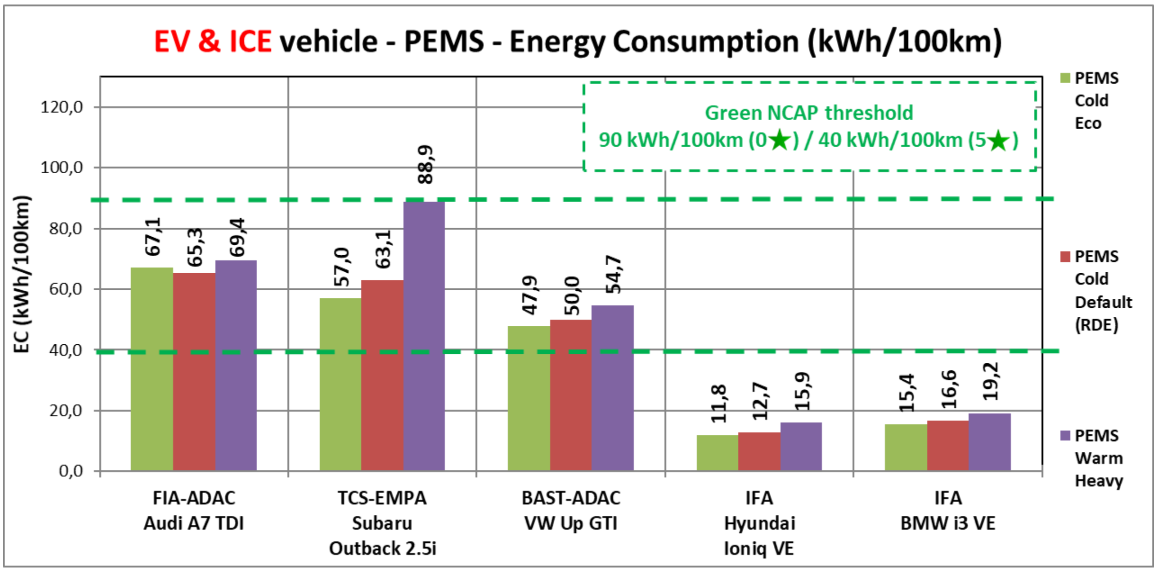


Figure 37 - – Energy consumption – Example of Diesel/Petrol/PEV vehicles - PEMS

		WLTC_Stand_Cold (average of 2 tests)		FTP75_Cold		BAB130_Warm		PEMS Cold Default (RDE)	
		Fuel (L/100km)	Energy (kWh/100km)	Fuel (L/100km)	Energy (kWh/100km)	Fuel (L/100km)	Energy (kWh/100km)	Fuel (L/100km)	Energy (kWh/100km)
Petrol	Ford Fiesta Gdi Euro6b	5,52	47,4	5,71	49,06	6,79	58,33	5,68	48,79
	Ford Fiesta Gdi Euro6d_temp	6,91	59,3	6,8	58,58	8,34	71,64	6,30	54,12
	Fiat Panda 0.9L	5,80	49,8	5,49	47,16	7,60	65,28	7,32	57,00
	Mercedes A200	6,95	59,7	7,40	63,57	7,11	61,07	6,45	55,41
	Subaru Outback 2.5i	8,50	73,0	8,99	77,22	10,50	90,20	7,24	63,05
	Volvo XC40	8,03	68,9	8,61	73,97	10,46	89,85	7,80	66,99
	VW Up GTI	5,30	52,2	5,68	56,00	7,11	70,10	5,82	49,97
Diesel	Audi A7 TDI	7,50	73,9	8,01	78,98	8,43	83,12	6,62	65,31
	BMW X1d	5,35	52,7	5,4	52,75	6,44	63,45	6,40	63,11
	VW Golf 1.6L TDI Euro6b	4,80	47,3	4,79	47,23	5,96	58,77	4,81	47,42
Average ICE		**6,46**	**58,4**	**6,69**	**60,45**	**7,87**	**71,18**	**6,44**	**57,12**
PEV	Hyundai Ioniq EV		13,2		11,70		19,30		12,70
	BMW i3 EV		14,1		13,60		19,80		16,60
Average EV			**13,7**		**12,65**		**19,6**		**14,7**
Average EV / Average ICE			-77%		-79%		-73%		-74%

Table 10 - Summary of energy consumption

The impact of the type of test and the WLTC & PEMS test conditions on the energy consumption of the Hyundai Ioniq & BMW i3 was the same as for the ICE vehicles. This did not concur with the energy efficiency results from the PEV Renault Zoe tested in the first validation test series, where the strategy of battery regeneration was favoured on a dynamic test.

cycle like the BAB130. The consequence of an optimized regeneration is to reinject energy into the battery during braking and thus benefit from a better energy balance at the end of the test.
The value of energy consumption from the two PEV was considerably lower than of the ICE vehicles for all the tests (-76% in average).

Please find below the performance of each vehicle in the Green NCAP rating by comparison of the energy consumption with the average of the low and high Green NCAP thresholds (65 kWh/100km).

		Green NCAP average threshold (kWh/100km)	WLTC_Stand_Cold		FTP75_Cold		BAB130_Warm		PEMS_Stand_Cold	
			Energy (kWh/100 km)	% threshold	Energy (kWh/100 km)	% threshold	Energy (kWh/100 km)	% threshold	Energy (kWh/100 km)	% threshold
Petrol	Ford Fiesta Gdi Euro6b	65	47,4	-27%	49,1	-25%	58,3	-10%	48,8	-25%
	Ford Fiesta Gdi Euro6d_temp	65	59,3	-9%	58,6	-10%	71,6	10%	54,1	-17%
	Fiat Panda 0.9L Euro6b	65	49,8	-23%	47,2	-27%	65,3	0%	57,0	-12%
	Mercedes A200	65	59,7	-8%	63,6	-2%	61,1	-6%	55,4	-15%
	Subaru Outback 2.5i	65	73,0	12%	77,2	19%	90,2	39%	63,1	-3%
	Volvo XC40	65	68,9	6%	74,0	14%	89,9	38%	67,0	3%
	VW Up GTI	65	52,2	-20%	56,0	-14%	70,1	8%	50,0	-23%
Diesel	Audi A7 TDI	65	73,9	14%	79,0	22%	83,1	28%	65,3	0%
	BMW X1d	65	52,7	-19%	52,8	-19%	63,4	-2%	63,1	-3%
	VW Golf 1.6L TDI Euro6b	65	47,3	-27%	47,2	-27%	58,8	-10%	47,4	-27%
PEV	Hyundai Ioniq VE	65	13,2	-80%	11,7	-82%	19,3	-70%	12,7	-80%
	BMW i3 VE	65	14,1	-78%	13,6	-79%	19,8	-70%	16,6	-74%
Average Test / Green NCAP average threshold				-22%		-19%		-4%		-23%

Table 11 - Vehicle positioning in the Green NCAP rating (Energy consumption)

7.7 CO2 Emissions – Comparative summary including type approval CO2 value

		TA Reference Value (g/km)	WLTC_Stand_Cold		FTP75_Cold		BAB130_Warm		PEMS_Stand_Cold	
			Value (g/km)	/ TA Ref.	Value (g/km)	/ TA Ref.	Value (g/km)	/ TA Ref.	Value (g/km)	/ TA Ref.
Petrol	Ford Fiesta Gdi Euro6b	97	124,5	28%	129,1	33%	152,3	57%	130,3	34%
	Ford Fiesta Gdi Euro6d_temp	136	157,0	15%	155,3	14%	189,7	39%	142,5	5%
	Fiat Panda 0.9L Euro6b	99	135,1	36%	127,8	29%	173,1	75%	150,0	52%
	Mercedes A200	143	157,5	10%	171,1	20%	164,7	15%	154,5	8%
	Subaru Outback 2.5i	166	192,3	16%	203,5	23%	204,1	23%	164,1	-1%
	Volvo XC40	194	188,1	-3%	194,9	0%	234,8	21%	186,0	-4%
	VW Up GTI	128	123,9	-3%	133,0	4%	165,3	29%	138,7	8%
Diesel	Audi A7 TDI	196	197,8	1%	211,2	8%	222,7	14%	174,9	-11%
	BMW X1d	121	140,1	16%	142,9	18%	168,7	39%	167,4	38%
	VW Golf 1.6L TDI Euro6b	109	126,3	16%	126,2	16%	156,9	44%	127,0	17%
Average Test/TA Ref				13%		16%		36%		15%

Table 12 – CO_2 emissions – Comparison with TA CO2 Value

For the Euro 6b vehicles (Ford Fiesta, VW Golf and Fiat PANDA), the values of CO_2 emissions obtained on the WLTC cold start (with a WLTP test mass) were on average 27% higher than the type approval values (obtained on NEDC test).
For Euro 6d Temp vehicles, the values of CO_2 emissions obtained on the WLTC cold start were on average 7% higher than the type approval values.
Except for the 3 Euro6b vehicles (Fiat Panda, the Ford Fiesta & VW Golf) and the Ford Fiesta GDi Euro6d_temp, the CO_2 emissions values obtained through the PEMS+_standard test were close to the type approval values.

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7.8 Impact of the evolution of input data (road load & test mass) on results from chassis dynamometer tests

For the validation phase, the test mass and the road load parameters were obtained from the Certificate of Conformity (CoC) of the tested vehicles. Especially for the Euro 6b vehicles, already tested for the first verification phase test series, the parameters used were the association between the test mass WLTP (see paragraph 5.1.2.7) and the coast down results from the CoC extracted from the UN Regulation No 83.

Below please find the summary of parameters used for the two test series, and the impact on the results.
The complete results are available in Annex 2.

7.8.1 Impact of the evolution of input data on the Ford Fiesta GDI Euro 6b

- **Summary of Road Load parameters and Test Mass used for the two test series on the Ford Fiesta euro 6b :**

Vehicle		Ford Fiesta 1.0 EcoBoost Euro6b	
Test series		**First verification phase**	**Validation phase**
Test Mass WLTP (kg)		1180 (Heavy 1550)	1317 (Heavy 1670)
Road Load	Road load Coefficient - F0	165,2	70,5 (heavy 89,448)
	Road load Coefficient - F1	0	0,0643
	Road load Coefficient - F2	0,0466	0,0360
Fuel		E10 reference fuel	
Gear Box		Manual 6	
Gearshift		GSI	
Air conditioner		Activated (Manual)	

Table 13 - Road Load parameters and masses – Ford Fiesta Euro 6b

- **Summary of emissions results of the Ford Fiesta Euro 6b :**

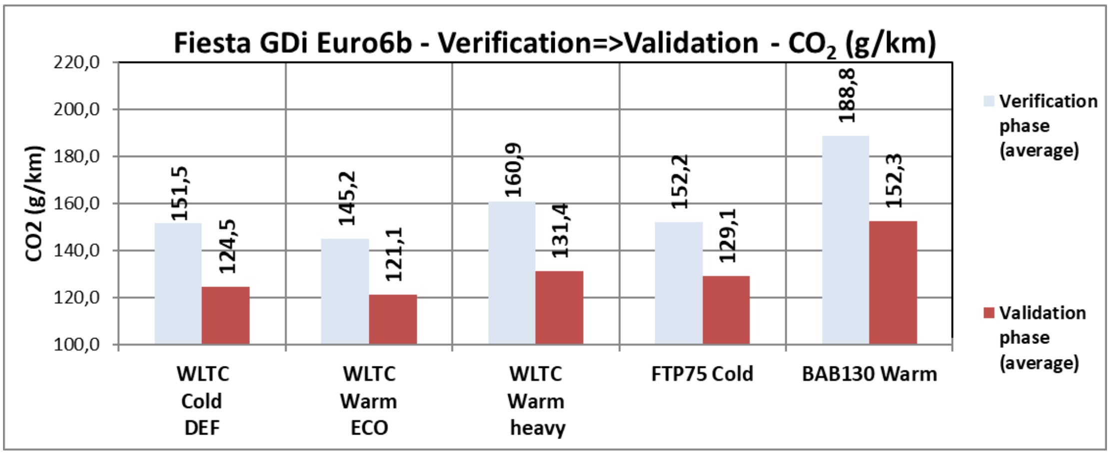


Figure 38 – CO2 Emissions from the Ford Fiesta Euro 6b – Comparison First verification & validation phases

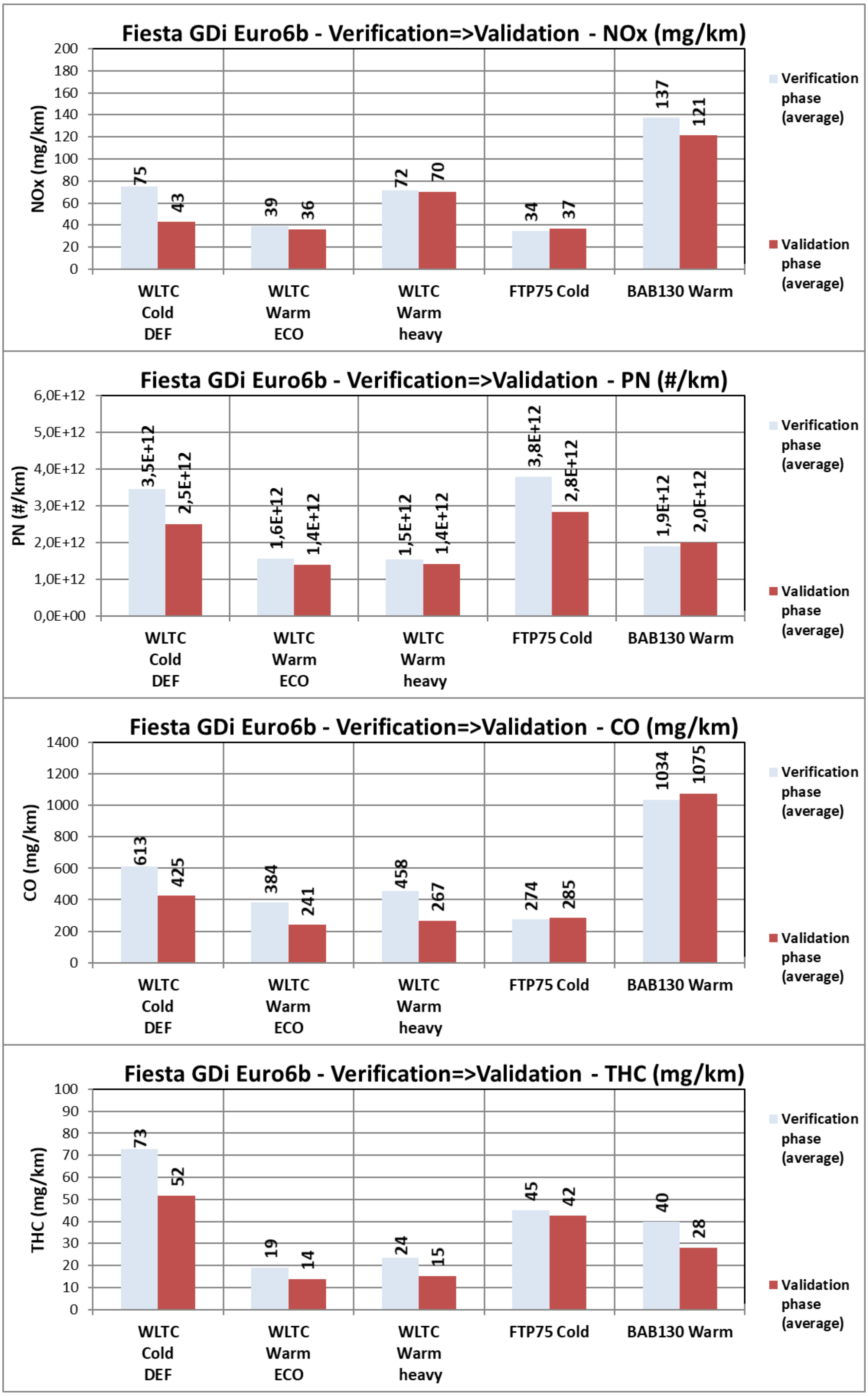


Figure 39 – Emissions of pollutants from the Ford Fiesta Euro 6b – Comparison First verification & validation phases

- **Summary of comparison of the Ford Fiesta Euro 6b :**

		CO	THC	NOx	PN	CO2
		mg/km	mg/km	mg/km	#/km	g/km
Synthesis comparision	**Abs.**	-94	-10	-10	-4,2E+11	-28
Validation/Verification	**Rel.**	-20%	-25%	-11%	-13%	-17%

Table 14 - Summary of comparison of the Ford Fiesta Euro 6b

Despite the increasing of the Test Mass (+137kg / +12%) and the decreasing of road load factor F0 (-95N / -57%) these generate a decrease of 17% of CO_2 emissions (stable for each type of tests). **The absolute values obtained in the WLTC with CoC road load settings (validation phase) were closer to PEMS+ values than the measurement values obtained from test using the WLTP default road load settings (first verification phase).**
It can be concluded that the pollutant emissions and energy efficiency levels are sensitive to the road load settings applied. This is an issue that Green NCAP will flag and that can partly be addressed through improvements of the engine management system tuning as well as through improvements of the emission abatement design as well as through fuel efficiency-relevant system and component design.

Concerning the emissions of pollutants, the impact is significant and mainly seen on the WLTC_Cold_default. Future robustness improvements may improve the situation.

7.8.2 Impact of the evolution of input data on the VW Gold TDI Euro 6b

- **Summary of Road Load parameters and Test Mass used for the two test series on the Golf :**

Vehicle		VW Golf 1.6L TDI Euro6b	
Test series		First verification phase	Validation phase
Test Mass WLTP (kg)		1492 (Heavy 1930)	1483 (Heavy 1840)
Road Load	Road load Coefficient - F0	208,9	89,5 (Heavy 111,045)
	Road load Coefficient - F1	0	0,681
	Road load Coefficient - F2	0,0483	0,0292
Fuel		B7 reference fuel	
Gear Box		Manual 5	
Gearshift		GSI	
Air conditioner		Activated (auto)	

Table 15 - Road Load parameters and masses – VW Golf TDI Euro6b

- **Summary of emissions results of the VW Golf TDI Euro 6b :**

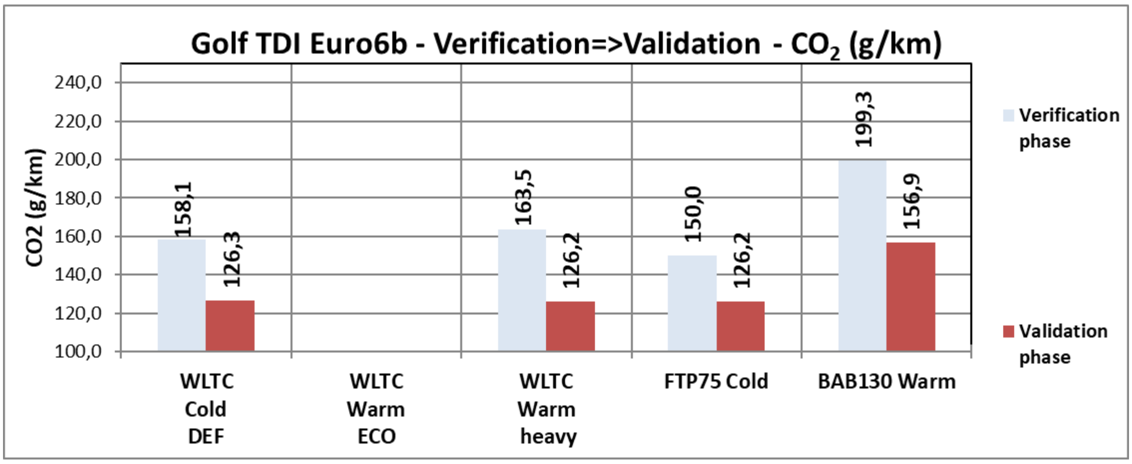


Figure 40 – CO2 Emissions from the VW Golf TDI Euro6b – Comparison First verification & validation phases

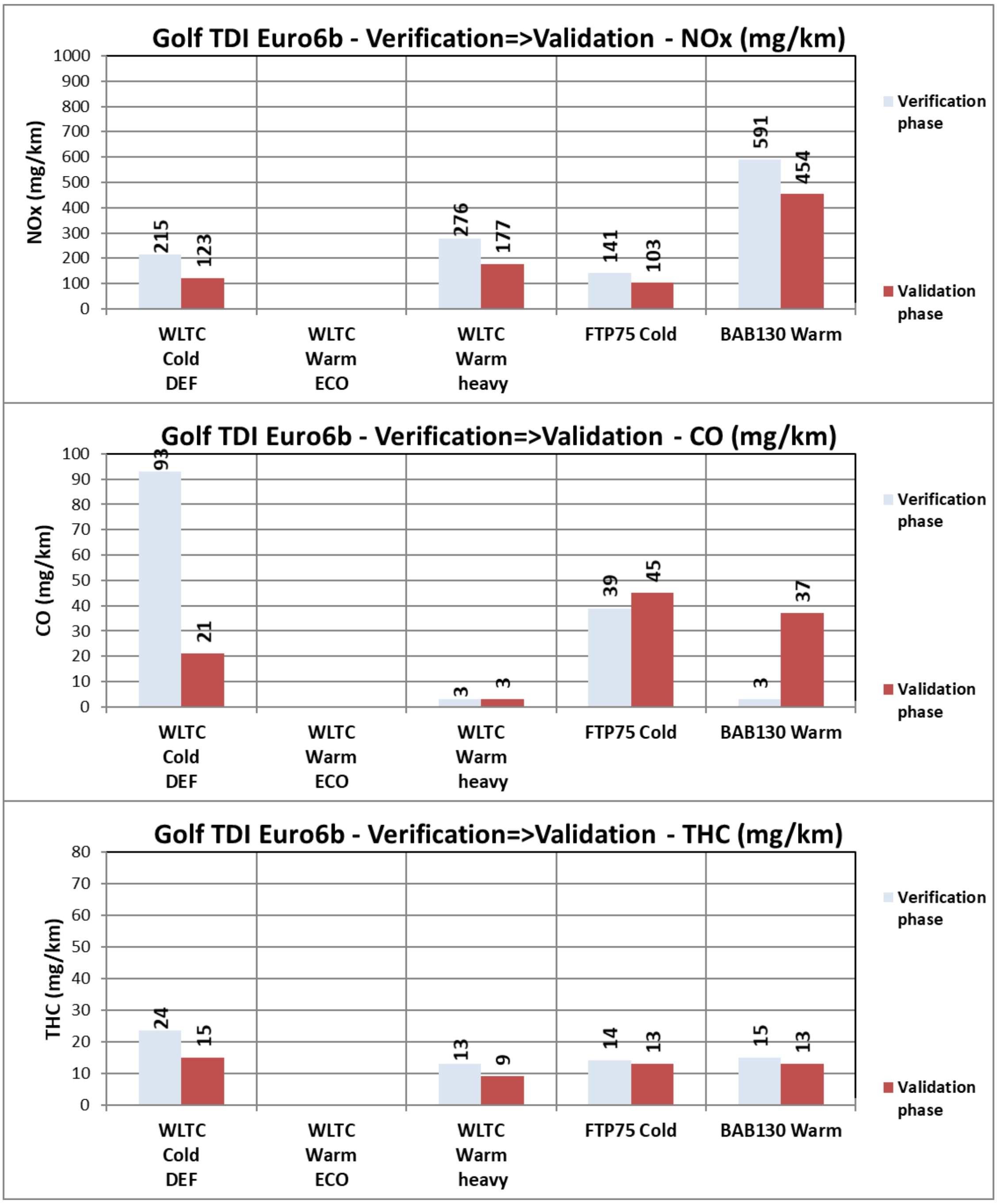


Figure 41 –Emissions of pollutants from the VW Golf TDI Euro6b – Comparison First verification & Validation phases

- **Summary of comparison of the Golf :**

		CO	THC	NOx	PN	CO2
		mg/km	mg/km	mg/km	#/km	g/km
Synthesis comparision Validation/Verification	**Abs.**	**-8**	**-4**	**-92**	**9,1E+10**	**-34**
	Rel.	**268%**	**-22%**	**-32%**	**86%**	**-20%**

Table 16 - Summary of comparison of the VW Golf TDI Euro 6b

Unlike for the Ford Fiesta Euro 6b, the values of test masses were similar. The decreasing of F0 (-119N / -57%) generated a decrease of 20% of CO_2 emissions. The same conclusion can be drawn as reported for the Ford Fiesta Euro 6b.

7.9 Sensitivity analysis of the dispersion of emission laboratory test results (example Audi A7 TDI diesel & Volvo XC40 petrol)

The dispersion of emission laboratory test results were mainly explained by driving following the GSI prescriptions on the vehicles equipped with a manual transmission. Because GSI cannot very well be anticipated, it caused peaks of NOx emissions during acceleration phases. This observation was made during the first validation phase. In approval testing when applying the regulatory WLTP procedure, a complex gear-shift pattern / algorithm was implemented that forced the test driver to shift gears very accurately. The penalty of not exactly following these programmed gear-shift prescriptions indicated on the driver aid, was that worst-case an emission test needed to be declared invalid. This hyper sensitivity of gear shifting in emission laboratory tests is an issue that needs to be addressed through improved vehicle system design. The consequence of shifting outside the tolerance bands around the gearshift moment programmed on the driver aid lead to substantially higher emissions under real-world conditions, which is not acceptable.

The peaks measured during the pilot program tests in the emission laboratory confirmed that in particular NOx emissions were very sensitive to gear-shift dynamics. Again, this is not reflecting real-world spread of the different ways how drivers shift gears in reality. Hence, Green NCAP therefore implemented an alternative, which is to shift gears as proposed by the manufacturer in accordance with the in-vehicle programmed GSI shift points.

For the validation phase, a significant dispersion was found on 2 vehicles (Audi A7 TDI diesel & Volvo XC40 petrol) between the two WLTC_Cold_default_mode tests (see paragraph 7.5.1)
The analysis of the deceleration check performed after the 2 tests did not show any evolution vehicle' rolling resistance. However, the two vehicles were equipped with an automatic transmission, whose sensitivity had an impact on the CO_2 emissions.

See below an example of CO_2 emissions associated to the driving on chassis dynamometer. These graphs show a constant increase in the gap cumulative CO2 mass between 2 similar cold tests.

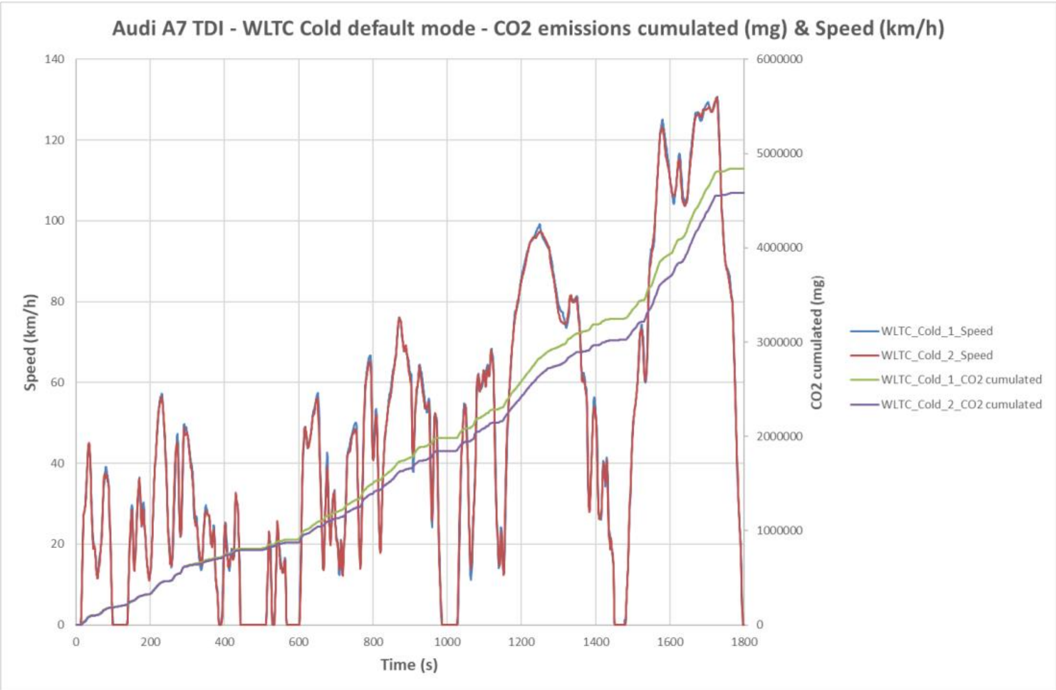


Figure 42- Audi A7 TDI – WLTC Cold 1 & 2

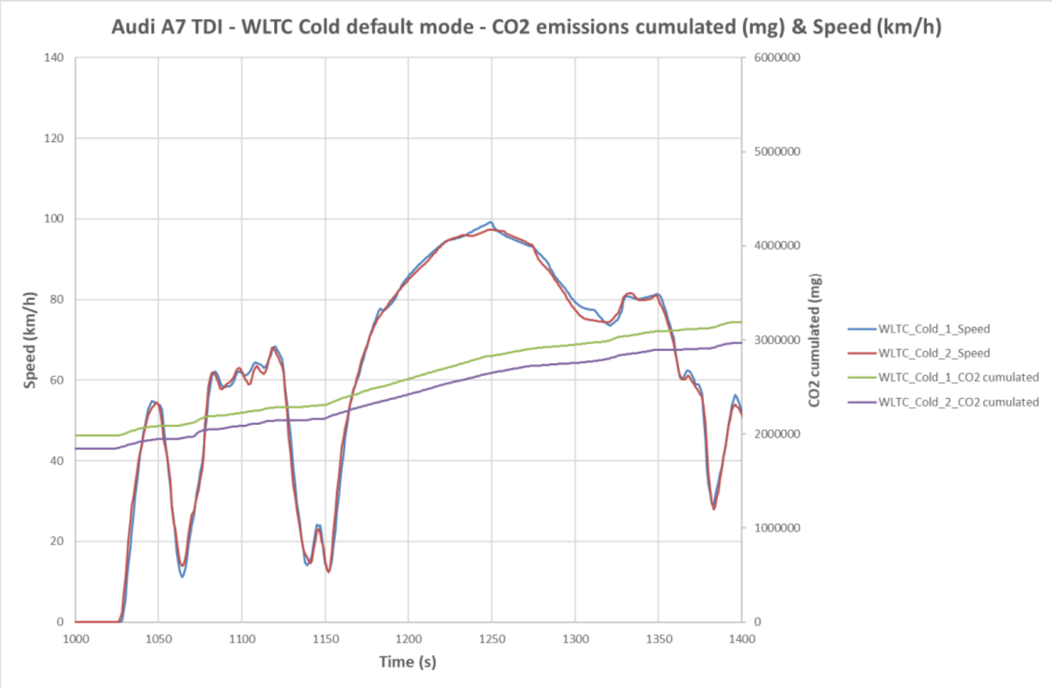


Figure 43 – Audi A7 TDI – WLTC Cold 1 & 2 – Focus on 3rd phase of test cycle

7.10 Focus on PEMS+ test conditions

7.10.1 PEMS+ test conditions (Weather & Traffic jam)

The tests performed for the validation phase test series took place over the summer period. The average outside temperature turned out to be +21°C within a range of [+12°C; +35°C].
The summary is contained in Annex 4.

7.10.2 PEMS+ test conditions (Driving & Engine map)

- **Analysis of driving dynamics:**

The results of CO_2 and CO emissions obtained from the Fiat Panda 0.9L and the Subaru Outback 2.5i showed the necessity to analyse the driving behaviour.

The driving dynamics has a strong impact on pollutant emissions and energy consumption, which can partly be explained from ICE natural characteristics but likely also to be influenced by manufacturer implemented fuelling and combustion initiation strategies. The post-processing of the speed signal provides dynamic data as used in the regulatory text.
The most explicit criterion is the mathematic product of V multiplied by .A_{pos}.
V.A_{pos} (m^2/s^3) is the actual vehicle speed per positive acceleration > 0.1 m/s^2, considering separately the urban, rural and motorway shares.

Please find on the next page a summary of the V.A_{pos} results from 5 vehicles of which the CO_2 emission results varied depending on the driving dynamics:

		PEMS Cold RDE	PEMS Cold Eco		PEMS Warm Heavy		Evolution of CO2 emissions
		value	value	/ RDE	value	/ RDE	
Ford Fiesta 1L €6b	$V.A_{pos}$ urban (m^2/s^3)	13,47	7,33	-46%	17,81	32%	Normal
	$V.A_{pos}$ rural (m^2/s^3)	17,63	13,58	-23%	24,72	40%	
	$V.A_{pos}$ motorway (m^2/s^3)	14,84	11,96	-19%	18,22	23%	
Ford Fiesta 1L €6d_temp	$V.A_{pos}$ urban (m^2/s^3)	12,41	10,56	-15%	15,81	27%	Normal
	$V.A_{pos}$ rural (m^2/s^3)	16,16	12,9	-20%	22,42	39%	
	$V.A_{pos}$ motorway (m^2/s^3)	16,08	11,74	-27%	24,14	50%	
Fiat Panda 0.9L	$V.A_{pos}$ urban (m^2/s^3)	12,02	9,23	-23%	17,04	42%	High on PEMS heavy test
	$V.A_{pos}$ rural (m^2/s^3)	20,52	13,04	-36%	23,45	14%	
	$V.A_{pos}$ motorway (m^2/s^3)	18,35	12,17	-34%	20,74	13%	
Subaru Outback 2.5i	$V.A_{pos}$ urban (m^2/s^3)	15,18	9,79	-36%	24,12	59%	High on PEMS heavy test
	$V.A_{pos}$ rural (m^2/s^3)	17,21	11,09	-36%	27,89	62%	
	$V.A_{pos}$ motorway (m^2/s^3)	14,84	8,71	-41%	34,26	131%	
Audi A7 TDI	$V.A_{pos}$ urban (m^2/s^3)	9,79	9,89	1%	13,7	40%	Low
	$V.A_{pos}$ rural (m^2/s^3)	13,22	12,66	-4%	23,55	78%	
	$V.A_{pos}$ motorway (m^2/s^3)	16,15	13,55	-16%	29,54	83%	

Table 17 - V.Apos results from 5 vehicles

The values of $V.A_{pos}$ were high on PEMS heavy test for the Subaru Outback 2.5i, and could explain the high value of CO_2 by the tuning to obtain a sporty vehicle characteristic (high sensitivity of acceleration on this type of vehicle driving mode).
The impact of driving dynamics on the Fiat Panda 0.9L (small displacement engine, low torque and power) and the Audi A7 TDI (high power and torque) were very different, as anticipated. The Fiat Panda 0.9L engine was challenged to its maximum capability on the PEMS heavy test (high values of CO_2 emissions) but without significant acceleration.
The engine of the Audi A7 TDI was not particularly challenged by the PEMS heavy test owing to its over-dimension capabilities. Hence, CO_2 emissions on the PEMS heavy test remained relatively steady despite the higher acceleration rates achieved.

- **Analysis of engine maps (engine load vs engine speed sampling cloud) and other engine variables:**

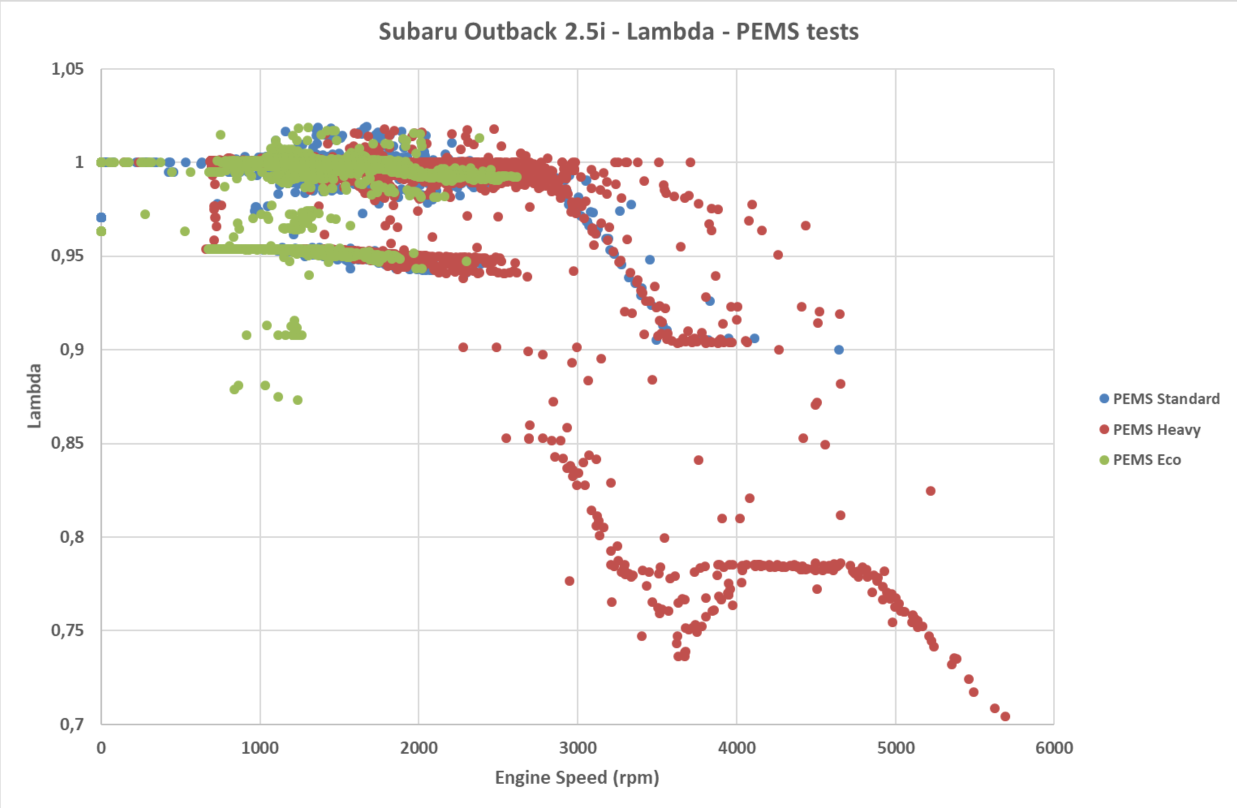


Figure 44 – PEMS tests – Outback 2.5i - Lambda vs engine speed

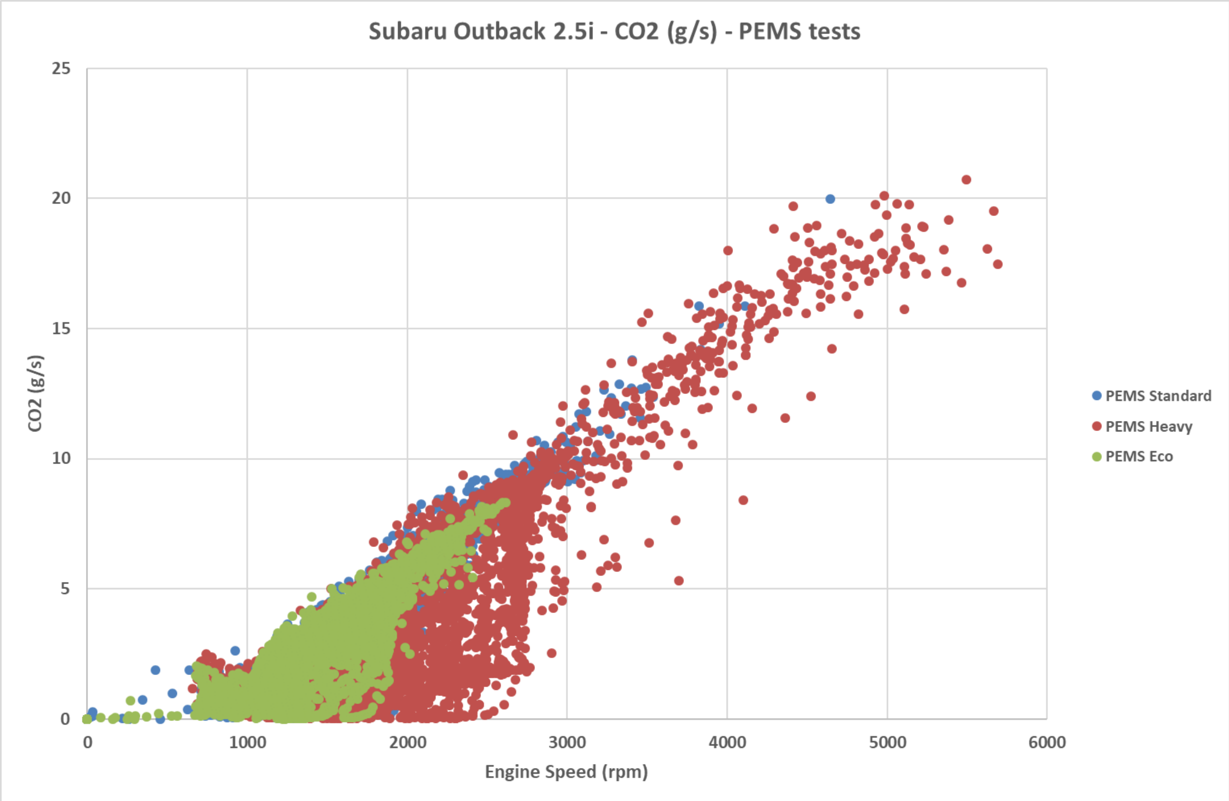


Figure 45 - PEMS tests – Outback 2.5i – CO2 mass flow emissions sampling clouds vs engine speed

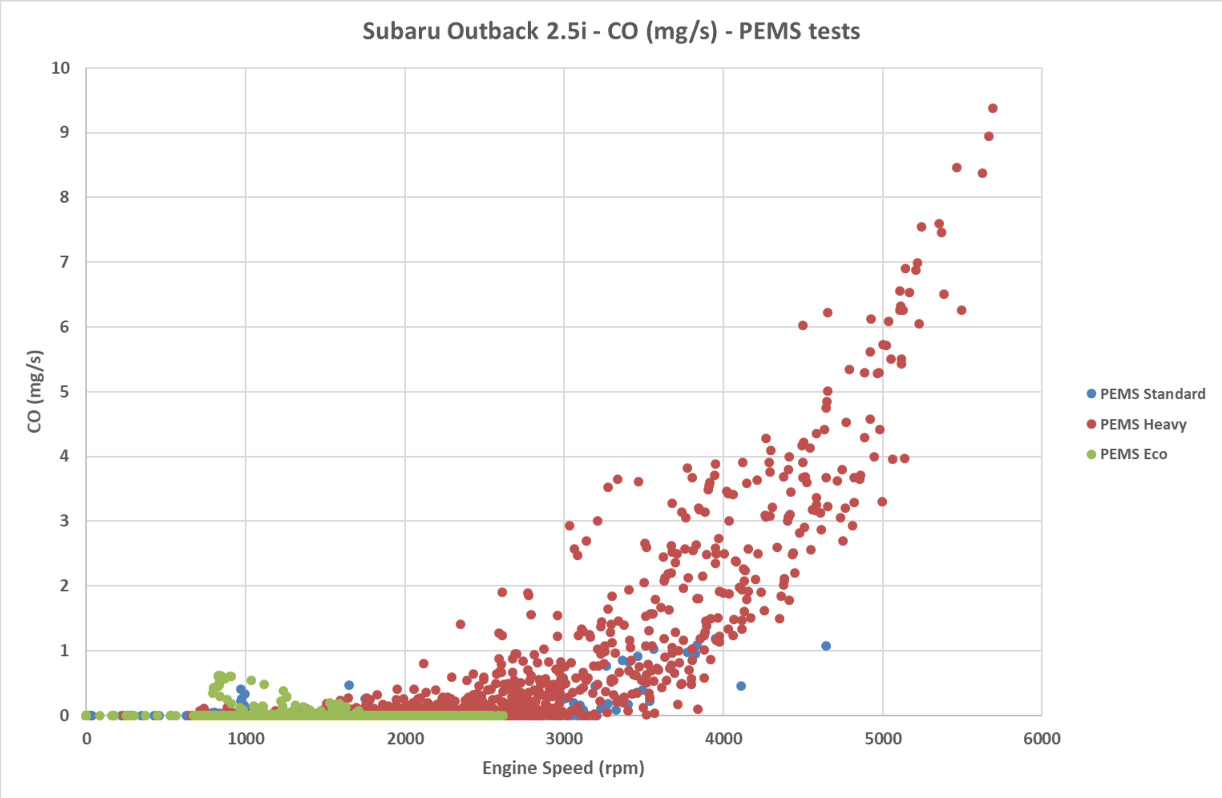


Figure 46 - PEMS tests – Outback 2.5i – CO emissions

The engine of the Outback 2.5i was challenged by the PEMS heavy test conditions, meaning that it was running at significantly higher engine loads than in a regular or eco PEMS test. Running at higher engine load typically results in higher heat exposure of the exhaust components (exhaust valves, lambda sensors, turbo turbine, three-way catalyst, GPF). Until now this overheating was addressed by fuelling enrichment in which the heat is extracted from the exhaust gas by evaporation of excessively added liquid fuel into gaseous fuel in the combustion chamber and exhaust. This excessive fuelling can be observed from Fig 44 in which lambda is commanded rich by the engine management system as of 3000 rpm under high load conditions. The consequence of this excessive fuelling are significantly increased CO_2 emissions and fuel consumption. Moreover, owing to incomplete combustion, excessively increased CO will be emitted (22 148 mg/km in the BAB130 test, see Fig. 21).

These fuelling strategies are no longer acceptable and need to be replaced with sustainable engine tuning over the life of the vehicle.

The value of lambda from OBD was not available on the Panda 0.9L, but the system response of increased CO_2 and CO emissions was comparable with the Subaru Outback 2.5i (already enriching mixture at lower engine speeds and engine loads).

8 ENGINE MAP (ENGINE LOAD VS ENGINE SPEED) AREA

The objective of this section is to highlight the differences in the engine operation map sampling areas for the different types of tests performed during the validation phase.
For the first validation phase, the plotting methodology by all laboratories was varied (OBD Engine load, fuel consumption, energy consumption…). The feedback was that the parameters used were not relevant, not reliable or robust. For the validation phase, a standardised methodology was applied:

- Engine speed (rpm)
- Engine load proxy: energy consumption (Wh/s) - standardised for ICE & Electric vehicles

The conversion from fuel mass flow (mg/s) into energy consumption (Wh/s) was performed in the same way as described in paragraph 7.6 (from the rating method).

The fuel consumption (mg/s) used for the conversion could be determined:

1- By the carbon balance method (Emission of pollutants containing C atoms, like HC, CO and CO_2)
2- By OBD using calculated OBD load value as proxy for engine load if the measurement of tailpipe emissions was not possible (full load test on the chassis dynamometer for example)

Both engine speed and engine load proxy data were obtained from modal second by second data. This means that the sampling clouds below were compiled based on sampling pollutant and CO_2 emissions every second during the entire emission test. An important element that cannot be visualised by these plots is sampling dynamics (slow or fast transitions from one operation point to the next).

Below are the coefficients used for the conversion of fuel consumption (mg/s) into energy consumption (Wh/s) :

Petrol	EU6 cert (E10)	11.56^{e}-3 (= 8.67 / 750)
Diesel	Diesel (B7)	11.80^{e}-3 (= 9.86 / 835)

The value of coefficients were calculated with the average of the WLTP reference fuel density.
For the vehicle test by EMPA-TCS in Switzerland, the conversion coefficient were adapted to the market fuel that was used for PEMS tests and analysed retro-actively.

The presentation on the next page only shows the example of the EMPA laboratory. All graphs from all vehicles are available in Annex 3.

8.1 Chassis dynamometer test sampling areas (WLTC cold - FTP75 cold - BAB130 warm – maximum engine load sweep curve)

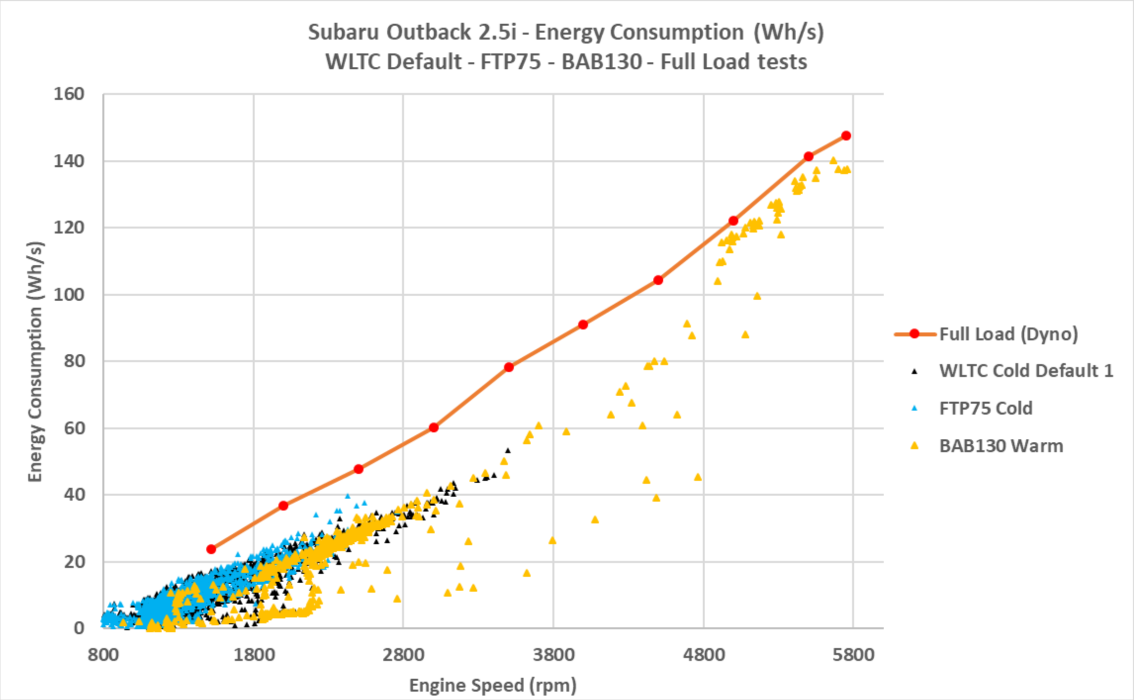


Figure 47- Chassis dynamometer & full load tests from emission laboratory test sampling areas of the Subaru Outback 2.5i and its maximum engine load sweep test curve.

The use of engine emission sampling area (scatter cloud) of a WLTC in terms of area coverage under the maximum load curve and its high dynamics were similar to the one of an FT75 test cycle in comparison with the WLTC test.

The BAB130 allowed to use the engine to the maximum of its capacities. However, from the plots it became obvious that a large engine speed – engine load area (white area between red maximum engine load curve and scatter areas) remains unexplored in any type of emission test, be it in highly dynamic test cycles in the emission laboratory or be it on the road under constrained driving conditions prescribed by the real-world test cycle boundary conditions.

In the long term, any vehicle propulsion unit will need to be clean and energy efficient in every operation point on and under the maximum engine load curve, which is the paradigm change that Green NCAP targets to achieve.

8.2 Chassis dynamometer test sampling areas (WLTC cold standard-mode, WLTC warm sport-mode and WLTC warm high payload)

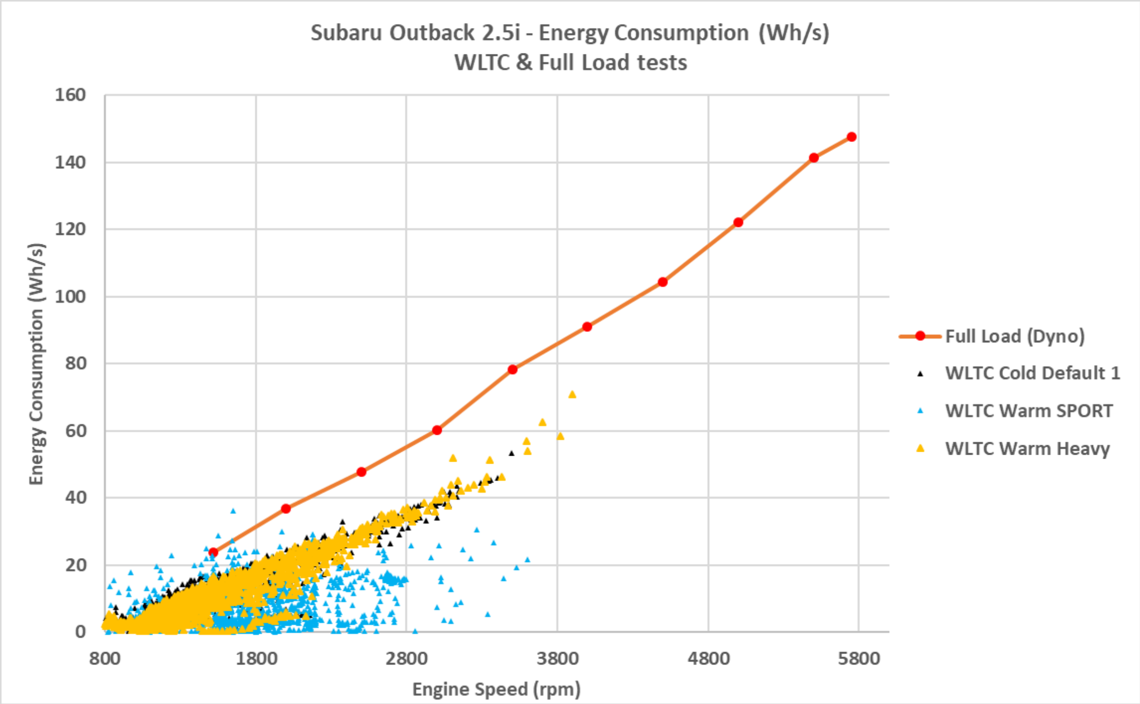


Figure 48-WLTC & full load tests from Subaru Outback 2.5i

When comparing the WLTC_heavy test cycle emissions' sampling area with the one as a result of a WLTC_default test cycle it becomes obvious that these largely overlap and still not sufficiently challenge the engine like e.g. the BAB130 test cycle. The Sport mode allowed to increase the engine speed without significantly increasing the engine load proxy, which results in higher engine power and a more sporty reaction of vehicle on dynamic operation of the accelerator pedal.

8.3 Chassis dynamometer test sampling areas, comparison WLTC & real-world PEMS tests

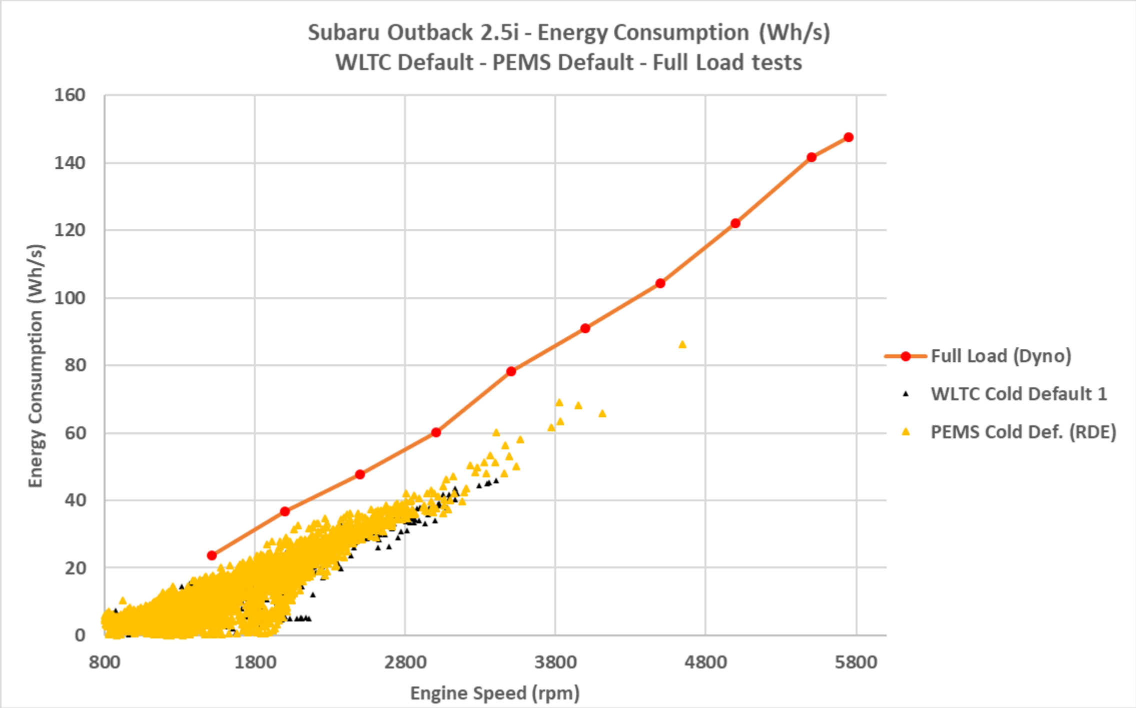


Figure 49 – WLTC, PEMS, and Full load tests from Subaru Outback 2.5i

The overlap of the PEMS_default test sampling scatter cloud with the one as a result of driving the WLTC_default test cycle indicates that the same constrained 'normal' areas are sampled. The 'unexplored' engine speed – engine load area (white surface) between the maximum engine load proxy curve and the 'normal' emissions sampling scatter areas is large, which is the reason that e.g. a PEMS heavy load test is needed to cover part of that operation area (see Fig 49).

8.4 Chassis dynamometer test sampling areas (PEMS+ emission sampling conditions in standard-driving mode, eco-mode and high payload)

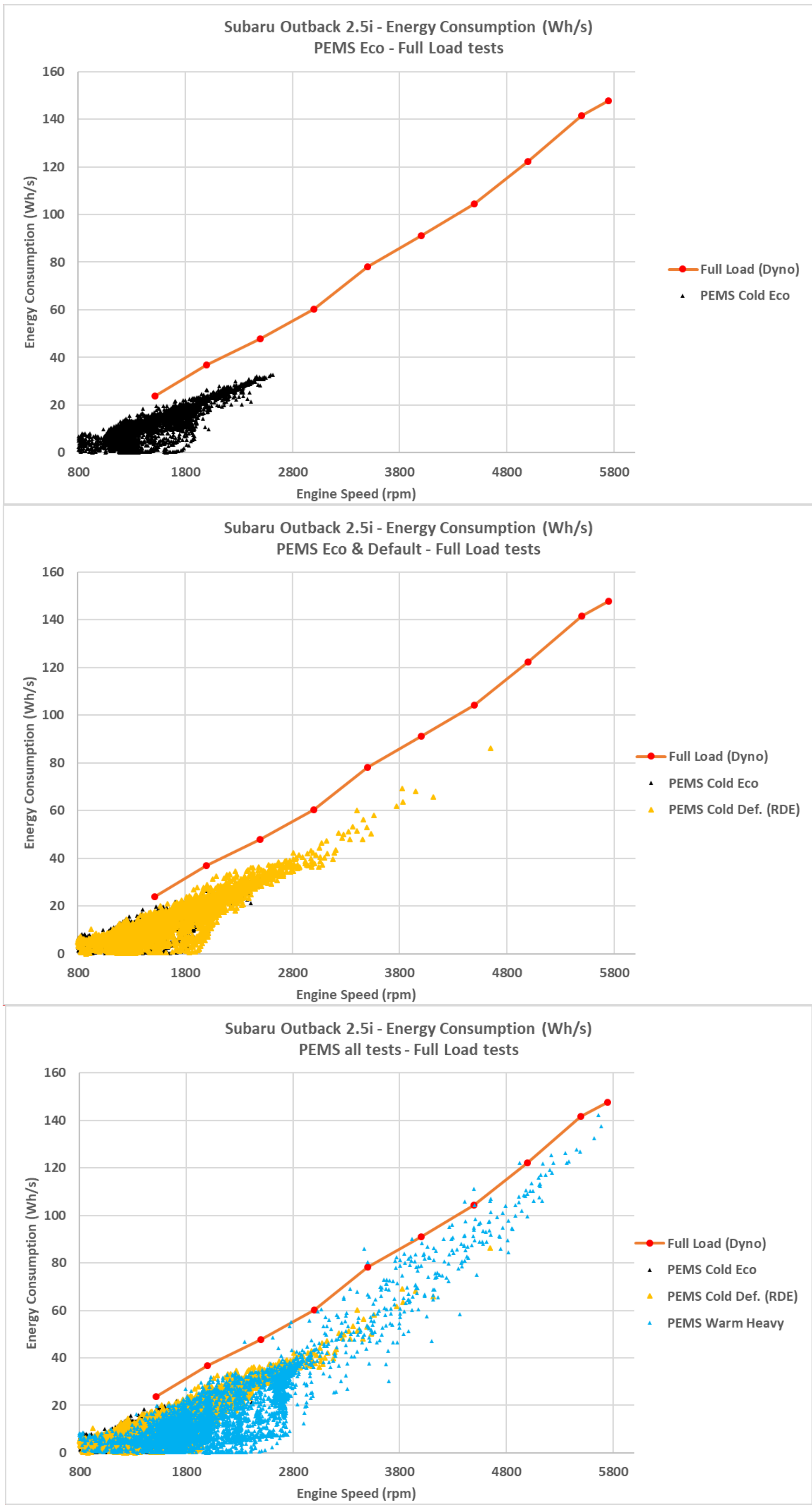


Figure 50 - PEMS and Full load tests from Subaru Outback 2.5i

In Eco mode the engine speed – engine load sampling area was rather small in comparison to the one as a result of driving the PEMS+ cold test in standard driving mode. By restricting this operation area, probably through the automatic gearbox, the engine may react in a lesser dynamic way on the accelerator pedal but allows to safe fuel and, if well calibrated / optimised, emitting less pollutants owing to a significantly lower engine flow. The larger sports mode sampling area allowed to take part of the unexplored engine operation area into account. Especially samples at the whole high load range were taken over the entire engine speed range, close to the maximum engine load proxy curve (maximum propulsion unit performance and capability).

9 VEHICLE RATING

The Green NCAP working group developed a scoring methodology for the vehicles tested resulting in a simple star rating (0 – 5). The rating sheet from the thirteen validation phase test vehicles is available in Annex 5.

Here is the summary:

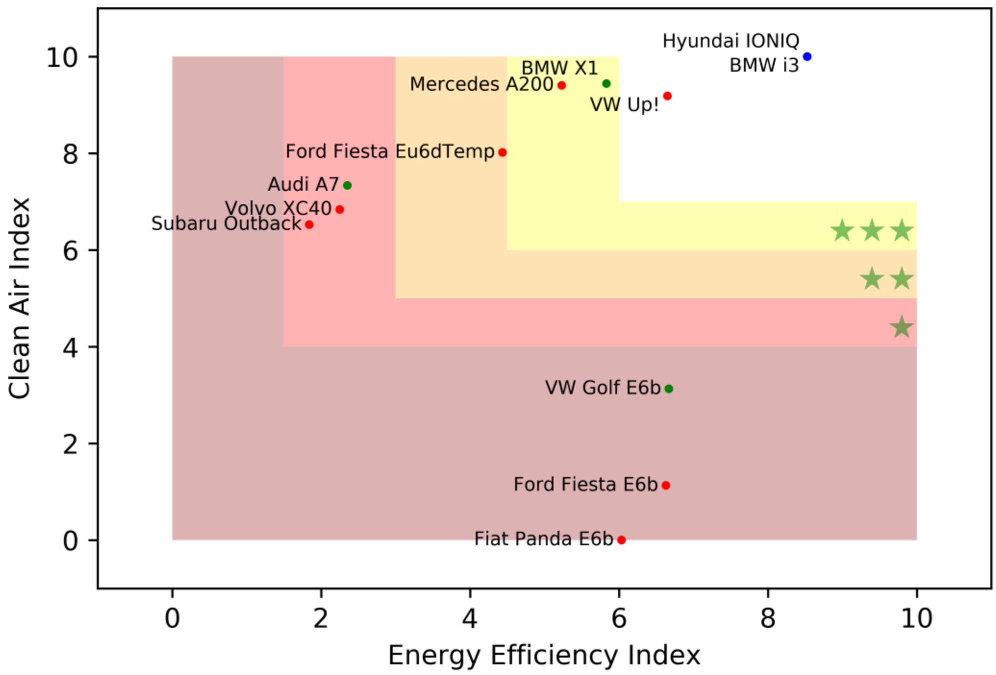


Figure 51 – Summary of vehicle scores and rating (plotted by CSI laboratory)

Stars	Vehicle	Clean Air Index	Efficiency Index
5	BMW i3 PEV Euro6b	10	8,5
5	Hyundai IONIQ PEV Euro6b	10	8,5
4	VW Up! Euro6d_temp	9,2	6,7
3	BMW X1d Euro6d_temp	9,4	5,8
3	Mercedes A200 Euro6d_temp	9,4	5,2
2	Ford Fiesta 1L EcoBoost Euro6d_temp	8	4,4
1	Audi A7 50 TDI Euro6d_temp	7,3	2,5
1	Subaru Outback 2.5i Euro6d_temp	6,5	1,8
1	Volvo XC40 T5 Euro6d_temp	6,8	2,3
0	Fiat Panda 0.9L Euro6b	0	6
0	Ford Fiesta 1L EcoBoost Euro6b	1,1	6,6
0	VW Golf Euro6b	3,1	6,7

Figure 52 - Summary of vehicle scores and ratings

The three Euro6b compliant vehicles had a good score for efficiency and a poor score for pollutants, resulting in an overall poor rating of 0 stars (the lowest scoring item of pollutant emissions and energy efficiency is determining the final rating)

This was opposite for the Euro6d_temp vehicles having high payload and equipped with a big displacement engine (petrol and diesel engines), scoring well on pollutant emissions (clean diesel and petrol cars) but being less efficient with the fuel resulting also in a poor rating (1 star). It was encouraging to identify that already during the validation test phase timeframe clean and energy efficient vehicles were available on the EU market that can be recommended to consumers.

This summary was representative of the validation test results obtained (see paragraph 7 and associated comments)

10 CONCLUSION

The validation test phase was conducted from June 2018 to October 2018, on thirteen representative test vehicles in eight different laboratories in Europe. The eight laboratories involved in the validation testing first passed through the Round Robin verification test series and the Green NCAP audit.
The first objective was to consolidate the feasibility of the test procedures and processes established by the Green NCAP technical working group established during the first verification test program conducted at the end of 2017 and beginning of 2018 and the round robin test program.

This objective has been reached and improvements have been made to test protocols out of which:

1. The increase of the test and soaking ambient temperature from 10°C to 14°C, to ease the planning constraints of laboratories.

2. Bypass of the reliance on OBD data for engine load monitoring, not systematically available and not sufficiently robust, by using measured data, that is, the energy consumption converted from carbon balance emission measurements and a “fuel / energy consumption conversion factor” to plot the engine operation area for all the tests. (See paragraph 8). This method allowed visualising how much test cycles and tests are complementary or redundant and moreover engine operation areas that are currently not sampled in any of the tests in the laboratory or on the road and hence left disregarded.

3. The development of a new maximum engine load sweep curve test methodology with a PEMS measuring on the road, (cf. paragraph 5.2.6). This method had positive feedback from the laboratories, and the relevance of results obtained are satisfying (See results and plots in Annex 3). The purpose was to prevent risking damage to laboratory equipment as the emission devices are usually not designed to deal with measurement of maximum power curves.

4. Harmonisation of the energy consumption determination for all powertrains to make them comparable within a common Energy Efficiency Index. To do so, fuel consumption of the conventional vehicles were converted into energy consumption (See paragraph 7.6) through a fixed conversion factor defined according to the reference fuel specifications. In future development if commercial fuels were to be used, the factor would have to be adapted to each test set.

5. Improvement of test mass and road load factor representatively, for tests on the chassis dynamometer taking as input the actual mass and type-approval road load parameters from the CoC for Euro6d_temp vehicles, instead of the default road load values initially used for the verification phase (based on WLTP default methodology, see paragraphs 7.8 and 7.5).

6. Investigation of the sensitivity of the GSI (gearshift indicator) on the chassis dynamometer for vehicles equipped with a manual transmission was carried out to limit the dispersion that had been acknowledged due to this device. The dispersion of results (CO2 & NOx emissions) between the two WLTC cold tests was lower than in the first verification phase, by the experience acquired on this driving mode.

7. Improvement of the time required to carry out the test program and associated cost reduction, by reducing the number and type of tests (See paragraph 5) as well as reducing the processing time of the test and rating results

The second objective was to build a database with publishable results and vehicle ratings, to monitor how vehicles react to the various test procedures and to develop a concrete rating process. This objective was achieved as the first batch of test results and associated datasets was completed from which a database was built. An improvement of the rating process was made possible by producing concrete results, a rating sheet is available for all tested vehicle (see paragraph 9 & Annex 5).

The consolidation of the results on the first batch of vehicles already highlighted trends and possible room for vehicle emission improvements. The global trends are detailed per pollutant and for the CO_2 emissions and Energy Consumption.

<u>NOx emissions:</u>

Except for the Golf TDI Euro6b and the Fiesta GDi Euro6b (under heavy conditions), all the vehicles had NOx emissions compliant with the Euro 6 limits on the WLTC tests (under all challenging test conditions).The vehicles were impacted differently by the different test conditions (See paragraph 7.1.1). Robust engine management and aftertreatment control were highlighted for a number of vehicles for which test conditions had a low impact (Audi A7 TDI, BMW X1d, VW UP! GTi, Subaru Outback 2.5i & Volvo XC40).

The comparison of the results from FTP75 and WLTC tests showed that these cycles gave similar results.
Regarding PEMS tests, exception made of the Audi A7 TDI, the impact of the “eco mode” was significant and positive leading to lower pollutants compared to the standard driving mode (downshifted on an average of -37%). The influence of the heavy load test on NOx emissions was not so obvious for all the vehicles, but the impact was still significant going from +52% to +246% (See paragraph 7.1.3).

PN emissions:

With the exception of the two Euro6b vehicles Ford Fiesta GDi and the Fiat Panda 0.9L MPi (post-fuel injection), all other vehicles complied with the PN Euro 6d limit (6e11#/km) in the various WLTC tests, under all challenging conditions. Regarding the impact of the test conditions, the trend of PN emissions was similar to the one from NOx emissions of petrol vehicles.

The vehicles equipped with GPF emitted a particularly low level during the FTP75 & BAB130 test cycles.

The same conclusions as for testing on the chassis dynamometer with respect to PN emissions could be made for the real-world tests. With the exception for the same vehicles as previously mentioned, all test vehicles emitted below the particle numbers Euro 6d limit.

The test conditions (eco & heavy engine load) had a significant impact on the emissions of the Subaru Outback 2.5i.

CO emissions:

In the WLTC & FTP75 test cycles, CO emissions were very low and way under the Euro 6 limit for the large majority of vehicles.

Only the vehicles equipped with MPI technology (post-fuel injection) were impacted by the PEMS heavy load test and the BAB130 robustness test cycle. This affected the Fiat Panda 0.9L Euro6b and Subaru Outback 2.5i. Euro6b. These excessive emissions come from air/fuel mixture enrichment at higher engine loads.

The CO emissions of the diesel vehicles were significantly below the limit.

THC emissions:

Except for the Euro6b Fiat PANDA 0.9L, the THC emissions of petrol and diesel vehicles were very low and significantly below the limit for all the tests.

CO_2 emissions:

The eco mode had a significantly positive impact on CO2 emissions, in comparison to the average value obtained from the tests conducted in standard driving mode: between -2% and -10% for the WLTC test (See paragraph 7.5.1) and -4% and -16% for the PEMS test (See. paragraph 7.5.3).

The impact of the sport mode in a WLTC test was significant, for the vehicles that were equipped with it, in comparison to the test results obtained in eco mode (between +2% & +12%).

The impact of heavy conditions on the WLTC was significant for the two vehicles Ford Fiesta 1L GDi Euro6b and Euro6d temp version (+ 6% and +5% respectively, in comparison with the average test values obtained in standard driving mode and including cold start), and the Fiat Panda 0.9L. These two vehicles were equipped with low displacement engines, and the last ones were associated with a MPI technology.

Except for the BMW X1d, the impact of the heavy mode on PEMS tests was important for all the vehicles compared with the standard one (between +5% & +45%).

The combined effect of driving style and manufacturer fuelling and combustion initiation strategies have a major impact on the results. Downsized engine vehicles tend to see their CO_2 emissions increased when tested in heavy conditions. Also the MPI technology results in an increase in CO2 emissions caused by enrichment of the air / fuel mixture at higher engine loads. A specific analysis of the Fiat Panda and the Subaru Outback results was made available in paragraph 7.10 and provides the details.

The emissions on the FTP75 cycle were similar to those on the WLTC. The emissions on BAB130 were substantially higher than on any other test cycle.

Energy Consumption:

The Green NCAP program needs to be able to compare pure electric vehicles to ICE vehicles. Therefore, in order to compare the energy efficiency of these vehicles with the conventional ICE other vehicles, it was necessary to convert the ICE vehicle fuel consumption (L/100km) in TtW energy consumption (kWh / 100km).

The two PEV tested in the validation phase, Hyundai Ioniq and BMW i3, have been used as benchmark in terms of TtW energy efficiency. The energy consumption value of these two vehicles was considerably lower than that of ICE vehicles for all tests (-76% on average).

The impact of the type of test and the WLTC & PEMS test conditions on the energy consumption of the two PEV was the same as for the ICE vehicles, whose the trend was the same as CO_2 emissions.

The output of this final phase of the pilot program also encompasses a recommendation for future optimisation of the Green NCAP fully fledged program procedures.

1. FTP75 and WLTC tests sampled in similar engine speed – engine load areas and gave similar results. Therefore, deleting the FTP75 test cycle from the test matrix could be a possibility to shorten the final Green NCAP test procedure.

2. It would be more relevant to compare WLTC_warm_eco and WLTC test results with a WLTC_warm_standard test instead of WLTC_cold_standard. Therefore, reintroducing the WLTC_warm_standard test cycle to the test matrix could improve the final Green NCAP test procedure.

3. This program allowed developing the use of fuel consumption from carbon balance (mg/s) as a reference for the calculation of energy consumption (Wh/s). This method is however restrictive because, in some cases, it is not possible to obtain a value of energy consumption and it only covers tank to wheel consumption. It is necessary that engine load (torque, IMEP or fuel mass flow) can be directly read from the vehicle over the OBD port. Today, the calculated OBD load variable is an engine control estimation made by the ECU software and not a measured value. Also, it is not reliable as it does not correlate with the actual engine load. Therefore, it is necessary to evaluate the quality of the OBD load variable by directly comparing it with the carbon balance load value and torque measurements during the next steps of the program.

4. All phases of the pilot program revealed that few tests with a DPF regeneration occurred. To easily disqualify tests with regeneration, it will be necessary to develop a quick and easy method to detect any regeneration to notify the driver in the shortest possible manner.

5. In order to improve the absolute results of CO_2 emissions, it will be needed to standardise the measurement of the battery current whose balance allows correcting the CO_2 value (RCB).

6. The validation phase did not reveal any problem with NOx emissions dispersion caused by the following of GSI on the chassis dynamometer. It can be concluded that this constraint was resolved by the laboratories. However, it will be necessary to develop a method to optimise shifting by GSI.

7. The heavy PEMS tests carried out on the Fiat Panda 0.9L and on the Subaru Outback 2.5i highlighted the need to revise the robustness test method, which must better take into account the kind of vehicle tested (sports car, small engine, etc.) in the definition of the test conditions. A study on this key issue is already ongoing within the working group. The objective will be to obtain more relevant and equitable test procedures independent from the type of vehicle and the laboratory in charge of the testing.

Overall, the pilot program has reached its objectives and succeeded in setting up a complete testing and rating process to incentivise greener cars in no more than 20 months' time. The Green NCAP program now enters in its Phase 1 with a fully-fledged program and intends to continue to improve the test procedures and assess the issues compiled in the road map such as driving resistance, cold test, new pollutants etc.

ANNEX 1

Summary of emissions test results
Validation phase

The grey box in the following tables correspond to non-performed tests or analysis problems during the tests

- **Petrol vehicles**

Vehicle	Cycle	Test	CO	THC	CH4	NMHC	NOx	PM	PN	CO2	FC	Energy
			mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	#/km	g/km	L/100km	kWh/100km
UTAC Ford Fiesta 1L GDi EcoBoost Euro6b (RRT)	**WLTC**	WLTC Cold Default 1	397	52	5	46	44		2,5E+12	124,5	5,52	47,4
		WLTC Cold Default 2	453	52	6	45	42		2,5E+12	124,4	5,52	47,4
		WLTC Warm ECO	241	14	3	11	36		1,4E+12	121,1	5,35	46,0
		WLTC Warm SPORT										
		WLTC Warm Heavy	267	15	3	12	70		1,4E+12	131,4	5,81	49,9
	US-BAB	FTP75 Cold	285	42	5	37	37		2,8E+12	129,1	5,71	49,1
		BAB130 Warm	1075	28	5	23	121		2,0E+12	152,3	6,79	58,3
	PEMS	PEMS Cold Default (RDE)	391				49		9,9E+11	130,3	5,68	48,8
		PEMS Cold Eco	231				25		2,1E+12	109,4	4,80	41,2
		PEMS Warm Heavy	521				74		1,1E+12	157,7	6,8	58,6
MIRA Ford Fiesta 1L GDi EcoBoost Euro6d_T	**WLTC**	WLTC Cold Default 1	140	24	3	20	18	1	3,5E+11	158,3	6,96	59,8
		WLTC Cold Default 2	156	26	4	22	22	0	3,8E+11	155,6	6,85	58,8
		WLTC Warm ECO	135	12	3	10	20	0	2,3E+11	154,2	6,78	58,2
		WLTC Warm SPORT										
		WLTC Warm Heavy	47	2	2	1	12	1	2,7E+11	165,3	7,26	62,4
	US-BAB	FTP75 Cold	186	24	3	21	16		3,3E+11	155,3	6,82	58,6
		BAB130 Warm	189	4	1	1	2		7,1E+11	189,7	8,34	71,6
	PEMS	PEMS Cold Default (RDE)	52				12		2,3E+11	142,5	6,3	54,1
		PEMS Cold Eco	84				10		1,9E+11	129,9	5,7	49,0
		PEMS Warm Heavy	10				27		4,1E+11	179,2	7,8	67,0
ACI-CSI Fiat Panda 0.9L Twinair	**WLTC**	WLTC Cold Default 1	690	77	7	70	35	3	6,0E+11	135,7	5,80	49,8
		WLTC Cold Default 2	647	69	6	63	30	3	4,3E+12	134,4	5,79	49,7
		WLTC Warm ECO	294	11	3	9	5	1	2,5E+12	125,0	5,40	46,4
		WLTC Warm SPORT	420	25	5	21	19	1	3,0E+12	126,5	5,43	46,6
		WLTC Warm Heavy	709	38	7	31	13	2	4,8E+12	138,9	5,98	51,4
	US-BAB	FTP75 Cold	466	85	6	78	49	3	6,0E+12	127,8	5,49	47,2
		BAB130 Warm	2882	53	17	38	4	2	5,3E+12	173,1	7,60	65,3
	PEMS	PEMS Cold Default (RDE)	721				14		3,1E+12	150,0	7,3	57,0
		PEMS Cold Eco	308				8		9,2E+11	140,5	6,8	53,2
		PEMS Warm Heavy	3571				30		1,4E+12	218,0	10,9	84,7
IDIADA Mercedes A200 120 kW Petrol	**WLTC**	WLTC Cold Default 1	142	30	3	27	21	1	2,3E+11	156,0	6,88	59,1
		WLTC Cold Default 2	233	46	4	41	26	1	3,1E+11	159,0	7,01	60,2
		WLTC Warm ECO	58	4	1	2	4	0	1,0E+10	142,3	6,26	53,8
		WLTC Warm SPORT	79	7	1	5	19	0	1,5E+09	158,7	6,99	60,0
		WLTC Warm Heavy	86	10		8	38		1,3E+10	159,5	6,87	59,0
	US-BAB	FTP75 Cold	217	30	3	27	17		4,1E+11	171,1	7,40	63,6
		BAB130 Warm	284	14	4	10	41	2,6	2,5E+10	164,7	7,11	61,1
	PEMS	PEMS Cold Default (RDE)	75	9			11		1,9E+10	154,5	6,45	55,4
		PEMS Cold Eco	71	7			6		2,6E+10	141,9	5,93	51,0
		PEMS Warm Heavy	416	11			35		4,2E+10	188,0	8,07	69,3

			CO	THC	CH4	NMHC	NOx	PM	PN	CO2	FC	Energy
			mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	#/km	g/km	L/100km	kWh/100km
TCS-EMPA Subaru Outback 2.5i	**WLTC**	WLTC Cold Default 1	717	41	4	39	19	0,2	3,3E+11	193,5	8,55	73,4
		WLTC Cold Default 2	644	48	3	49	22	0,2	5,4E+11	191,0	8,44	72,5
		WLTC Warm ECO										
		WLTC Warm SPORT	372	0	1	1	11	0,1	1,3E+11	191,2	8,42	72,3
		WLTC Warm Heavy	574	2	1	2	11	0,1	9,5E+10	192,3	8,48	72,8
	US-BAB	FTP75 Cold	638	55	4	52	28	0,1	4,7E+11	203,5	8,99	77,2
		BAB130 Warm	22148	55	26	26	3	1,5	1,9E+12	204,1	10,50	90,2
	PEMS	PEMS Cold Default (RDE)	238				14		7,6E+10	164,1	7,2	63,1
		PEMS Cold Eco	185				8		6,4E+10	148,4	6,5	57,0
		PEMS Warm Heavy	9535				14		5,2E+11	216,8	10,2	88,9
ICRT-ADAC Volvo XC40	**WLTC**	WLTC Cold Default 1	122	23	5	23	15	0	4,4E+11	193,9	8,27	71,0
		WLTC Cold Default 2	113	19	4	19	14	0	3,1E+11	182,2	7,78	66,8
		WLTC Warm ECO	103	2	1	2	1	0	5,6E+10	176,0	7,77	66,7
		WLTC Warm SPORT	111	4	2	4	4	0	1,7E+10	197,8	8,73	75,0
		WLTC Warm Heavy	97	5	3	5	3	0	5,9E+09	186,5	7,95	68,3
	US-BAB	FTP75 Cold	155	37	5	37	13	0	6,4E+11	194,9	8,61	74,0
		BAB130 Warm	6664	27	13	28	19	3	5,1E+11	234,8	10,46	89,9
	PEMS	PEMS Cold Default (RDE)	135				6		7,2E+09	186,0	7,8	67,0
		PEMS Cold Eco	98				3		3,2E+10	176,8	7,4	63,7
		PEMS Warm Heavy	226				5		1,2E+10	195,2	8,2	70,4
BAST-ADAC VW Up GTI	**WLTC**	WLTC Cold Default 1	189	31		31	14	0	2,2E+11	126,1	5,39	53,1
		WLTC Cold Default 2	172	36		36	16	0	1,7E+11	121,7	5,20	51,3
		WLTC Warm ECO	51	4		4	11	0	5,4E+10	121,3	5,17	51,0
		WLTC Warm SPORT										
		WLTC Warm Heavy	38	5		5	16	0	6,5E+10	128,9	5,50	54,2
	US-BAB	FTP75 Cold	105	37		37	22	0	2,1E+11	133,0	5,68	56,0
		BAB130 Warm	967	22		23	7	3,2	2,5E+11	165,3	7,11	70,1
	PEMS	PEMS Cold Default (RDE)	122				15		4,2E+10	138,7	5,8	50,0
		PEMS Cold Eco	130				13		3,2E+10	132,8	5,6	47,9
		PEMS Warm Heavy	92				15		6,2E+10	151,9	6,4	54,7

- **Diesel & PEV vehicles**

Vehicle	Cycle	Test	CO	THC	CH4	NMHC	NOx	PM	PN	CO2	FC	Energy
			mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	#/km	g/km	L/100km	kWh/100km
FIA-ADAC Audi A7 TDI	**WLTC**	WLTC Cold Default 1	181	31			31	0	3,5E+08	202,4	7,67	75,6
		WLTC Cold Default 2	123	26			26	0	1,1E+09	193,3	7,32	72,2
		WLTC Warm ECO	19	7			27	0	6,6E+08	181,5	6,87	67,7
		WLTC Warm SPORT	55	12			19	0	4,3E+08	187,6	7,10	70,0
		WLTC Warm Heavy	37	10			9	0	3,5E+08	181,1	6,86	67,6
	US-BAB	FTP75 Cold	198	37			29	0	5,3E+08	211,2	8,01	79,0
		BAB130 Warm	25	2			262	1	1,0E+10	222,7	8,43	83,1
	PEMS	PEMS Cold Default (RDE)	81				9		5,6E+08	174,9	6,6	65,3
		PEMS Cold Eco	60				15		4,7E+08	179,8	6,8	67,1
		PEMS Warm Heavy	46				29		1,3E+09	185,9	7,0	69,4
MIRA BMW X1d	**WLTC**	WLTC Cold Default 1	67	26	20	8	21	0,1	1,1E+11	139,0	5,30	52,3
		WLTC Cold Default 2	58	28	20	8	18	0,1	2,8E+10	141,3	5,39	53,1
		WLTC Warm ECO	26	21	19	4	7	0,1	2,4E+11	135,6	5,17	51,0
		WLTC Warm SPORT	23	21	19	3	20	0,1	1,3E+08	137,7	5,25	51,8
		WLTC Warm Heavy	15	19	18	2	6	0,1	3,5E+08	140,4	5,35	52,8
	US-BAB	FTP75 Cold	217	37	25	14	90	0,9	2,2E+10	142,9	5,35	52,8
		BAB130 Warm	38	55	47	11	3	0,0	8,6E+07	168,7	6,44	63,4
	PEMS	PEMS Cold Default (RDE)	134				45		2,7E+09	167,4	6,4	63,1
		PEMS Cold Eco	117				31		2,3E+08	141,8	5,4	53,3
		PEMS Warm Heavy	64				91		2,9E+08	168,6	6,4	63,1
ADAC VW Golf 1.6L TDI Euro6b (RRT)	**WLTC**	WLTC Cold Default 1	12	13			105	0	3,2E+09	126,2	4,79	47,2
		WLTC Cold Default 2	30	17			140	0	1,2E+10	126,4	4,80	47,3
		WLTC Warm ECO										
		WLTC Warm SPORT										
		WLTC Warm Heavy	3	9			177	0	7,6E+09	126,2	4,79	47,2
	US-BAB	FTP75 Cold	45	13			103	0	4,8E+11	126,2	4,79	47,2
		BAB130 Warm	37	13			454	0,7	6,3E+09	156,9	5,96	58,8
	PEMS	PEMS Cold Default (RDE)	36				74		7,3E+09	127,0	4,8	47,4
		PEMS Cold Eco	19				43		3,8E+09	115,2	4,4	43,0
		PEMS Warm Heavy	34				124		3,8E+09	134,1	5,1	50,1
IFA Hyundai Ioniq EV	**WLTC**	WLTC Cold Default 1										13,2
		WLTC Cold Default 2										
		WLTC Warm ECO										12,7
		WLTC Warm SPORT										12,8
		WLTC Warm Heavy										14,7
	US-BAB	FTP75 Cold										11,7
		BAB130 Warm										19,3
	PEMS	PEMS Cold Default (RDE)										12,7
		PEMS Cold Eco										11,8
		PEMS Warm Heavy										15,9
IFA BMW i3 EV	**WLTC**	WLTC Cold Default 1										14,9
		WLTC Cold Default 2										13,2
		WLTC Warm ECO										12,9
		WLTC Warm SPORT										
		WLTC Warm Heavy										16,7
	US-BAB	FTP75 Cold										13,6
		BAB130 Warm										19,8
	PEMS	PEMS Cold Default (RDE)										16,6
		PEMS Cold Eco										15,4
		PEMS Warm Heavy										19,2

ANNEX 2

Summary of emissions test results
validation vs verification test phases
Ford Fiesta Euro6b & VW Golf Euro6b

- **Ford Fiesta 1L GDi Euro6b :**

Ford Fiesta 1L EcoBoost Euro6b			CO	THC	NOx	PN	CO2
			mg/km	mg/km	mg/km	#/km	g/km
WLTC Cold DEF	Verification phase		613	73	75	3,5E+12	151,5
	Validation phase		425	52	43	2,5E+12	124,5
	Comparision Validation/Verification	Abs.	**-188**	**-21**	**-32**	**-9,5E+11**	**-27,1**
		Rel.	**-31%**	**-29%**	**-43%**	**-27%**	**-18%**
WLTC Warm ECO	Verification phase		384	19	39	1,6E+12	145,2
	Validation phase		241	14	36	1,4E+12	121,1
	Comparision Validation/Verification	Abs.	**-143**	**-5**	**-3**	**-1,7E+11**	**-24,1**
		Rel.	**-37%**	**-27%**	**-7%**	**-11%**	**-17%**
WLTC Warm heavy	Verification phase		458	24	72	1,5E+12	160,9
	Validation phase		267	15	70	1,4E+12	131,4
	Comparision Validation/Verification	Abs.	**-191**	**-8**	**-1**	**-1,4E+11**	**-29,5**
		Rel.	**-42%**	**-35%**	**-2%**	**-9%**	**-18%**
FTP75 Cold	Verification phase		274	45	34	3,8E+12	152,2
	Validation phase		285	42	37	2,8E+12	129,1
	Comparision Validation/Verification	Abs.	**11**	**-3**	**2**	**-9,4E+11**	**-23,1**
		Rel.	**4%**	**-6%**	**7%**	**-25%**	**-15%**
BAB130 Warm	Verification phase		1034	40	137	1,9E+12	188,8
	Validation phase		1075	28	121	2,0E+12	152,3
	Comparision Validation/Verification	Abs.	**41**	**-12**	**-16**	**1,1E+11**	**-36,5**
		Rel.	**4%**	**-30%**	**-12%**	**6%**	**-19%**
Synthesis comparision Validation/Verification		**Abs.**	**-94**	**-10**	**-10**	**-4,2E+11**	**-28**
		Rel.	**-20%**	**-25%**	**-11%**	**-13%**	**-17%**

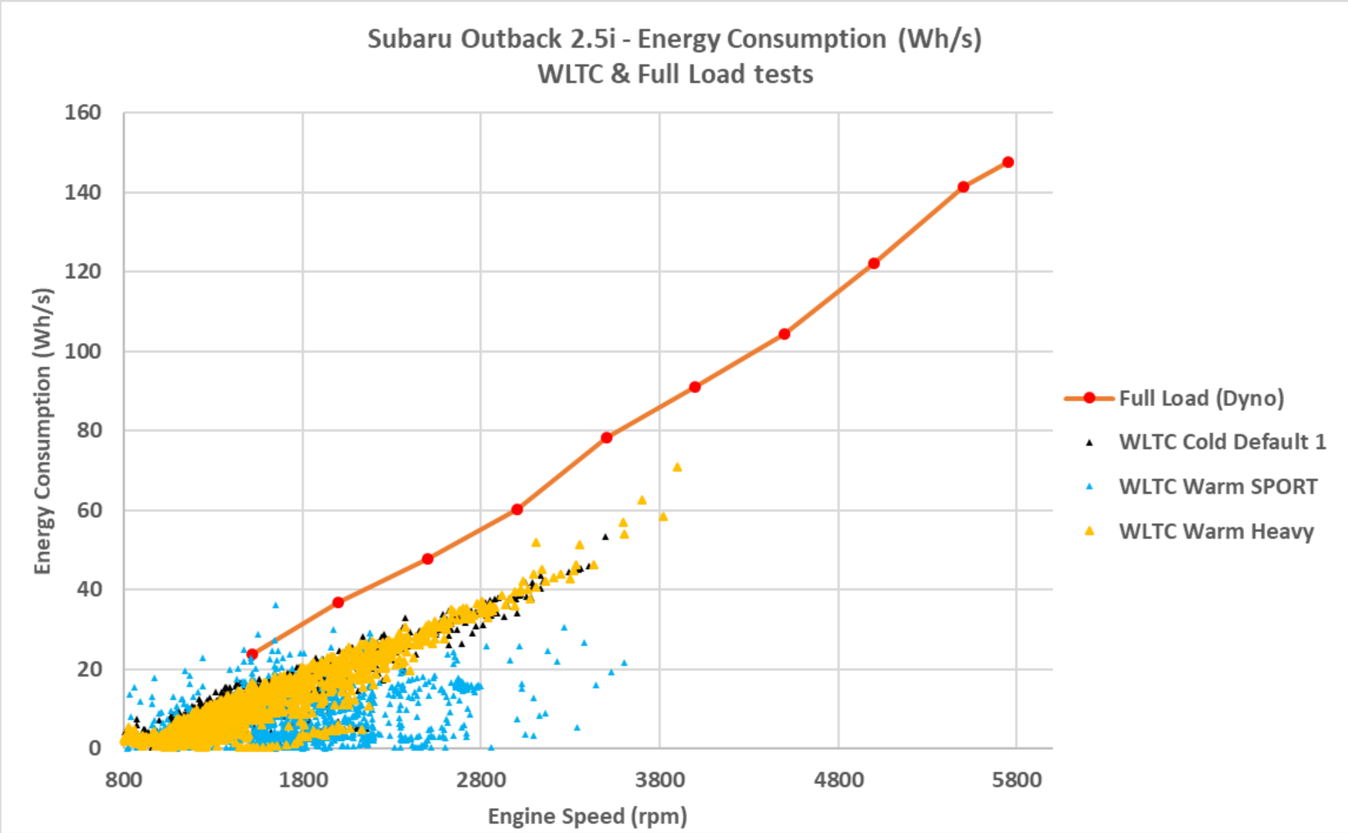
- **VW Golf TDI Euro6b :**

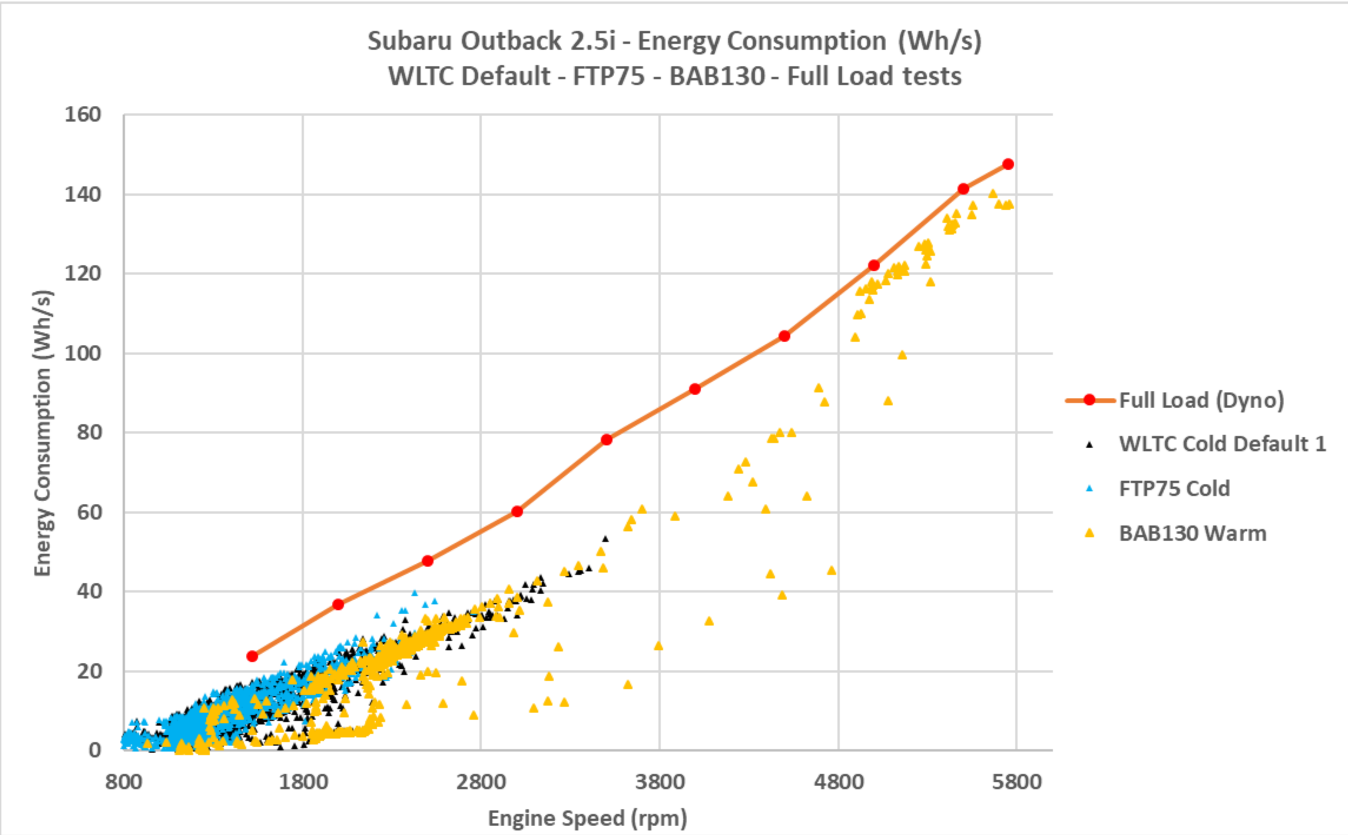
VW Golf 1.6L TDI Euro6b			CO	THC	NOx	PN	CO2
			mg/km	mg/km	mg/km	#/km	g/km
WLTC Cold DEF	Verification phase		93	24	215	2,0E+10	158,1
	Validation phase		21	15	123	7,5E+09	126,3
	Comparision Validation/Verification	Abs.	**-72**	**-9**	**-93**	**-1,2E+10**	**-31,8**
		Rel.	**-77%**	**-36%**	**-43%**	**-62%**	**-20%**
WLTC Warm ECO	Verification phase						
	Validation phase						
	Comparision Validation/Verification	Abs.					
		Rel.					
WLTC Warm heavy	Verification phase		3	13	276	4,6E+09	163,5
	Validation phase		3	9	177	7,6E+09	126,2
	Comparision Validation/Verification	Abs.	**0**	**-4**	**-99**	**3,1E+09**	**-37,3**
		Rel.	**0%**	**-31%**	**-36%**	**67%**	**-23%**
FTP75 Cold	Verification phase		39	14	141	1,0E+11	150,0
	Validation phase		45	13	103	4,8E+11	126,2
	Comparision Validation/Verification	Abs.	**6**	**-1**	**-38**	**3,8E+11**	**-23,8**
		Rel.	**15%**	**-7%**	**-27%**	**372%**	**-16%**
BAB130 Warm	Verification phase		3	15	591	9,3E+09	199,3
	Validation phase		37	13	454	6,3E+09	156,9
	Comparision Validation/Verification	Abs.	**34**	**-2**	**-137**	**-2,9E+09**	**-42,4**
		Rel.	**1133%**	**-13%**	**-23%**	**-32%**	**-21%**
Synthesis comparision Validation/Verification		**Abs.**	**-8**	**-4**	**-92**	**9,1E+10**	**-34**
		Rel.	**268%**	**-22%**	**-32%**	**86%**	**-20%**

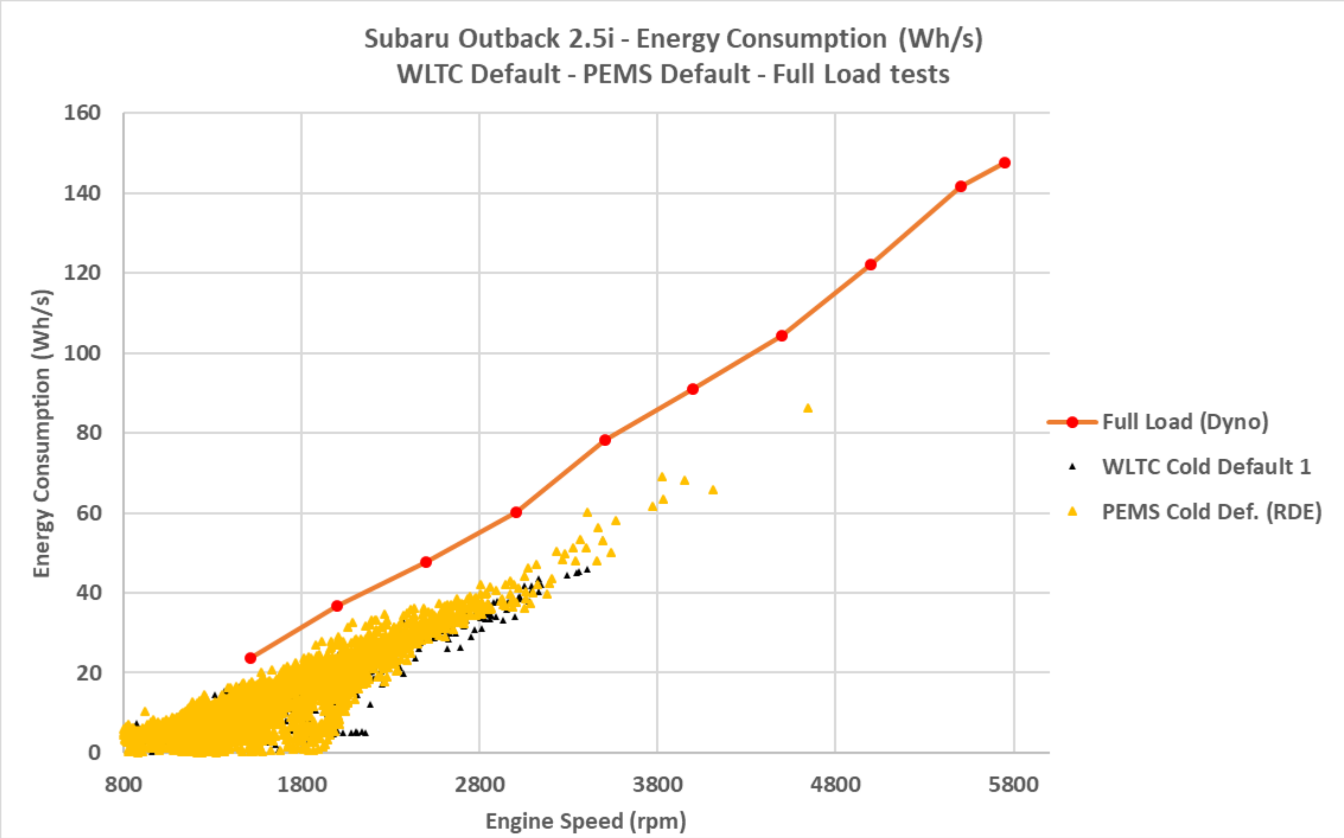
ANNEX 3

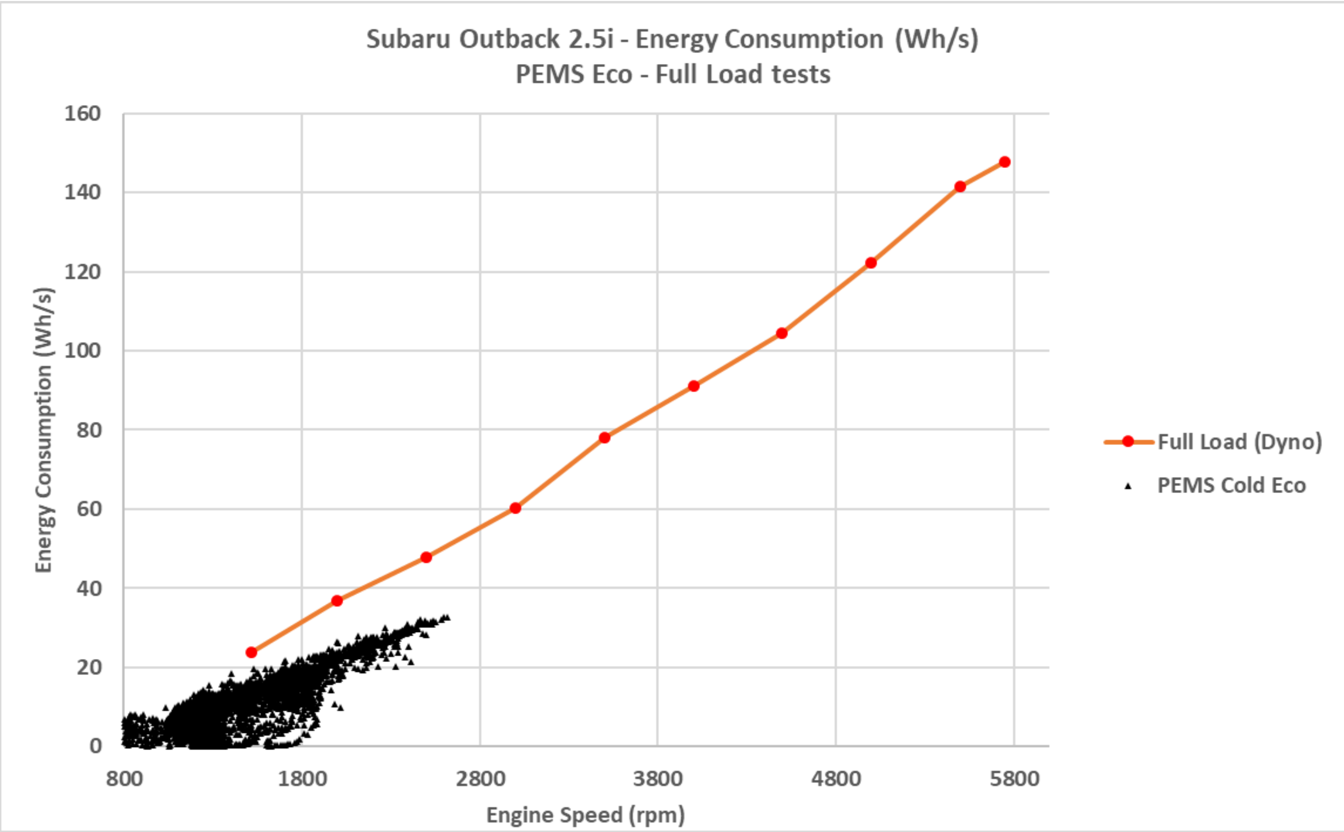
Engine speed – engine load sampling area from all vehicles

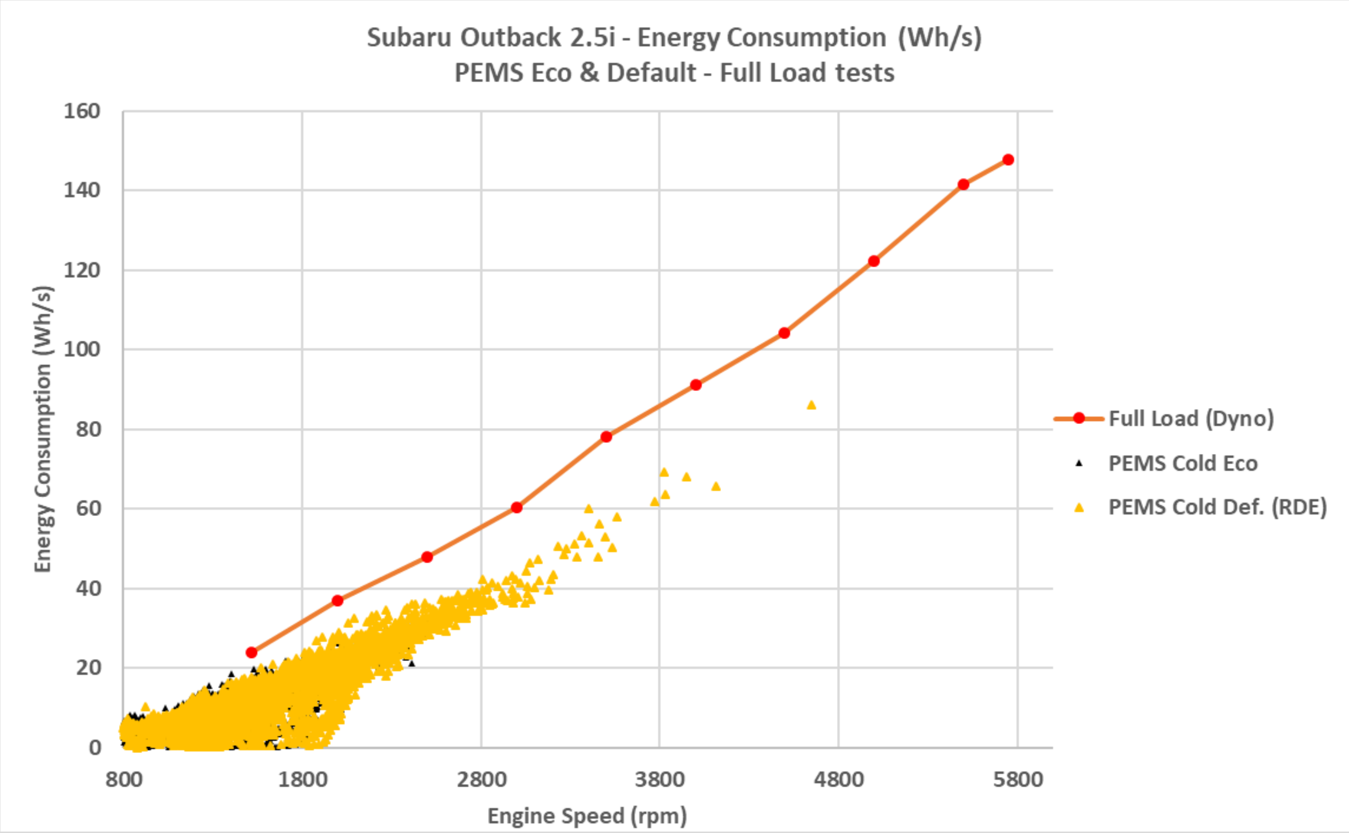
- **Subaru Outback 2.5i from EMPA-TCS**

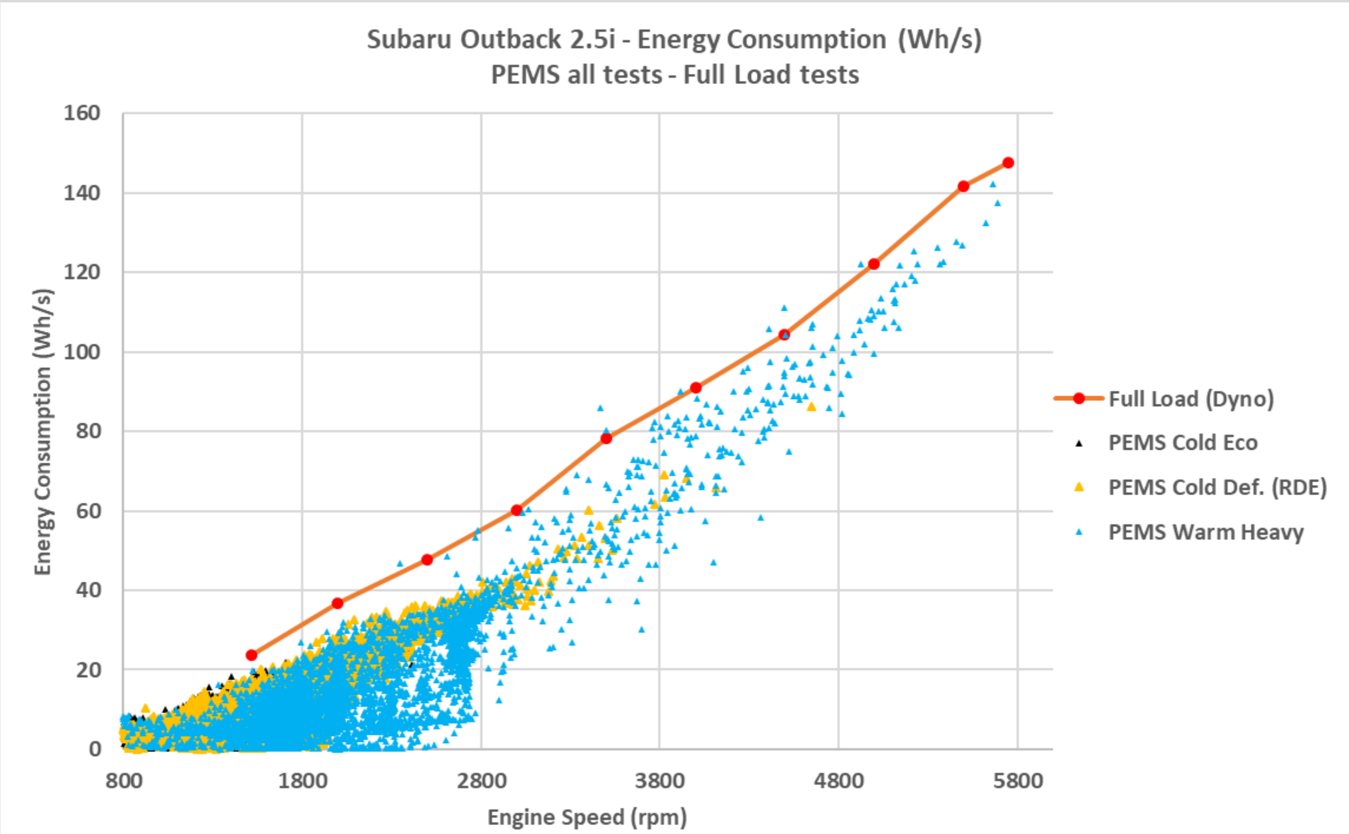




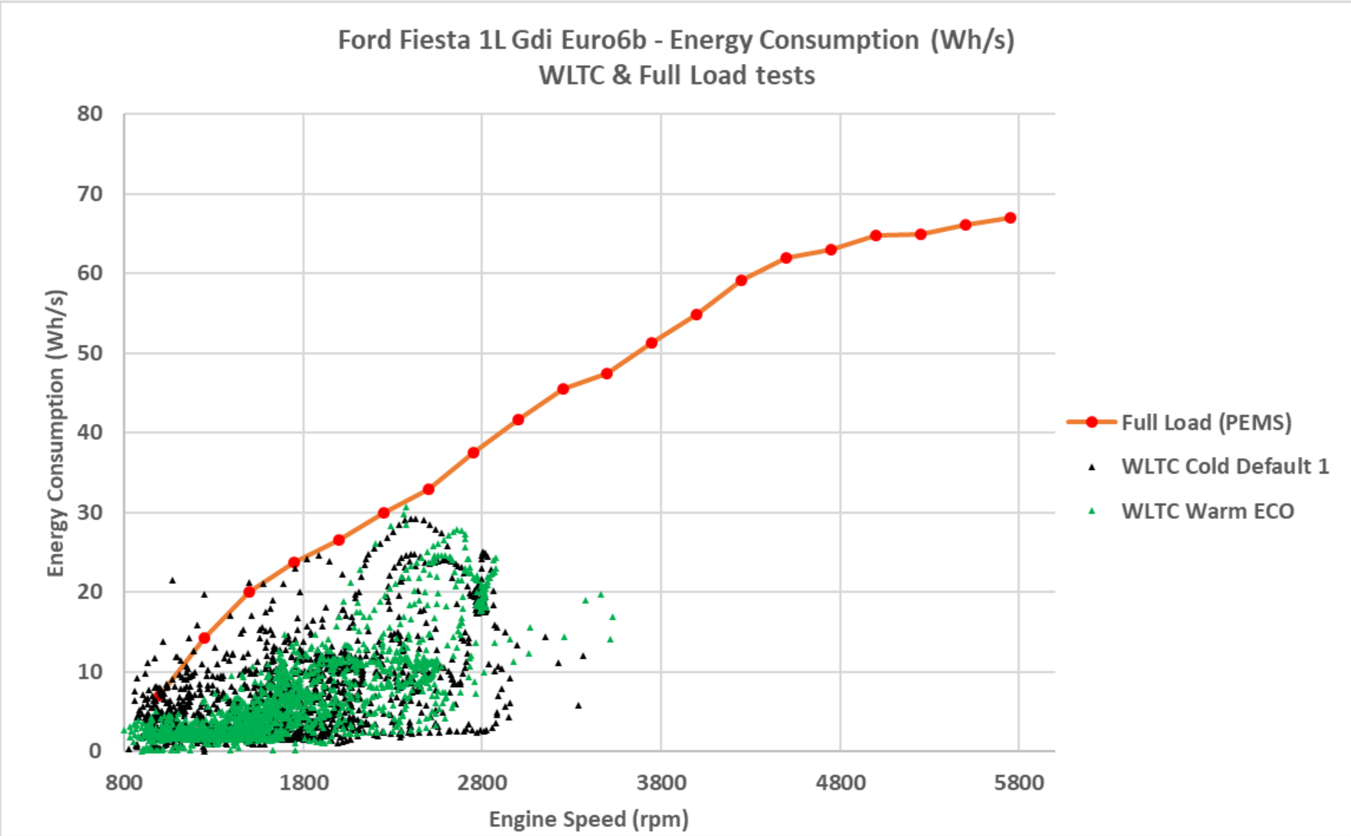

Subaru Outback 2.5i - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

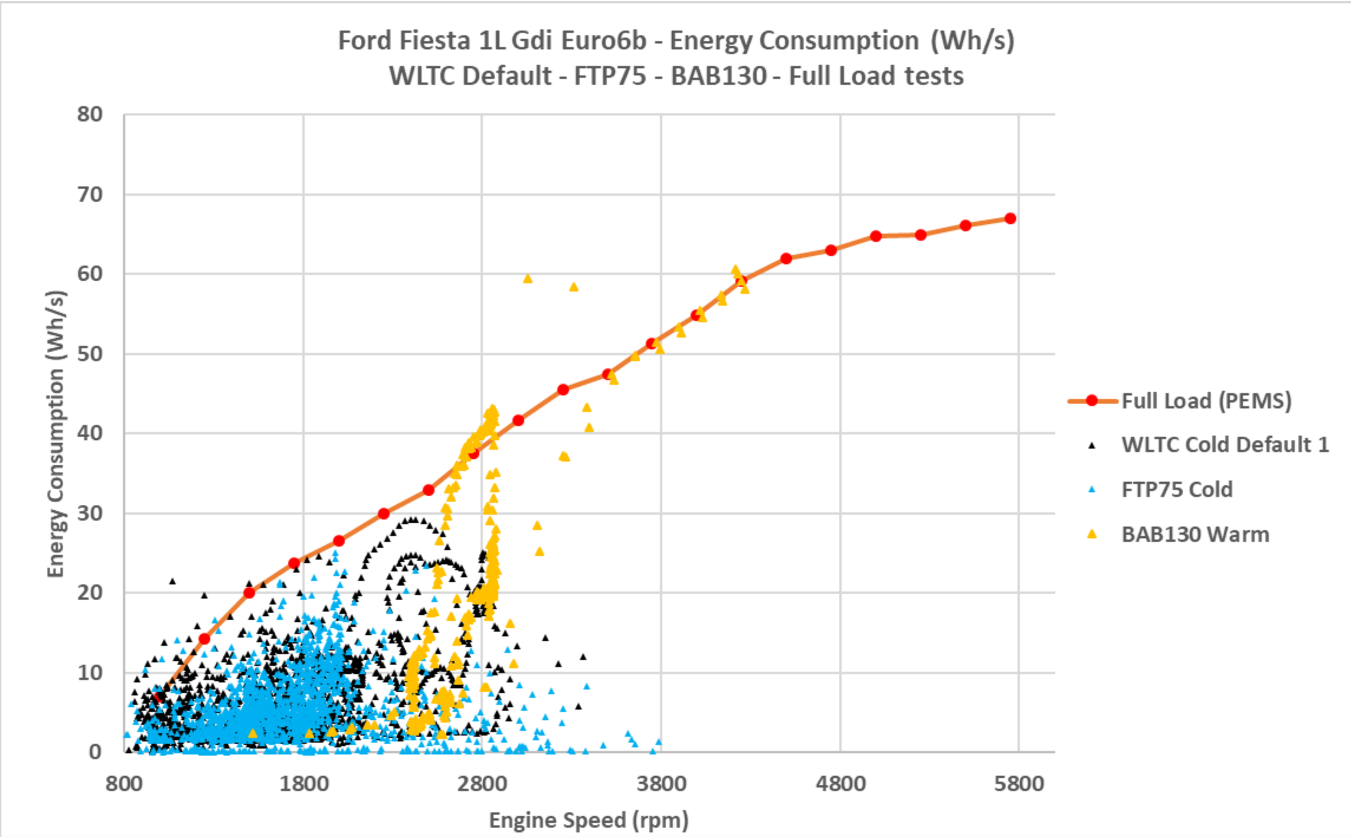

Subaru Outback 2.5i - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco

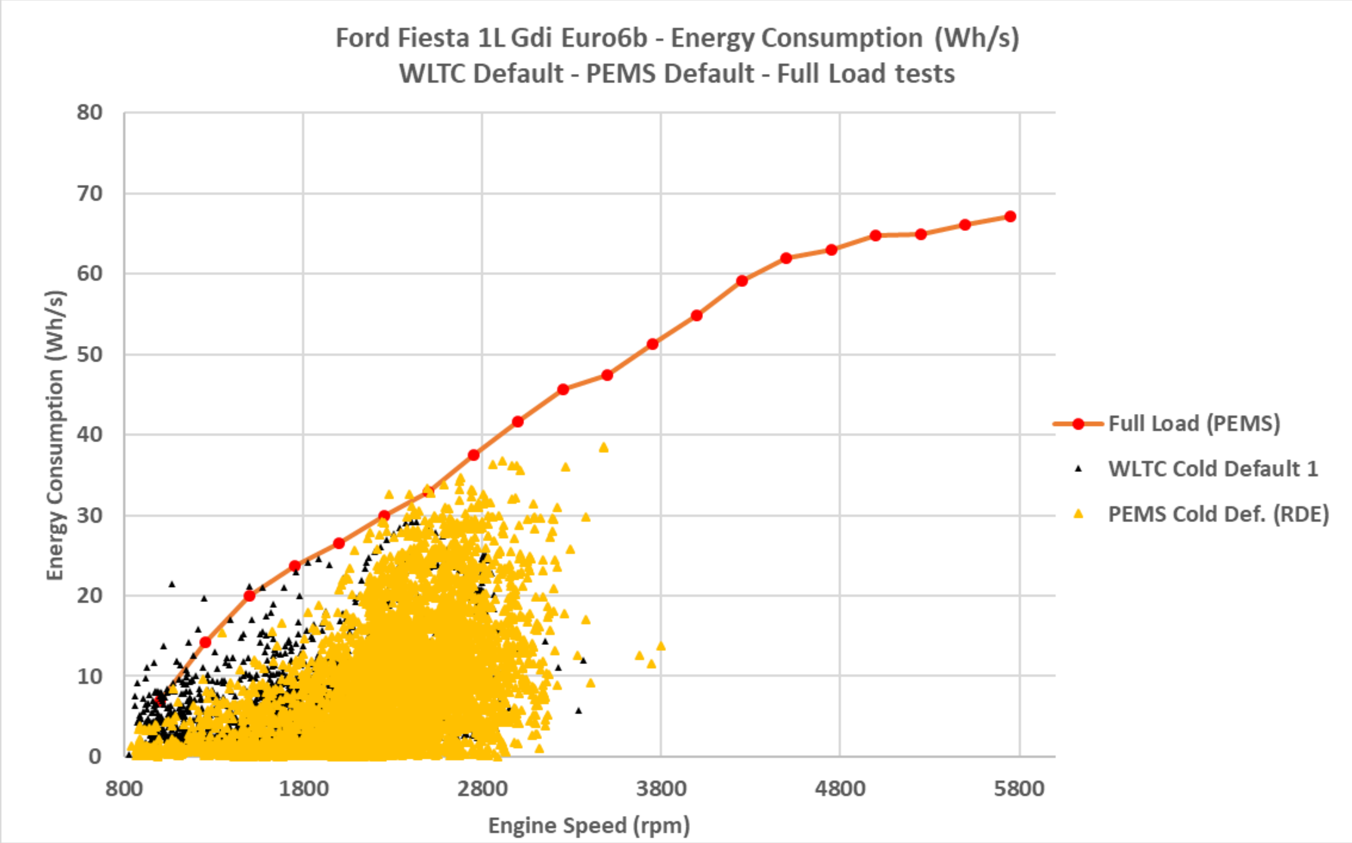

Subaru Outback 2.5i - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)

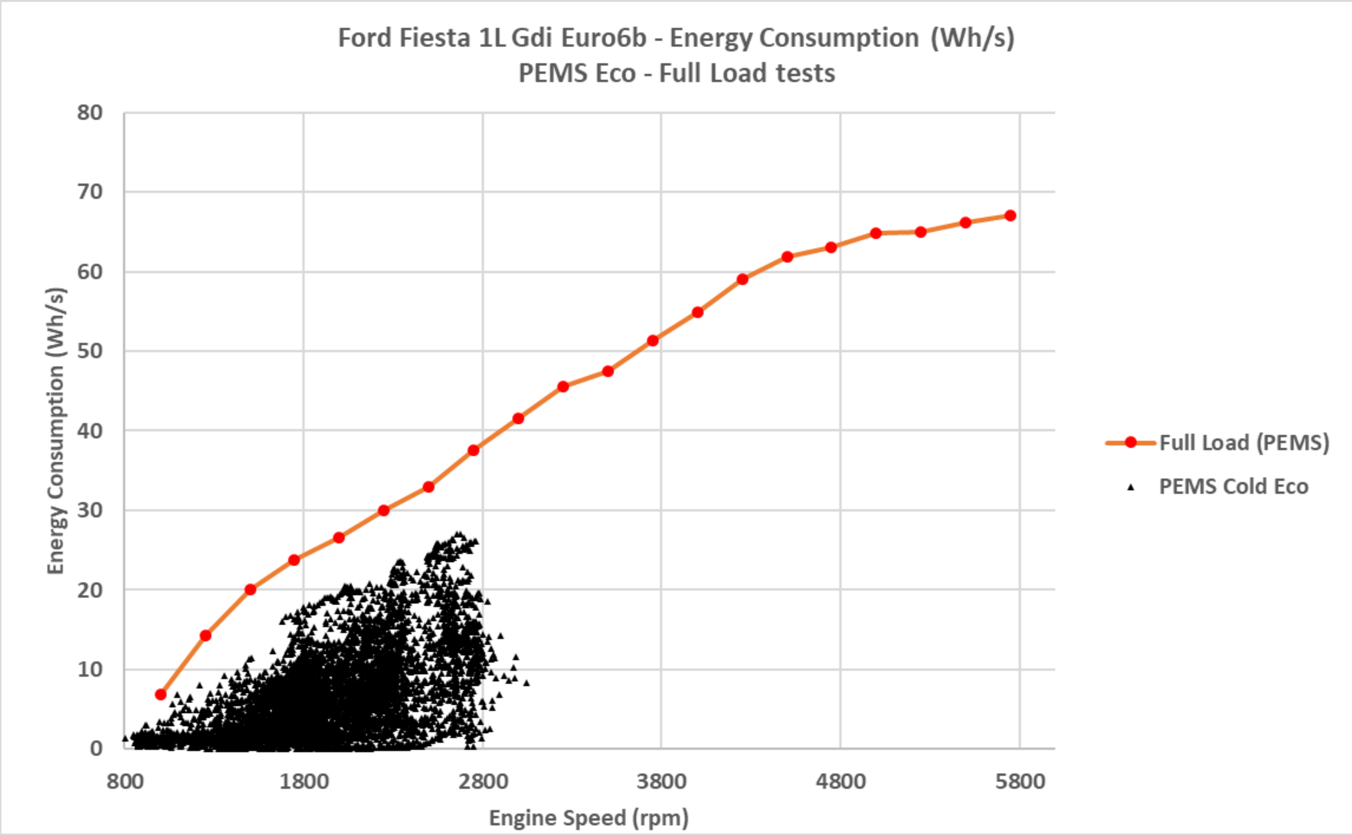

Subaru Outback 2.5i - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

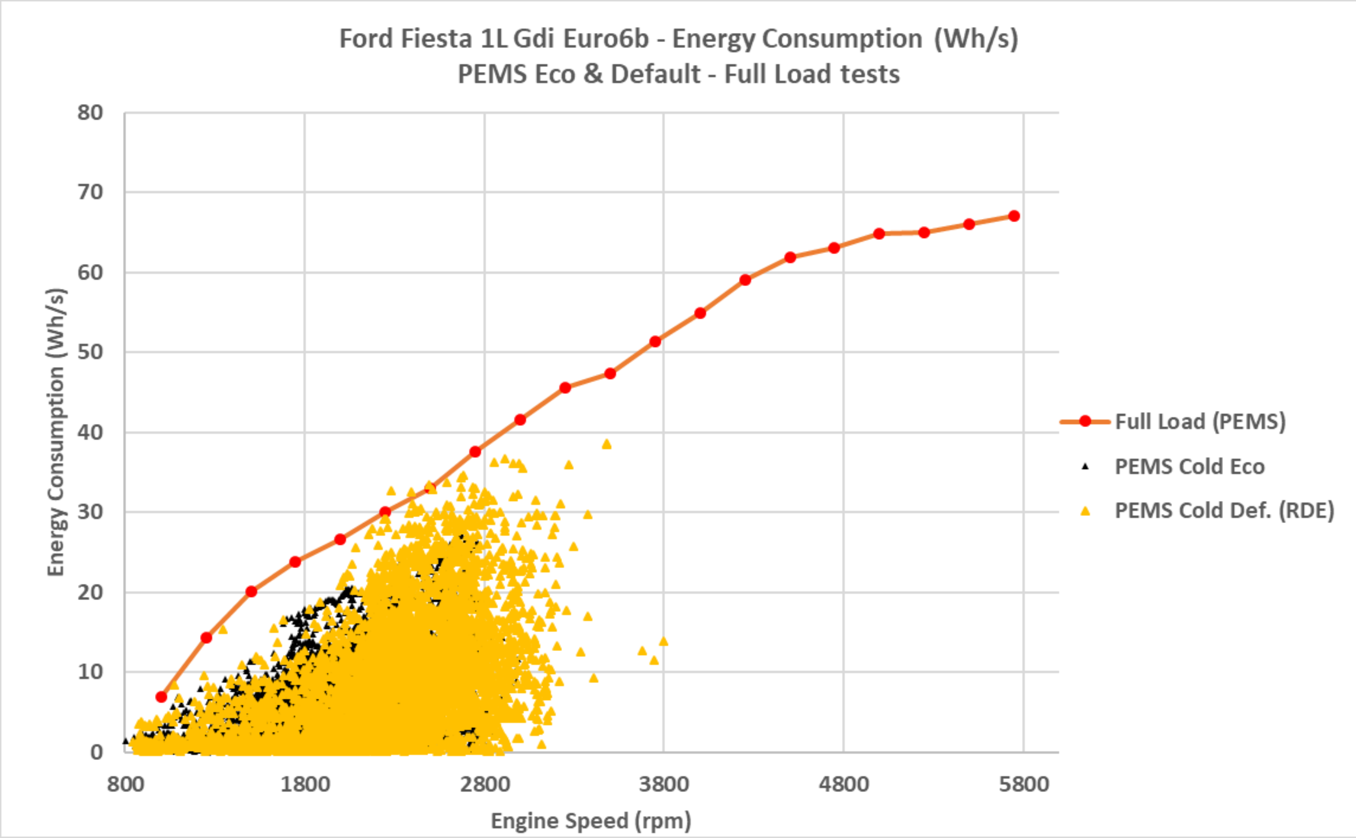
- **Ford Fiesta 1L GDi Euro6b from UTAC**

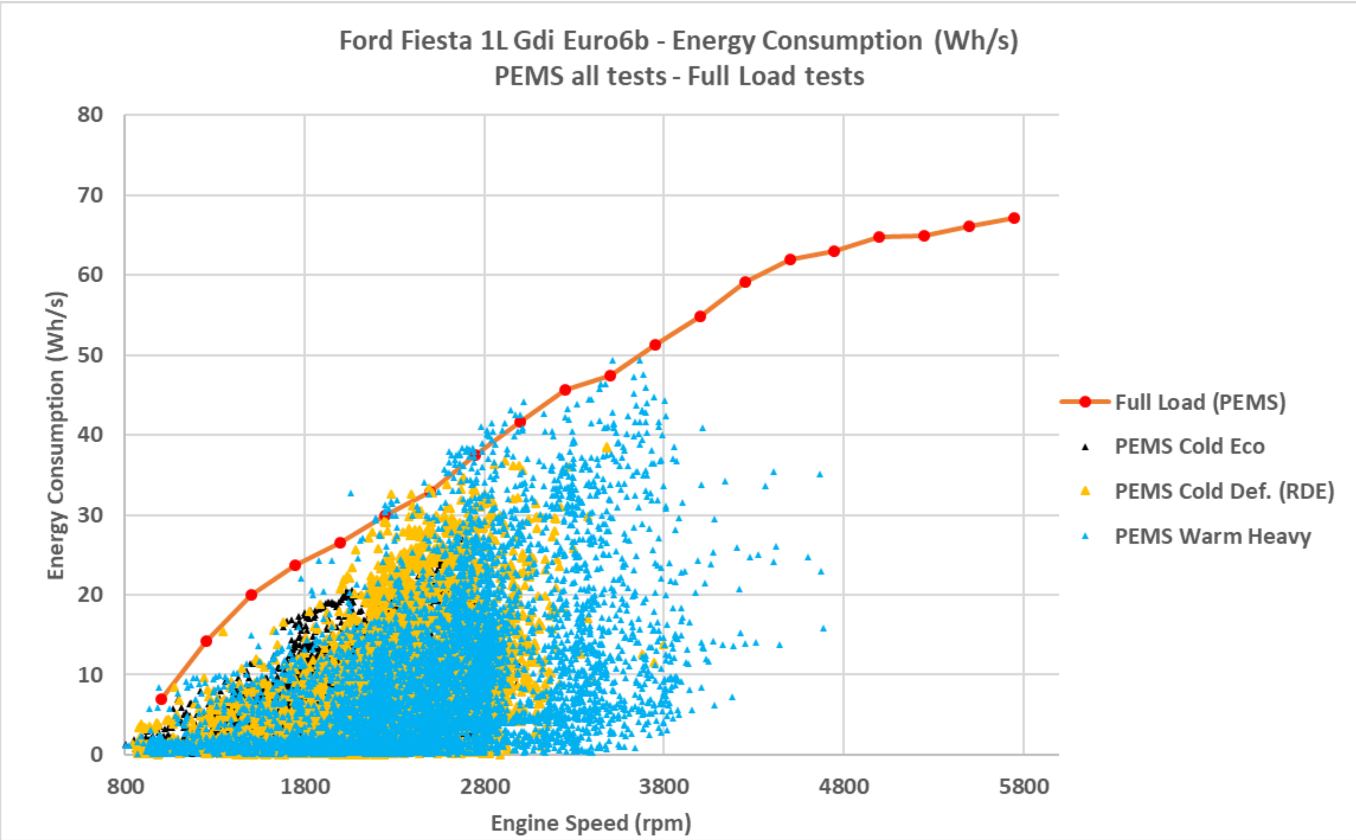




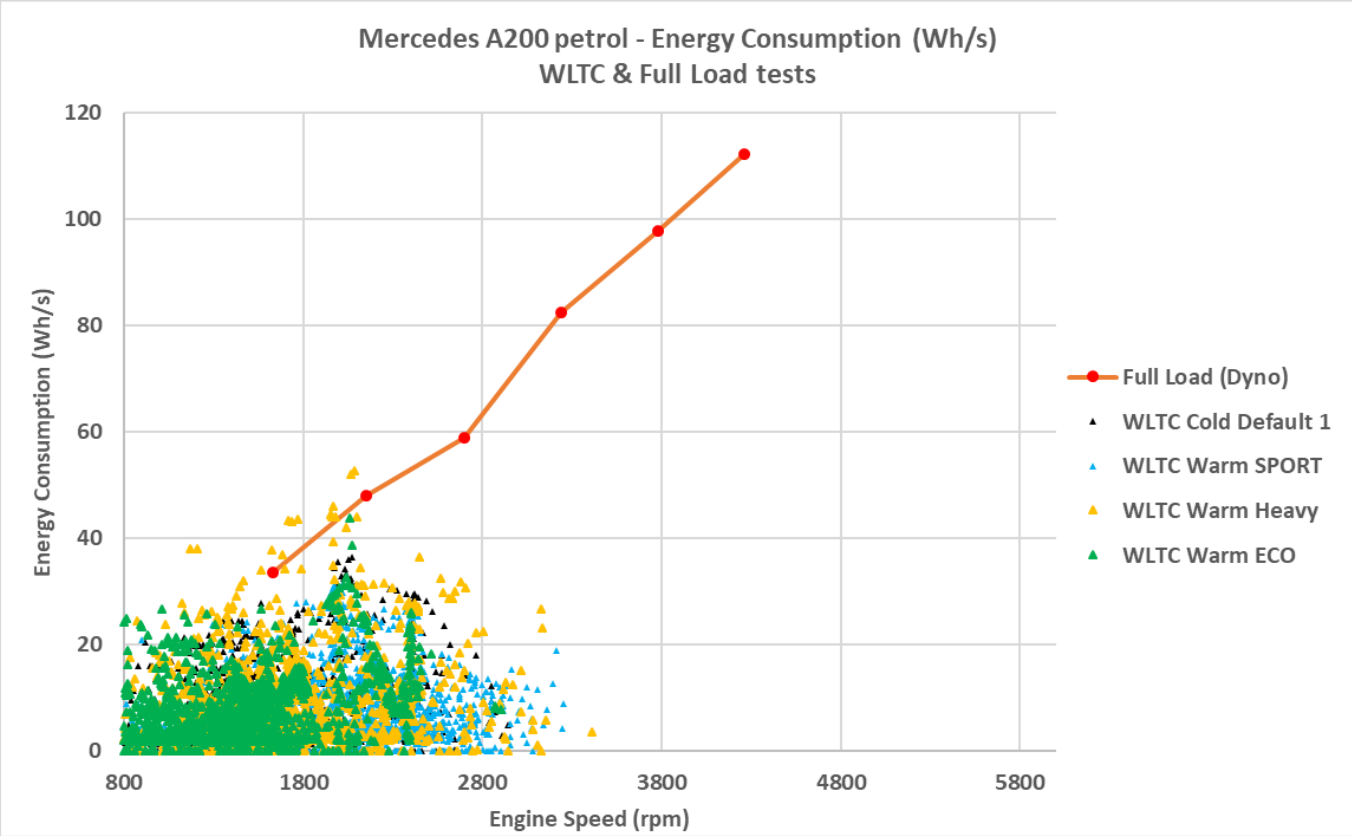

Ford Fiesta 1L Gdi Euro6b - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (PEMS)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

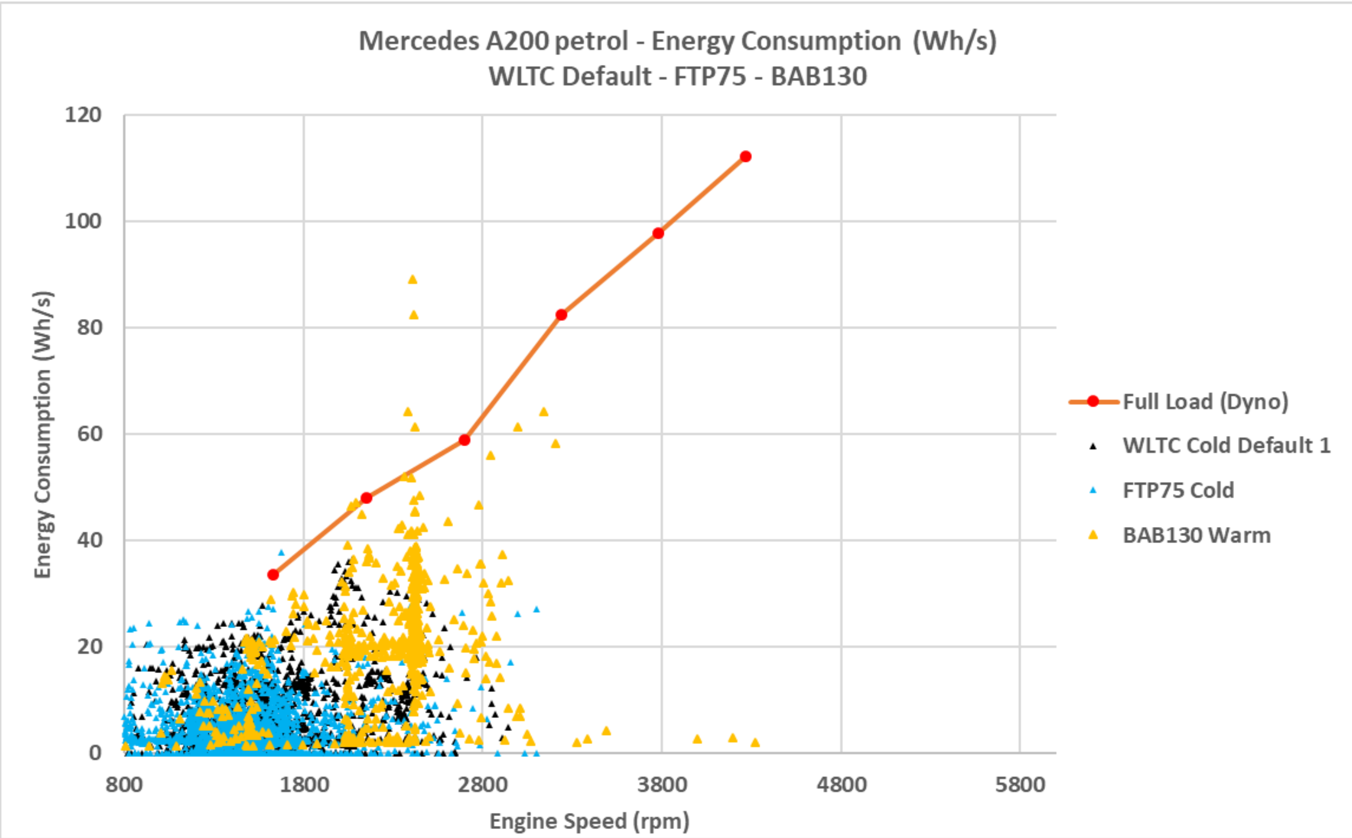

Ford Fiesta 1L Gdi Euro6b - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (PEMS)
PEMS Cold Eco

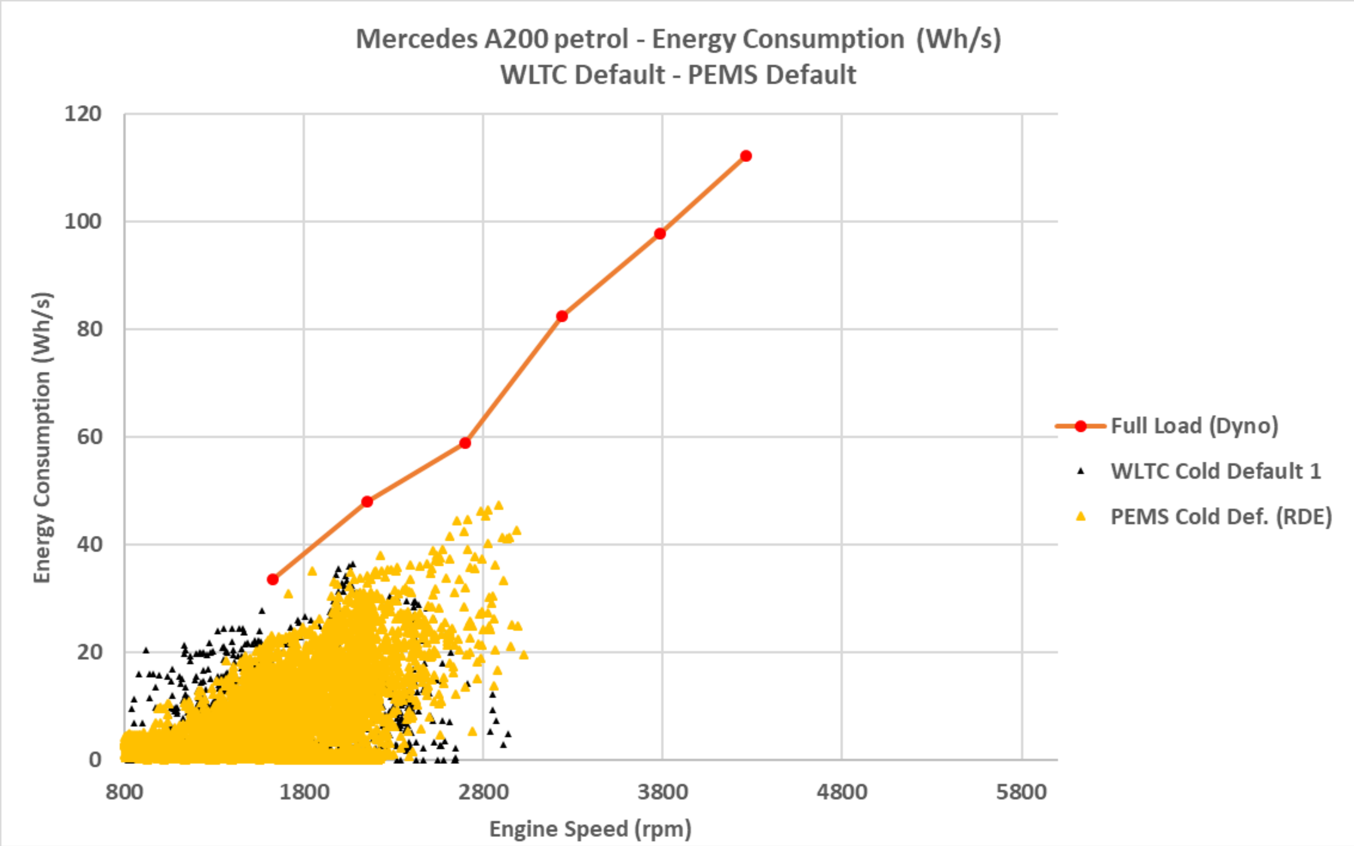

Ford Fiesta 1L Gdi Euro6b - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)

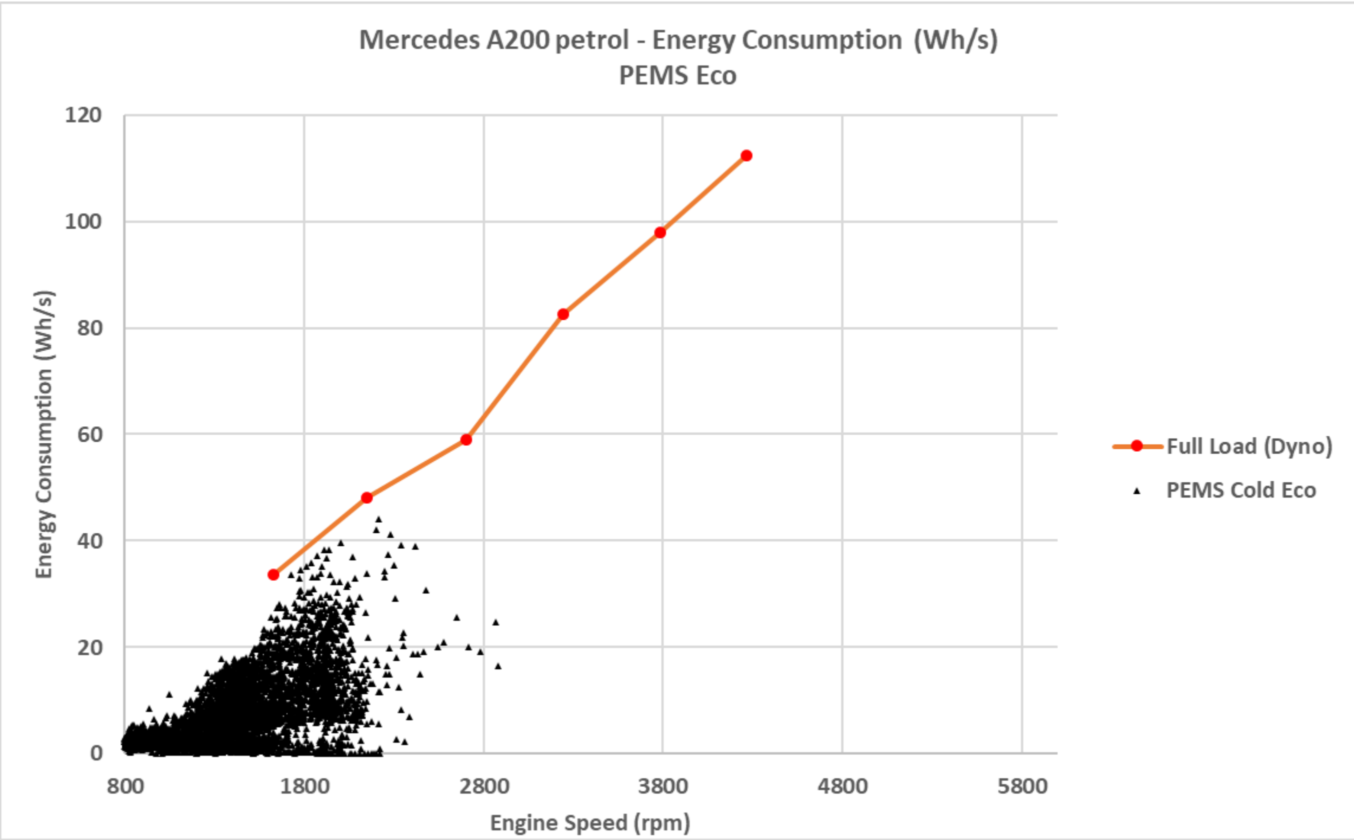

Ford Fiesta 1L Gdi Euro6b - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

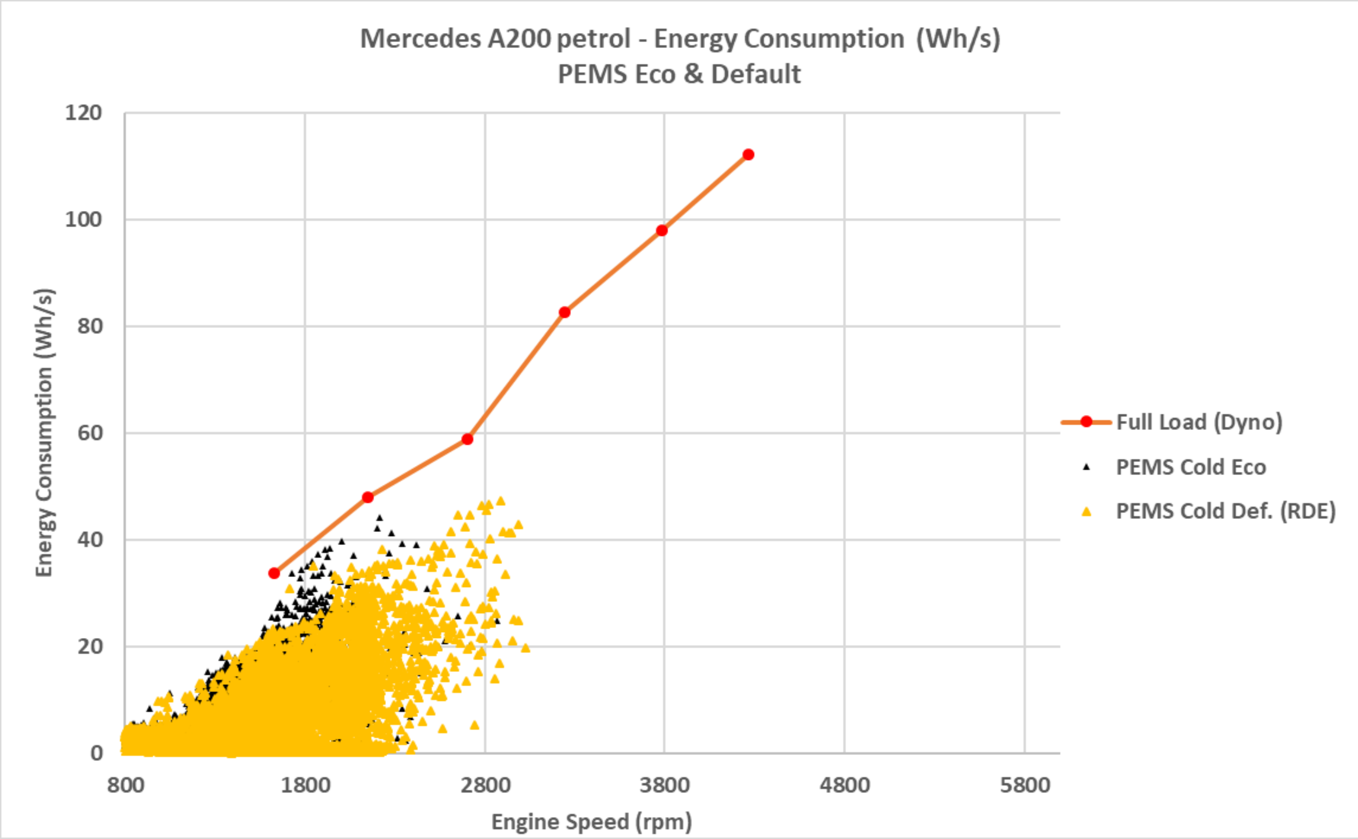
- **Mercedes A200 Petrol from IDIADA**

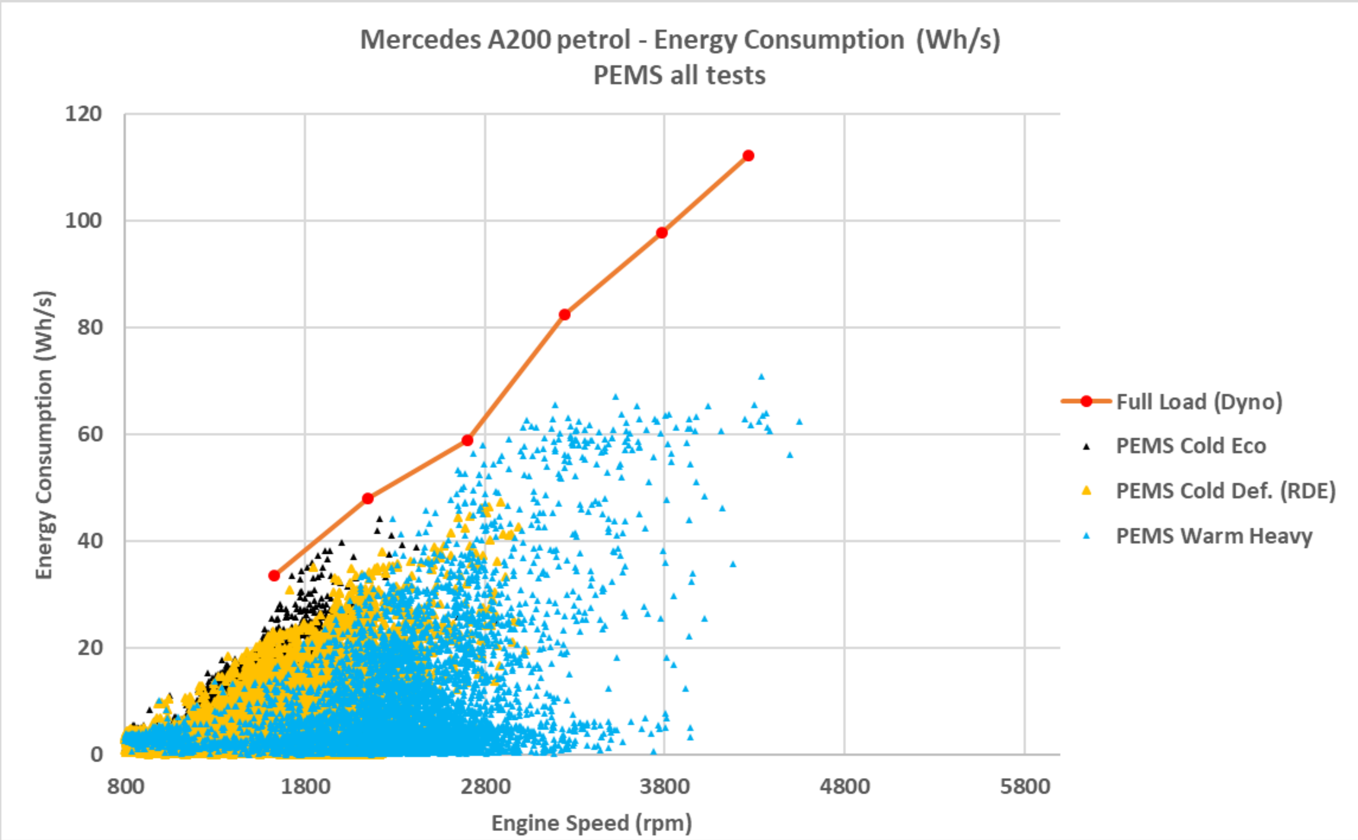




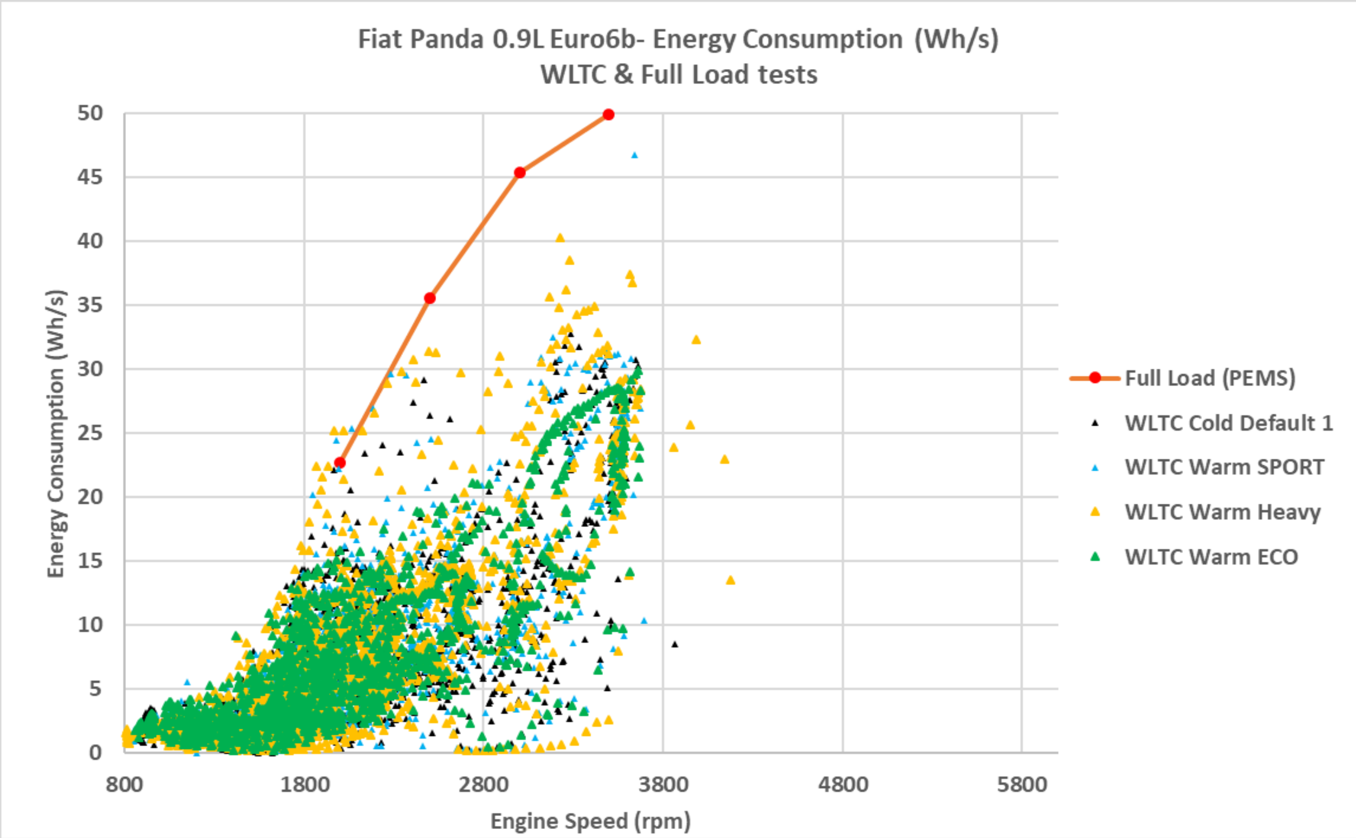

Mercedes A200 petrol - Energy Consumption (Wh/s)
WLTC Default - PEMS Default
Energy Consumption (Wh/s)
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

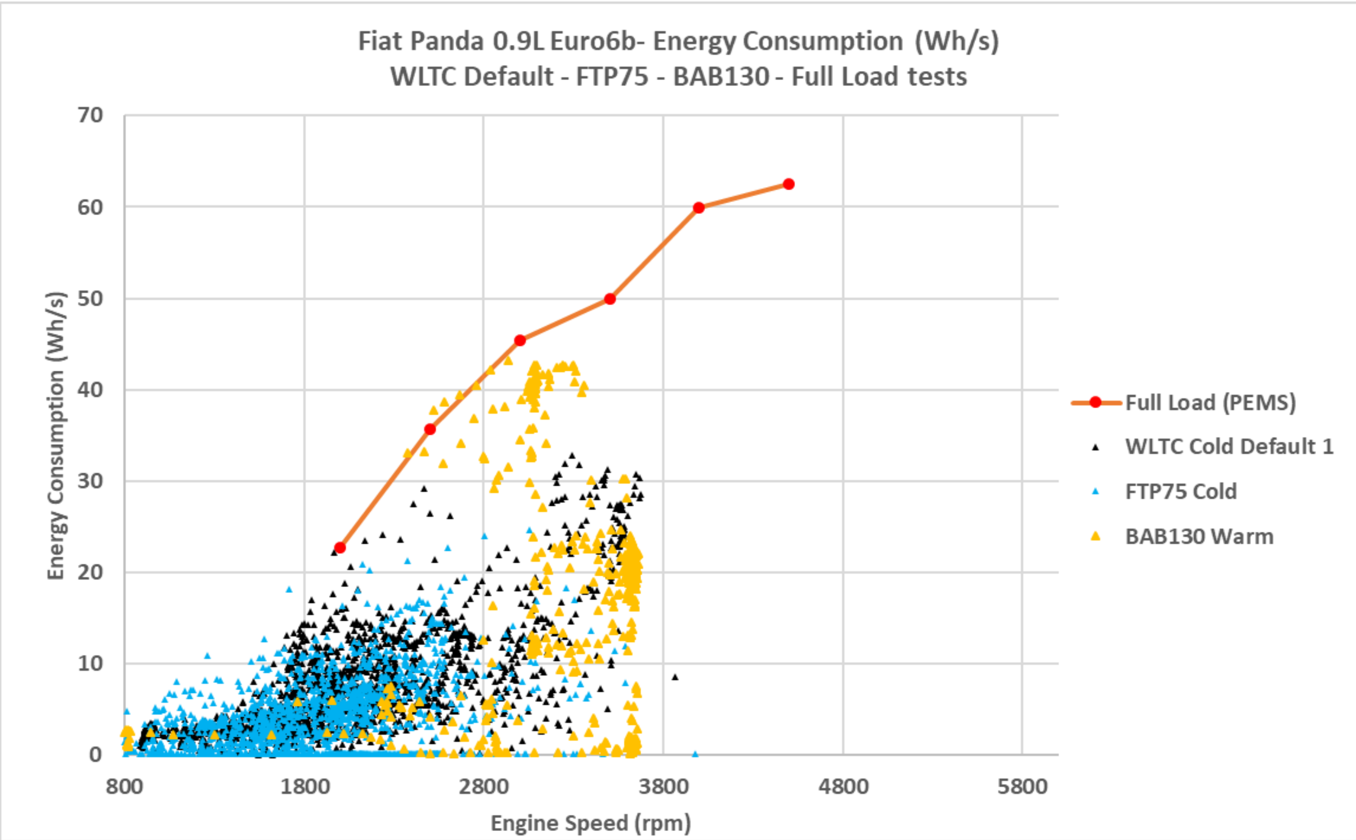

Mercedes A200 petrol - Energy Consumption (Wh/s)
PEMS Eco
Energy Consumption (Wh/s)
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco

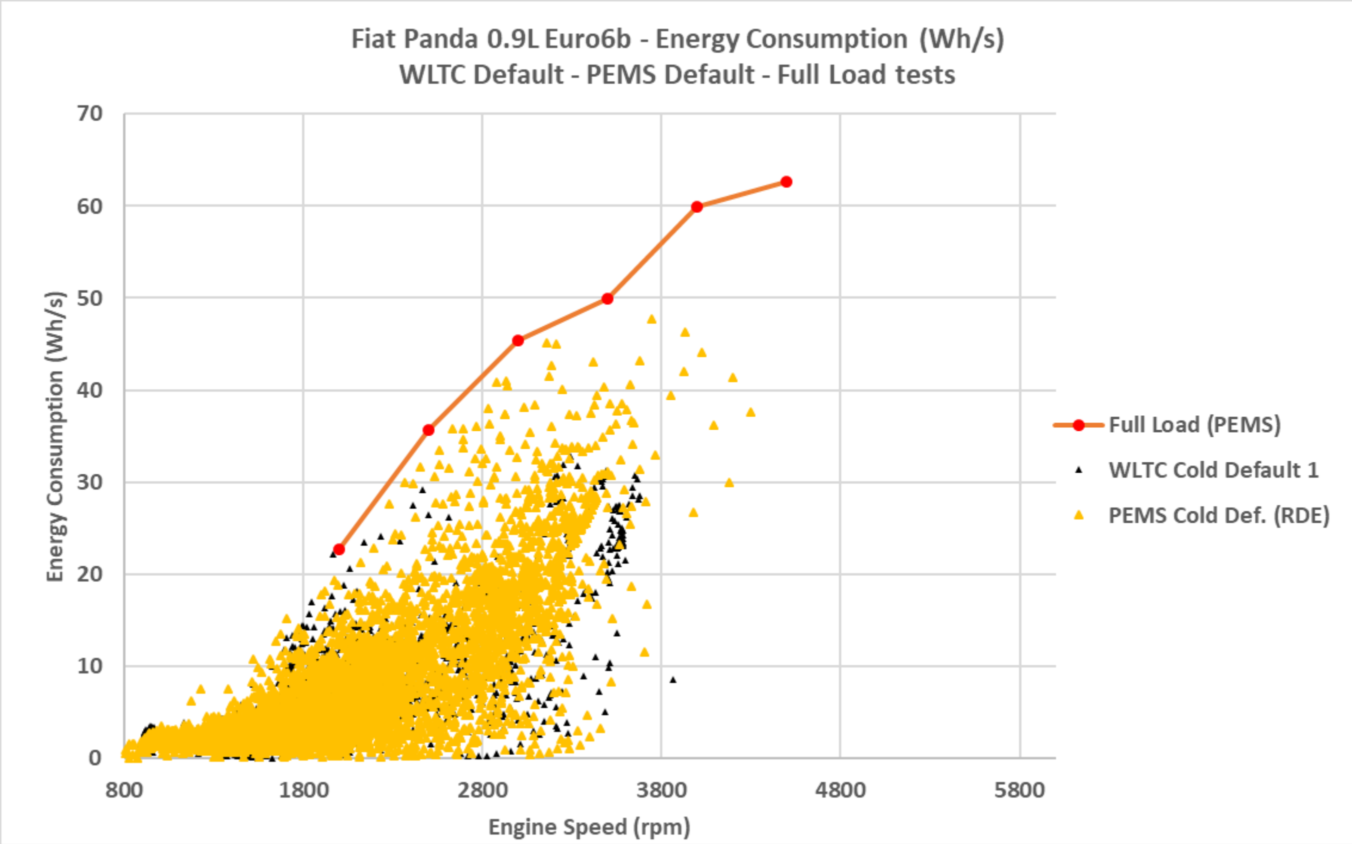

Mercedes A200 petrol - Energy Consumption (Wh/s)
PEMS Eco & Default
Energy Consumption (Wh/s)
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)

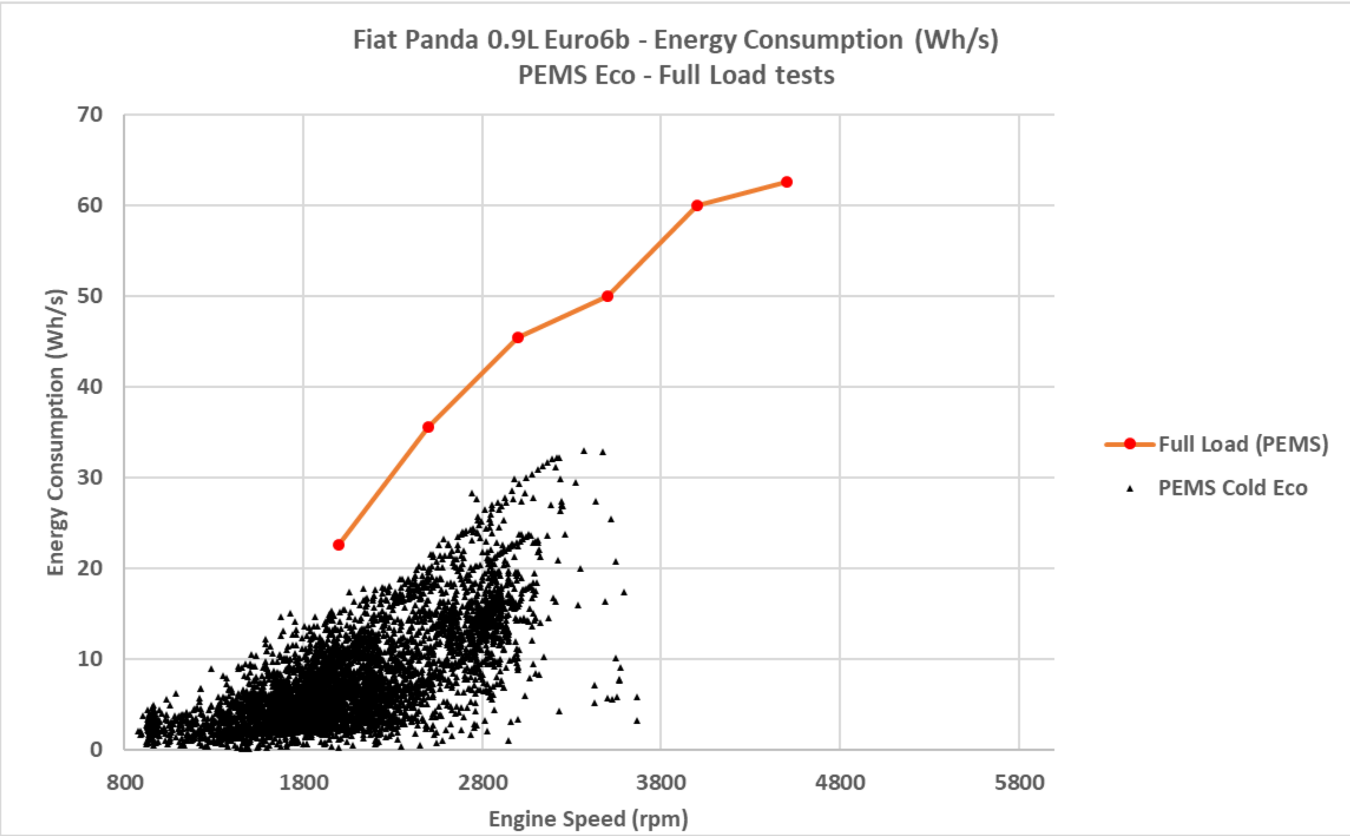

Mercedes A200 petrol - Energy Consumption (Wh/s)
PEMS all tests
Energy Consumption (Wh/s)
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

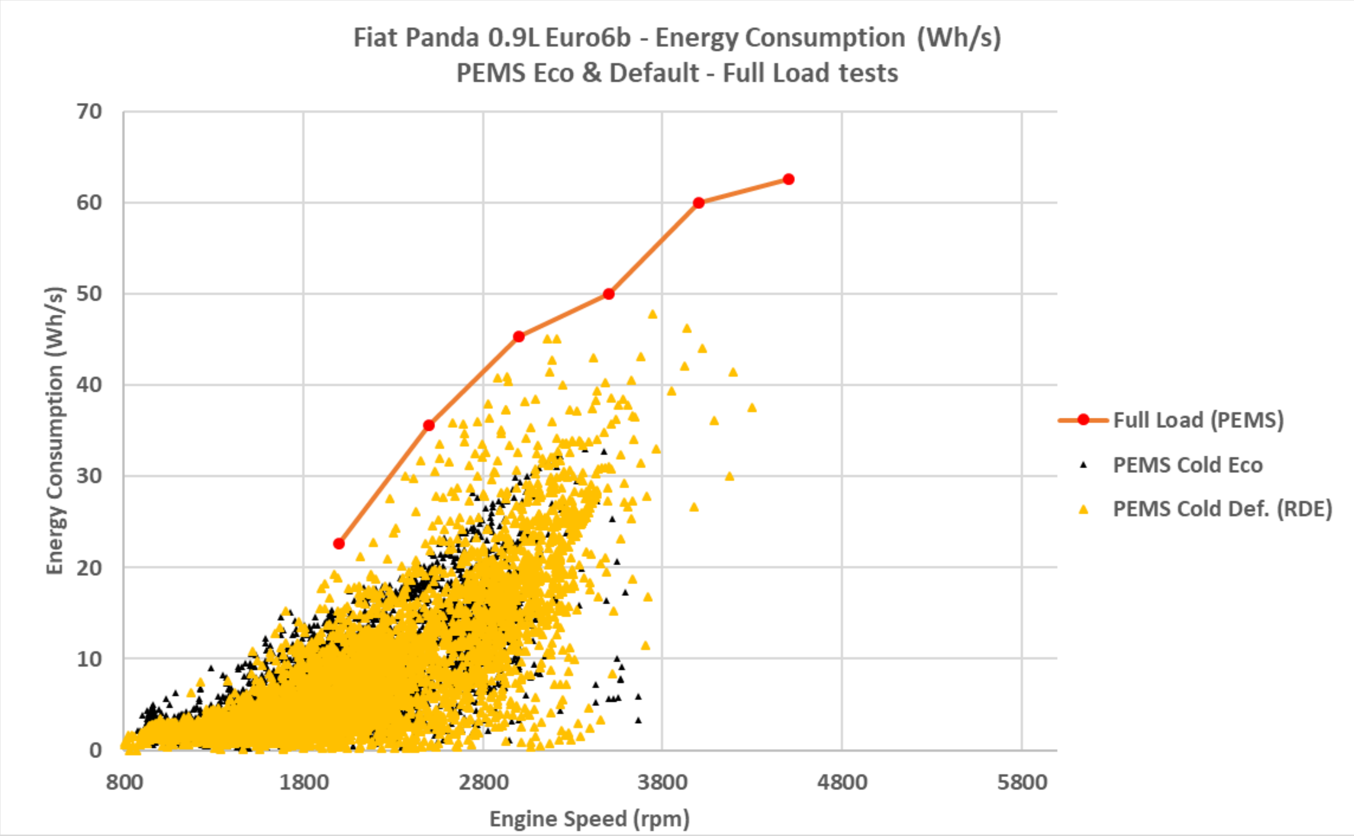
- **Fiat Panda 0.9L Euro6b from CSI**

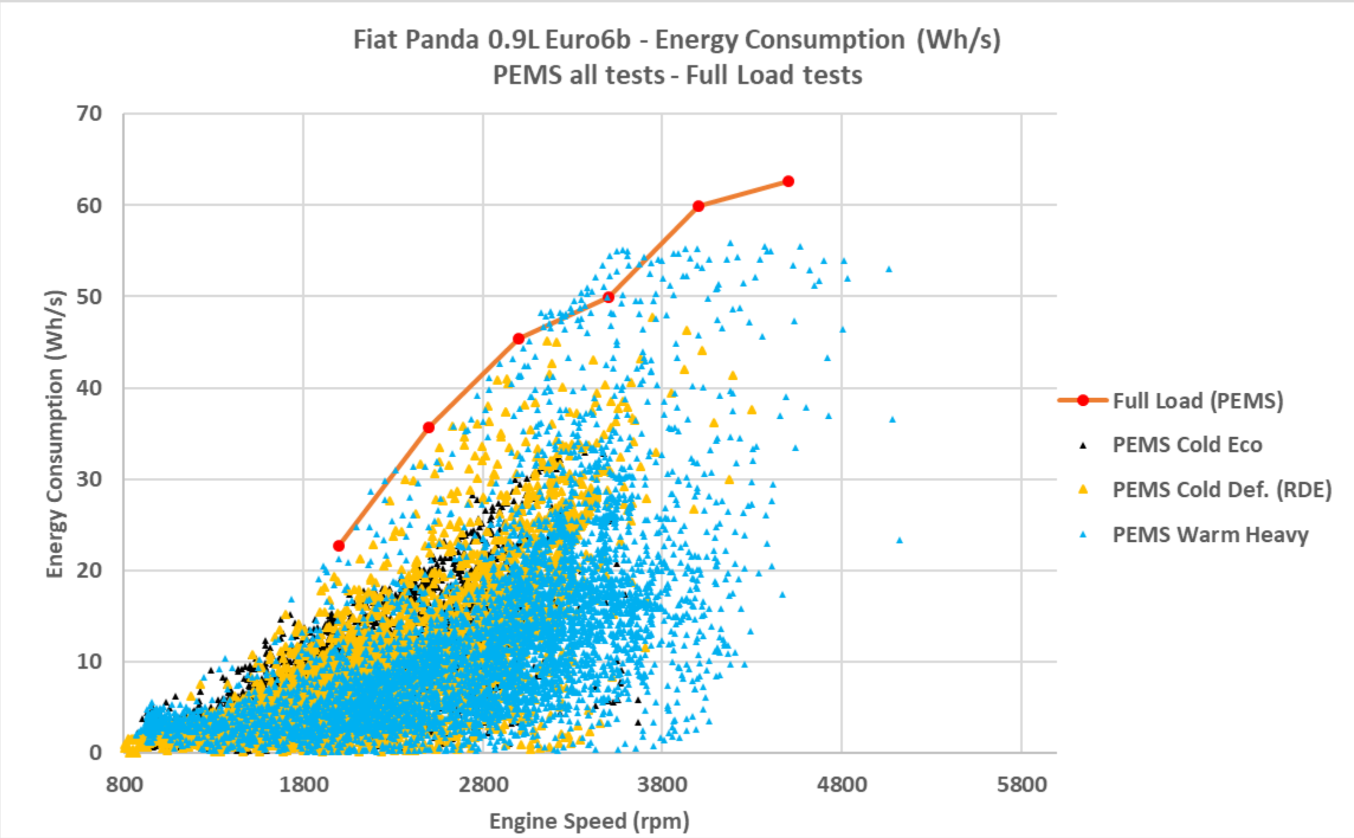




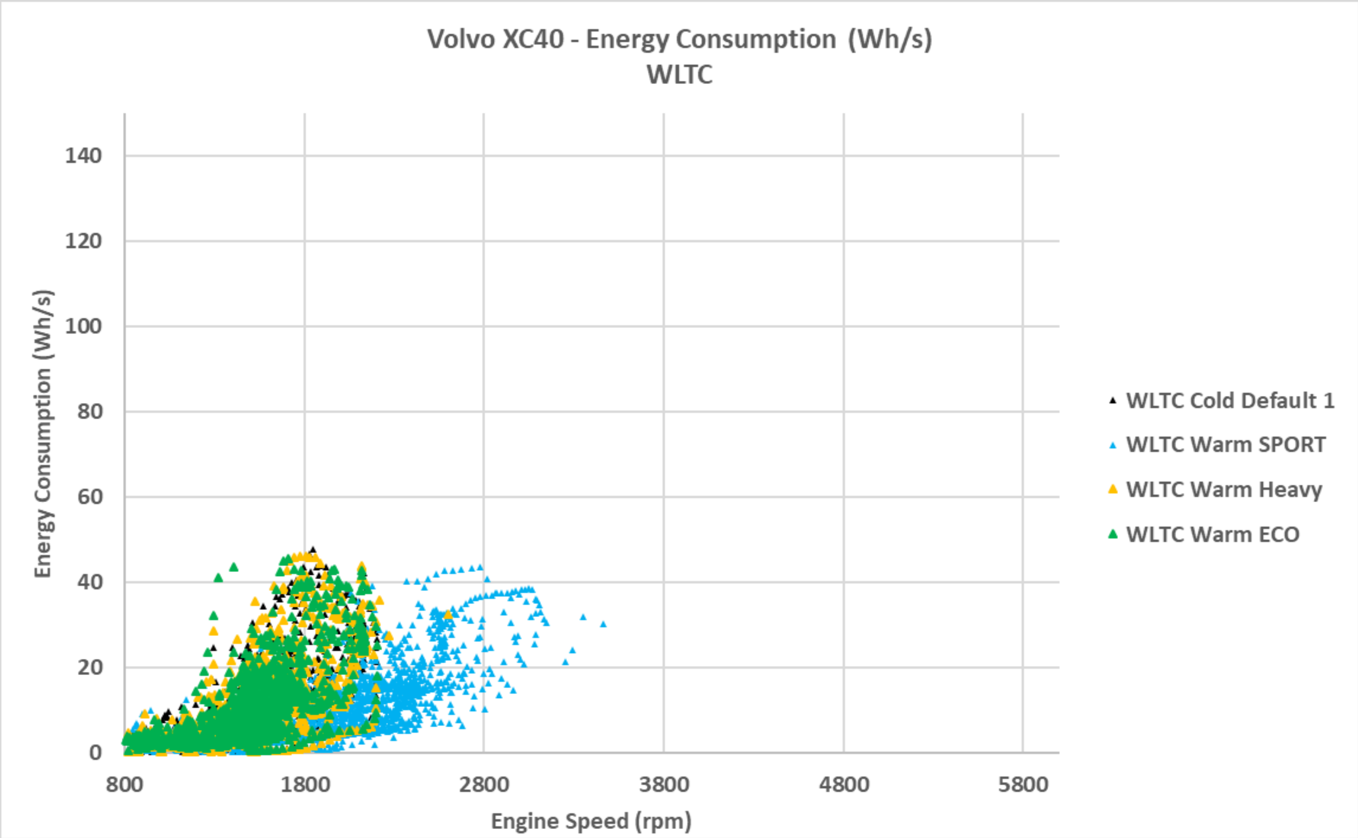

Fiat Panda 0.9L Euro6b - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
800
1800
2800
3800
4800
5800
Full Load (PEMS)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

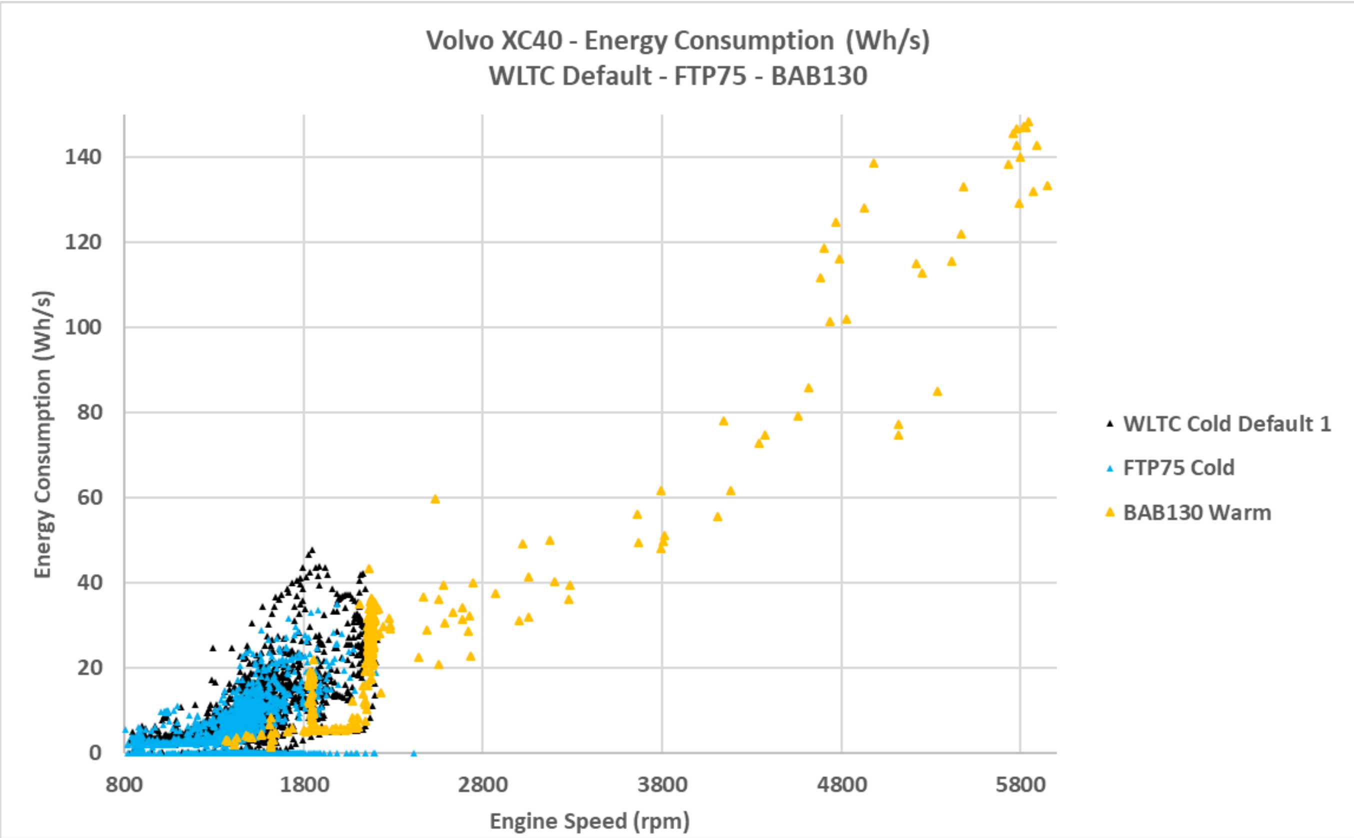

Fiat Panda 0.9L Euro6b - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
800
1800
2800
3800
4800
5800
Full Load (PEMS)
PEMS Cold Eco

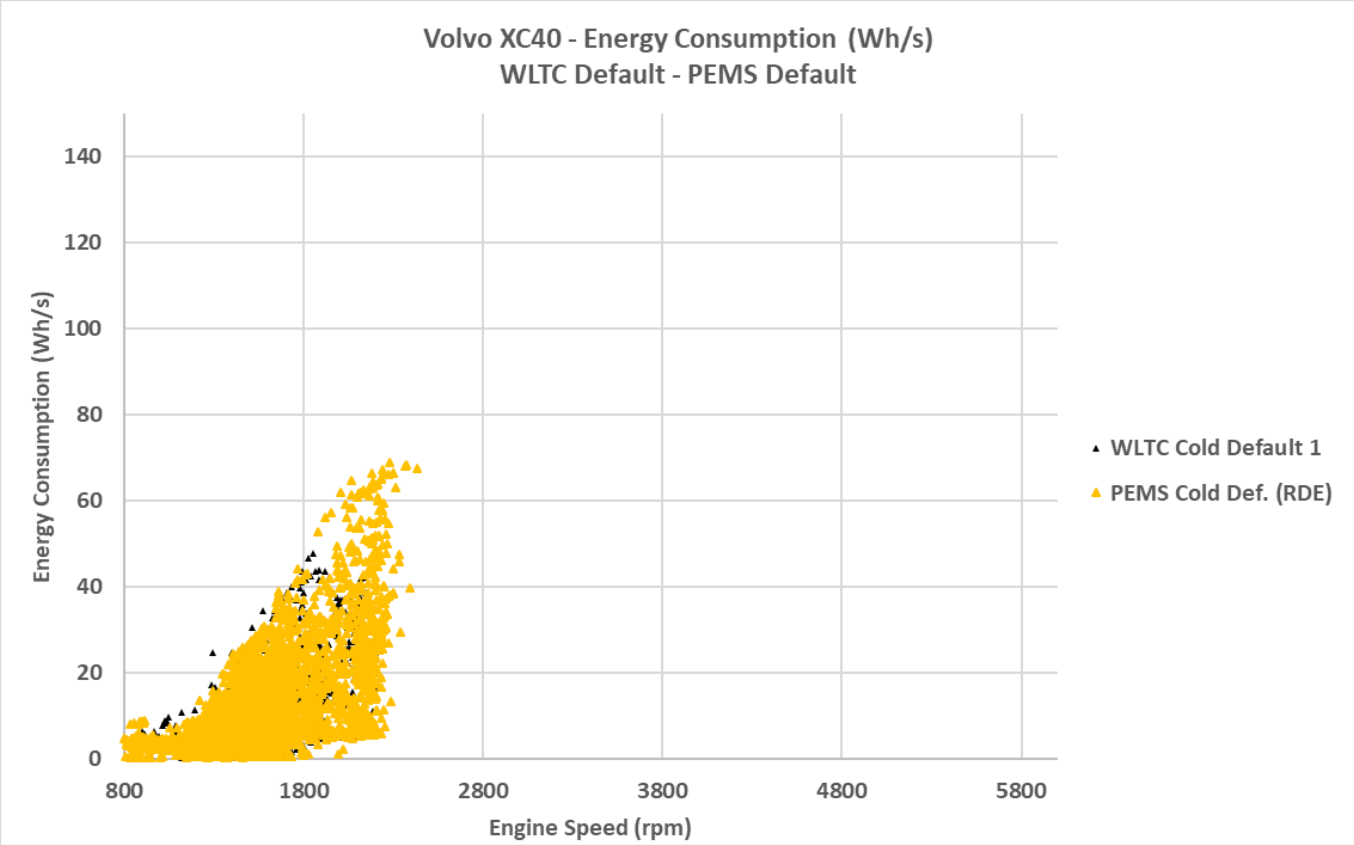

Fiat Panda 0.9L Euro6b - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
800
1800
2800
3800
4800
5800
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)

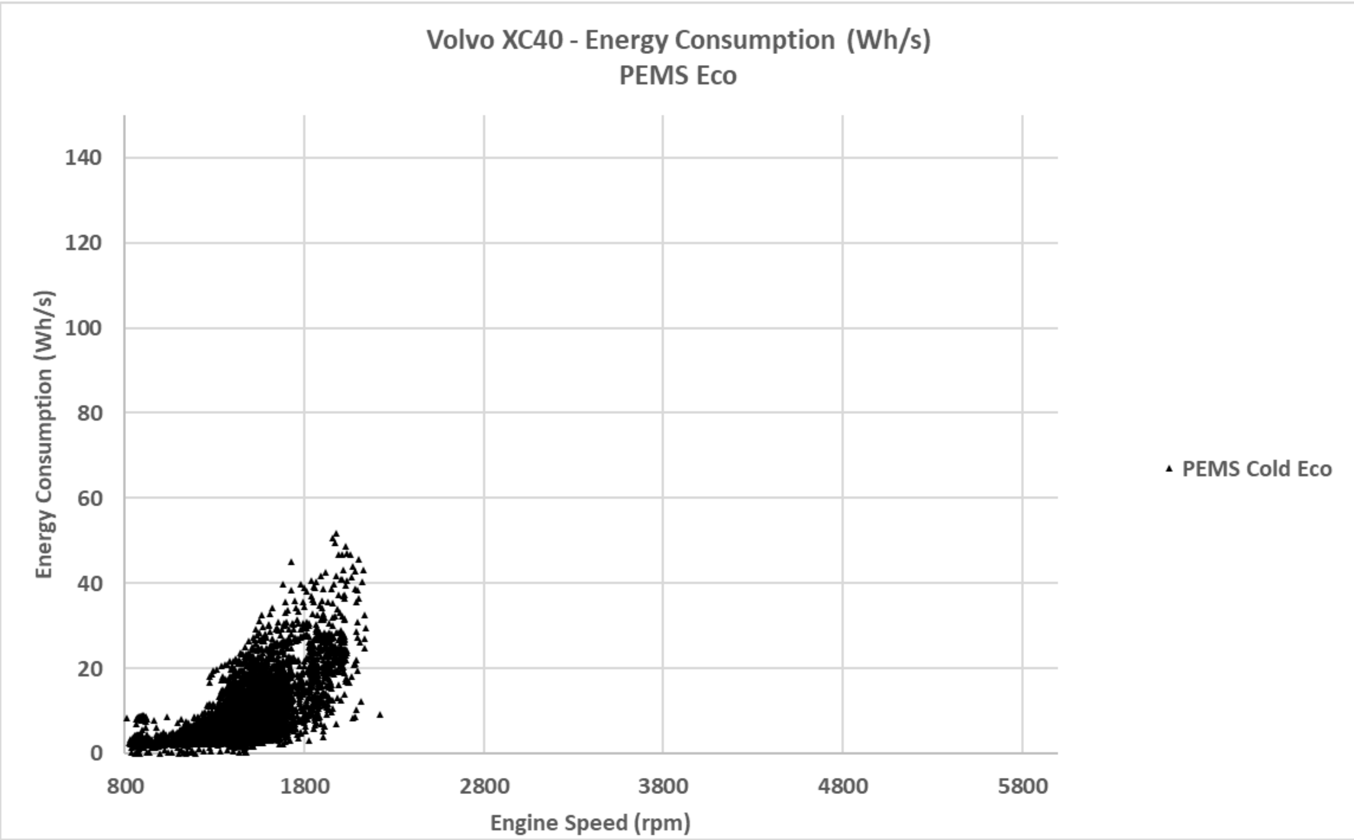

Fiat Panda 0.9L Euro6b - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
800
1800
2800
3800
4800
5800
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

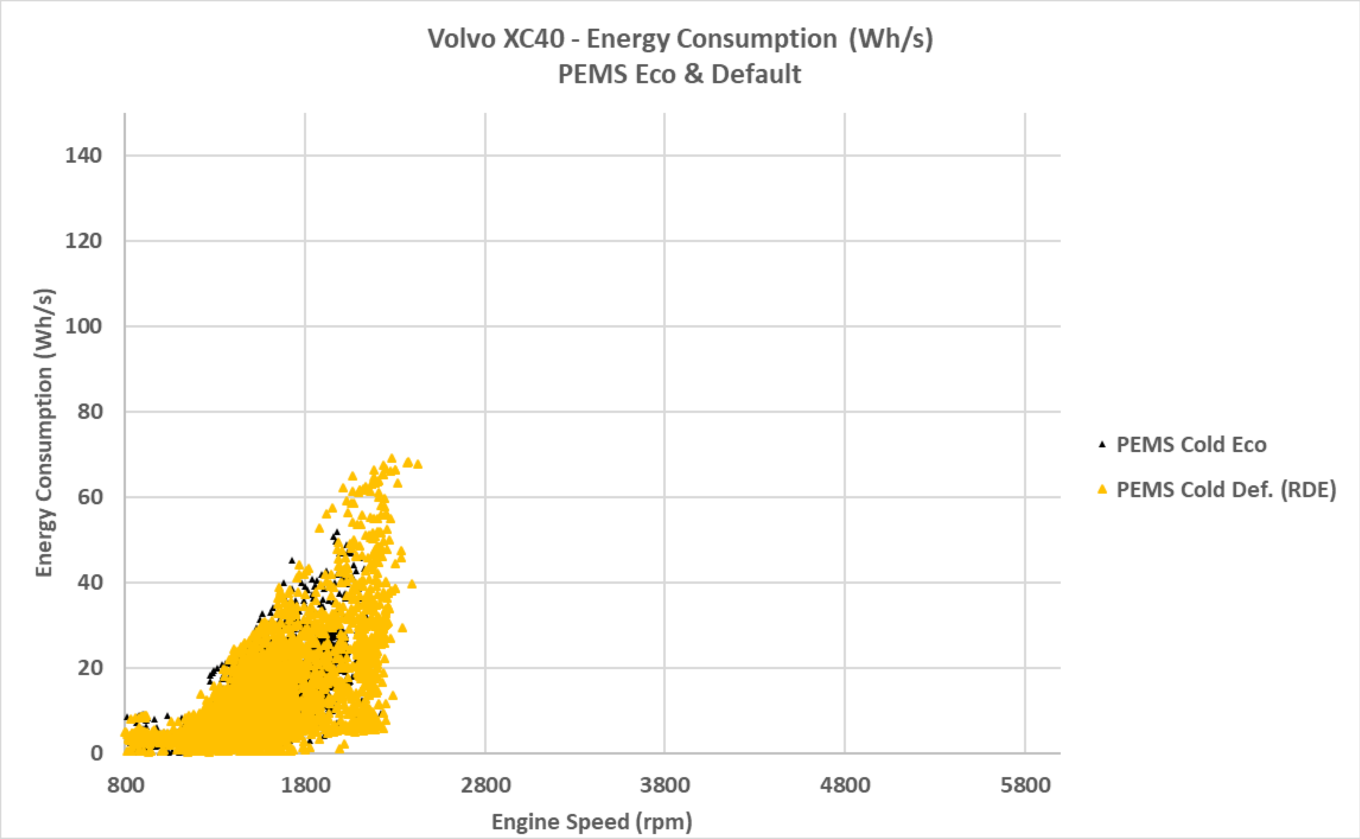
- **Volvo XC40 from ADAC (without Energy Consumption on full load test)**

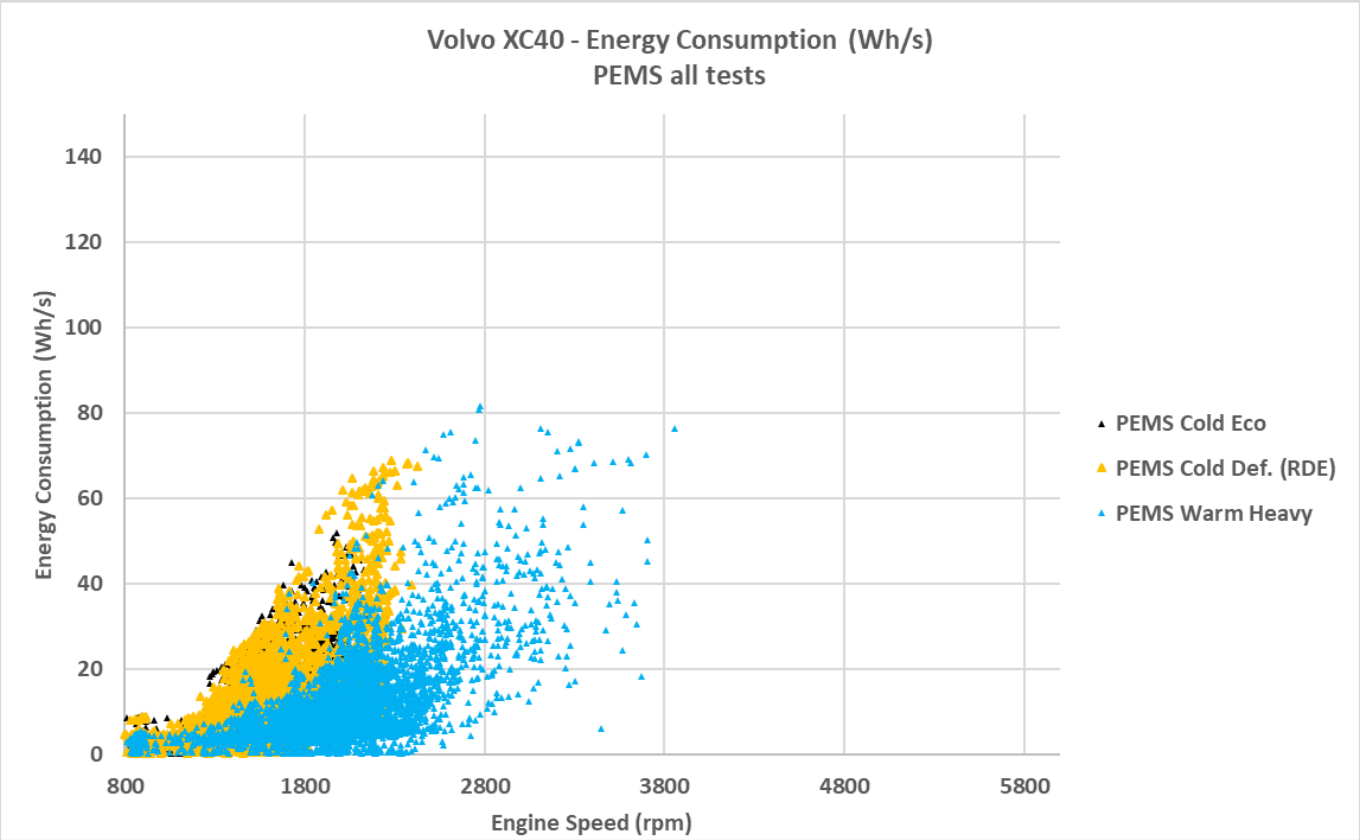




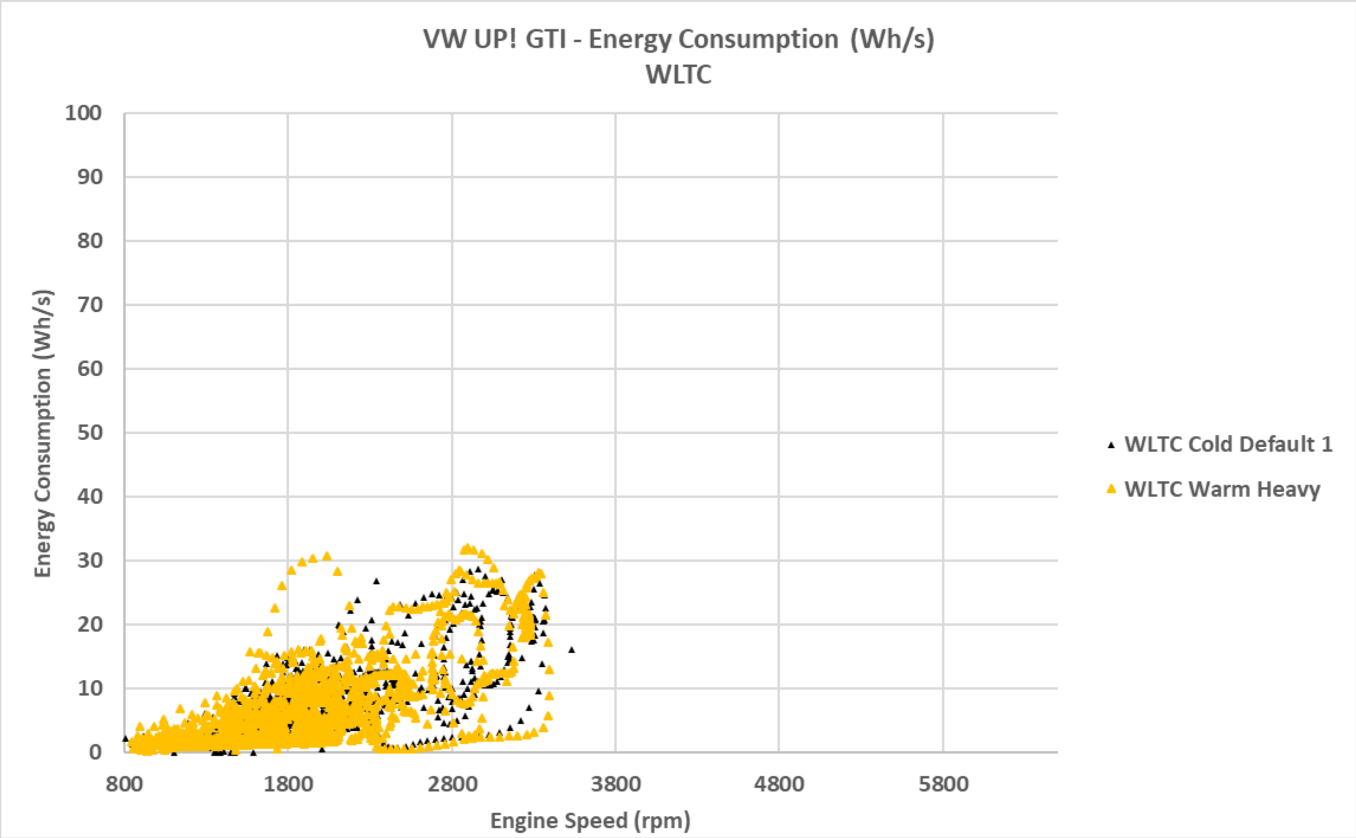

Volvo XC40 - Energy Consumption (Wh/s)
WLTC Default - PEMS Default
Energy Consumption (Wh/s)
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

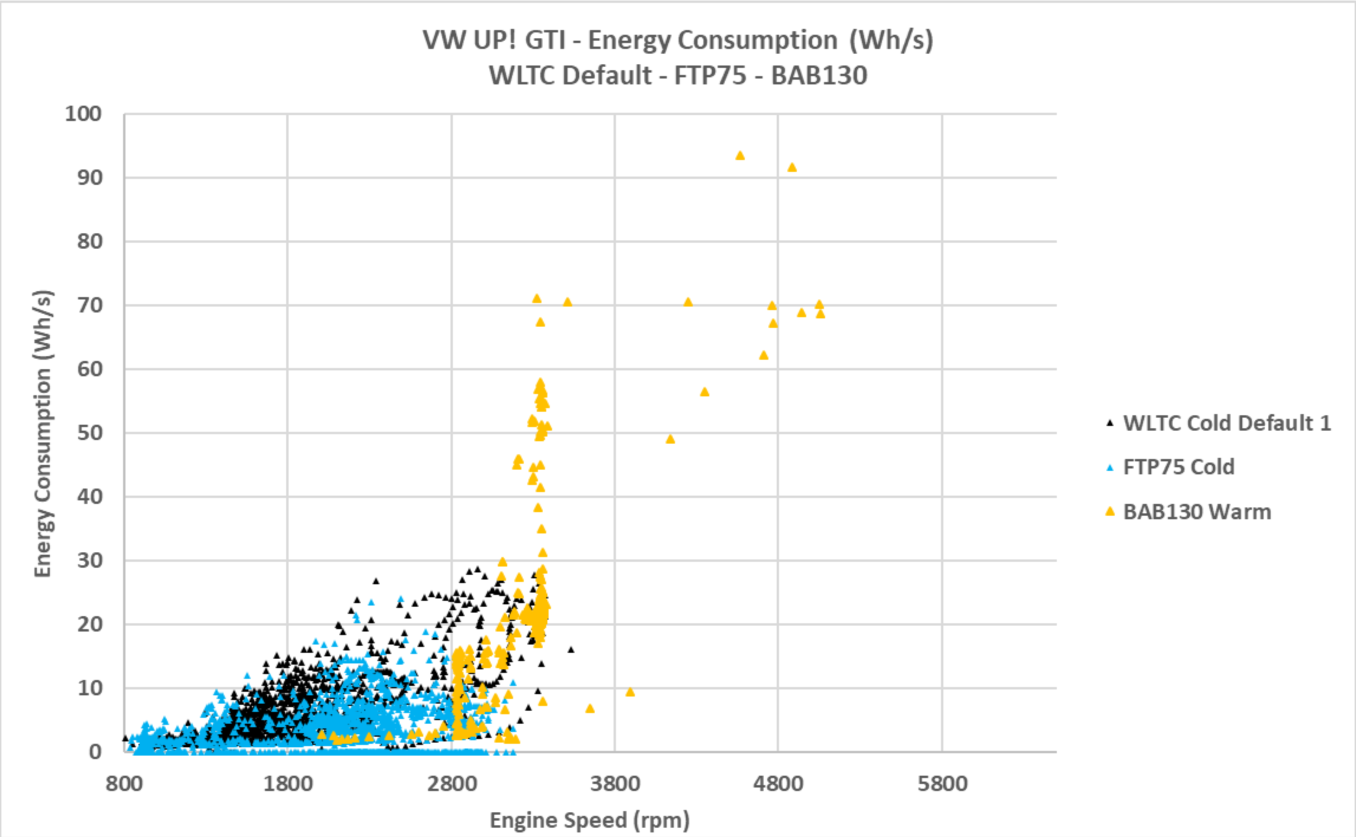

Volvo XC40 - Energy Consumption (Wh/s)
PEMS Eco
Energy Consumption (Wh/s)
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco

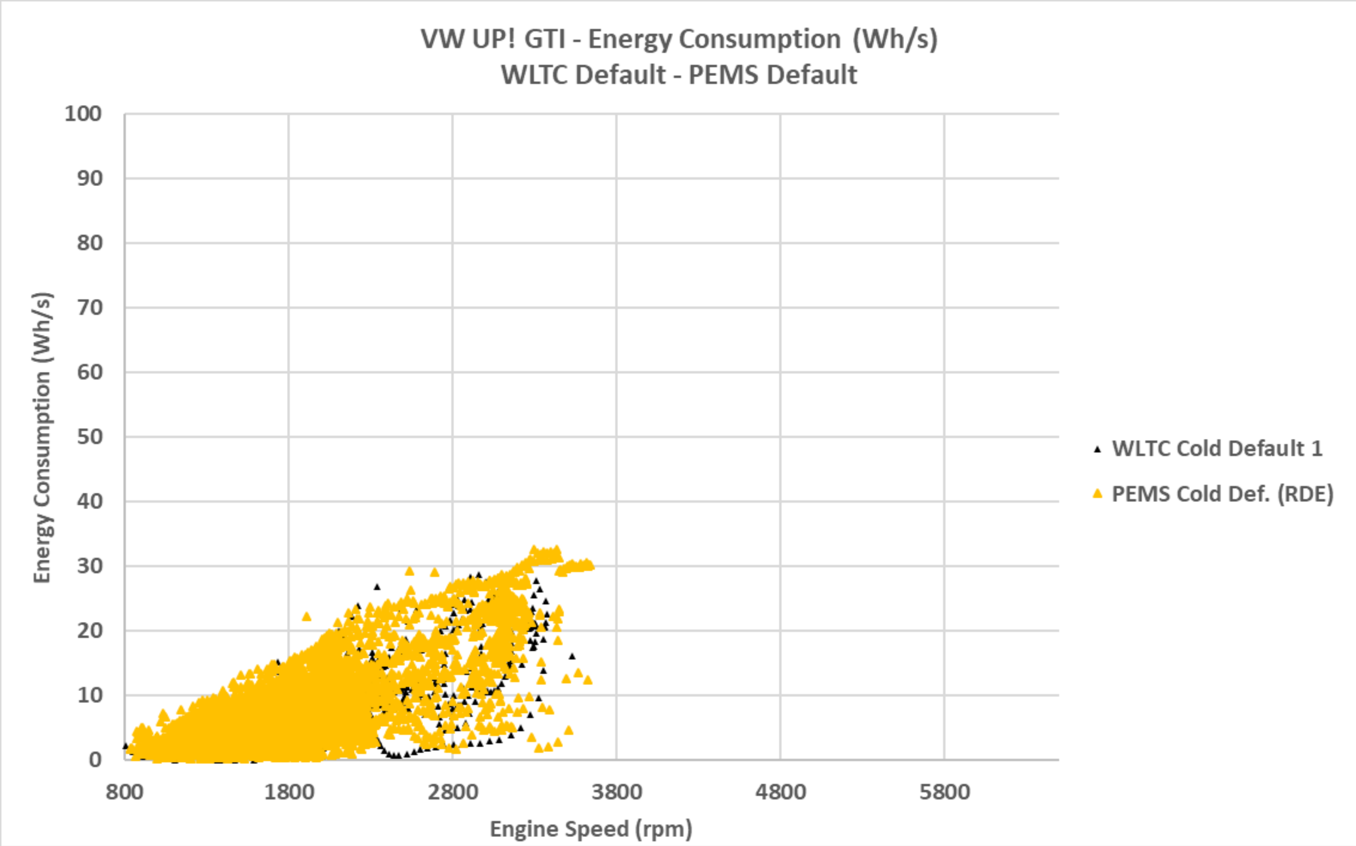

Volvo XC40 - Energy Consumption (Wh/s)
PEMS Eco & Default
Energy Consumption (Wh/s)
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco
PEMS Cold Def. (RDE)

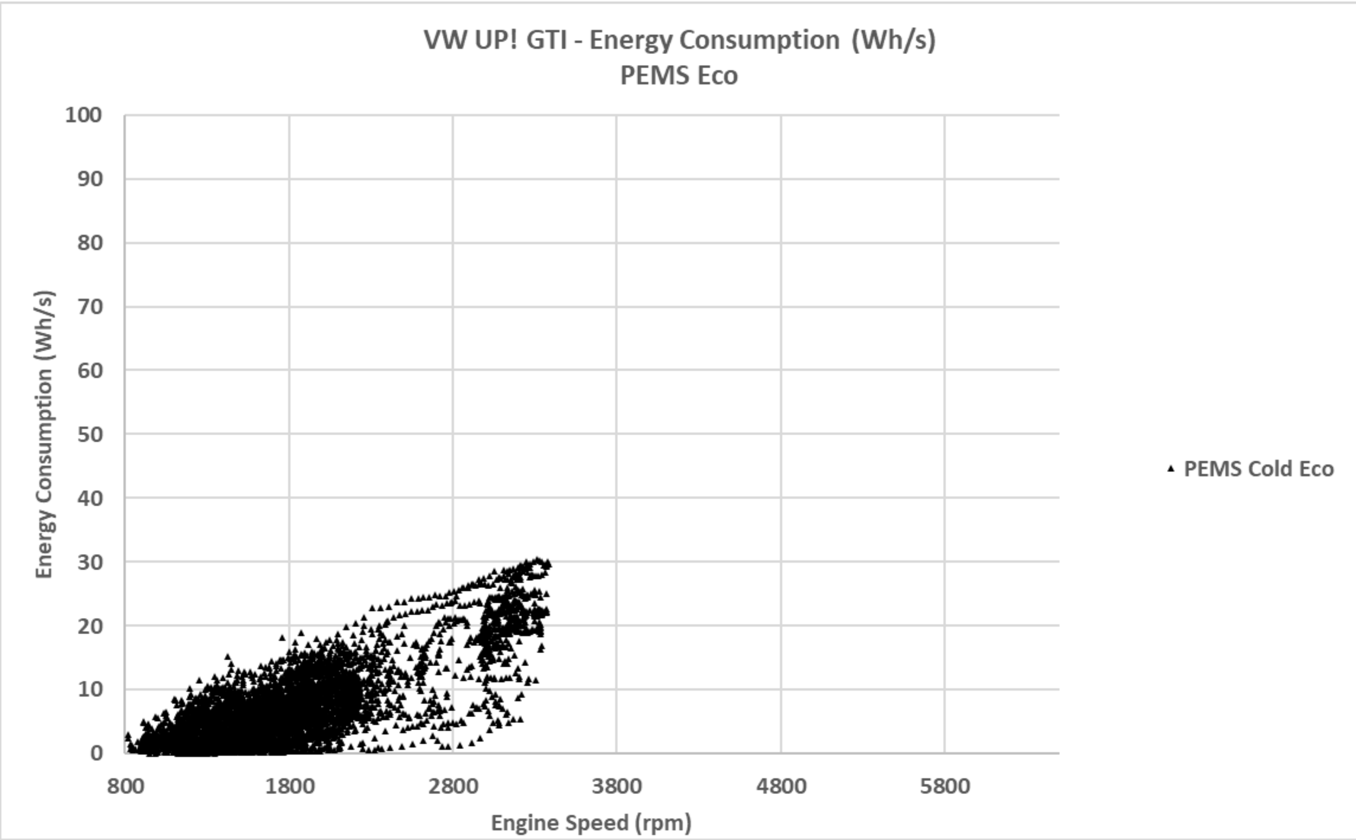

Volvo XC40 - Energy Consumption (Wh/s)
PEMS all tests
Energy Consumption (Wh/s)
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

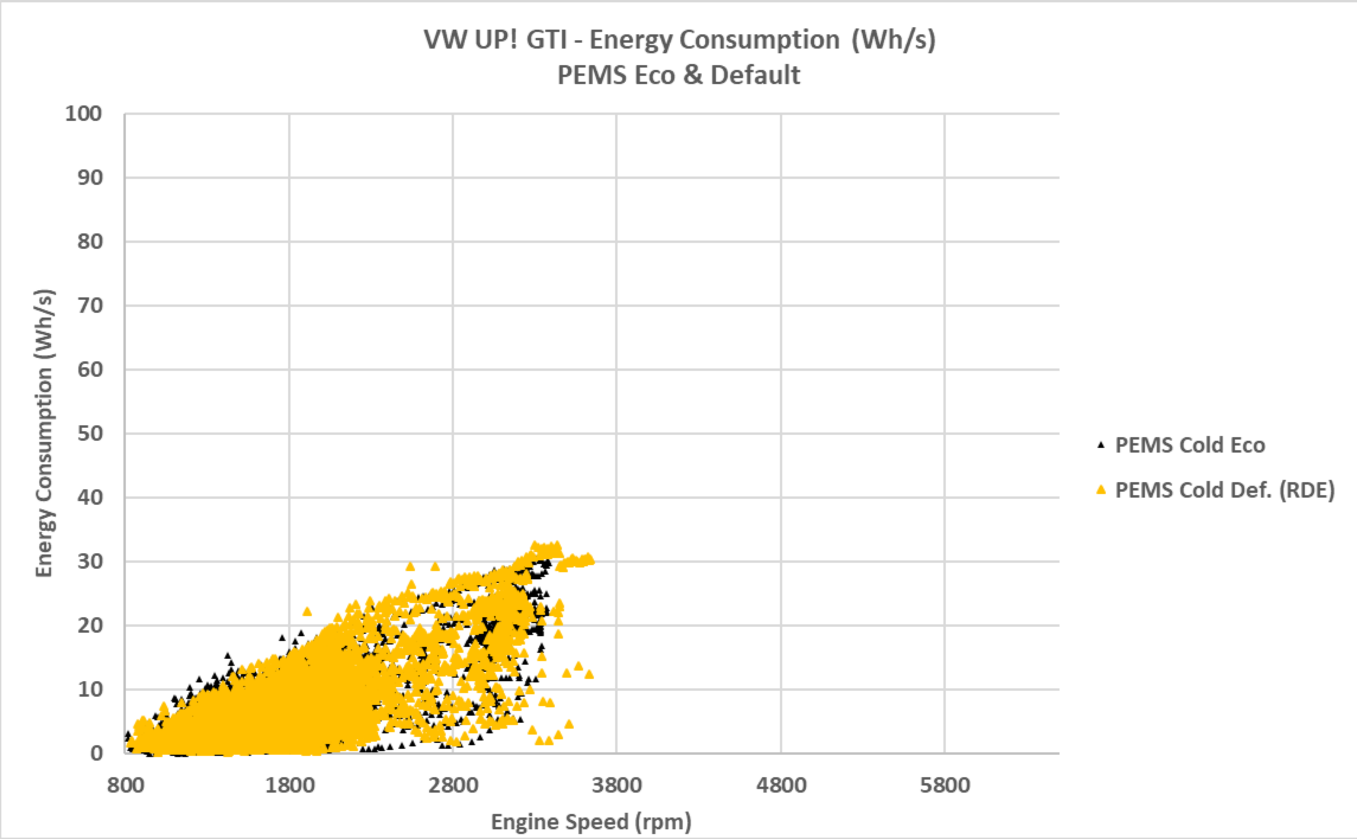
- **VW Up! GTI from ADAC** **(without Energy Consumption on full load test)**

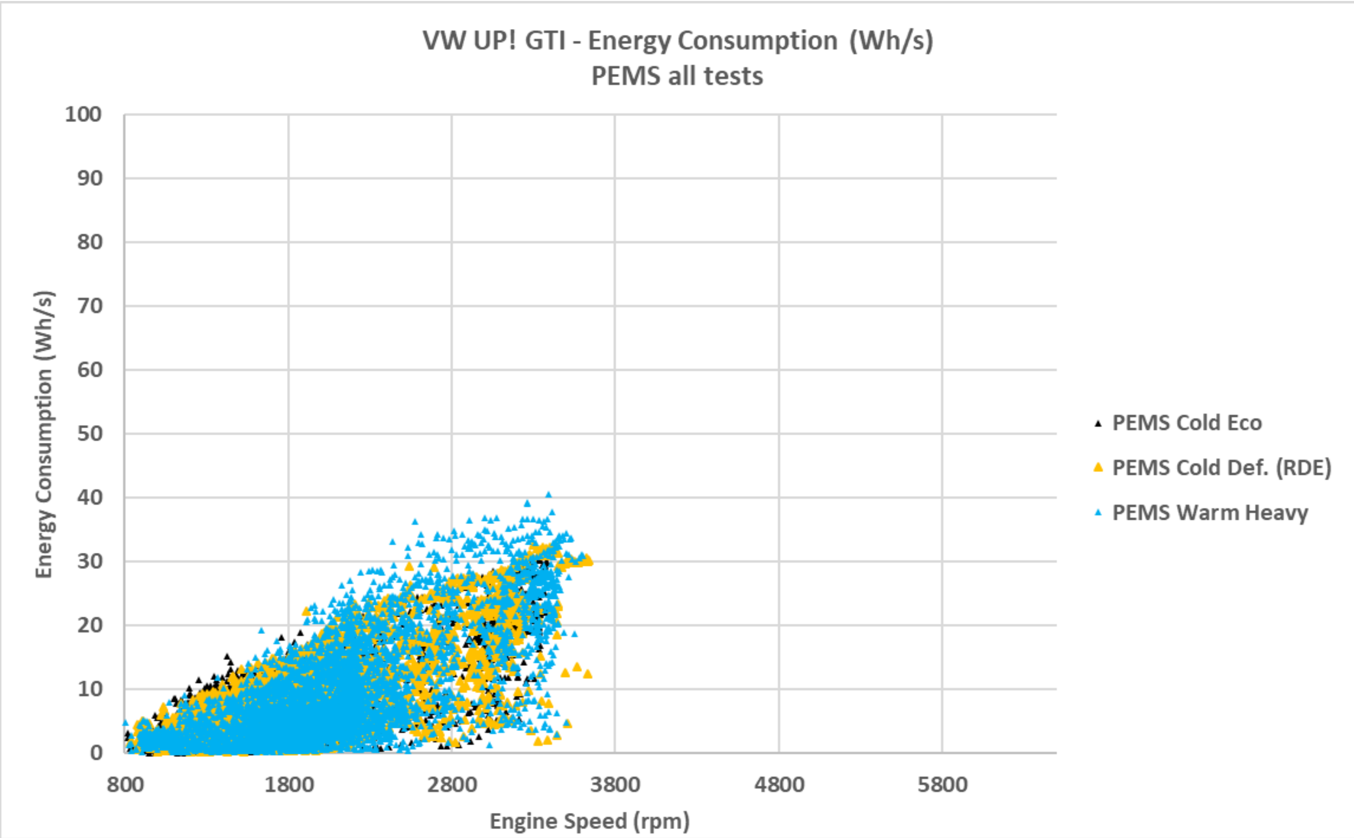




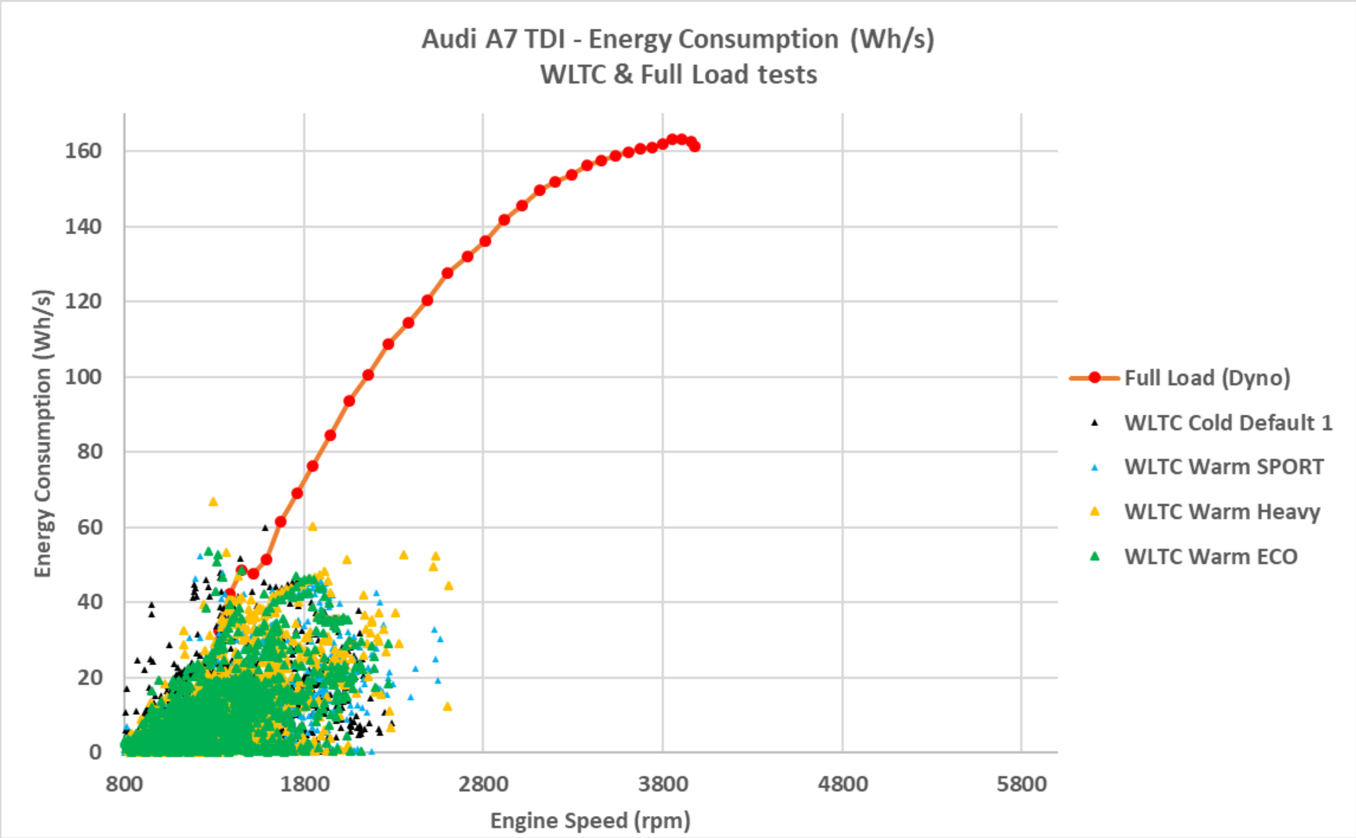

VW UP! GTI - Energy Consumption (Wh/s)
WLTC Default - PEMS Default
Energy Consumption (Wh/s)
100
90
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

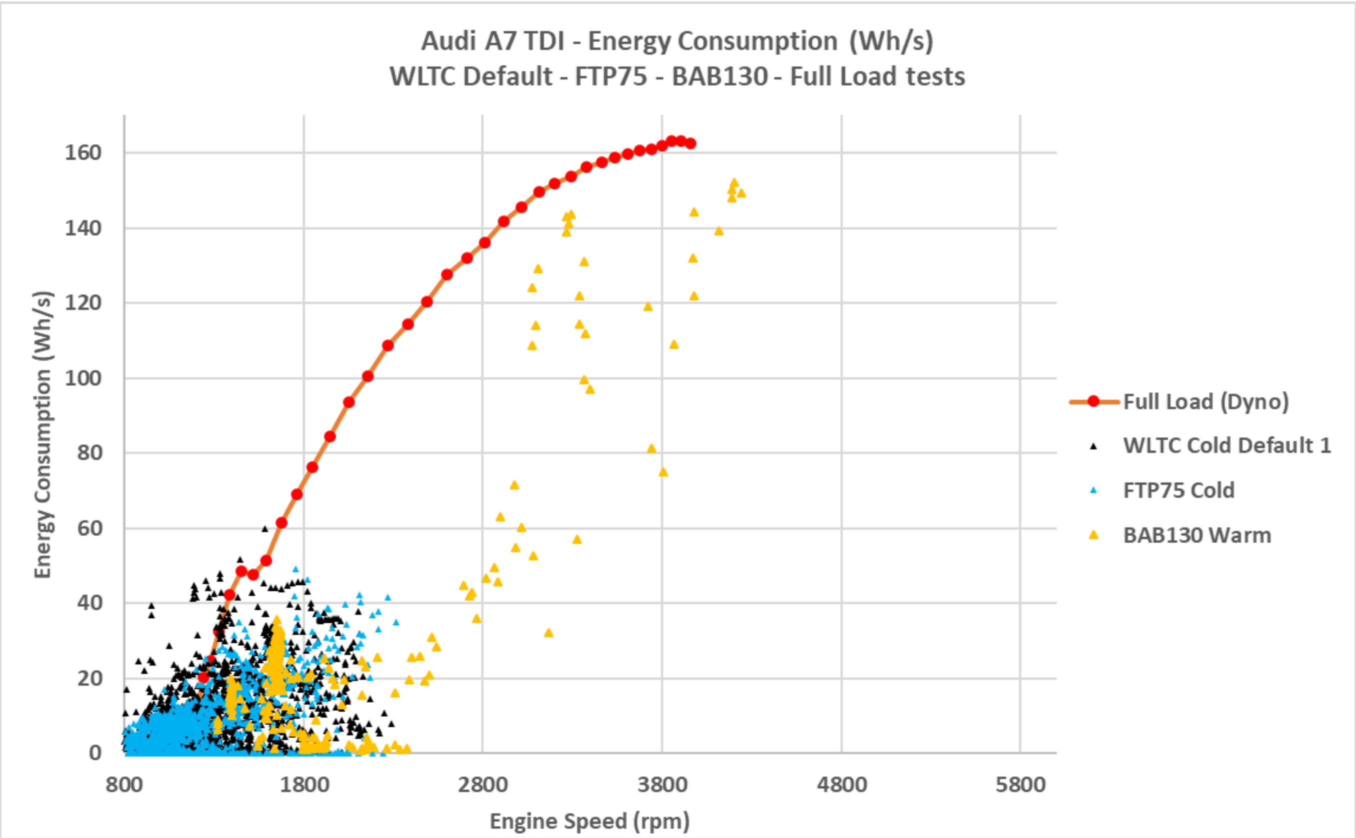

VW UP! GTI - Energy Consumption (Wh/s)
PEMS Eco
Energy Consumption (Wh/s)
100
90
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco

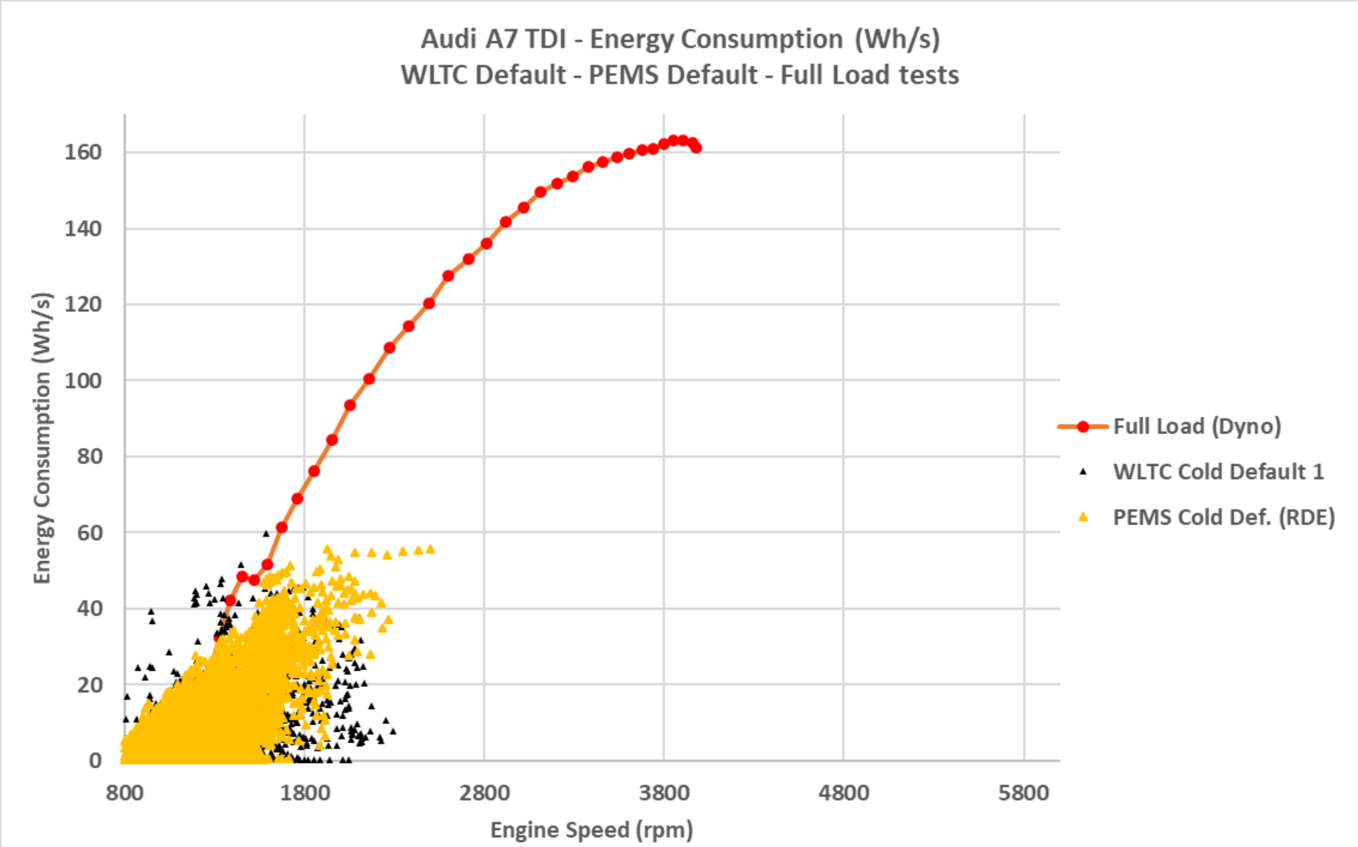

VW UP! GTI - Energy Consumption (Wh/s)
PEMS Eco & Default
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
80
90
100
800
1800
2800
3800
4800
5800
PEMS Cold Eco
PEMS Cold Def. (RDE)

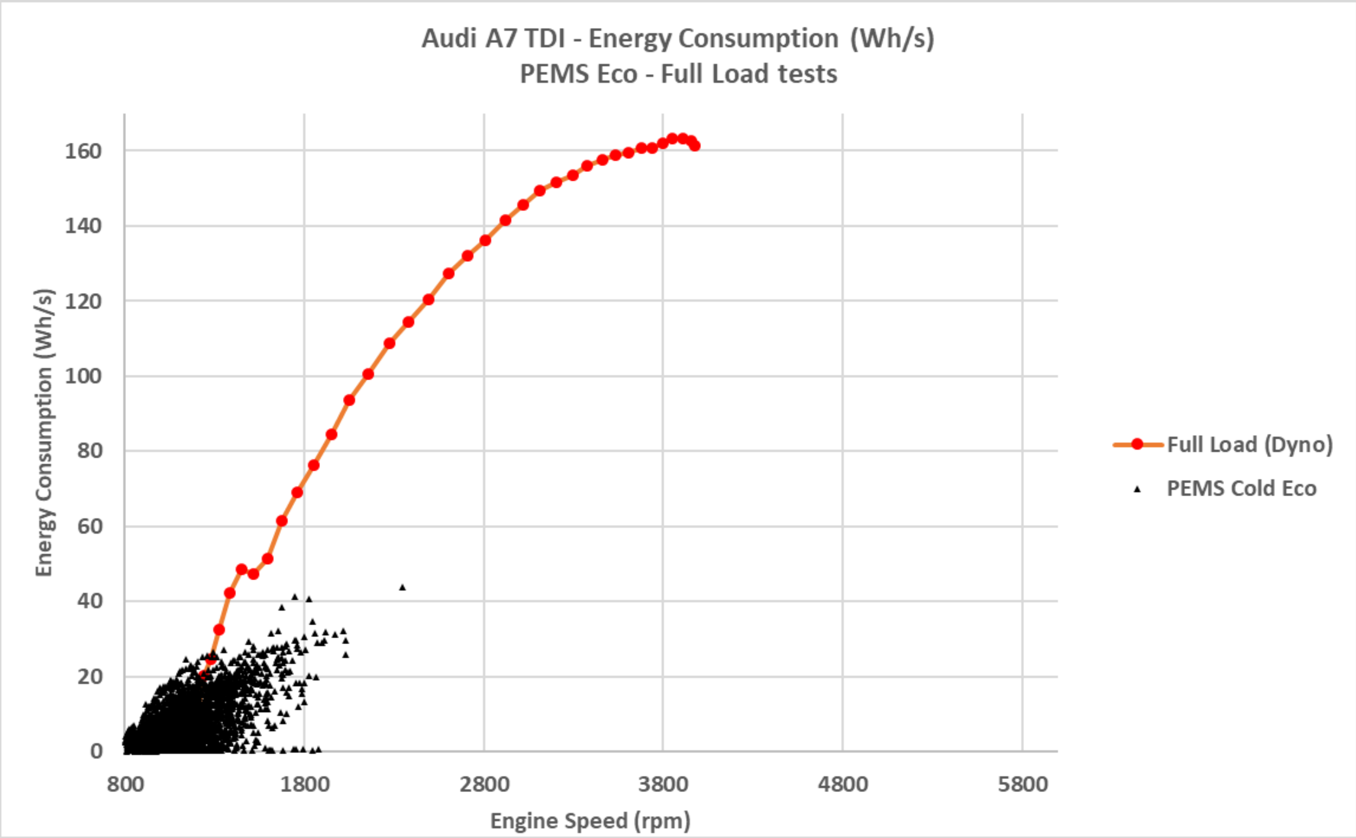

VW UP! GTI - Energy Consumption (Wh/s)
PEMS all tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
80
90
100
800
1800
2800
3800
4800
5800
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

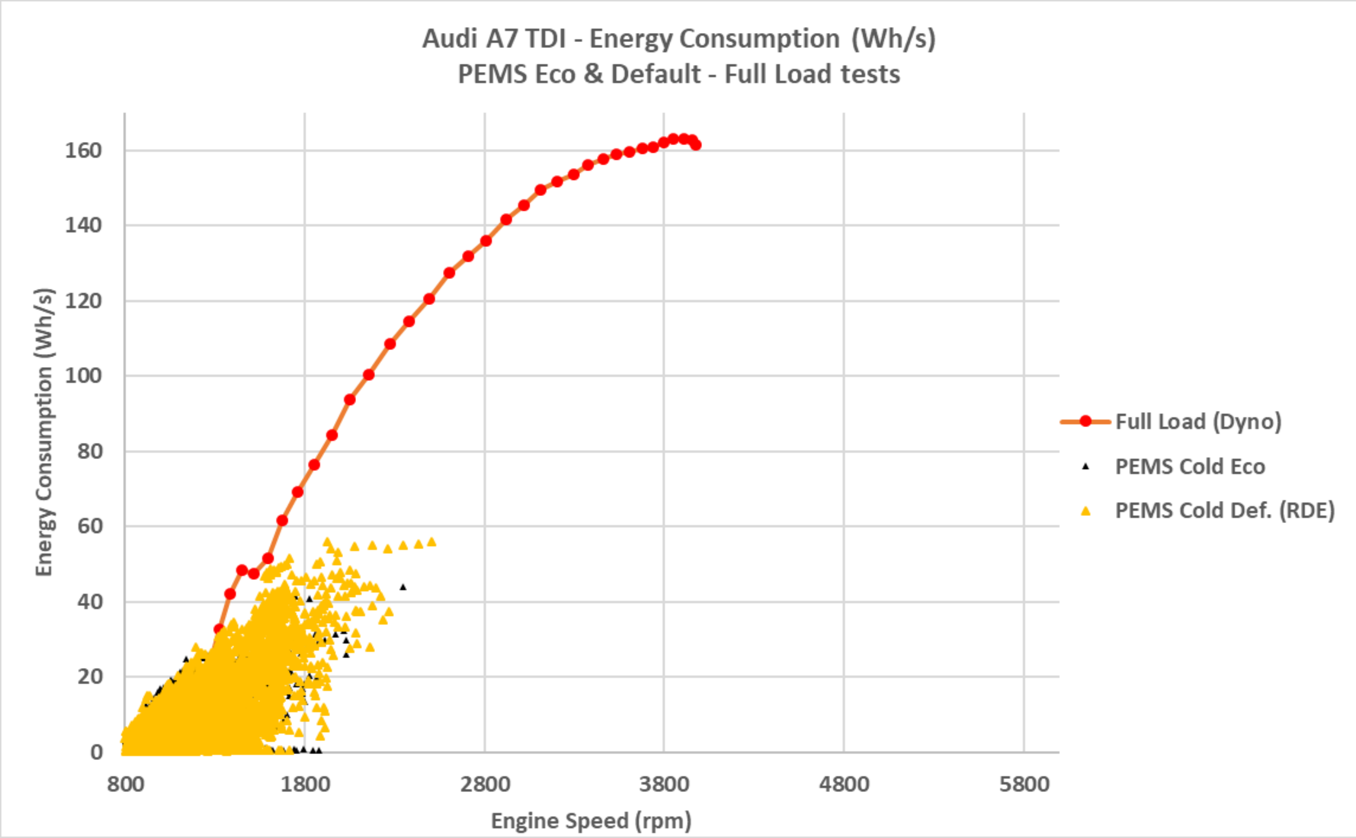
- **Audi A7 TDI from ADAC**

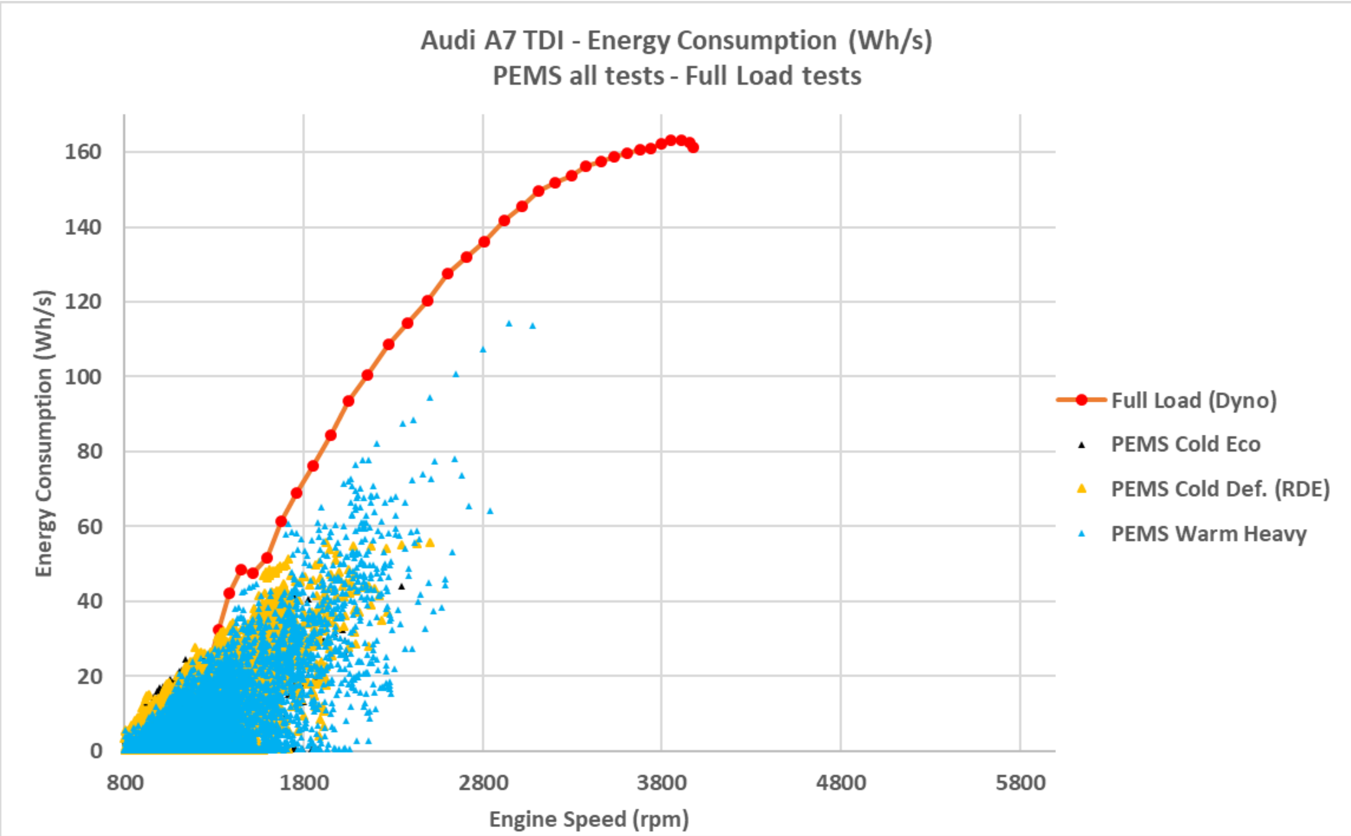




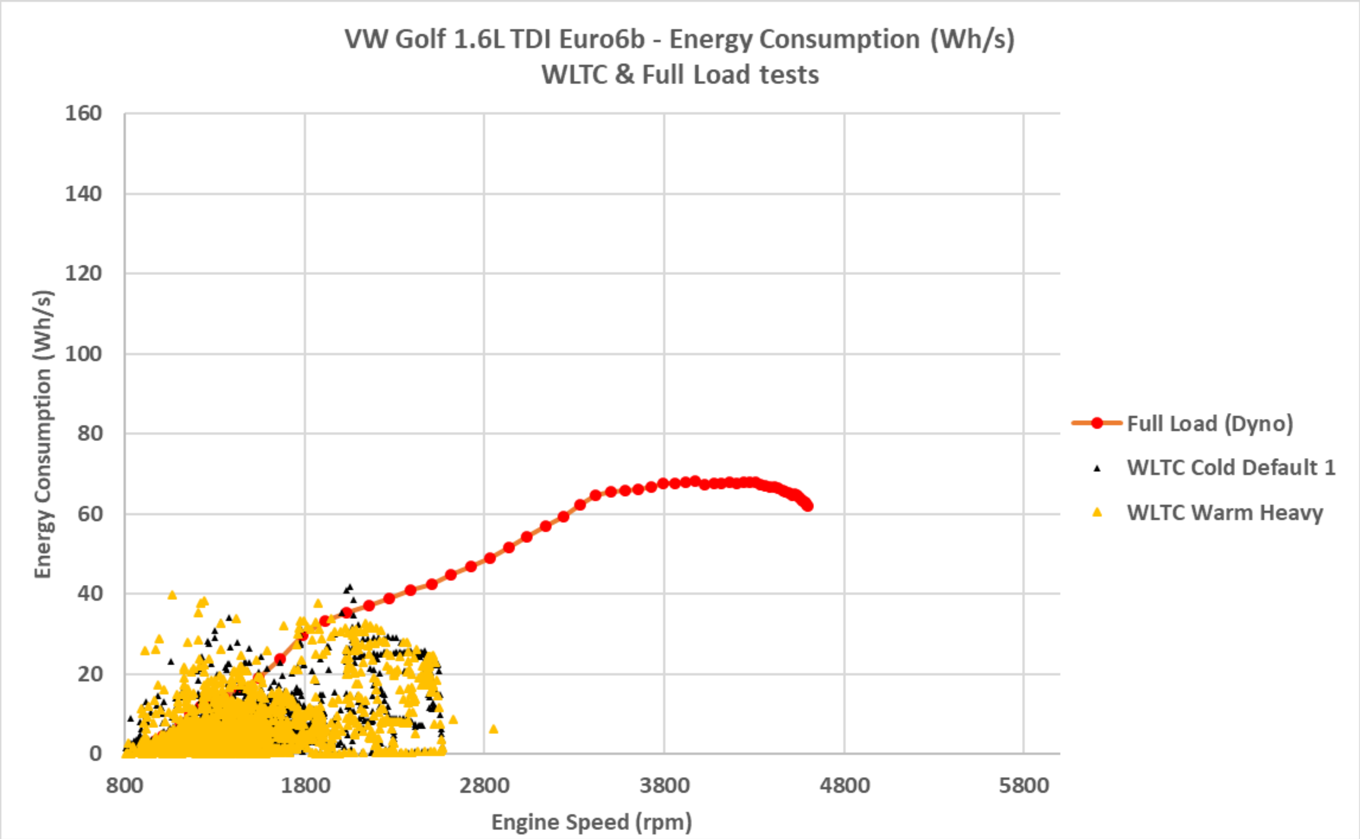

Audi A7 TDI - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

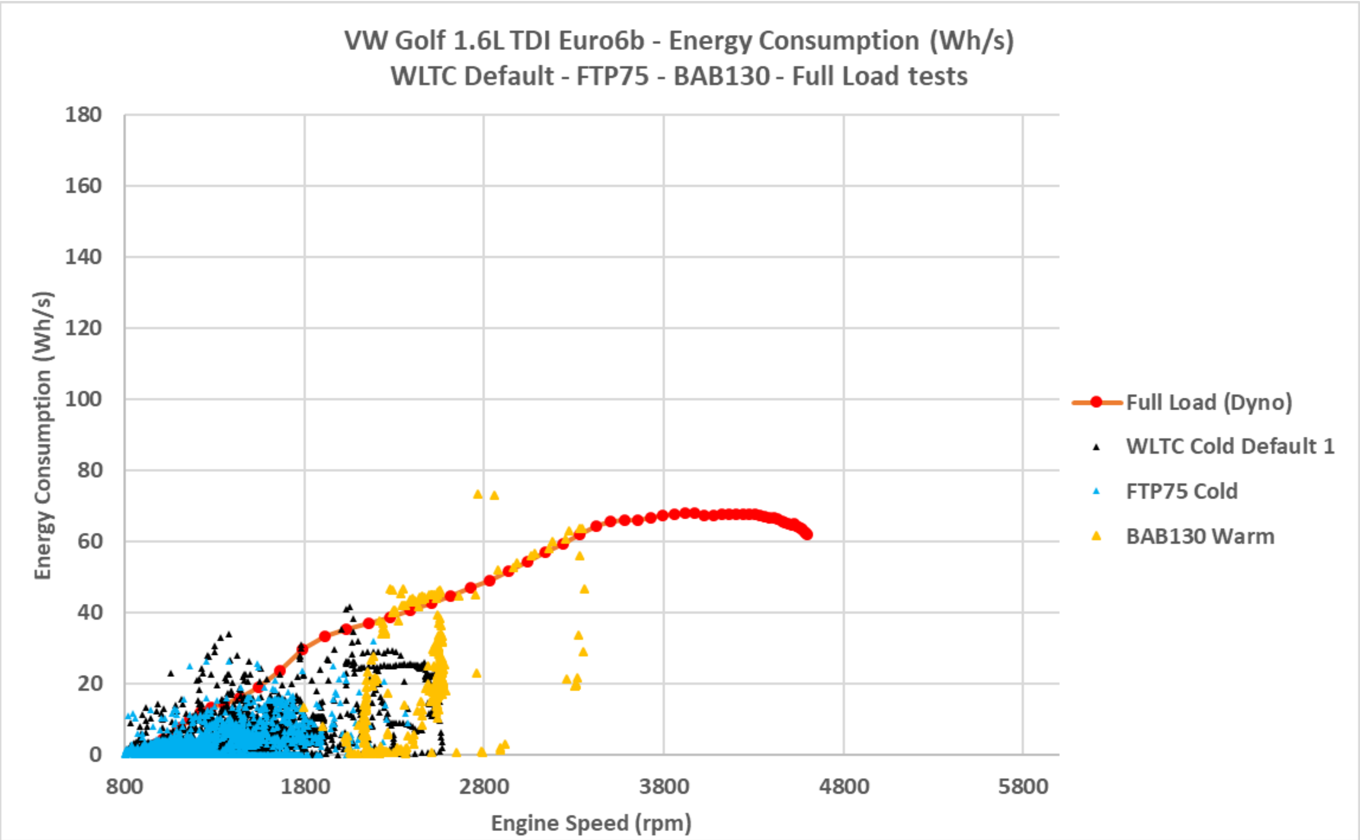

Audi A7 TDI - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco

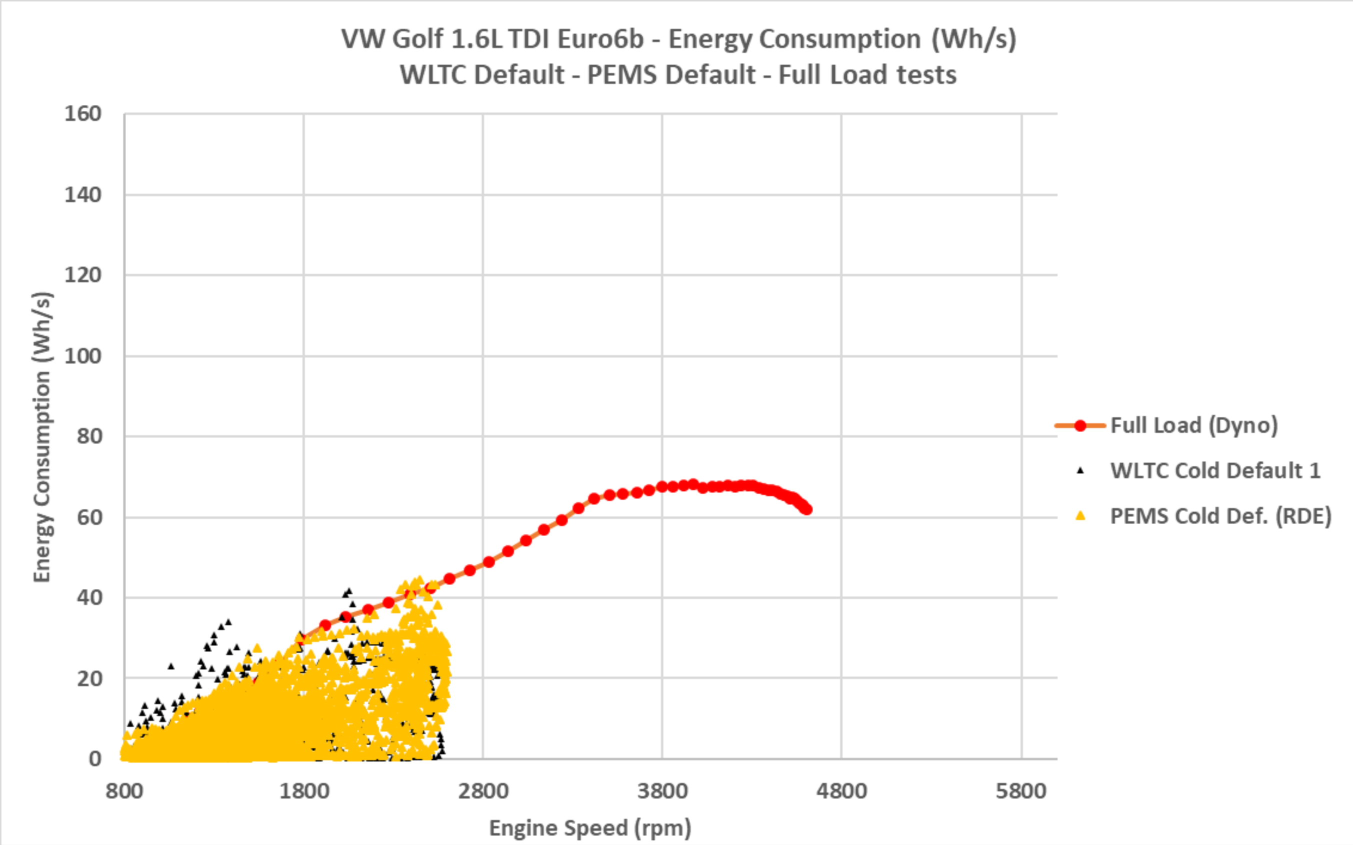

Audi A7 TDI - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)

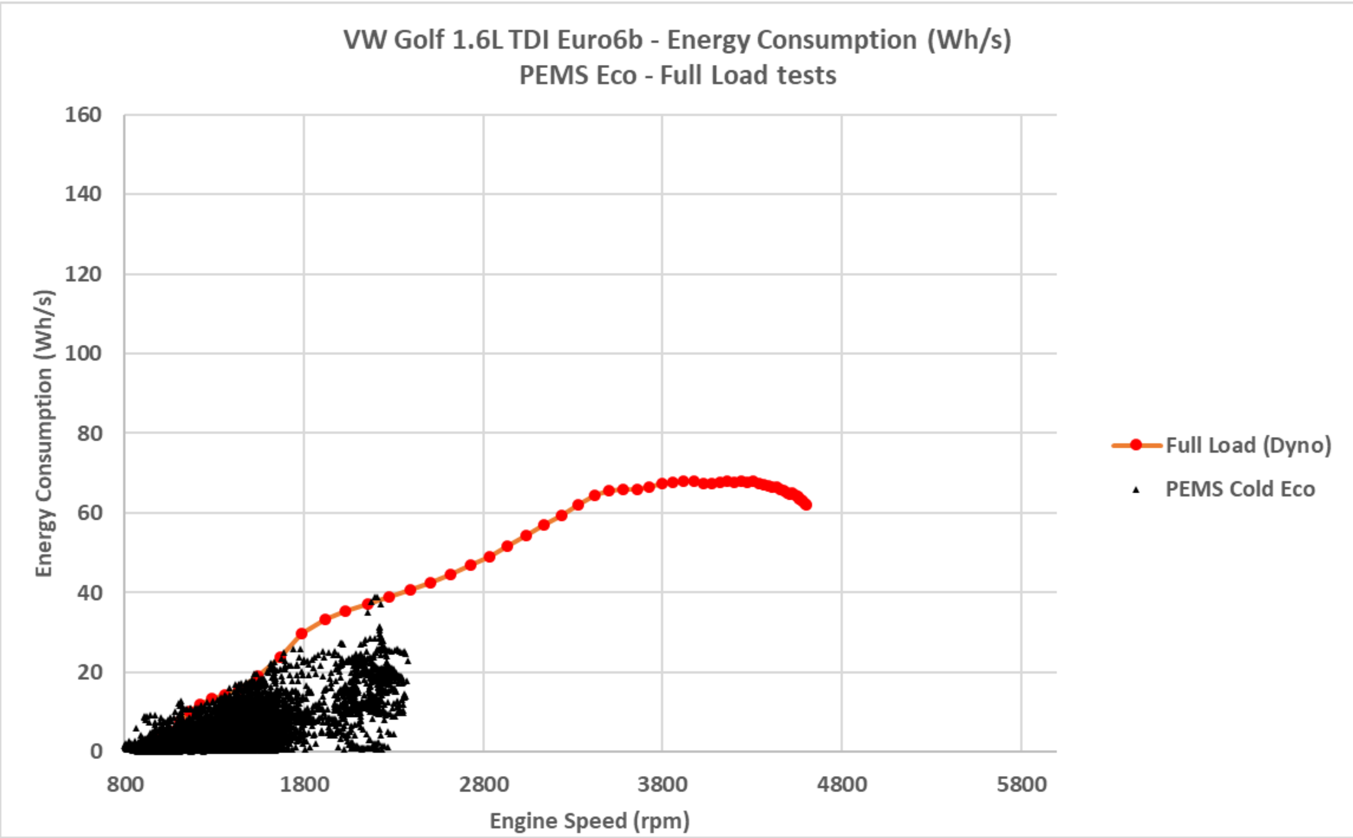

Audi A7 TDI - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

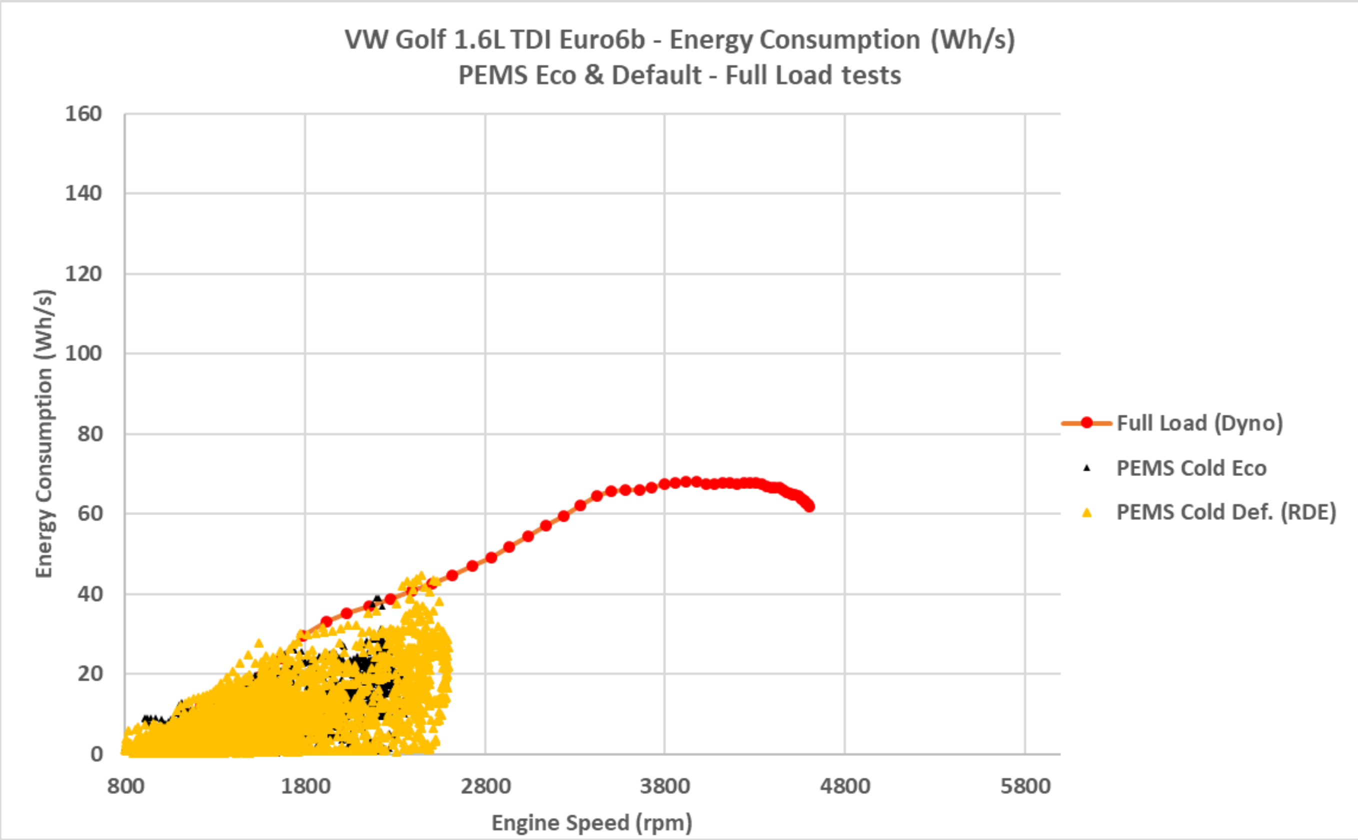
- **VW Golf 1.6L TDI Euro6b from ADAC**

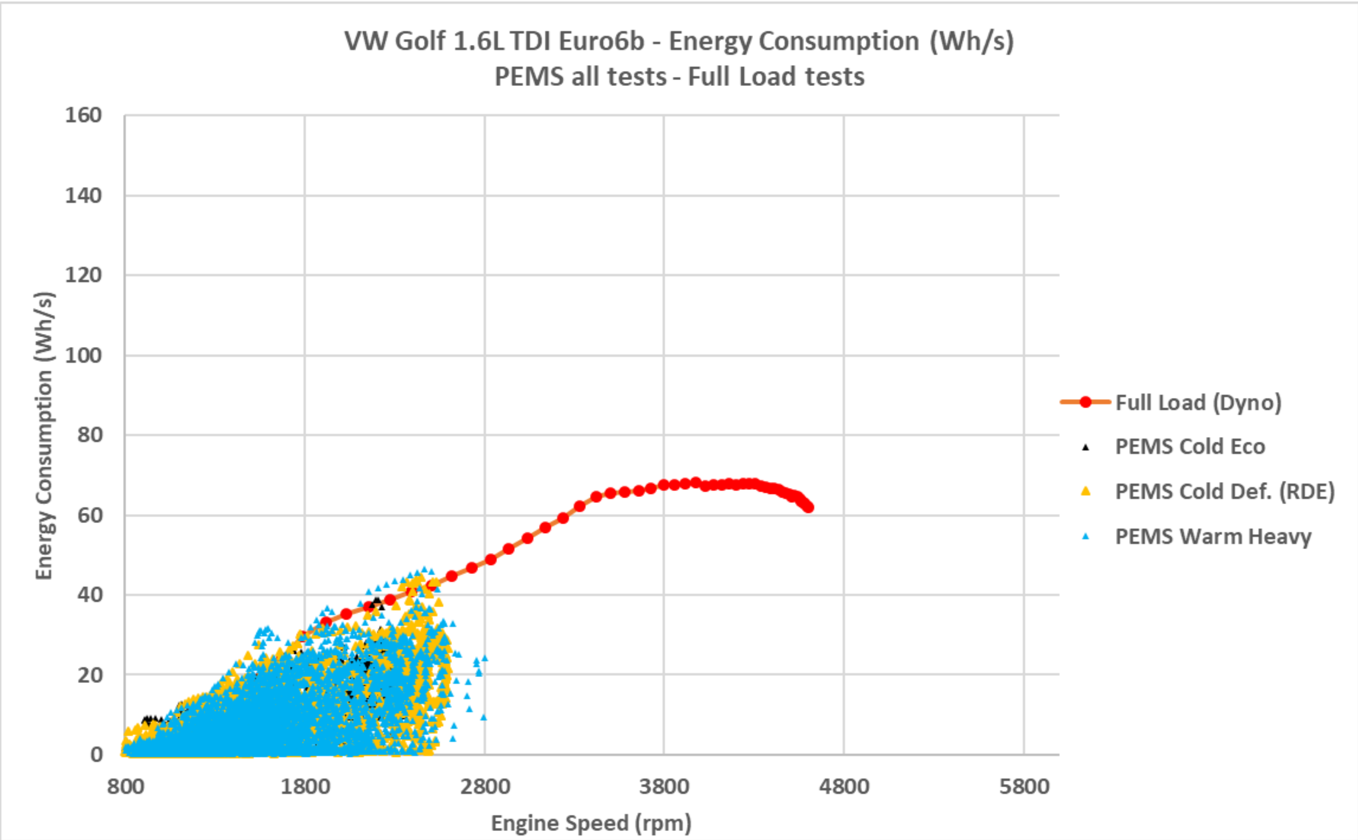




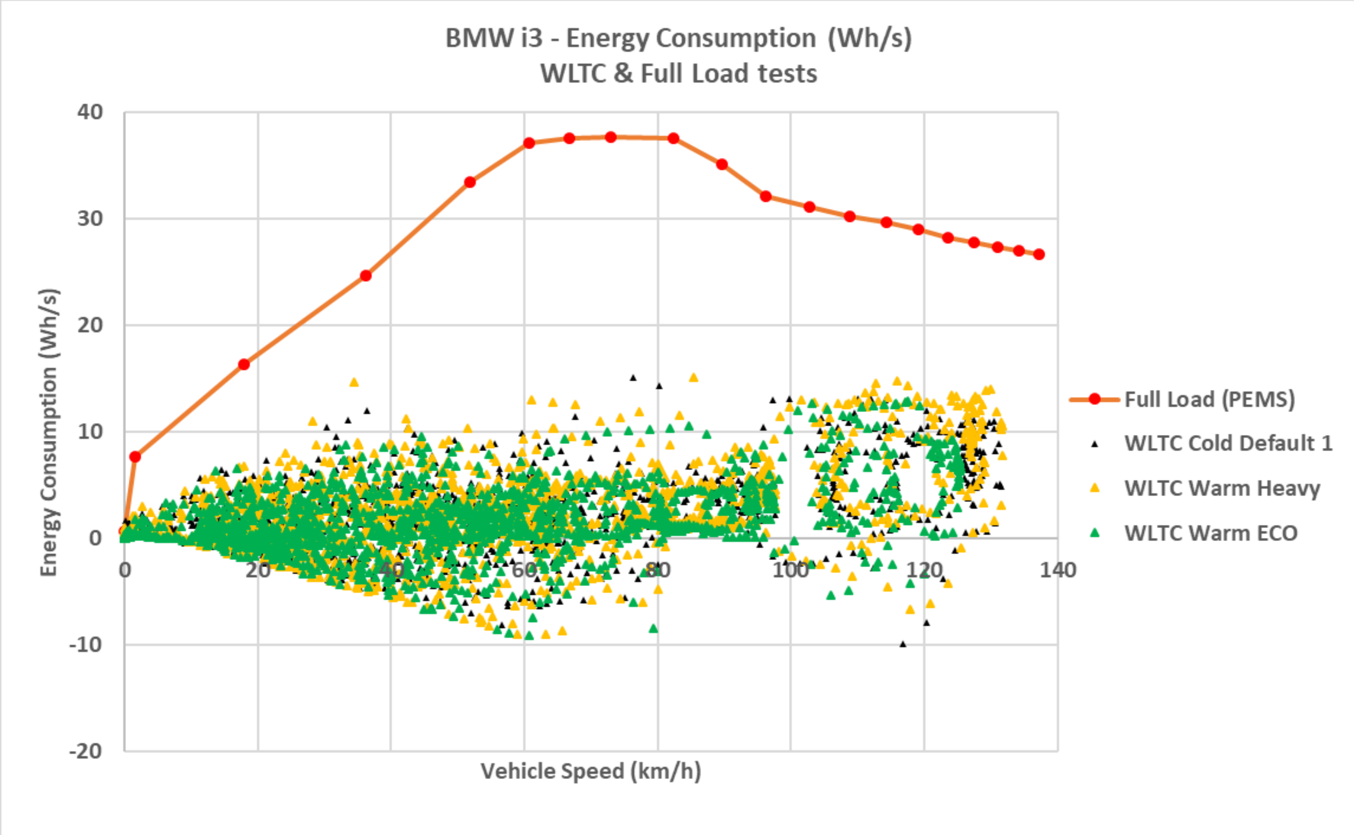

VW Golf 1.6L TDI Euro6b - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

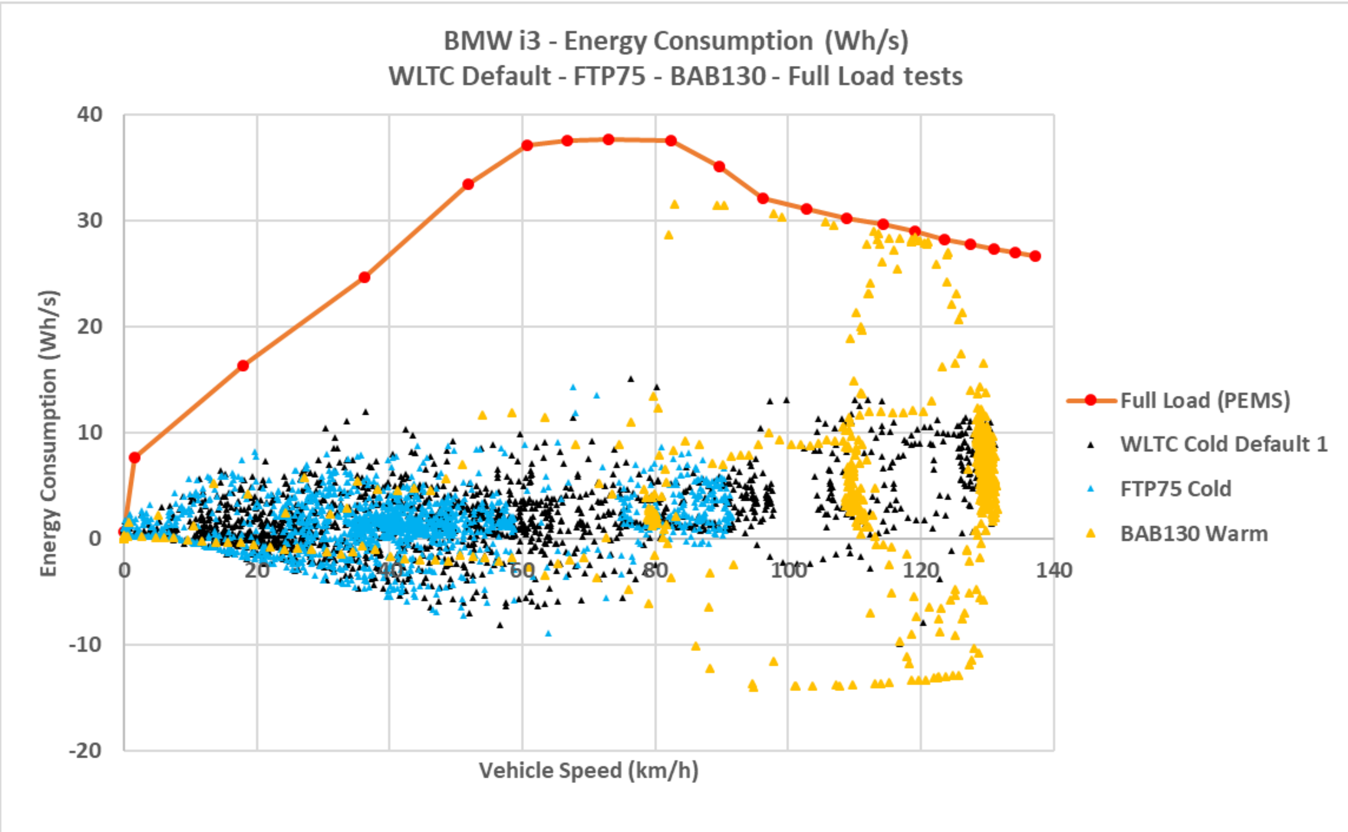

VW Golf 1.6L TDI Euro6b - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
160
140
120
100
80
60
40
20
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
Full Load (Dyno)
PEMS Cold Eco

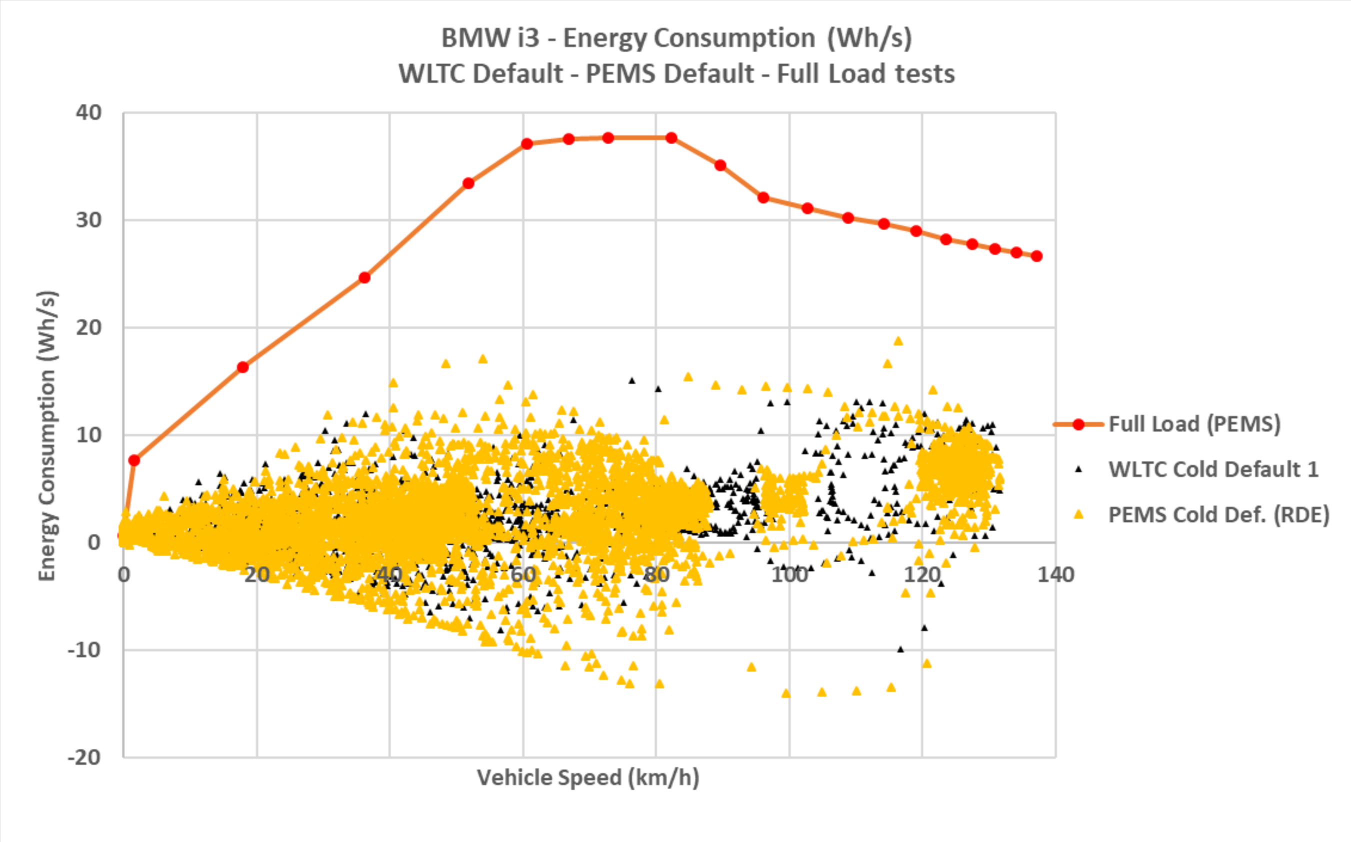

VW Golf 1.6L TDI Euro6b - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)

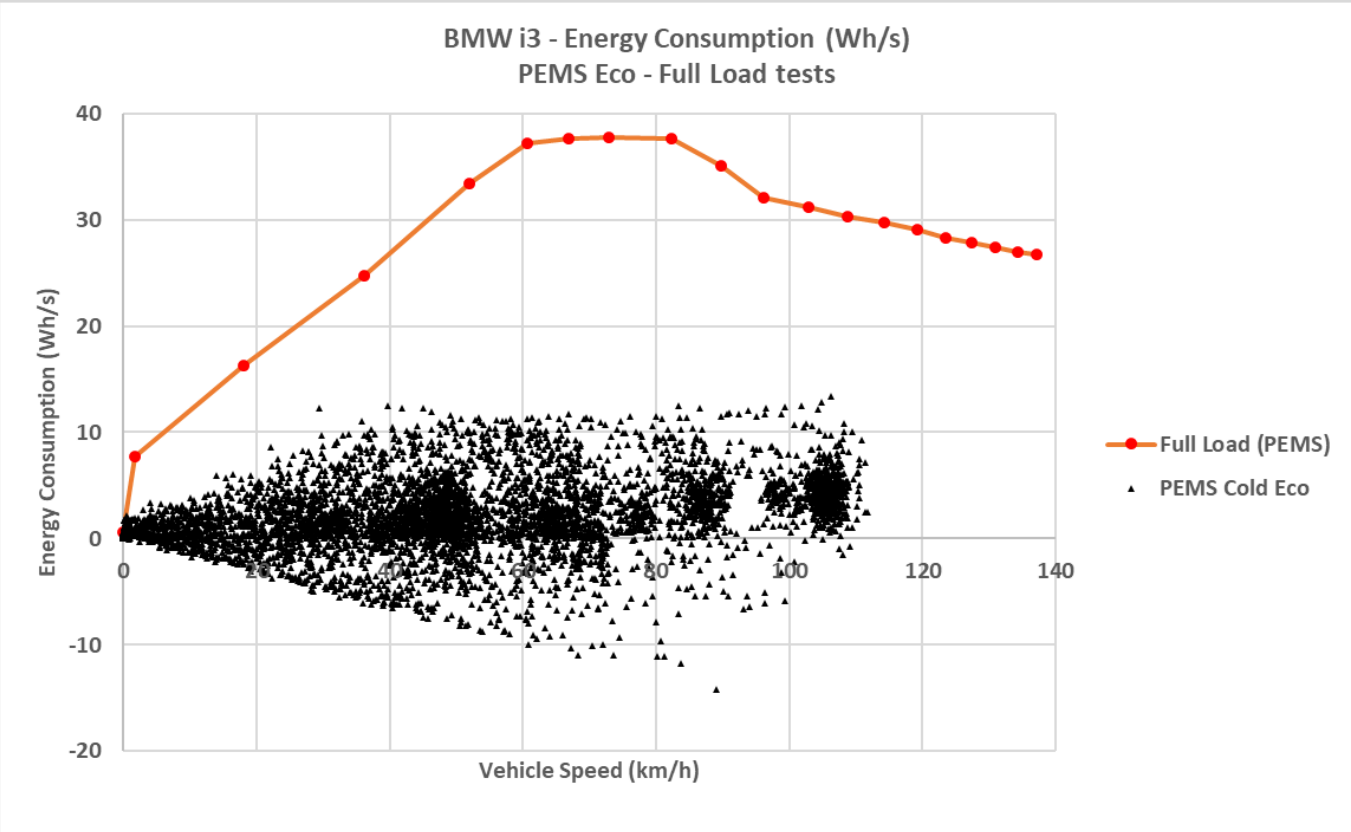

VW Golf 1.6L TDI Euro6b - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
20
40
60
80
100
120
140
160
800
1800
2800
3800
4800
5800
Full Load (Dyno)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

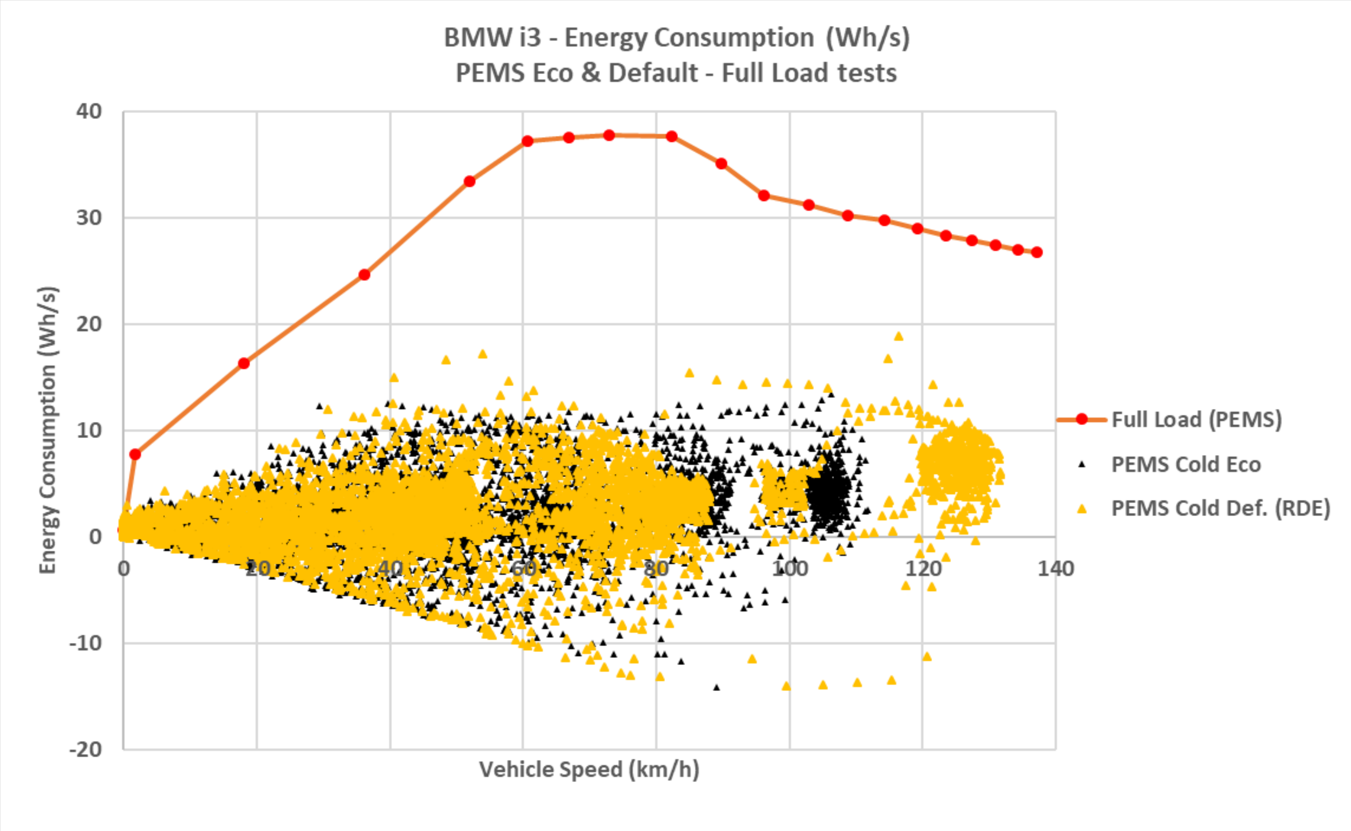
- **BMW i3 from IFA** (Vehicle Speed in reference instead of Engine speed not available by OBD)

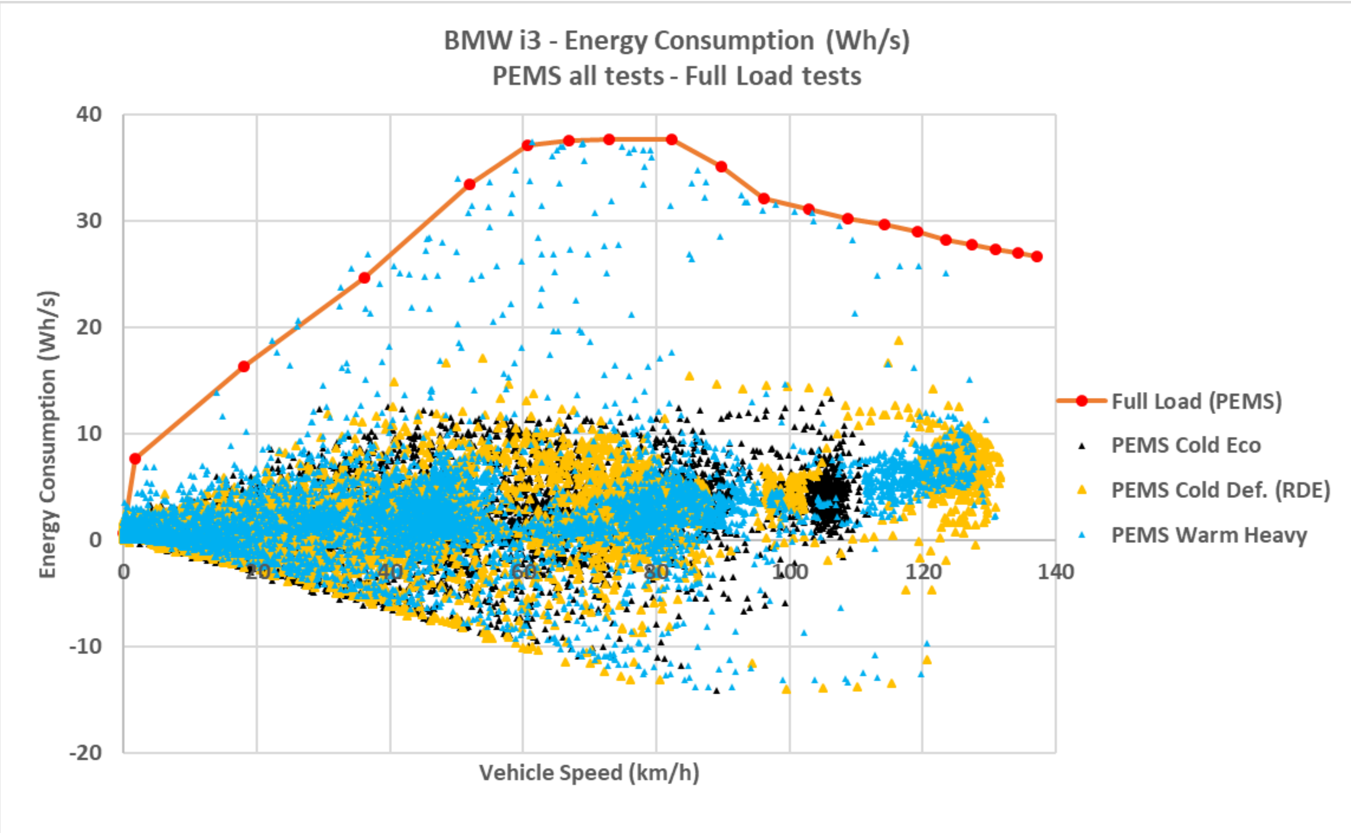




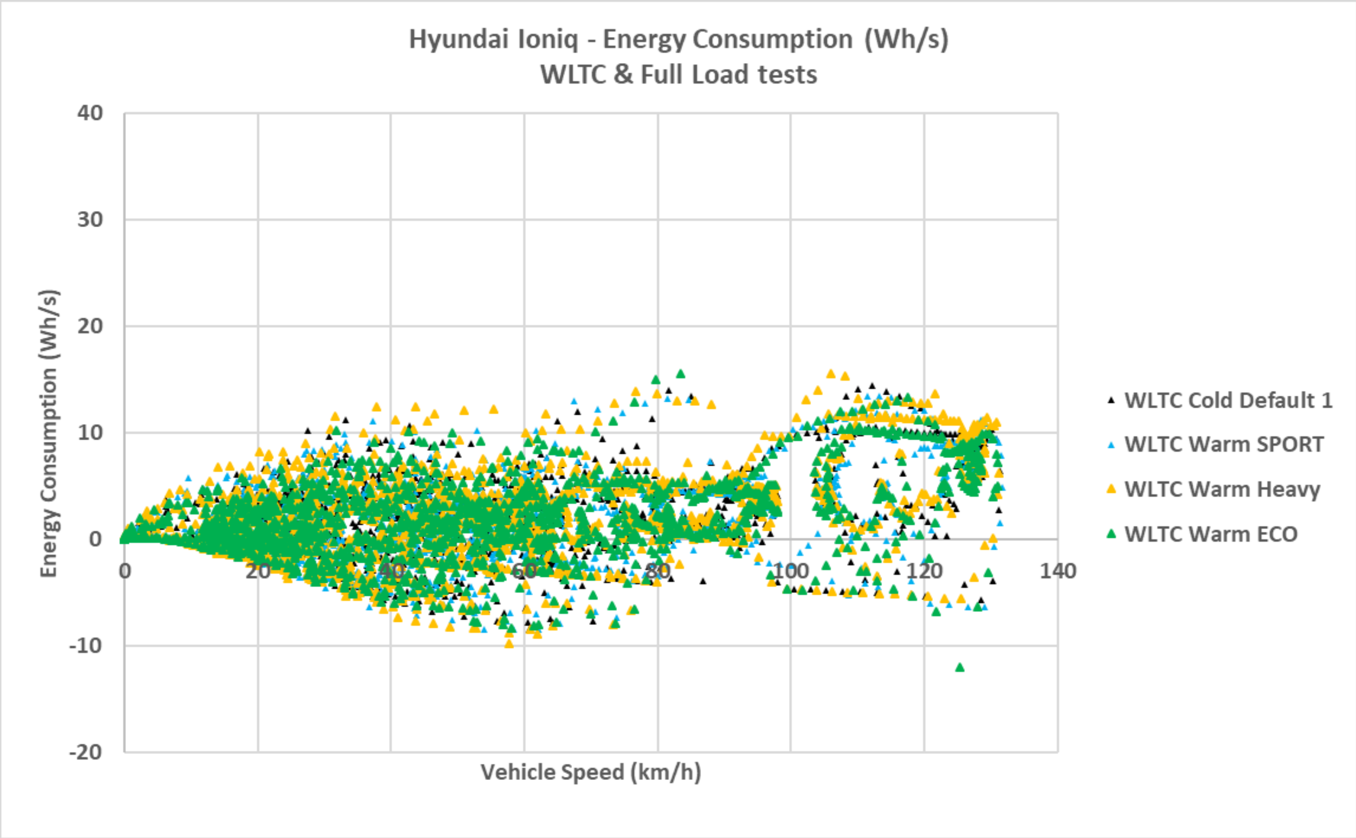

BMW i3 - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
Vehicle Speed (km/h)
Full Load (PEMS)
WLTC Cold Default 1
PEMS Cold Def. (RDE)

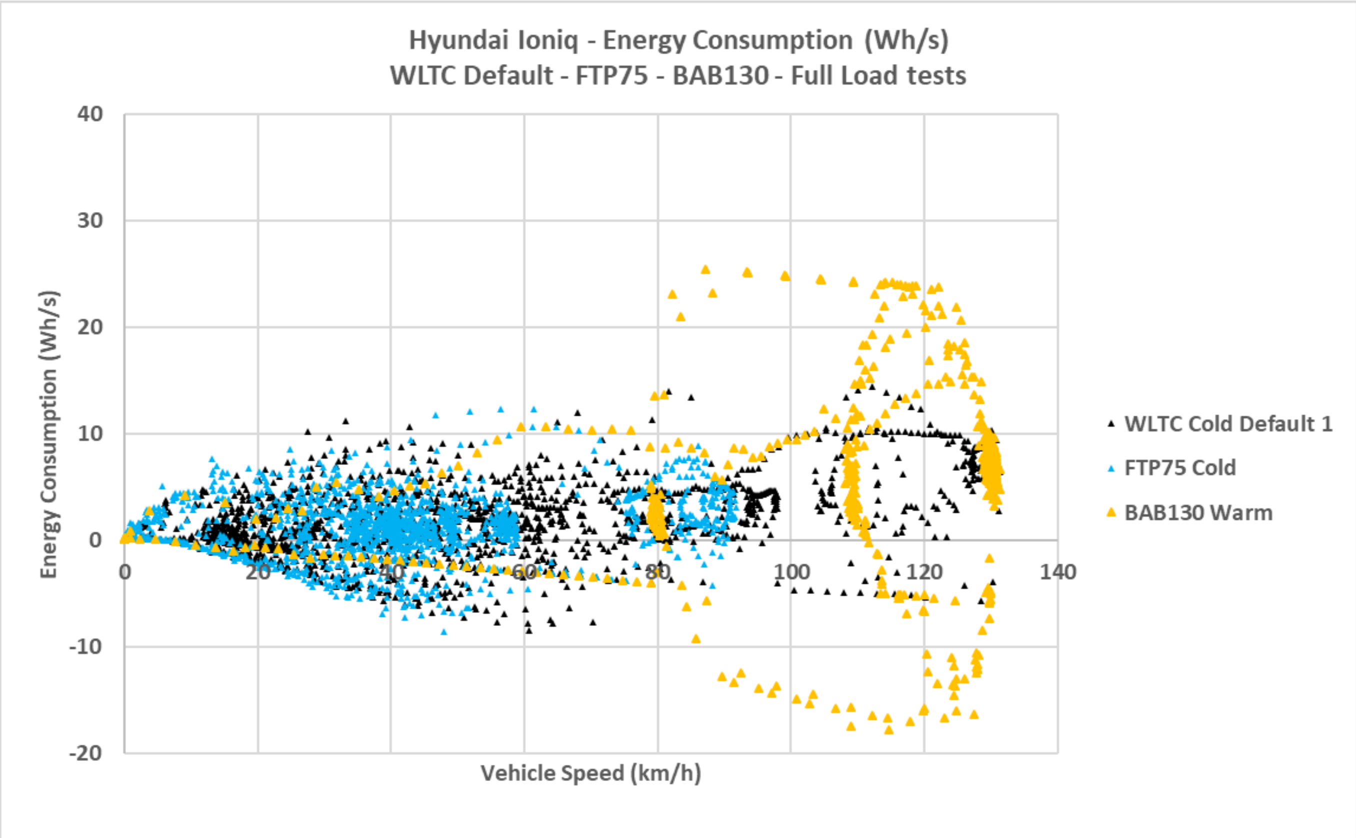

BMW i3 - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
Vehicle Speed (km/h)
Full Load (PEMS)
PEMS Cold Eco


BMW i3 - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
Vehicle Speed (km/h)
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)

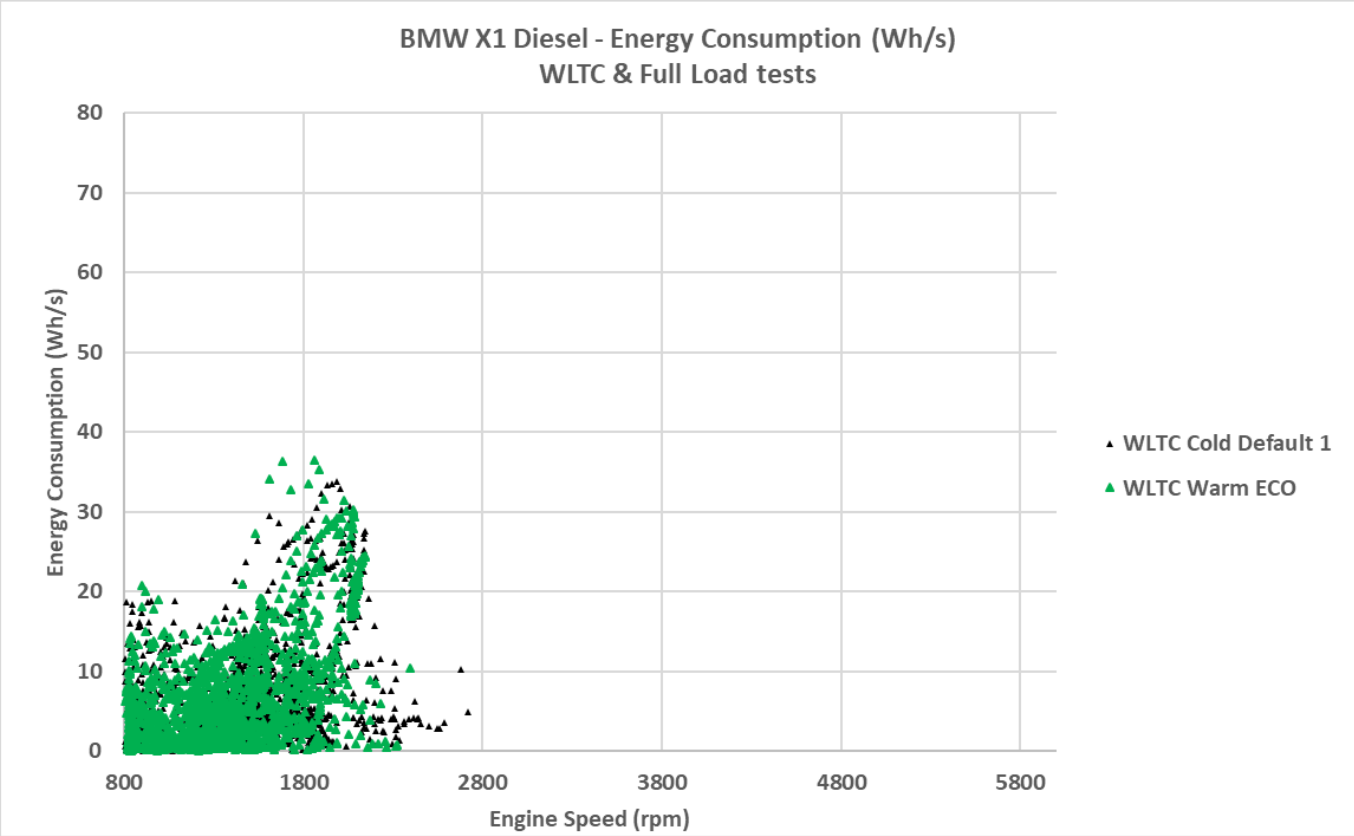

BMW i3 - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
Vehicle Speed (km/h)
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
Full Load (PEMS)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

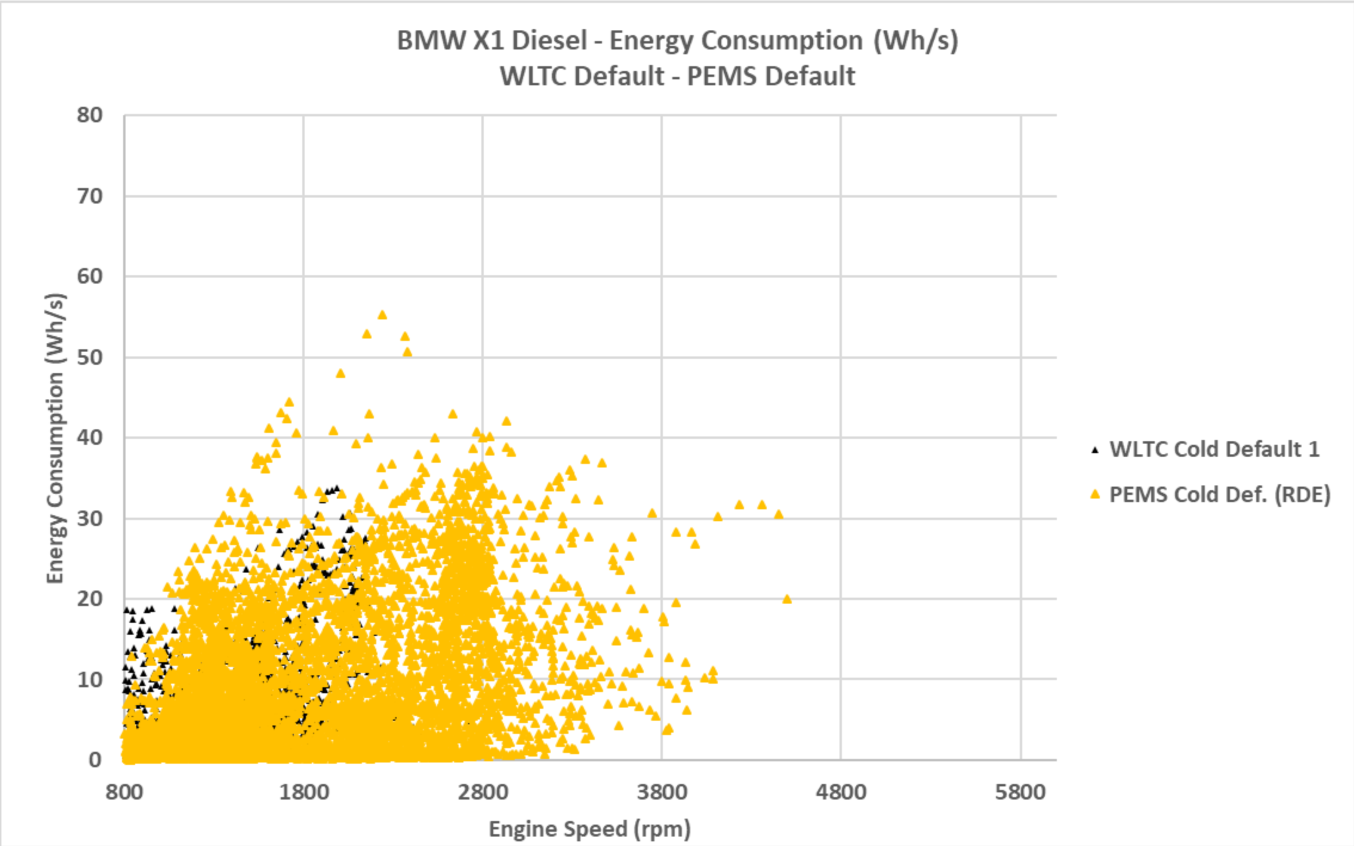
- **Hyundai Ionic from IFA** (Vehicle Speed in reference instead of Engine speed not available by OBD)

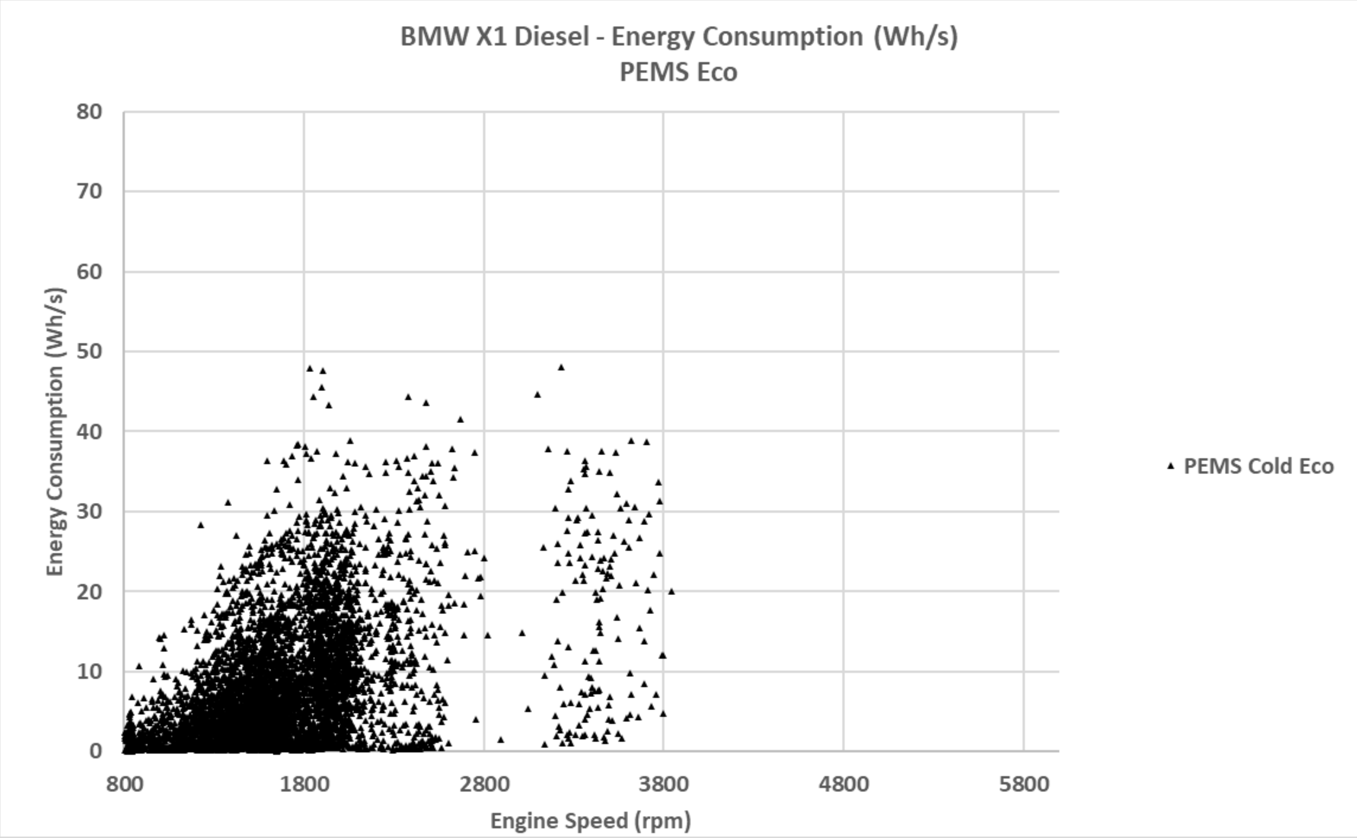


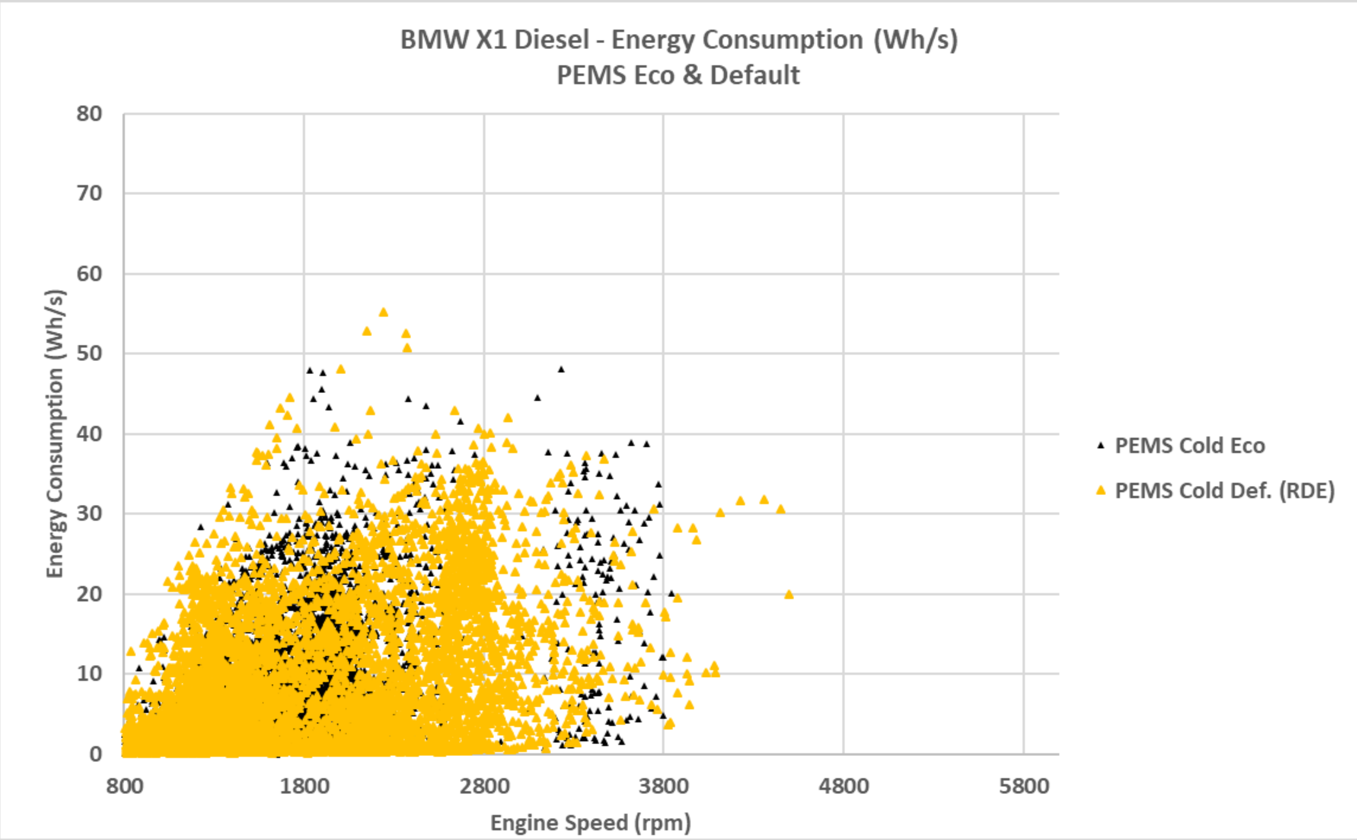


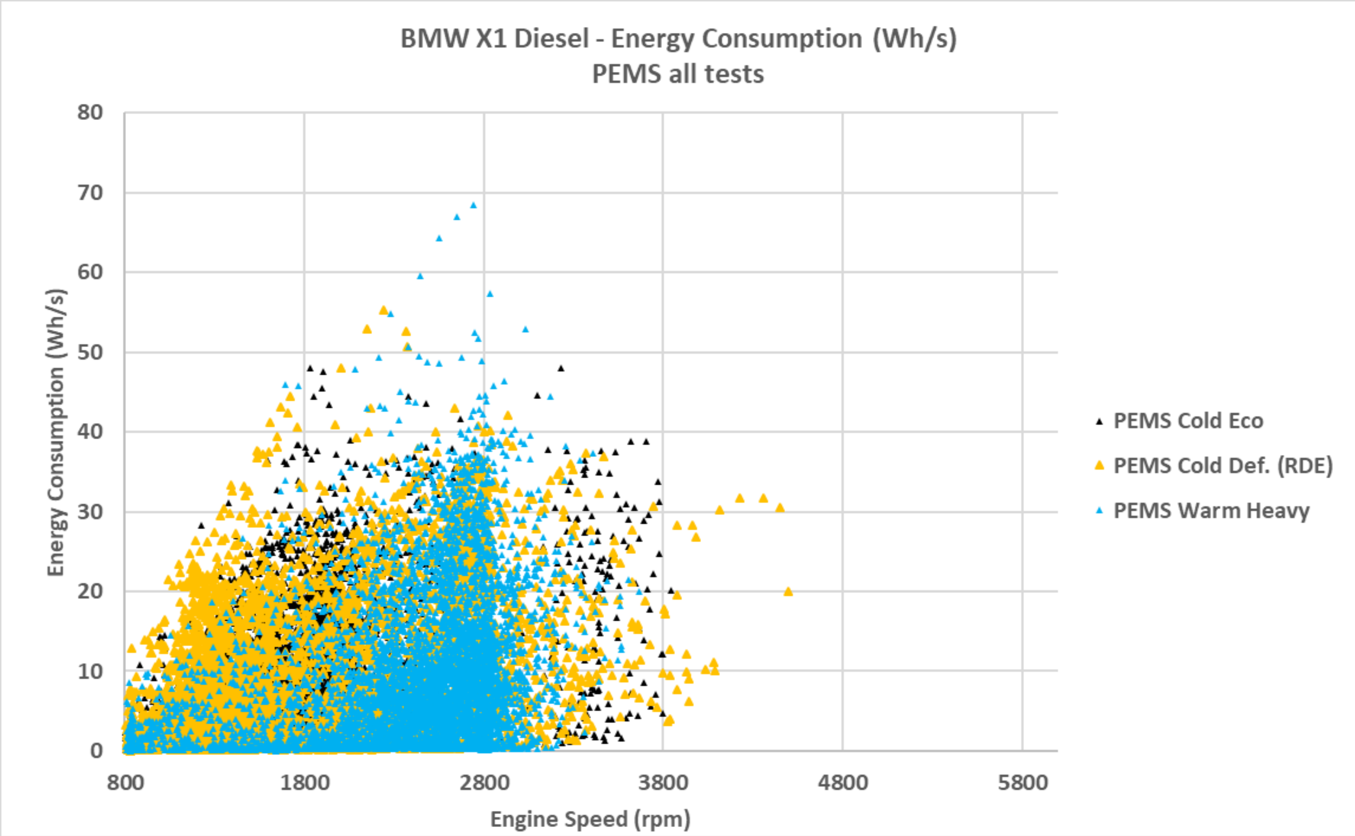
- **BMW X1 Diesel from MIRA (without Energy Consumption on full load test)**



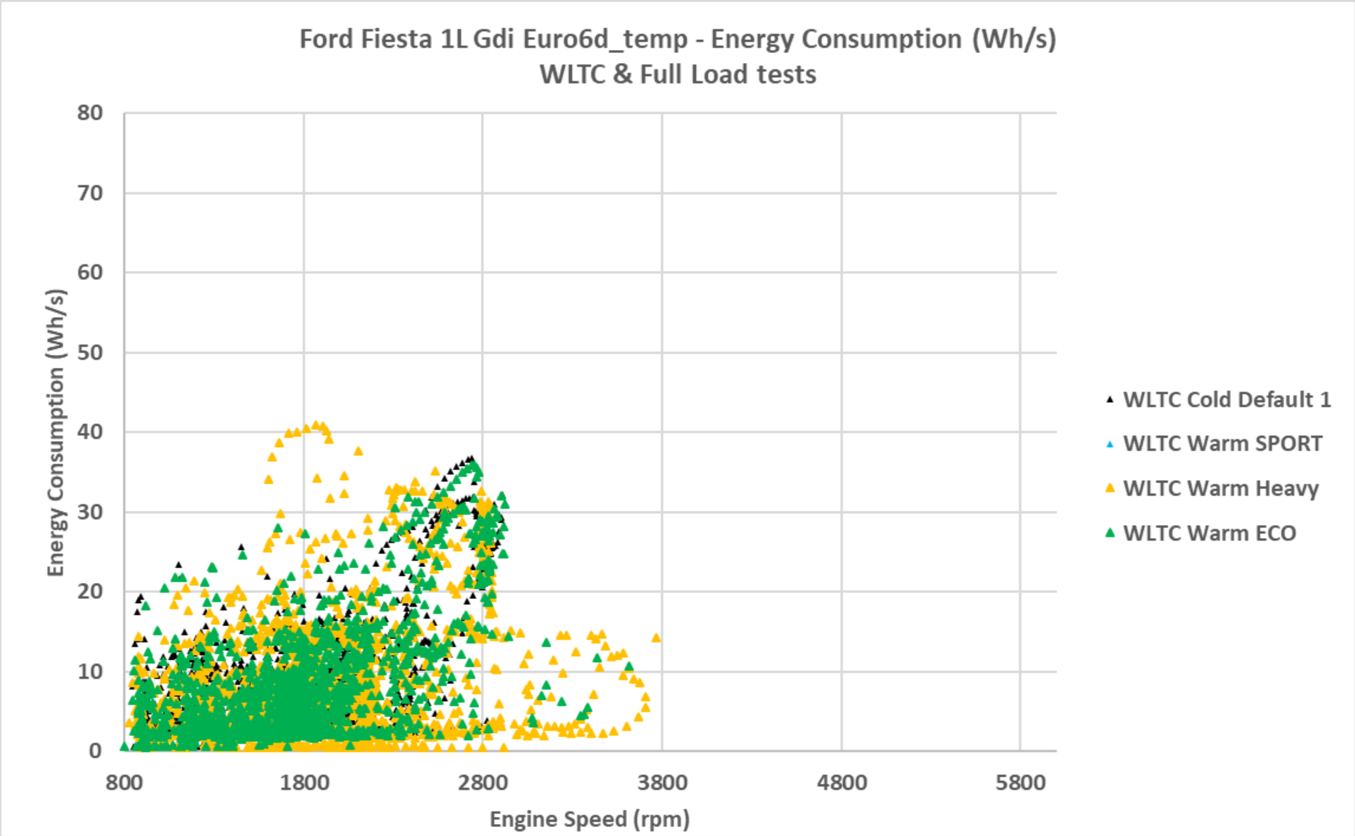


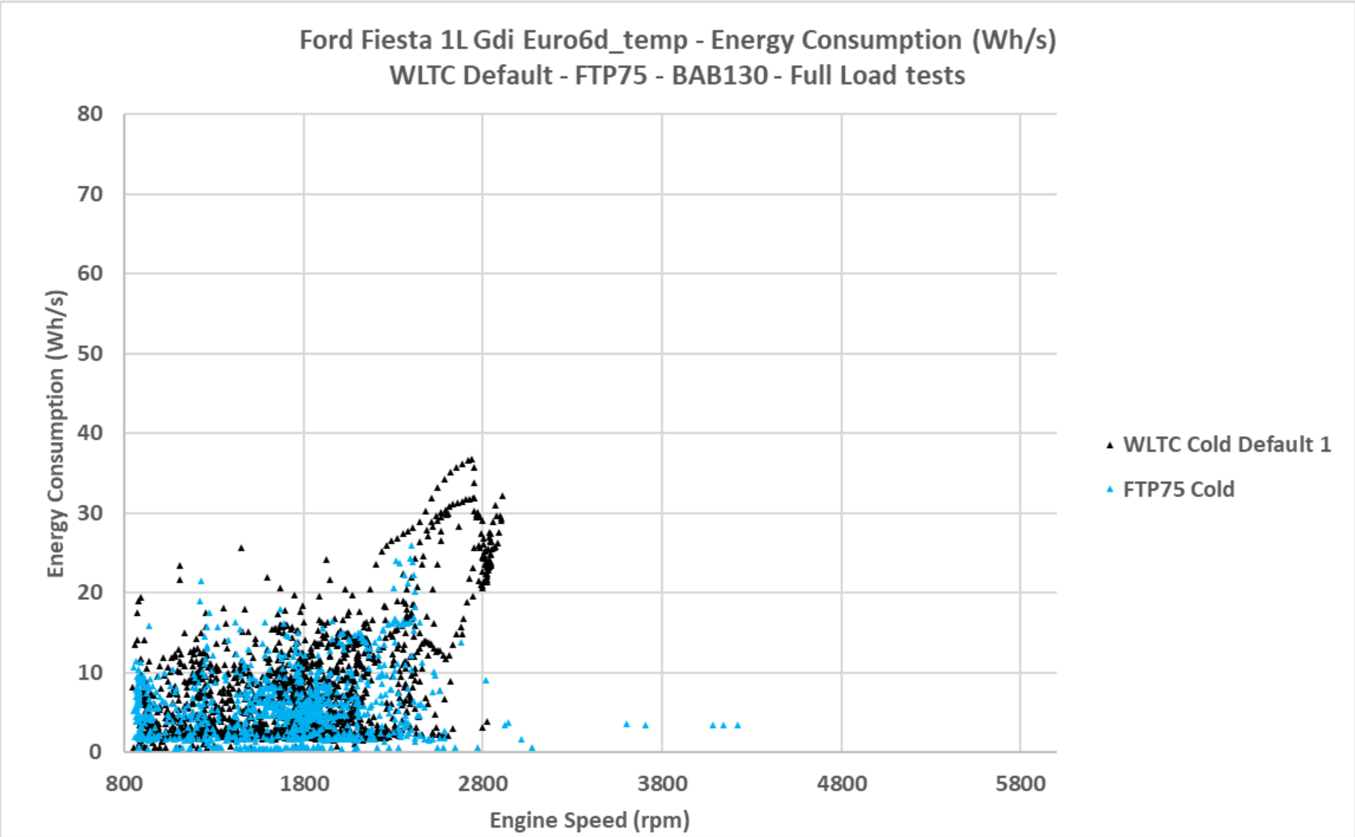

BMW X1 Diesel - Energy Consumption (Wh/s)
PEMS Eco
Energy Consumption (Wh/s)
0
10
20
30
40
50
60
70
80
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco

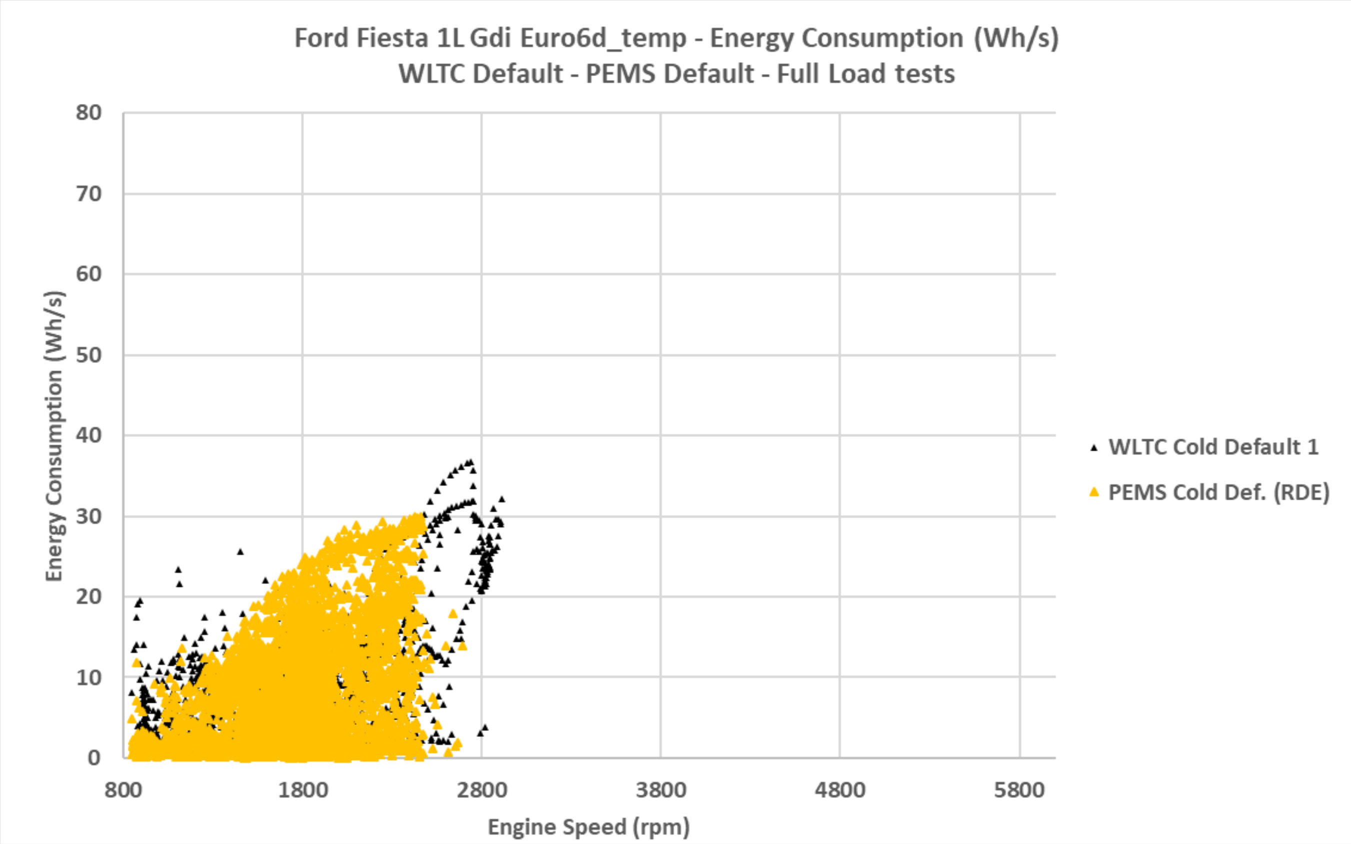

BMW X1 Diesel - Energy Consumption (Wh/s)
PEMS Eco & Default
Energy Consumption (Wh/s)
0
10
20
30
40
50
60
70
80
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco
PEMS Cold Def. (RDE)

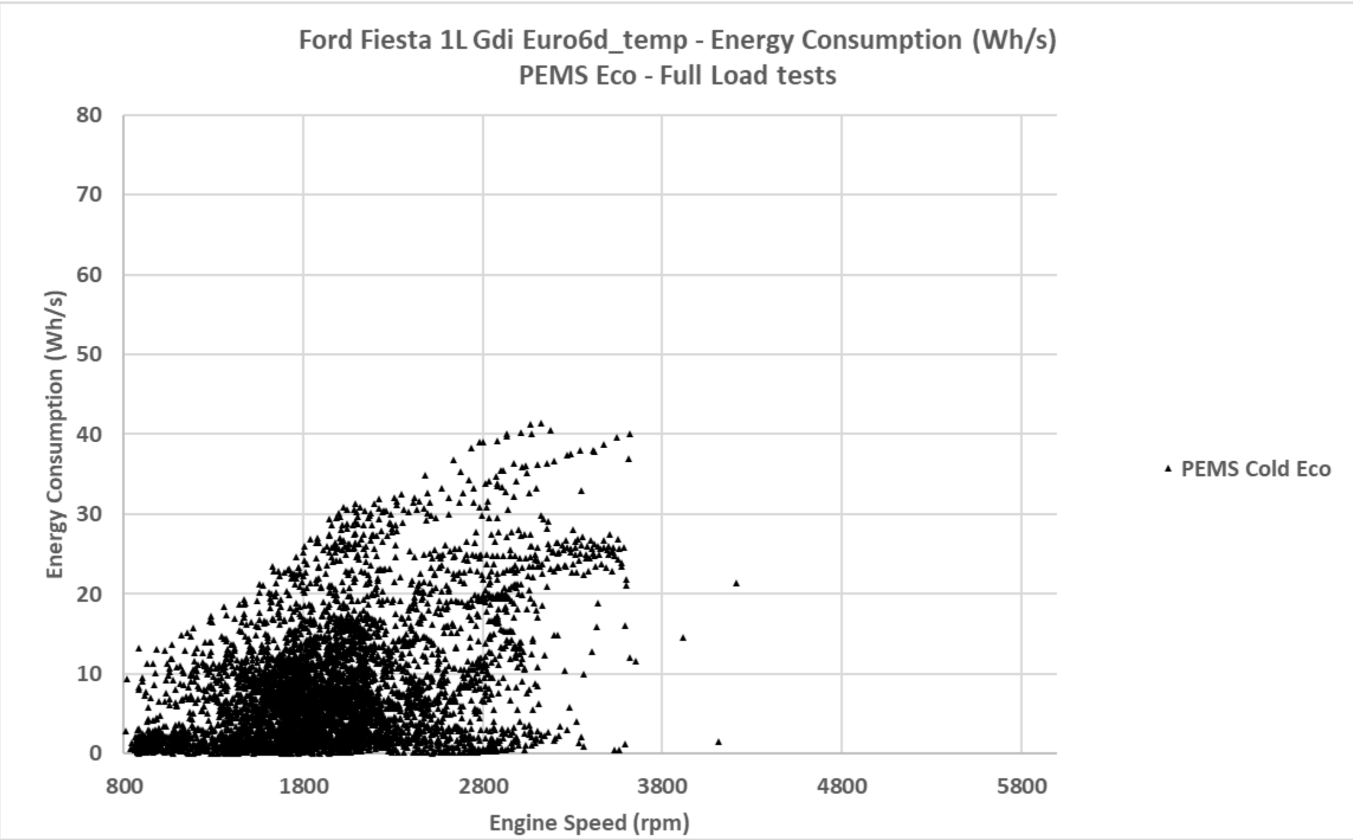

BMW X1 Diesel - Energy Consumption (Wh/s)
PEMS all tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

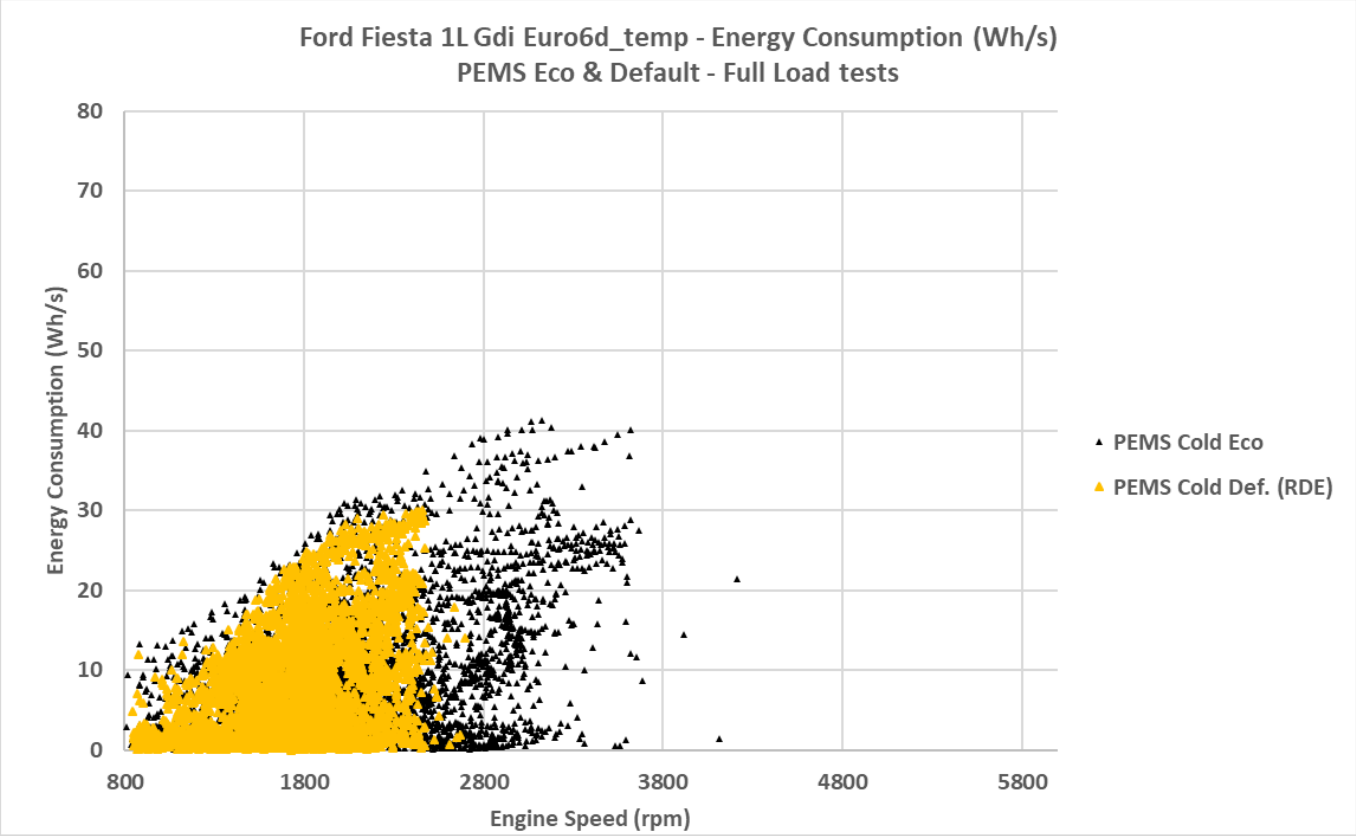
- **Ford Fiesta 1L GDi Euro6d temp from MIRA (without Energy Consumption on full load test)**

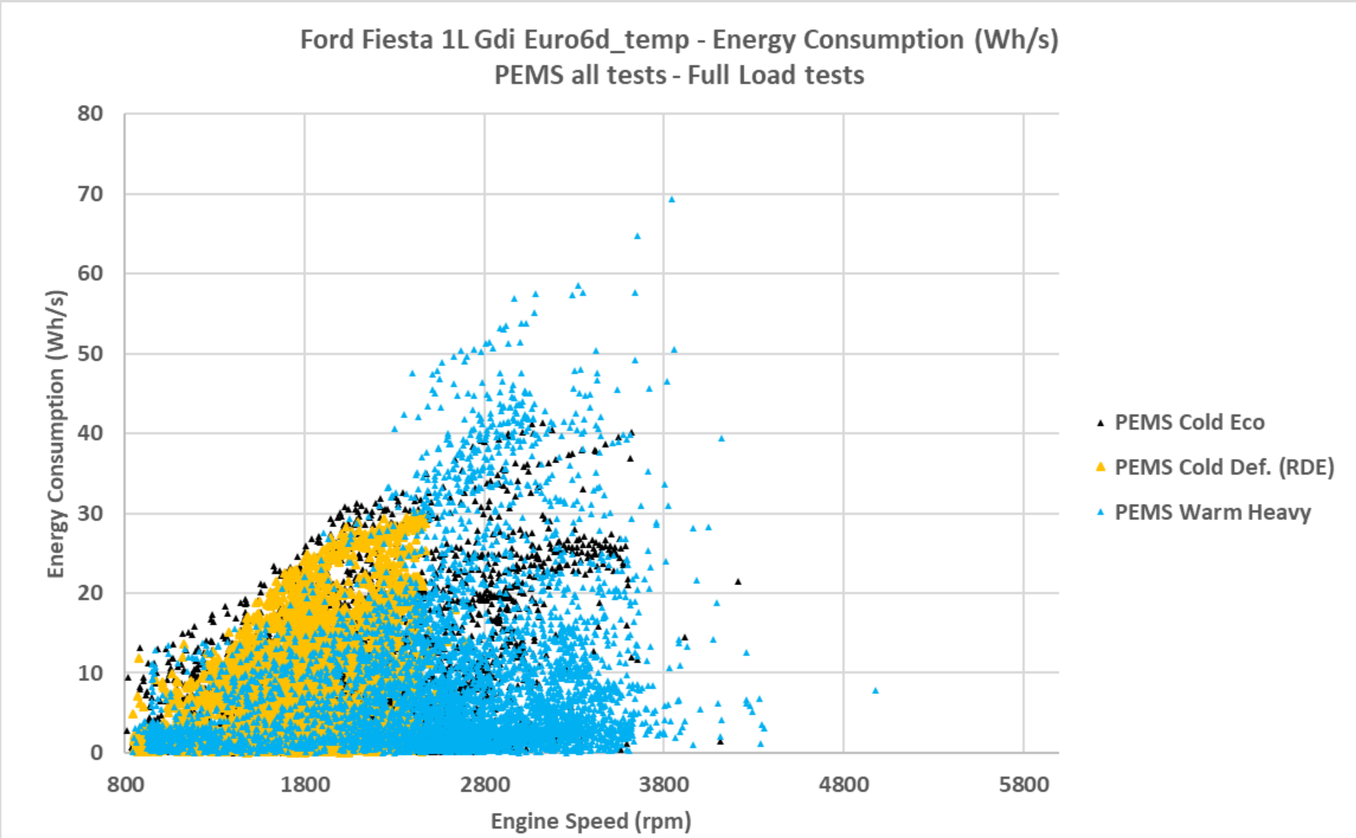





Ford Fiesta 1L Gdi Euro6d_temp - Energy Consumption (Wh/s)
WLTC Default - PEMS Default - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
WLTC Cold Default 1
PEMS Cold Def. (RDE)


Ford Fiesta 1L Gdi Euro6d_temp - Energy Consumption (Wh/s)
PEMS Eco - Full Load tests
Energy Consumption (Wh/s)
80
70
60
50
40
30
20
10
0
800
1800
2800
3800
4800
5800
Engine Speed (rpm)
PEMS Cold Eco


Ford Fiesta 1L Gdi Euro6d_temp - Energy Consumption (Wh/s)
PEMS Eco & Default - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
80
800
1800
2800
3800
4800
5800
PEMS Cold Eco
PEMS Cold Def. (RDE)


Ford Fiesta 1L Gdi Euro6d_temp - Energy Consumption (Wh/s)
PEMS all tests - Full Load tests
Energy Consumption (Wh/s)
Engine Speed (rpm)
0
10
20
30
40
50
60
70
80
800
1800
2800
3800
4800
5800
PEMS Cold Eco
PEMS Cold Def. (RDE)
PEMS Warm Heavy

ANNEX 4

SUMMARY OF PEMS+ TEST CONDITIONS

		Fiesta 1L €6b	Fiesta 1L €6d_t	Panda 0,9L	A200
PEMS Cold Standard	Test mass	1322	1441	1244	1717
	T° outside	12	16	29	24
	Weather	Dry Air condi. OFF	Dry Air condi.ON 20°C	Sunny Air condi. ON	Good conditions Air condi. ON
	Traffic Jam	Normal + construction on motorway part	Moderate	Busy on urban and first part of rural	Normal
PEMS Cold Eco	Test mass	1315	1370	1225	1679
	T° outside	22	19	33	31
	Weather	Dry Air condi. OFF	Dry Air condi. OFF	Sunny Air condi. ON	Good conditions Air condi. ON
	Traffic Jam	Normal	Moderate	Normal	Normal
PEMS Warm Heavy	Test mass	1500	1513	1413	1762
	T° outside	12	18	35	31
	Weather	Dry Air condi. ON	Dry Air condi. ON Max	Sunny Air condi. ON	Good conditions Air condi. ON
	Traffic Jam	Normal + construction on motorway part	Moderate	Normal	Normal

		Outback 2.5i	XC40	UP GTI
PEMS Cold Standard	Test mass	1795	1889	1200
	T° outside	18	24	25
	Weather	Dry & Sunny Air condi. OFF	Dry Air condi.ON 20°C	Dry Air condi.ON 20°C
	Traffic Jam	Moderate until average	Normal	Normal
PEMS Cold Eco	Test mass	1795	1889	1200
	T° outside	16	13	23
	Weather	Dry & Sunny Air condi. OFF	Wet road Air condi. ON 20°C	Warm & Dry Air condi.OFF
	Traffic Jam	Moderate until low	Normal	Normal
PEMS Warm Heavy	Test mass	2055	2220	1400
	T° outside	19	26	30
	Weather	Cloudy, partly dry, partly wet Air condi. ON Max	Dry Air condi.ON 20°C	Dry Air condi.ON 20°C
	Traffic Jam	Moderate	Normal	Normal

		A7	Golf TDI €6b	BMW X1d	Ionic (EV)	BMW i3 (EV)
PEMS Cold Standard	Test mass	2216	1490	1723	1540	1295
	T° outside	18	32	10	27	12
	Weather	-	Dry Air condi.ON 20°C	Mid-sun Air condi.ON auto	Dry & Sunny Air condi. ON	Dry Air condi.ON (2/5)
	Traffic Jam	-	Normal	Normal	Little traffic	Busy at the beginning of test
PEMS Cold Eco	Test mass	2216	1490	1712	-	1295
	T° outside	15	22	14	-	9
	Weather	Dry Air condi. ON	Dry Air condi.ON 25°C	Sunny Air condi. ON auto	-	Dry Air condi.ON (2/5)
	Traffic Jam	Normal	Normal	Normal	-	Busy at the beginning of test
PEMS Warm Heavy	Test mass	2535	1840	2042	1820	1295
	T° outside	21	26	16	31	19
	Weather	? Air condi. ON	Dry Air condi.ON 20°C	Sunny Air condi. ON auto	Dry & Sunny Air condi. ON	Dry Air condi.ON (max)
	Traffic Jam	Normal	Normal	Normal	Little traffic	Busy at the beginning of test

ANNEX 5

RATING SHEET
VALIDATION PHASE

- **Subaru Outback 2.5i from EMPA-TCS**

green ncap

Subaru	Outback	2019	★★★★★

Clean Air Index	Energy Efficiency Index
6,5	1,8

	WLTC-cold	6,8	Energy Consumption (WLTC-cold)	3,2
	WLTC-warm	2,8	Energy Consumption (WLTC-warm/eco/sport)	3,1
	WLTC -eco	2,8	Energy Consumption 1) (PEMS+)	-
	WLTC -sport	2,8	Energy Consumption (BAB130)	0,0
	PEMS+	6,9	Energy Consumption 1) (suppl PEMS)	-
	BAB130	0,0	Driving Range 1)	-
	suppl. PEMS 1)	-	Driving Resistance 1)	-
Total Score	22,2		6,3	
Max Points available	34,0		34,0	
Index	**6,5**		**1,8**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Subaru	Outback
Specs (cc/kW)	2500	129
Applies to VIN:	Applies to All Outback's	
Powerunit(s)	petrol	
Actual mass (kg)	1695	
Average consumption (in WLTC tests)		
fuel	8,4	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)1)		
fuel	n.a.	l/ 100km
electric energy	n.a.	kWh/100km

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- **Ford Fiesta 1L GDi Euro6b from UTAC**

Ford	Fiesta 1L EcoBoost	2019	★★★★★

Clean Air Index	Energy Efficiency Index
1,1	6,6

	WLTC-cold	0,00	Energy Consumption (WLTC-cold)	8,4
	WLTC-warm	0,52	Energy Consumption (WLTC-warm/eco/sport)	7,9
	WLTC -eco	0,35	Energy Consumption 1) (PEMS+)	-
	WLTC -sport	0,35	Energy Consumption (BAB130)	6,2
	PEMS+	2,63	Energy Consumption 1) (suppl PEMS)	-
	BAB130	0,00	Driving Range 1)	-
	suppl. PEMS 1)	-	Driving Resistance 1)	-
Total Score	3,8		22,5	
Max Points available	34,0		34,0	
Index	1,1		6,6	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Ford	Fiesta 1L EcoBoost
Specs (cc/kW)	998	74
Applies to VIN:	applies to all Euro 6B Fiesta's	
Powerunit(s)	petrol	
Actual mass (kg)	1293	
Average consumption (in WLTC tests)		
fuel	5,4	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test) 1)		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

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- **Ford Fiesta 1L GDi Euro6d_temp from MIRA**

Ford	Fiesta 1L EcoBoost	2019	★★★★★

8,0	4,4
Clean Air Index	Energy Efficiency Index

	WLTC-cold	7,4	Energy Consumption (WLTC-cold)	5,9
	WLTC-warm	2,7	Energy Consumption (WLTC-warm/eco/sport)	5,6
	WLTC -eco	2,7	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	2,7	Energy Consumption (BAB130)	3,5
	PEMS+	6,4	Energy Consumption [1] (suppl PEMS)	-
	BAB130	5,4	Driving Range [1]	-
	suppl. PEMS [1]	-	Driving Resistance [1]	-
Total Score	27,3		15,1	
Max Points available	34,0		34,0	
Index	**8,0**		**4,4**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

TEST DETAILS		
Vehicle	Ford	Fiesta 1L EcoBoost
Specs (cc/kW)	998	92
Applies to VIN:	applies to all Euro 6D Fiesta's	
Powerunit(s)	petrol	
Actual mass (kg)	1293	
Average consumption (in WLTC tests)		
fuel	6,8	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)[1]		
fuel	n.a.	l/ 100km
electric energy	n.a.	kWh/100km

- **Fiat Panda 0.9L Euro6b from CSI**

green ncap

Fiat	Panda	2019	★★★★★

Clean Air Index	Energy Efficiency Index
0,0	6,0

	WLTC-cold	0,0	Energy Consumption (WLTC-cold)	7,9
	WLTC-warm	0,0	Energy Consumption (WLTC-warm/eco/sport)	7,8
	WLTC -eco	0,0	Energy Consumption [1)] (PEMS+)	-
	WLTC -sport	0,0	Energy Consumption (BAB130)	4,8
	PEMS+	0,0	Energy Consumption [1)] (suppl PEMS)	-
	BAB130	0,0	Driving Range [1)]	-
	suppl. PEMS [1)]	-	Driving Resistance [1)]	-
Total Score	0,0		20,5	
Max Points available	34,0		34,0	
Index	**0,0**		**6,0**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Fiat	Panda
Specs (cc/kW)	875	62.5
Applies to VIN:	Applies to All Panda's (petrol)	
Powerunit(s)	petrol	
Actual mass (kg)	1121	
Average consumption (in WLTC tests)		
fuel	5,5	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

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- **Mercedes A200 Petrol from IDIADA**

green ncap

Mercedes Benz A200	2019	★★★★★

Clean Air Index	Energy Efficiency Index
9,4	5,2

	WLTC-cold	8,1	Energy Consumption (WLTC-cold)	6,1
	WLTC-warm	3,0	Energy Consumption (WLTC-warm/eco/sport)	6,1
	WLTC -eco	3,0	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	3,0	Energy Consumption (BAB130)	5,7
	PEMS+	7,0	Energy Consumption [1] (suppl PEMS)	-
	BAB130	7,9	Driving Range [1]	-
	suppl. PEMS [1]	-	Driving Resistance [1]	-
Total Score	32,0		17,8	
Max Points available	34,0		34,0	
Index	**9,4**		**5,2**	

RATING REQUIREMENTS 2018

	Clean Air Index	Energy Efficiency Index
★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Mercedes Benz	A200
Specs (cc/kW)	1333	120
Applies to VIN:	Applies to All A200's	
Powerunit(s)	petrol	
Actual mass (kg)	1425	
Average consumption (in WLTC tests)		
fuel	6,6	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)[1]		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **Volvo XC40 Petrol from ADAC**

Volvo	XC40 T5	2019	★★★★★

Clean Air Index	Energy Efficiency Index
6,8	2,3

	WLTC-cold	7,3	Energy Consumption (WLTC-cold)	4,1
	WLTC-warm	3,0	Energy Consumption (WLTC-warm/eco/sport)	3,6
	WLTC -eco	3,0	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	3,0	Energy Consumption (BAB130)	0,0
	PEMS+	7,0	Energy Consumption [1] (suppl PEMS)	-
	BAB130	0,0	Driving Range [1]	-
	suppl. PEMS [1]	-	Driving Resistance [1]	-
Total Score	23,3		7,7	
Max Points available	34,0		34,0	
Index	**6,8**		**2,3**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

TEST DETAILS		
Vehicle	Volvo	XC40 T5
Specs (cc/kW)	1969	182
Applies to VIN:	Applies to all XC40 T5's	
Powerunit(s)	petrol	
Actual mass (kg)	1802	
Average consumption (in WLTC tests)		
fuel	8,1	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **VW Up GTI from ADAC**

VW	Up! GTI	2019	★★★★★

Clean Air Index	Energy Efficiency Index
9,2	6,7

	WLTC-cold	8,3	Energy Consumption (WLTC-cold)	8,8
	WLTC-warm	3,0	Energy Consumption (WLTC-warm/eco/sport)	8,1
	WLTC -eco	3,0	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	3,0	Energy Consumption (BAB130)	5,7
	PEMS+	7,0	Energy Consumption [1] (suppl PEMS)	-
	BAB130	7,0	Driving Range [1]	-
	suppl. PEMS [1]	-	Driving Resistance [1]	-
Total Score	31,2		22,6	
Max Points available	34,0		34,0	
Index	**9,2**		**6,7**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	VW	Up! GTI
Specs (cc/kW)	999	85
Applies to VIN:	Applies to All Up! GTI's	
Powerunit(s)	petrol	
Actual mass (kg)	1101	
Average consumption (in WLTC tests)		
fuel	5,2	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **Audi A7 TDI from ADAC**

Audi	A7 50 TDI	2019	★★★★★

Clean Air Index	Energy Efficiency Index
7,3	2,5

	WLTC-cold	8,9	Energy Consumption (WLTC-cold)	3,2
	WLTC-warm	3,0	Energy Consumption (WLTC-warm/eco/sport)	3,9
	WLTC -eco	3,0	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	3,0	Energy Consumption (BAB130)	1,4
	PEMS+	7,0	Energy Consumption [1] (suppl PEMS)	-
	BAB130	0,0	Driving Range [1]	-
	suppl. PEMS [1]		Driving Resistance [1]	-
Total Score	24,9		8,5	
Max Points available	34,0		34,0	
Index	**7,3**		**2,5**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Audi	A7 50 TDI
Specs (cc/kW)	2967	210
Applies to VIN:	Applies to All A7 TDI's	
Powerunit(s)	diesel	
Actual mass (kg)	2146	
Average consumption (in WLTC tests)		
fuel	7,1	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test) [1]		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **VW Golf 1.6L TDI Euro6b from ADAC**

green ncap

VW	Golf 1.6 TDI	2019	★★★★★

Clean Air Index	Energy Efficiency Index
3,1	6,7

	WLTC-cold	0,0	Energy Consumption (WLTC-cold)	8,5
	WLTC-warm	1,7	Energy Consumption (WLTC-warm/eco/sport)	7,9
	WLTC -eco	1,7	Energy Consumption [1] (PEMS+)	-
	WLTC -sport	1,7	Energy Consumption (BAB130)	6,2
	PEMS+	5,5	Energy Consumption [1] (suppl PEMS)	-
	BAB130	0,0	Driving Range [1]	-
	suppl. PEMS [1]	-	Driving Resistance [1]	-
Total Score	10,6		22,7	
Max Points available	34,0		34,0	
Index	**3,1**		**6,7**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

TEST DETAILS		
Vehicle	VW	Golf 1.6 TDI
Specs (cc/kW)	1598	85
Applies to VIN:	Applies to All Golf's 1.6 TDI	
Powerunit(s)	diesel	
Actual mass (kg)	1390	
Average consumption (in WLTC tests)		
fuel	4,7	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **Hyundai Ioniq PEV from IFA**

Hyundai	IONIQ	2019	★★★★★

10,0	8,5
Clean Air Index	Energy Efficiency Index

	WLTC-cold	9,0	Energy Consumption (WLTC-cold)	10,0
	WLTC-warm	3,0	Energy Consumption (WLTC-warm/eco/sport)	9,0
	WLTC -eco	3,0	Energy Consumption 1) (PEMS+)	-
	WLTC -sport	3,0	Energy Consumption (BAB130)	10,0
	PEMS+	7,0	Energy Consumption 1) (suppl PEMS)	-
	BAB130	9,0	Driving Range 1)	-
	suppl. PEMS 1)	-	Driving Resistance 1)	-
Total Score	34,0		29,0	
Max Points available	34,0		34,0	
Index	10,0		8,5	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	Hyundai	IONIQ
Specs (cc/kW)	n/a	88
Applies to VIN:	Applies to All Ionic's BEV	
Powerunit(s)		electric
Actual mass (kg)	1475	
Average consumption (in WLTC tests)		
fuel	n.a.	l/100km
electric energy	12,8	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/ 100km
electric energy	n.a.	kWh/100km

UTAC CERAM UTAC DIGITALLY SIGNED

- **BMW X1d from MIRA**

green ncap

BMW	X1	2019	★★★★★

9,4	5,8
Clean Air Index	Energy Efficiency Index

	WLTC-cold	8,7	Energy Consumption (WLTC-cold)	7,5
	WLTC-warm	2,7	Energy Consumption (WLTC-warm/eco/sport)	7,0
	WLTC -eco	2,7	Energy Consumption [1] (PEMS+)	0,0
	WLTC -sport	3,0	Energy Consumption (BAB130)	5,3
	PEMS+	6,5	Energy Consumption [1] (suppl PEMS)	0,0
	BAB130	8,6	Driving Range [1]	0,0
	suppl. PEMS [1]	0,0	Driving Resistance [1]	0,0
Total Score	32,1		19,8	
Max Points available	34,0		34,0	
Index	**9,4**		**5,8**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	BMW	X1
Specs (cc/kW)	1995	110
VIN number	Applies to All X1's	
Powerunit(s)	diesel	
Actual mass (kg)	1604	
Average consumption (in WLTC tests)		
fuel	5,2	l/100km
electric energy	n.a.	kWh/100km
Worst case consumption (suppl PEMS test)[1]		
fuel	n.a.	l/100km
electric energy	n.a.	kWh/100km

- **BMW i3 from IFA**

BMW	**i3**	**2019**	★★★★★

Clean Air Index	Energy Efficiency Index
10,0	**8,5**

	WLTC-cold	**9,0**	Energy Consumption (WLTC-cold)	**10,0**
	WLTC-warm	**3,0**	Energy Consumption (WLTC-warm/eco/sport)	**9,0**
	WLTC -eco	**3,0**	Energy Consumption 1) (PEMS+)	-
	WLTC -sport	**3,0**	Energy Consumption (BAB130)	**10,0**
	PEMS+	**7,0**	Energy Consumption 1) (suppl PEMS)	-
	BAB130		Driving Range 1)	-
	suppl. PEMS 1)	-	Driving Resistance 1)	-
Total Score	34,0		29,0	
Max Points available	34,0		34,0	
Index	**10,0**		**8,5**	

RATING REQUIREMENTS 2018

★★★★★	8,0	7,5
★★★★☆	7,0	6,0
★★★☆☆	6,0	4,5
★★☆☆☆	5,0	3,0
★☆☆☆☆	4,0	1,5

1): test not operational yet

TEST DETAILS		
Vehicle	BMW	i3
Specs (cc/kW)	-	125
Applies to VIN:	Applies to All i3's	
Powerunit(s)		electric
Actual mass (kg)	1270	
Average consumption (in WLTC tests)		
fuel	n.a.	l/100km
electric energy	13,1	kWh/100km
Worst case consumption (suppl PEMS test)		
fuel	n.a.	l/ 100km
electric energy	n.a.	kWh/100km

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