European Commission

EU-Commission JRC Contribution to EVE

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22nd Meeting of the GRPE Informal Working Group on Electric Vehicles and the Environment (EVE).

Joint Research Centre

Presentation Summary

- **Presentation of the EU-Commission JRC activities, as possible contributions to the EVE IWG:**
  - **Desktop research: big data platform TEMA;**
  - **Laboratory research: xEV testing;**
- **EVE IWG activities summary**
- **JRC proposal for the EVE IWG**

EU-Commission JRC Activities as possible contributions to the EVE IWG:

- **Desktop research: big data platform TEMA;**

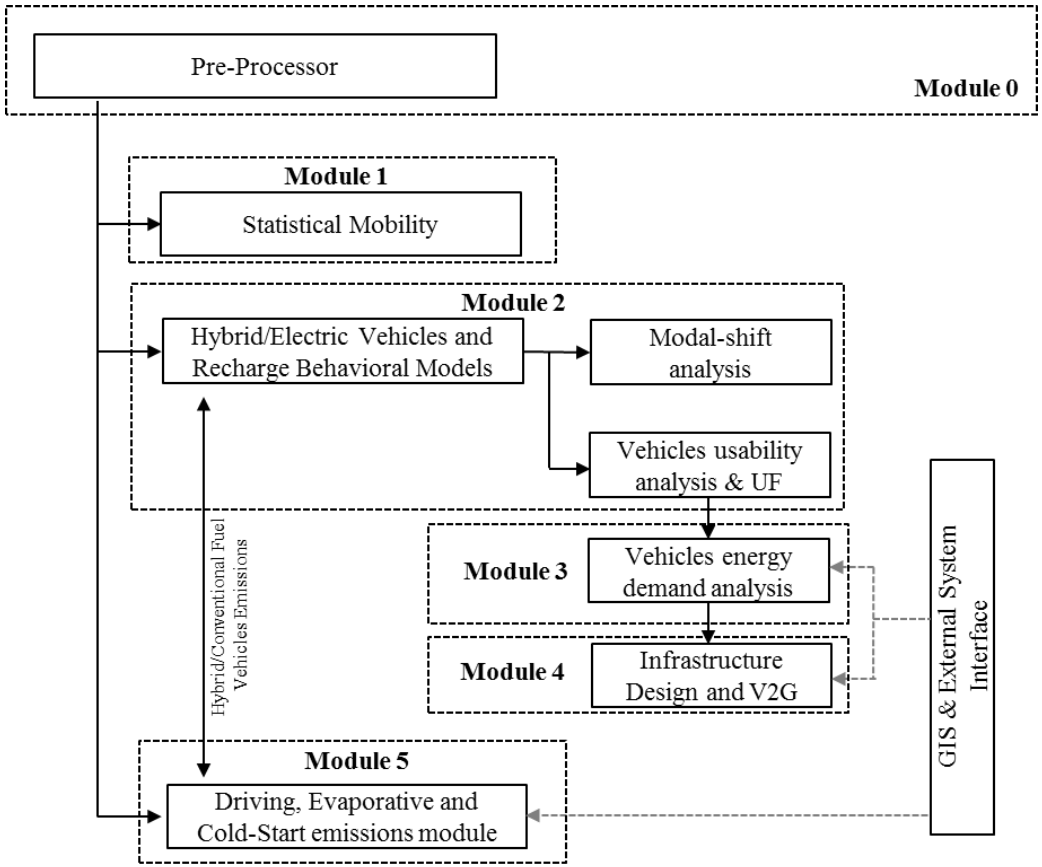
Since 2012 JRC is developing TEMA: Transport tEchnology and Mobility Assessment platform

- TEMA is a flexible and modular big data platform, based on GPS mobility data and natively interfaced with GIS.

- TEMA reproduces large scale transportation systems in real-world conditions varying technological constraints, thus assessing the potential of innovative vehicle technologies in realistic scenarios (e.g. environmental impact, energy efficiency, infrastructure design and sustainability).

- TEMA is policy-focused: its output has been already used for various policy support activities, i.e. revision of the Regulation (EC) No 715/2007 on type approval of motor vehicles with respect to evaporative emissions from LDVs, Directive 2014/94/EU on the deployment of alternative fuels infrastructure.

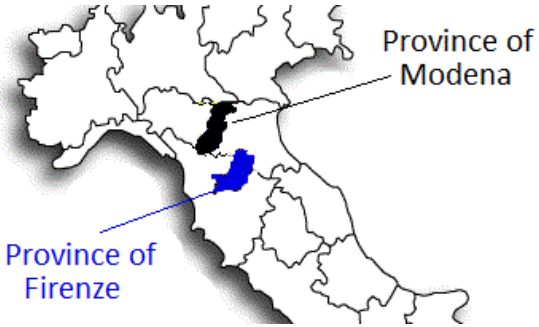
Modular Structure of TEMA



← Transportation Data
Vehicle technologies (xEV)
Behavioral models

→ Mobility Statistics
Usability analyses (UF)
Energy demand
Infrastructure design
V2G & V2X
Emissions (ICE/xEVs, driving / evaporative / cold-start)

Input of TEMA (Italy)



Transportation Data

	Monitored Vehicles	Database lines (after cleaning) [·10^6]	Trips No. [·10^6]	Trips' length [km·10^6]
Province of Modena	16,263	15.998	2.642	14.98
Province of Firenze	12,478	32.008	1.870	20.66

Vehicle Technologies (xEVs):

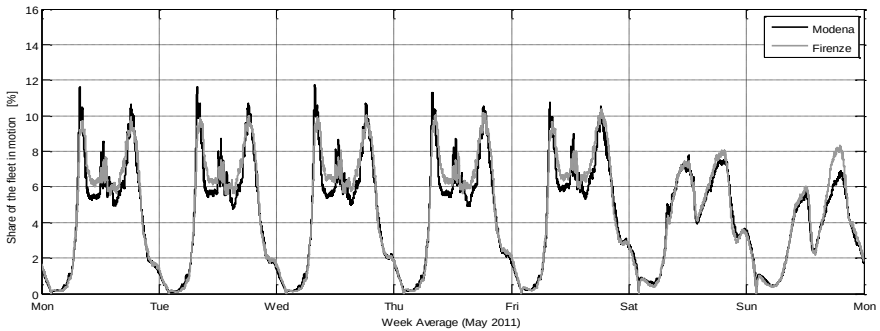
- EVs, from 450 to 2600 kg (curb weight) – from 13 to 85 kWh (battery size) – from 70 to 265 Wh/km (consumption);
- PHEV;
- Open Parameters;

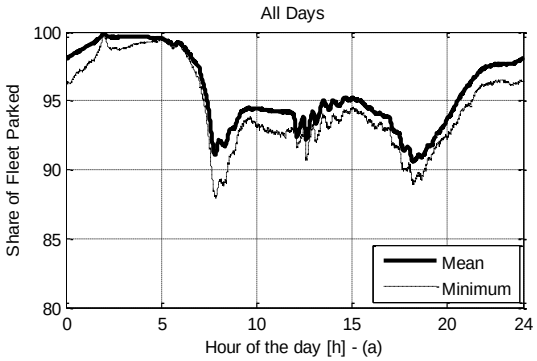
Behavioral Models (recharge with 16 behaviors):

- opportunistic-unconstrainted /constrained / price-based / smart-grid;
- AC (3.3 kW/10kW) and DC (50 kW);

Results of TEMA (Italy)

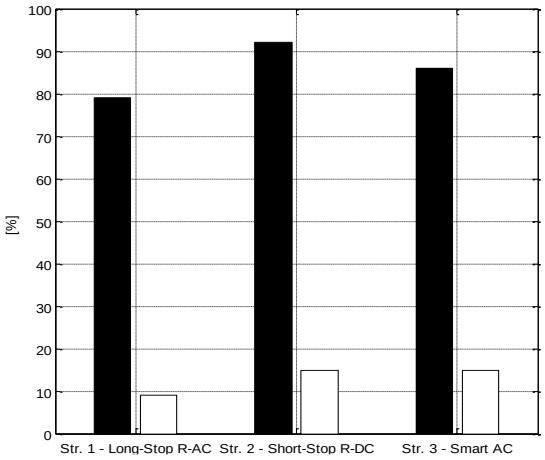
Mobility Statistics:



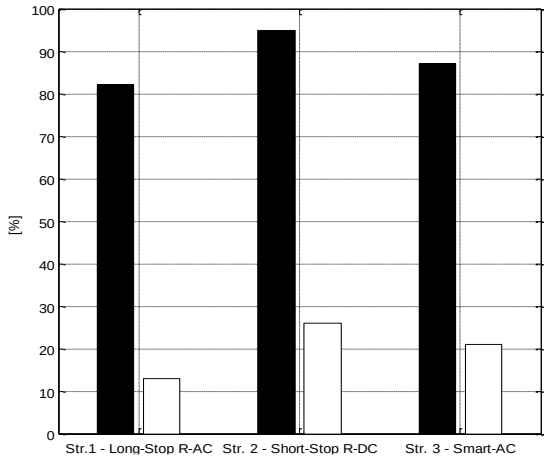


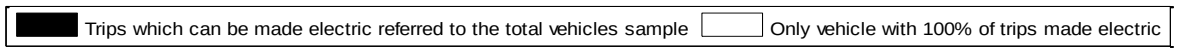
Usability Analyses:

BEV (16kWh @ 185 Wh/km)



BEV (24kWh @ 210 Wh/km)

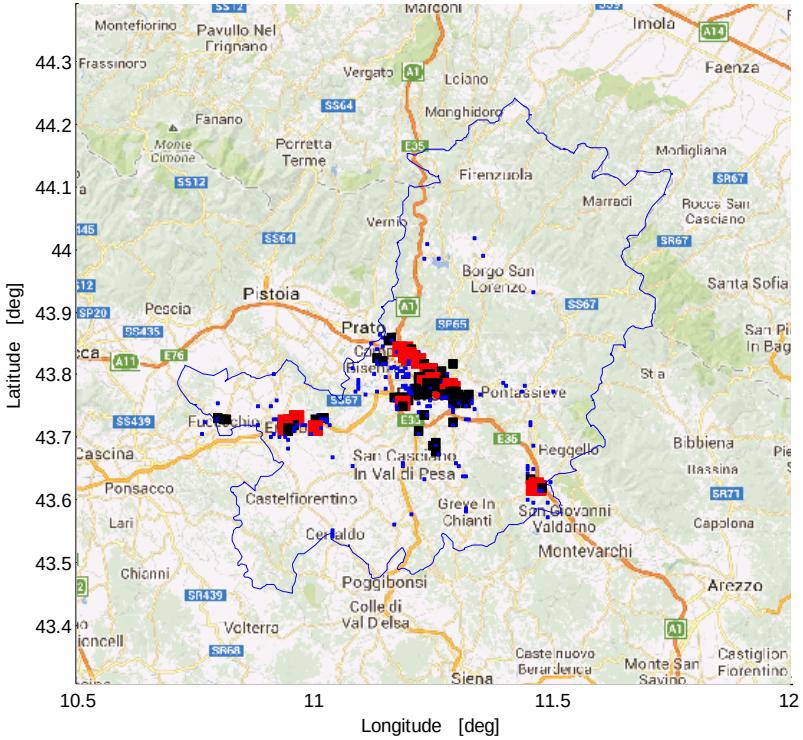




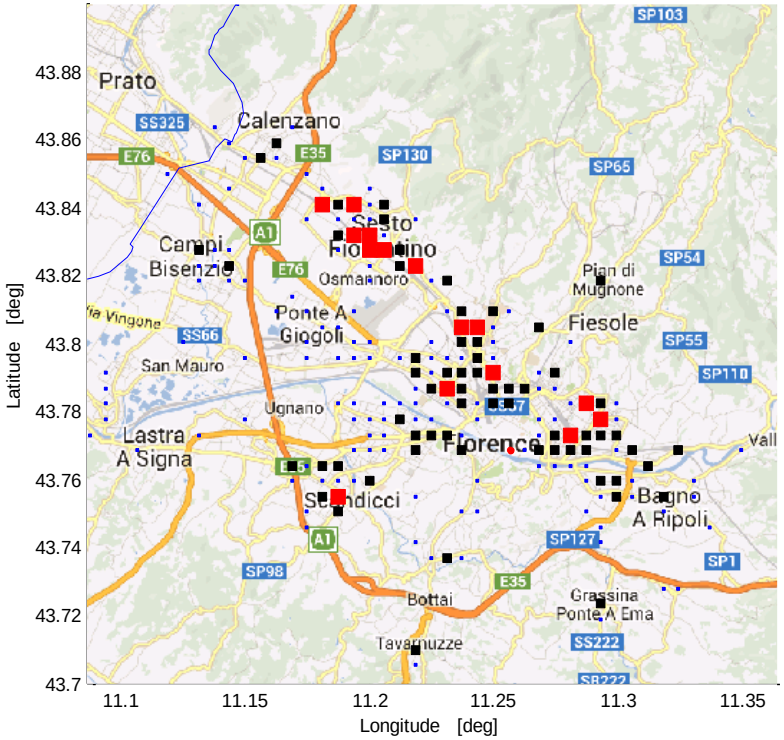
Results of TEMA (Italy)

Energy Demand
(Florence – Italy / BEV 24 kW @ 210 Wh/km + Long-Stop Random AC)

(a)



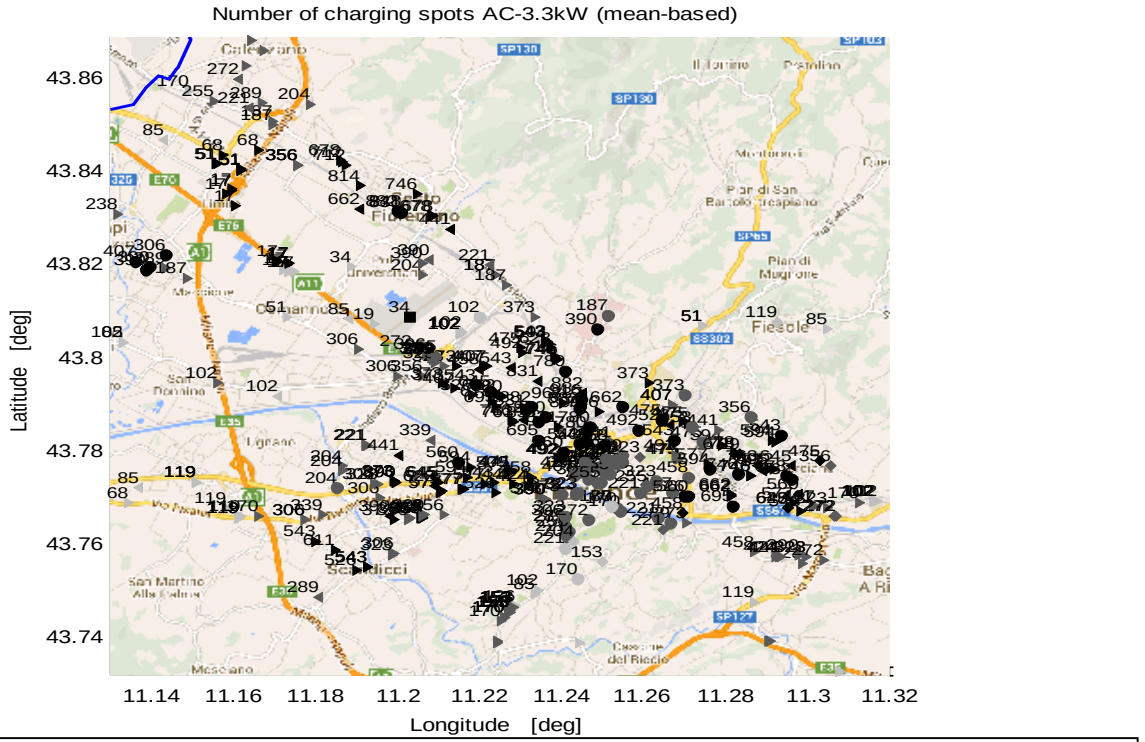
(b)



20 < kWh/day < 50 ■ 50 < kWh/day < 100 ■ kWh/day >100

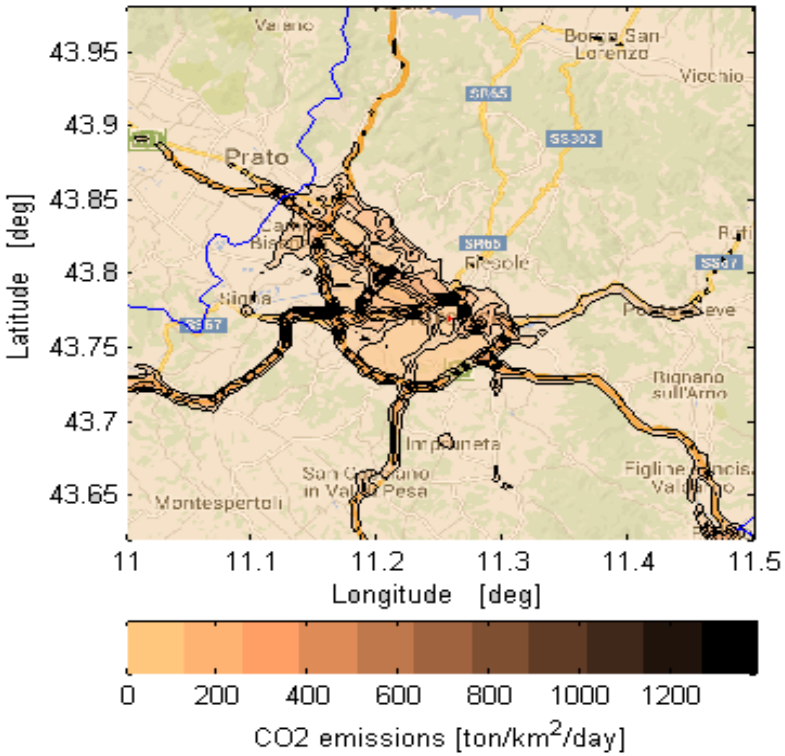
Results of TEMA (Italy)

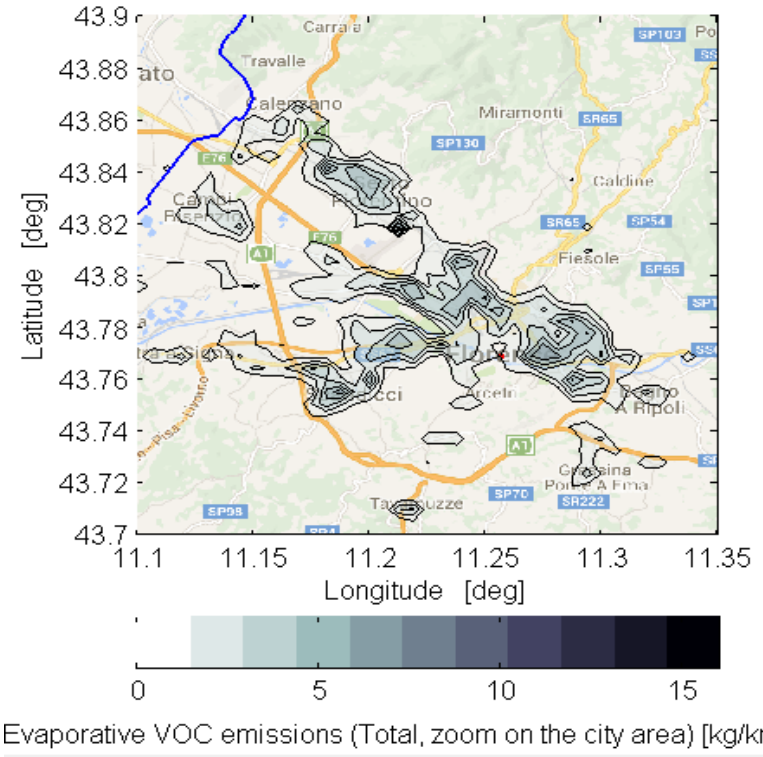
Infrastructural Design
(Florence – Italy / BEV 24 kW @ 210 Wh/km + Long-Stop Random AC)



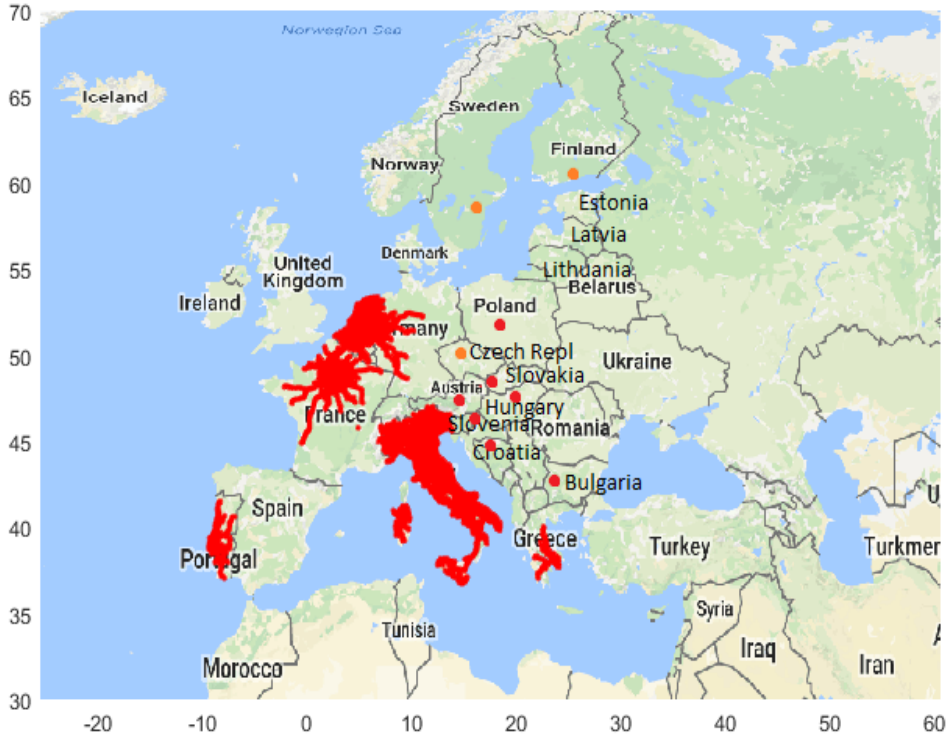
Results of TEMA (Italy)

Emissions Results (Driving (CO_2 – CO –NOx – HC)/Evaporative(VOCs))





Further applications of TEMA (EU-wide – IT/NL/BE/FR/DE/PT/GR)



	No. of vehicles	Total trips lengths [km·10^6]	Number of days
Province of Modena	16,263	14.98	31
Province of Firenze	12,478	20.66	31
Province of Amsterdam	197,754	19.86	7
Province of Brussels	96,802	11.21	14
Province of Paris	171,220	38.39	7
Province of Athens	15,366	1.49	7
Province of Lisbon	7,522	2.48	7
Province of Krefel	4,160	0.97	7

EU-Commission JRC Activities as possible contributions to the EVE IWG

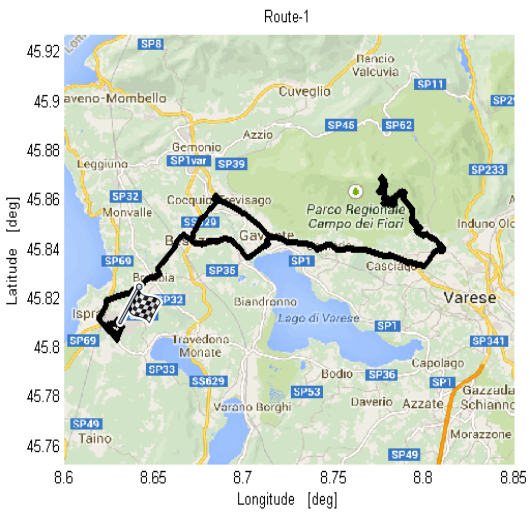
- **Laboratory research: xEV testing;**

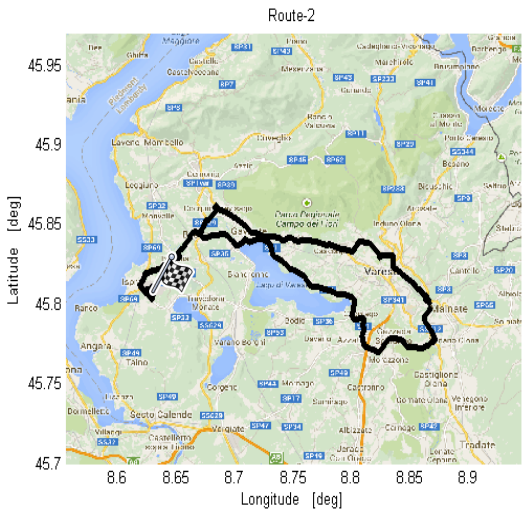
Since 2013 JRC is testing xEVs for policy support purposes:

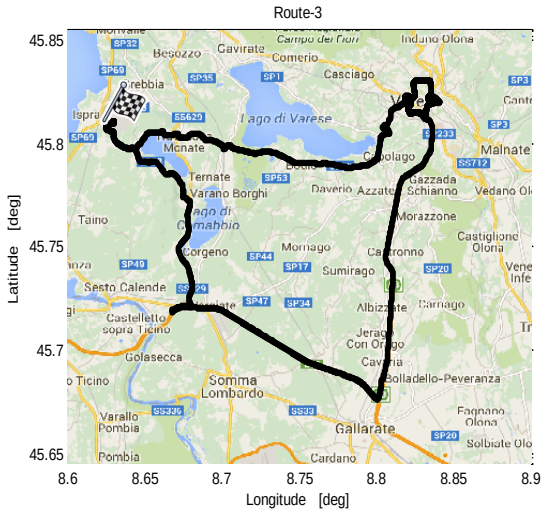
2013/14 Test Campaigns:

- **A-segment passenger vehicle BEV, 16 kWh, 1,080 kg, 35 kW electric motor;**
- **C-segment SUV, parallel hybrid in through-the-road configuration, 120 kW-ICE + 27 kW-EM (19% DoH), 3.1 kWh battery (NiMH);**
- **C-segment passenger vehicle BEV, 24 kWh, 1,520 kg, 80 kW;**

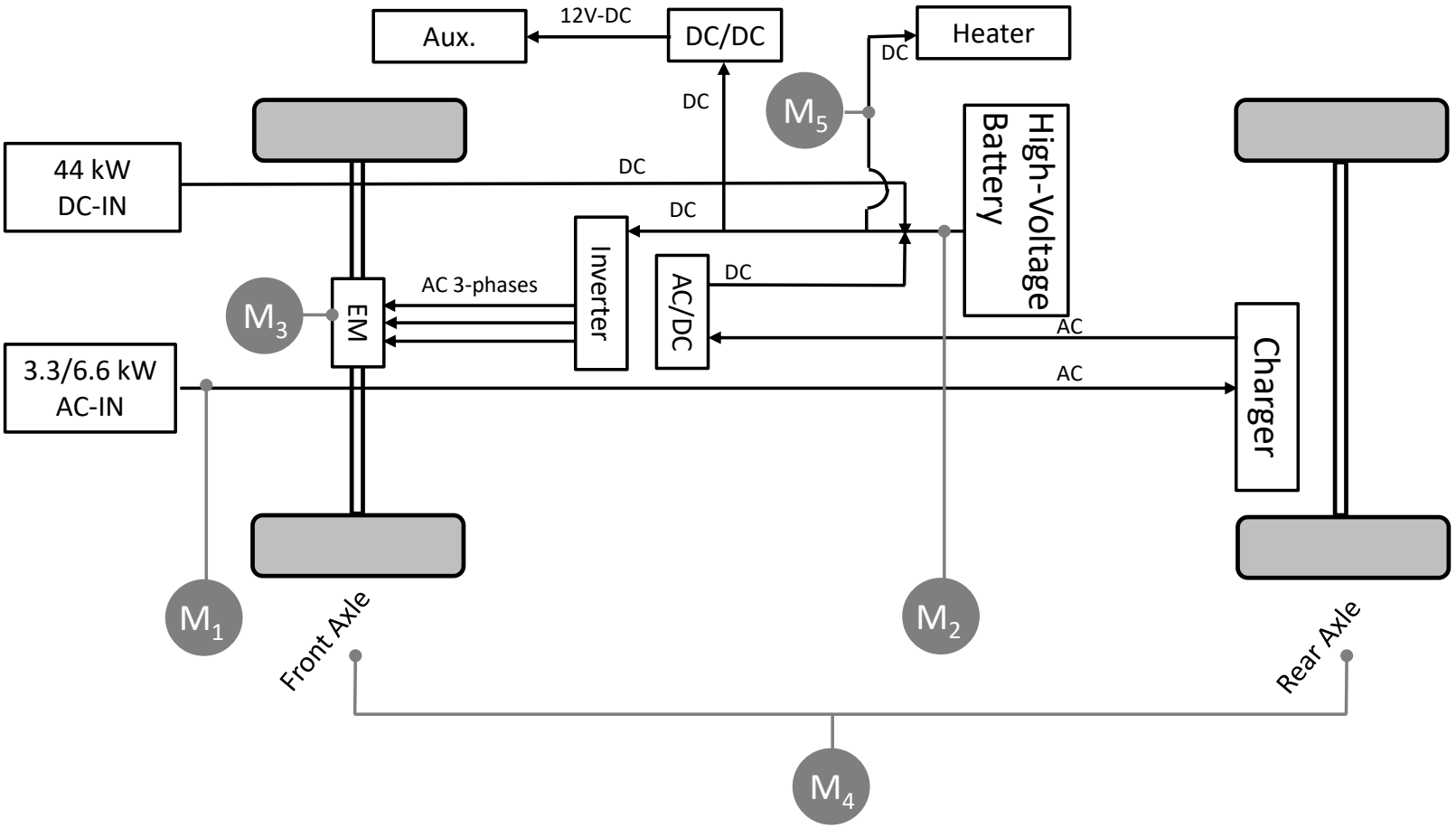
	Laboratory (Dyno)	On-road
A-segment BEV	✓	-
C-segment HEV	✓	✓
C-segment BEV	✓	✓





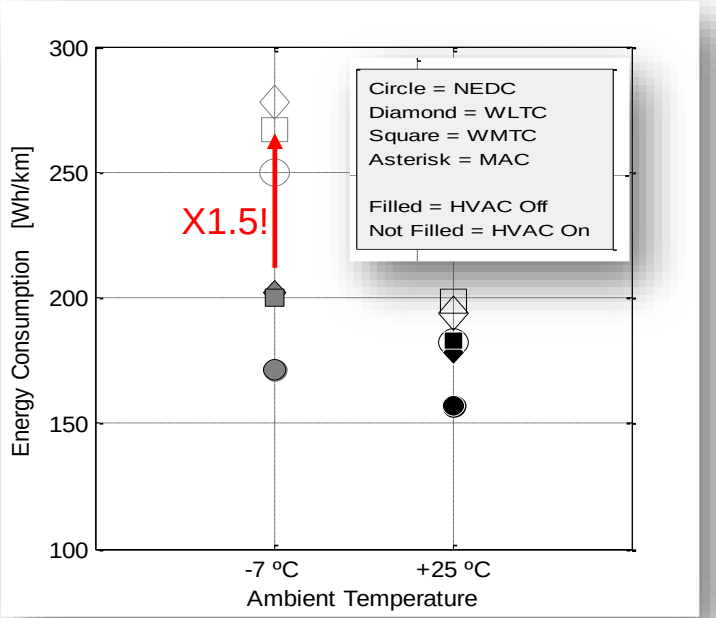


2014 Test Campaigns: C-segment BEV (Vehicle schematic)



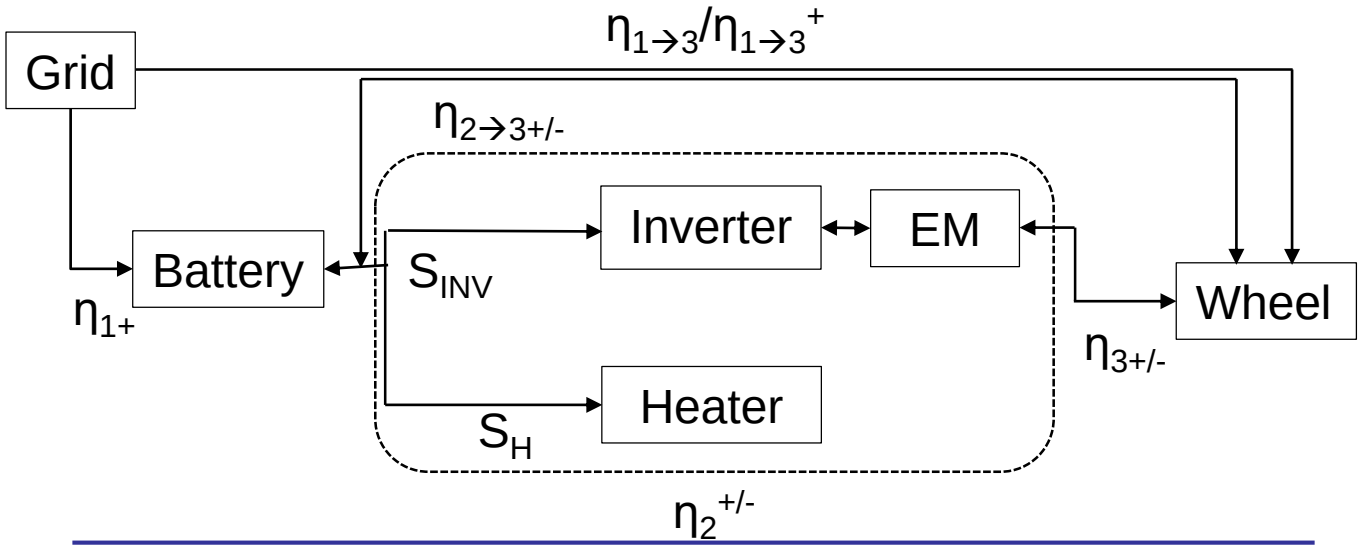
2014 Test Campaigns: C-segment BEV (Energy Cons. & Range)

	NEDC range [km] [Wh/km] (l/100 km)	WLTC range [km] [Wh/km] (l/100 km)	WMTC range [km] [Wh/km] (l/100 km)	RANGE TEST [km]
TAmb. = +25 ºC HVAC OFF	130.7 156.9 (1.76)	114.9 178.4 (2.00)	112.1 182.9 (2.05)	NEDC 126.5 WLTC 117.8 WMTC 116.8
TAmb. = +25 ºC HVAC ON	112.6 182.0 (2.04)	105.6 194.0 (2.18)	103.2 198.6 (2.23)	-
TAmb. = -7 ºC HVAC OFF	119.8 171.2 (1.92)	101.5 202.0 (2.27)	102.5 200.1 (2.25)	NEDC 112.2
TAmb. = -7 ºC HVAC ON	82.0 250.0 (2.81)	73.7 278.1 (3.12)	76.9 266.6 (2.99	-



2014 Test Campaign: C-segment BEV (Efficiencies)

$\eta_{1\rightarrow3}$	NEDC	WLTC	WMTC
TAmb. = +25 ºC HVAC OFF	74.3%	75.2%	79.0%
TAmb. = +25 ºC HVAC ON	64.4%	68.9%	72.2%
TAmb. = -7 ºC HVAC OFF	67.7%	65.9%	71.4%
TAmb. = -7 ºC HVAC ON	46.6%	48.3%	53.9%



Summary of EVE Group activities

- **As per status report of Part A of the Nov. 2014 mandate for EVE-IWG (Nov. 2016):**
  - **Battery performance and durability (in-vehicle);**
  - **Determination of the powertrain performance in hybrid configuration;**
  - **Method of stating energy consumption;**
  - **Battery recycling/recyclability;**

JRC proposal for the EVE Group

Battery performance and durability (in-vehicle);	✓	TEMA-based model
Determination of the powertrain performance in hybrid configuration;	✓	Lab-activities round-robin(?) Proposal of test matrix(?)
Method of stating energy consumption;	-	To be shifted to Group of Experts on Energy Efficiency
Battery recycling/recyclability	-	Removed as per Part B

JRC proposal for the EVE Group (Battery performance and durability)

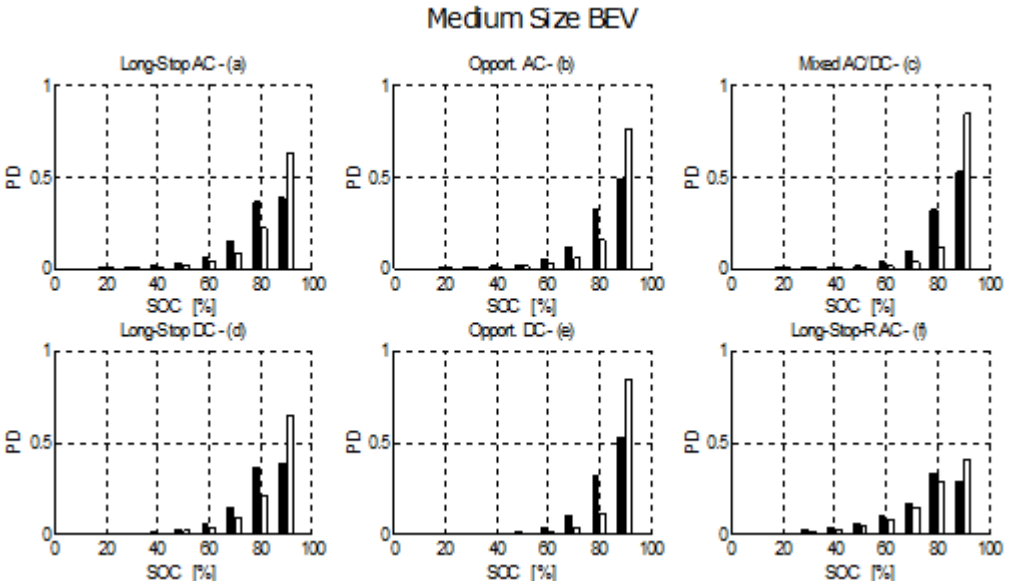
In-vehicle Battery ageing mechanisms (FEV report @ EVE 16) "*Battery Durability in Electrified Vehicle Applications: A Review of Degradation Mechanisms and Durability Testing*":

- Chemistry;
- DoD & in-vehicle battery cycling;
- Charging rate (AC-3.3 kW/9 kW, 50 kW, 100 kW, 350 kW?);
- Driving cycle (urban-highway-combined) & aggressiveness;
- Environmental conditions (temperature);
- Mechanical stress (vibrations);
- Usage (mileage driven – recharges), kWh exchanged;

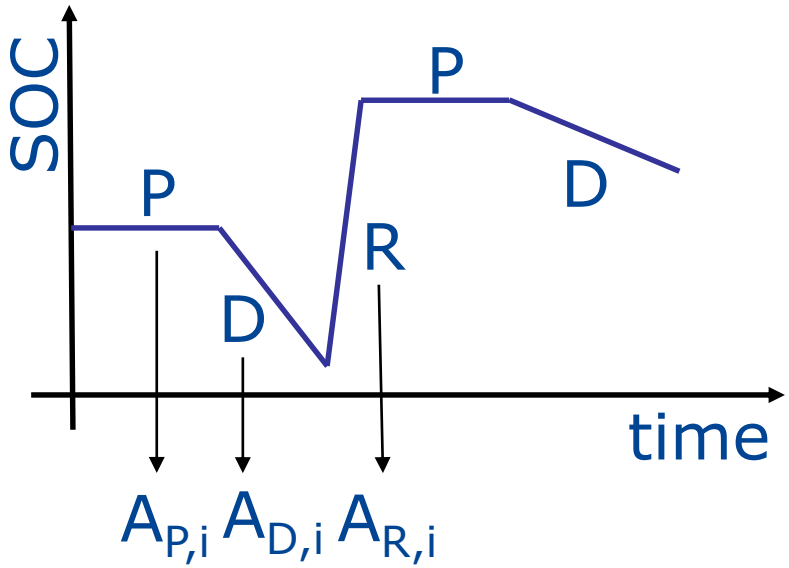
JRC aims at contributing to expand the knowledge base via driving data analyses (next slide)

JRC proposal for the EVE Group (Battery performance and durability)

TEMA statistics
DoD – Charge Rate - Usage



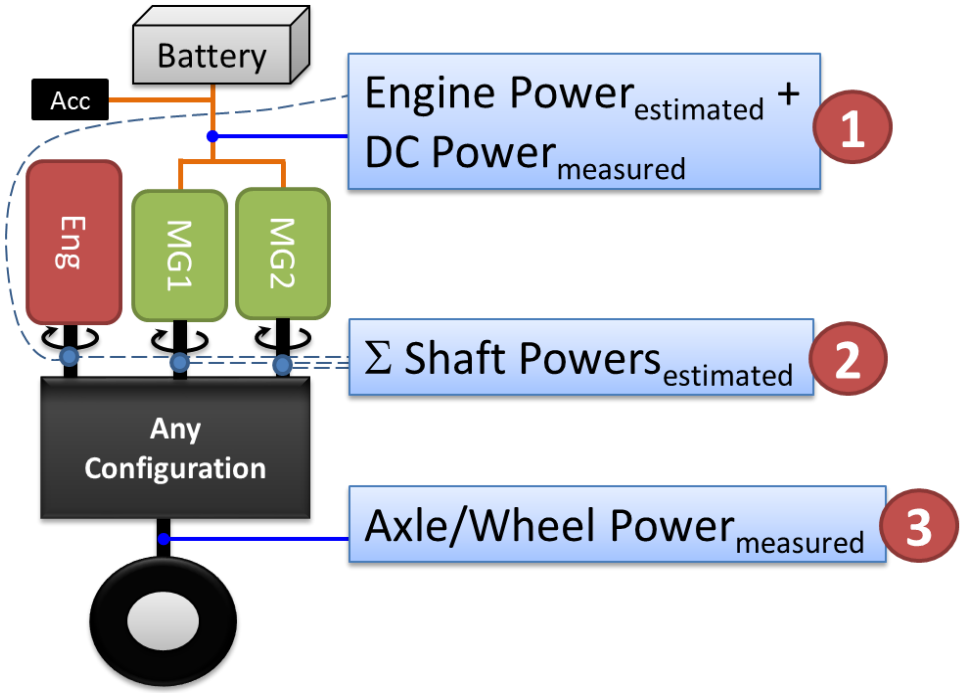
Implementing in TEMA an in-vehicle battery ageing model

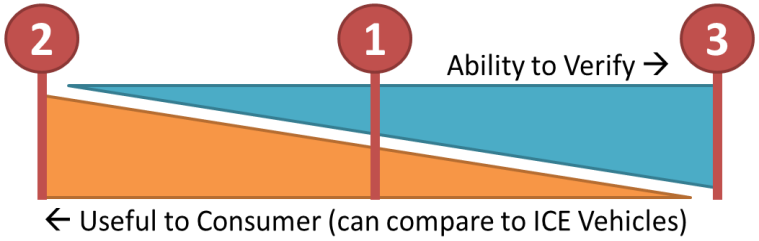


$$A=\Sigma(A_{P,I} + A_{D,I} + A_{R,i})$$

JRC proposal for the EVE Group (Determination of the powertrain performance in hybrid configuration)

Update on the SAE J2908 Activities (ANL Mike Duoba @ EVE 16):





JRC proposal for the EVE Group (Determination of the powertrain performance in hybrid configuration)

Status:

1. Reference Method (Chassis Dyno Testing);
2. Candidate Method (Component testing and calculation)

JRC is open to discuss the possibility to conduct validation testing necessary to confirm validity of the methods

Main References:

- M. De Gennaro, E. Paffumi, G. Martini, Big Data for supporting low-carbon transport in Europe: applications, challenges and opportunities, Big Data Research, Volume 6, December 2016, pp. 11-25.
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- M. De Gennaro, E. Paffumi, G. Martini, U. Manfredi, S. Vianelli, F. Ortenzi, A. Genovese, Experimental Test Campaign on a Battery Electric Vehicle: Laboratory Test Results (Part 1), SAE Int. J. Alt. Power. 4(1):2015, doi:10.4271/2015-01-1167, 2015.
- E. Paffumi, M. De Gennaro, G. Martini, U. Manfredi, S. Vianelli, F. Ortenzi, A. Genovese, Experimental Test Campaign on a Battery Electric Vehicle: On-Road Test Results (Part 2), SAE Int. J. Alt. Power. 4(2):2015, doi:10.4271/2015-01-1166, 2015.
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