EMISSIONS OF A LIGHT DUTY MULTIFUEL VEHICLE UNDER URBAN DRIVING CONDITIONS

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General background: legislation

- *Directive 2009/30/EC, (fuel quality) target: reduce GHG emissions per unit of energy at least by 6% until 2020.*
- *Regulation 79/2009 target: ensure the proper functioning of hydrogen-powered motor vehicles by specifying harmonized safety requirements.*
- *No existing specific methods to type-approve vehicles fueled by H_2-CNG blends.*

General background

- *Assessment of transport technologies using real-world emissions measurements*

- *CO_2 regulations of light (EC/443/2009) and heavy-duty vehicles (on-going development of EU HDV CO2 testing procedures: Model based, real-world PEMS measurements could be used as validation test methods)*

- *Objective of the present research: development of data evaluation methods for real-world CO_2 emissions, to establish links with vehicle/engine characteristics and/or operating conditions (speed, road grade, etc...)*

In-use emissions testing

Recent Legislative Developments:

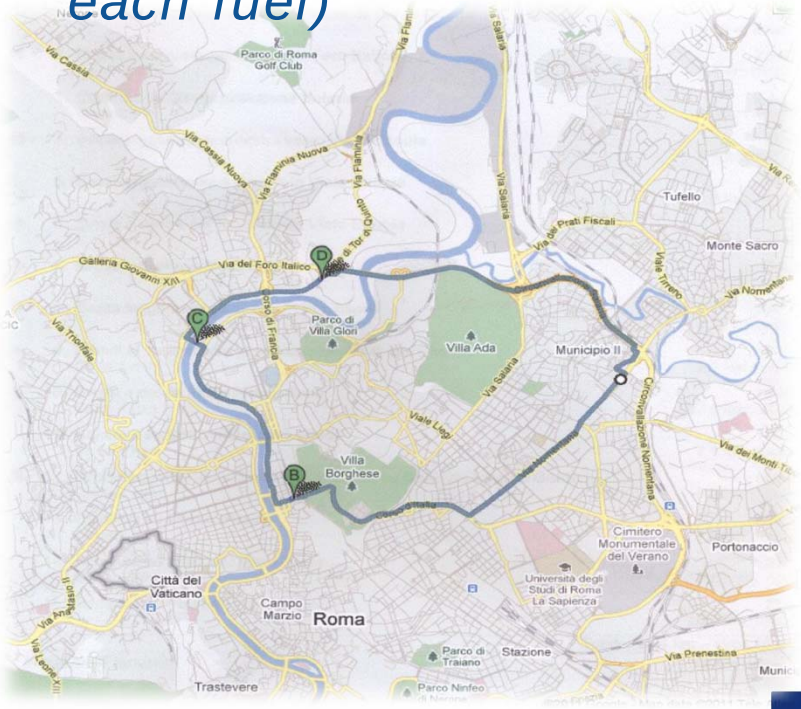
- *Publication of the PEMS based In-Service Conformity (ISC) provisions for the future EURO VI standards, (also applicable to EURO V engines)*
- *European PEMS Pilot Program for Non Road Mobile Machinery (NRMM) engines*
- *PEMS candidate method to check and to limit the Real Driving Emissions (RDE) of Light Duty Vehicles from Euro 6 standards onwards (2014)*

Objectives of the study

- *To develop methods to make use of the in-use emissions data collected with PEMS.*
- *To study the exhaust emissions as function of the CNG-hydrogen in real-world driving conditions.*
- *To relate on-road data with test cell data*
- *To asses the greenhouse gasses emission reduction obtained by means of hydrogen blends.*

Data used for the study

- *Real-world measurements from a EURO 4 light-duty vehicle*
- *5 different fuels used: Gasoline, CNG, CNG+10%H_2, CNG+20%H_2, CNG+30%H_2.*
- *Vehicle tested on an urban route 17Km long (two tests for each fuel)*



Vehicle specifications

BRAND	**FIAT**
MODEL	Panda
YEAR	2007
DISPLACEMENT	1242 cm^3
FUEL	Gasoline CNG Hydrogen-CNG Blends
Max Power (gasoline/CNG)	44/38 kW
After treatment	3-way catalyst

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PEMS installation

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PEMS installation

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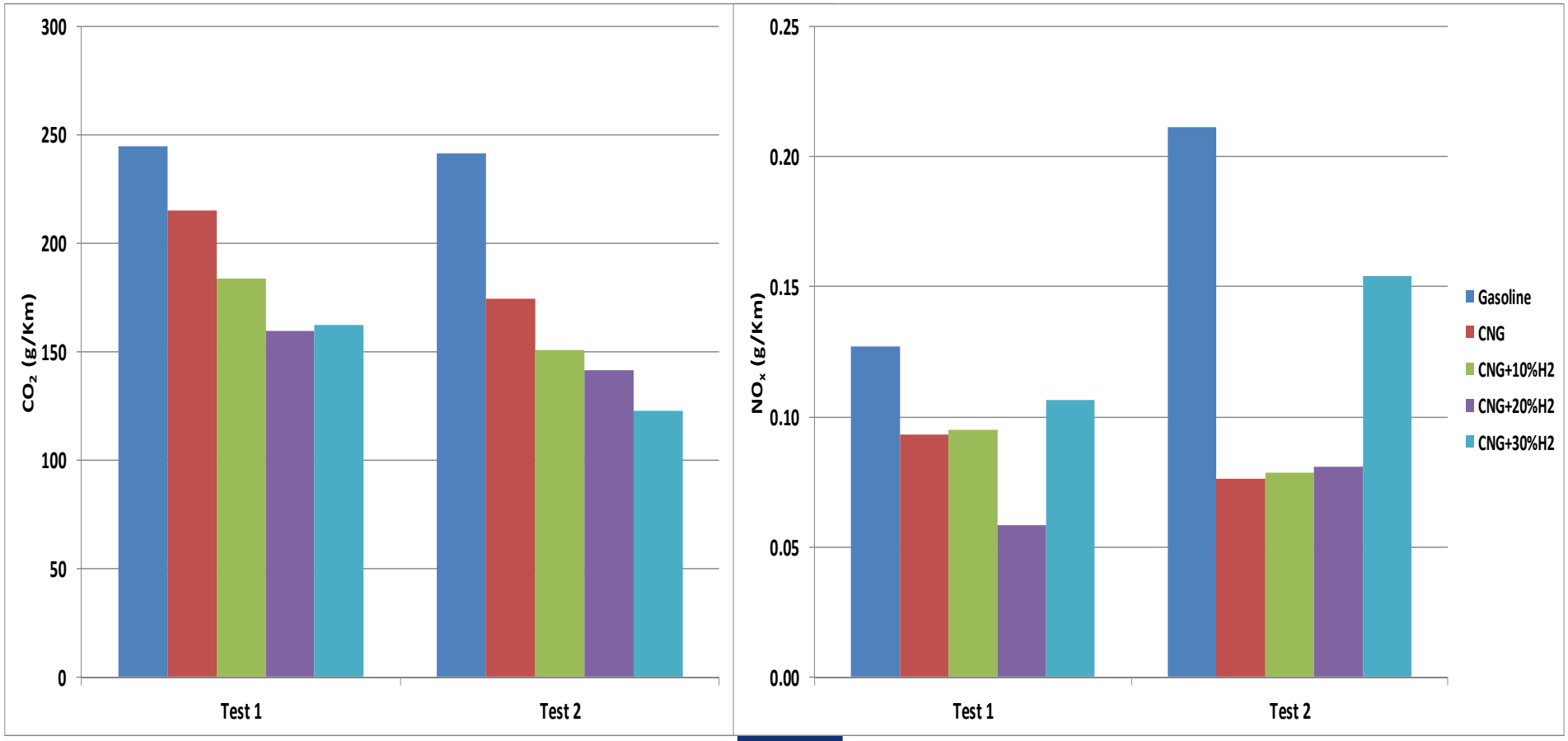
Results: Trip averaged emissions

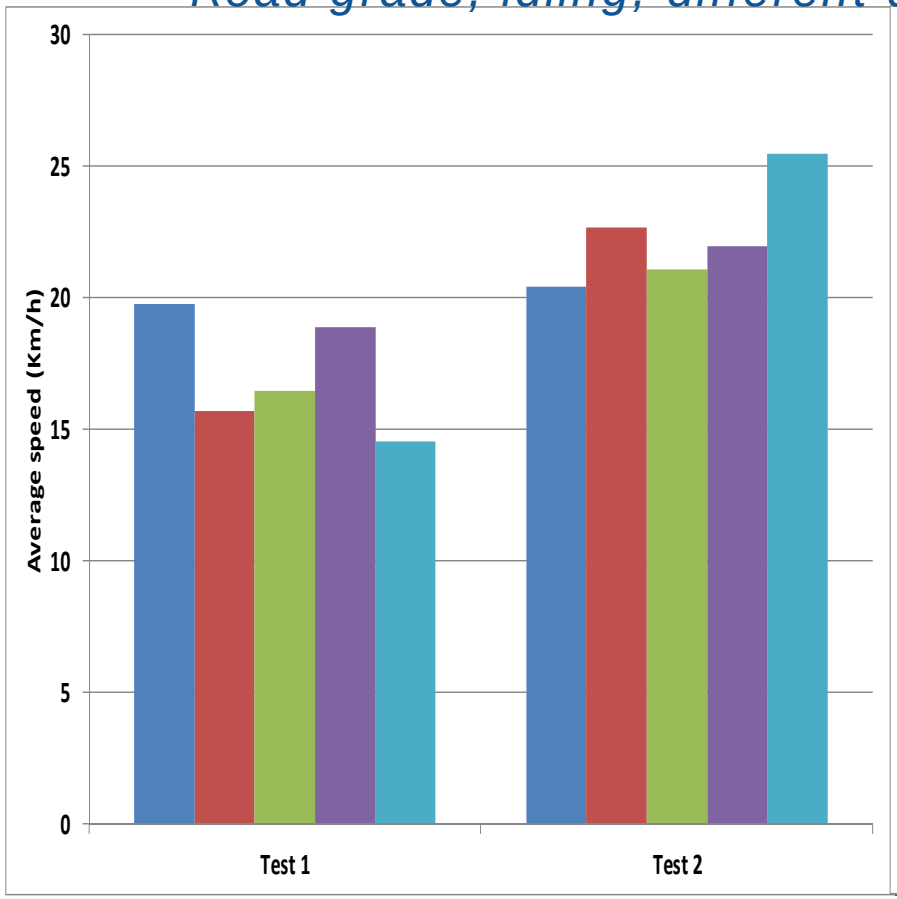


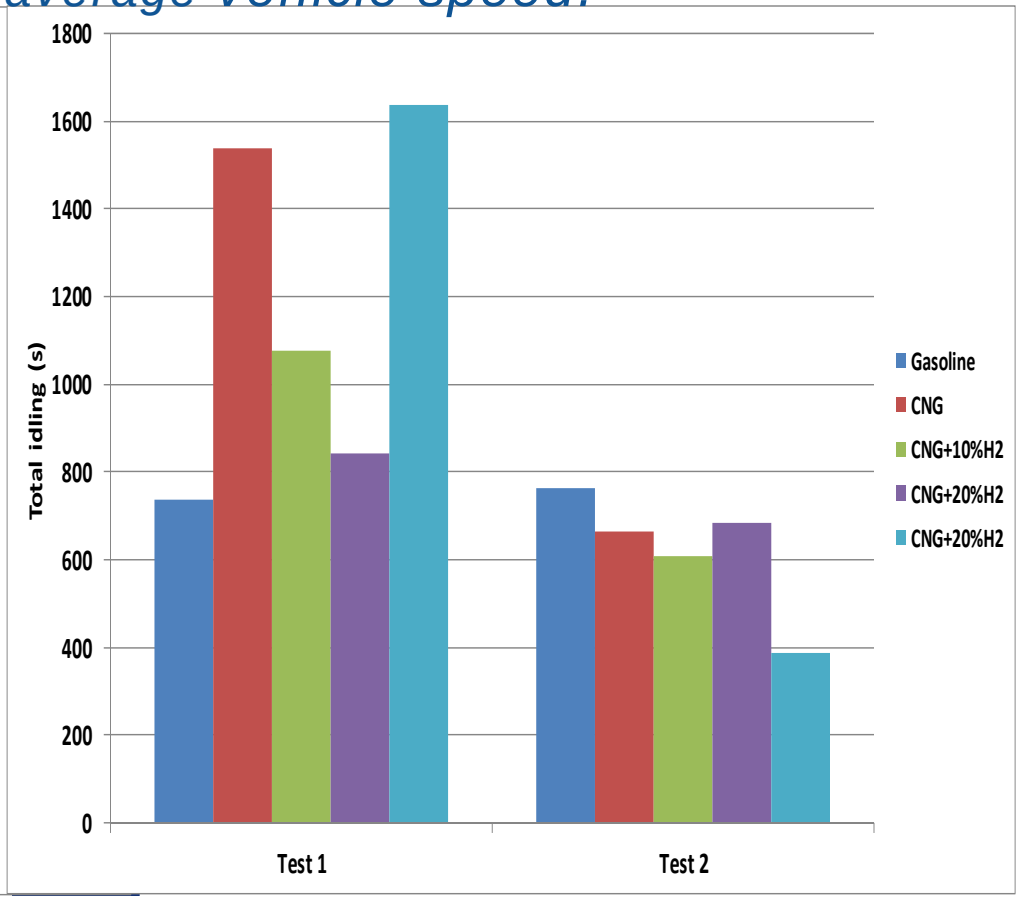
Trip averaged emissions

Trip averaged emissions strongly influenced by traffic conditions

Difficult to have direct comparison with standard test cycle due to:

Road grade, idling, different average vehicle speed.





Averaging window approach

- *Moving averaging window – Distance based (4 and 11 km, using a time increment equal to the data sampling frequency)*

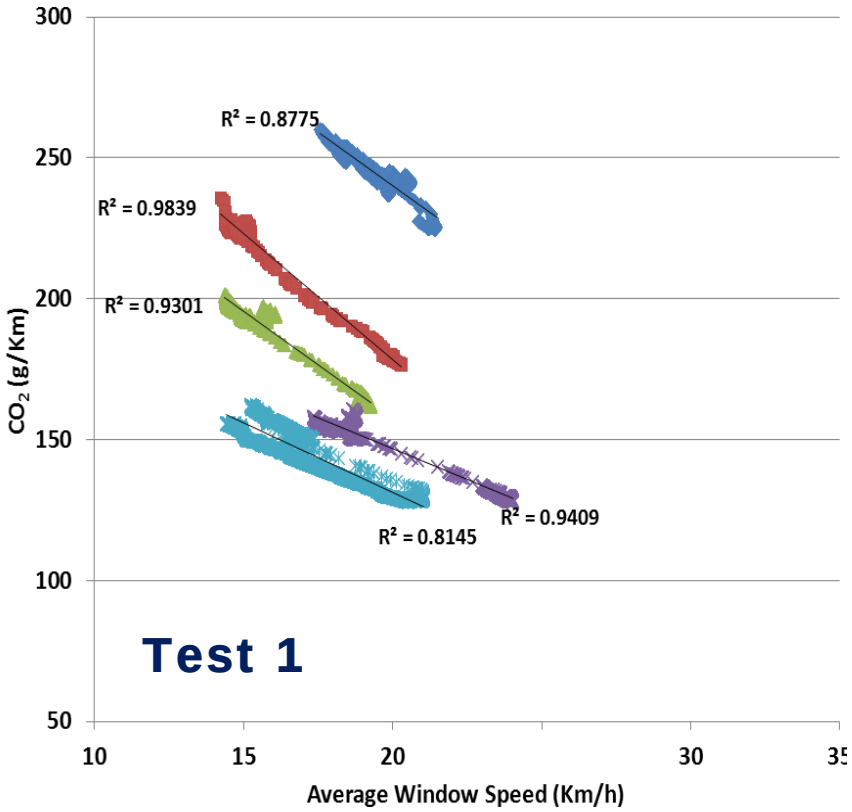
- *Data binning according to the parameters governing the vehicle dynamics and therefore the fuel consumption and the emissions*
  - **Average speed**
  - **Average road grade**
  - **Average relative positive acceleration (RPA)**
  - ***Exception: Aerodynamic effects assumed to remain constant within a speed range (effect of front wind had to be neglected)***

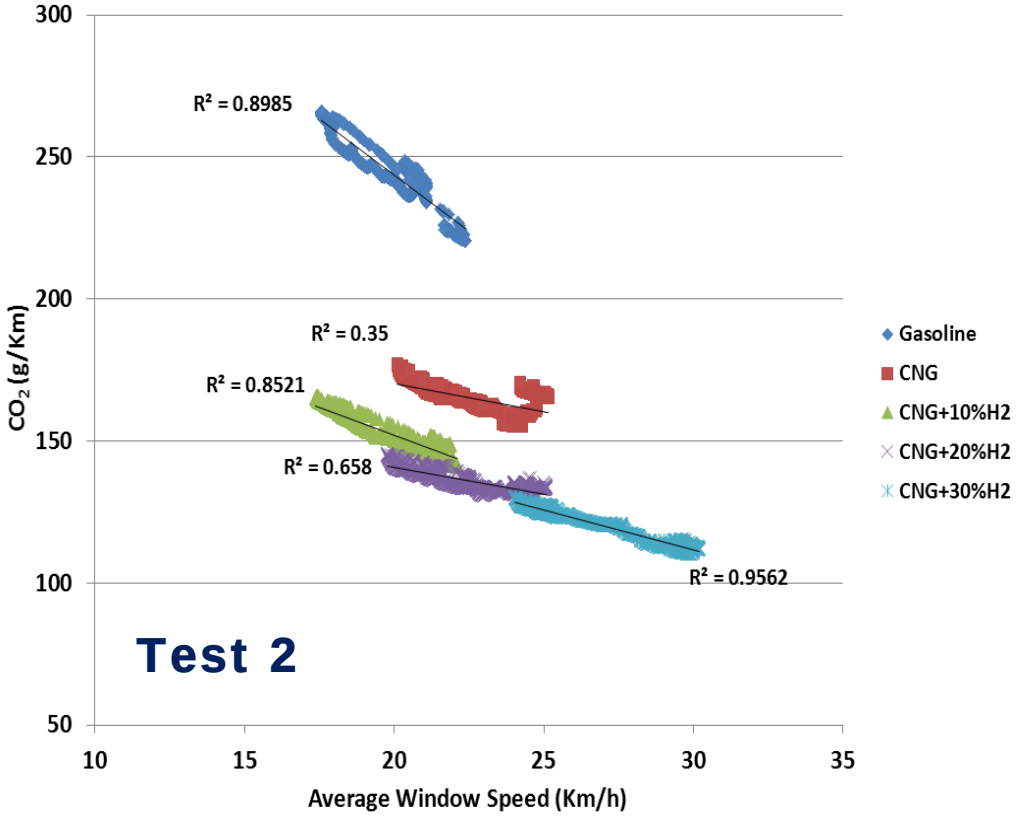
- *Statistics conducted in the different bins*

- *Comparison with ECE (urban part of NEDC)*

Results

- *Averaging reference distance = NEDC length, 11.007 km.*
- *Average road grade between -0.25% and 0.25%.*
- *Distribution of CO_2 emissions (g/km) as function of the average window speed.*





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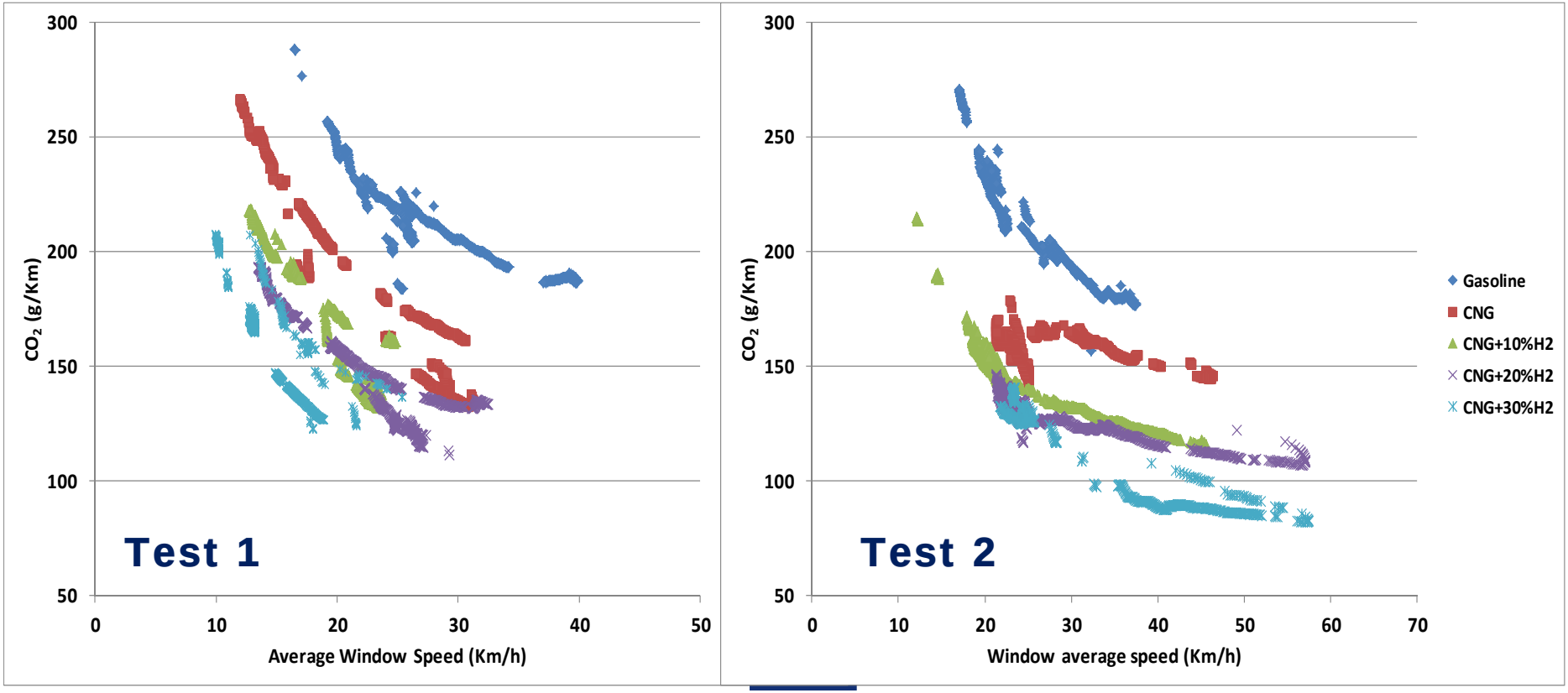
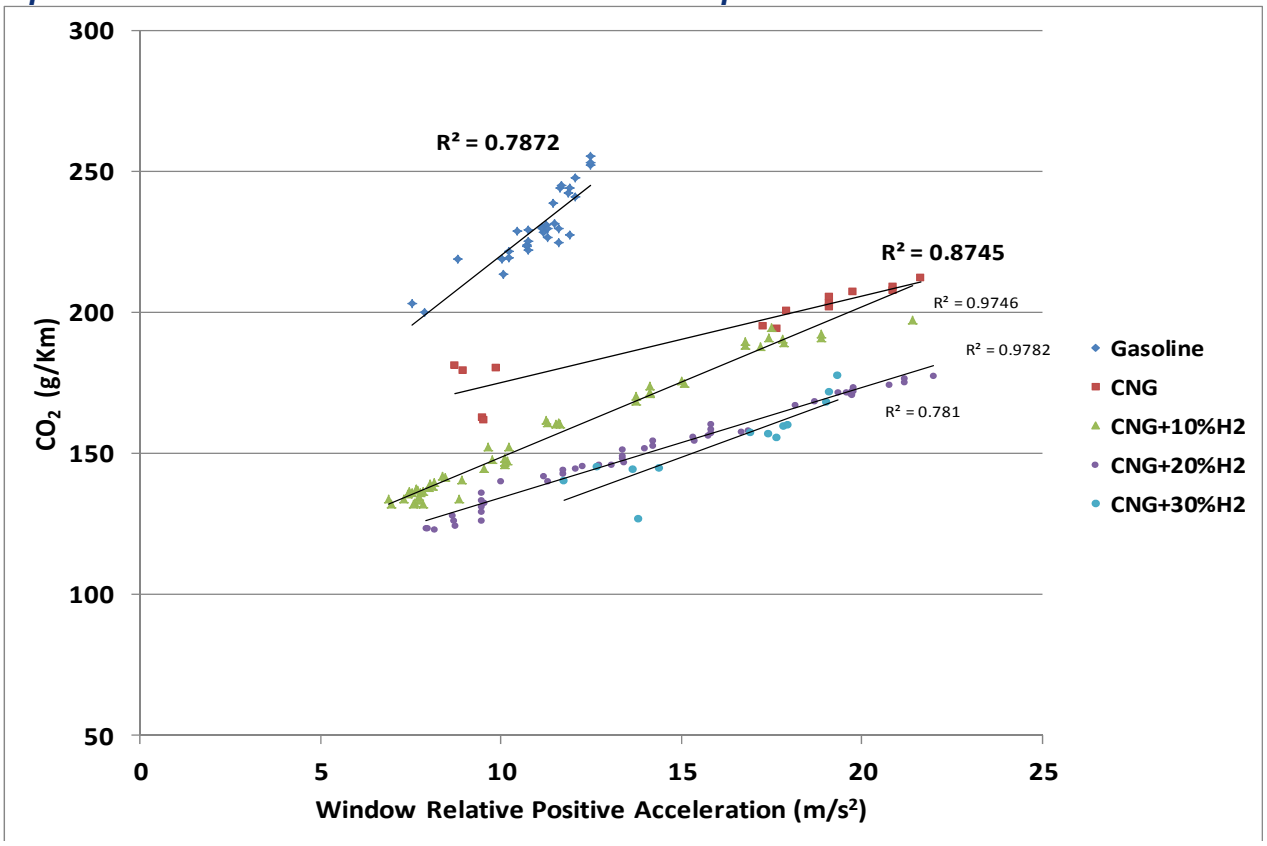
Results

- *Averaging reference distance = ECE 15 length, 4.052 km.*
- *Average road grade between -0.25% and 0.25%.*
- *Distribution of CO_2 emissions (g/km) as function of the average window speed.*



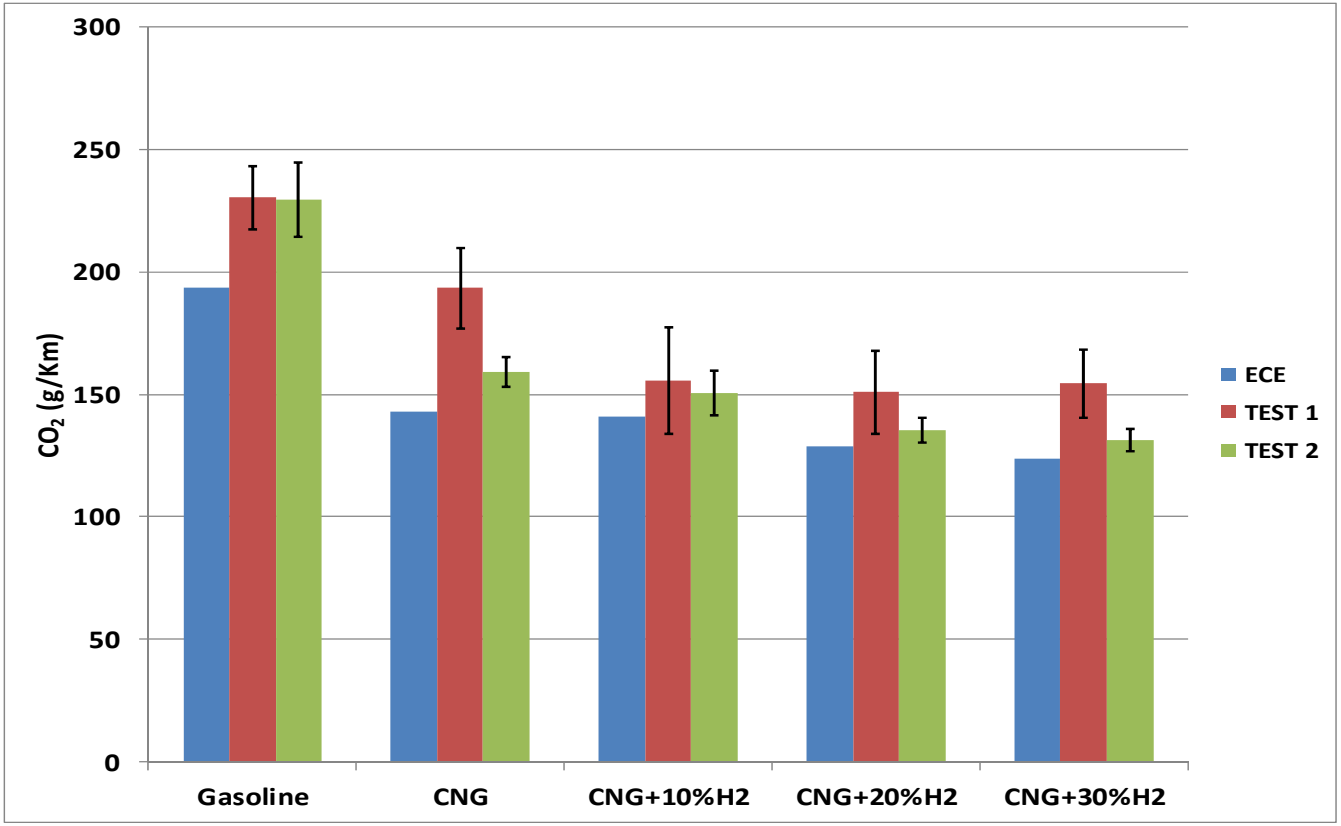
Results

- *Averaging reference distance = ECE 15 length, 4.052 km.*
- *Average road grade between -0.25% and 0.25%, max idle 33%.*
- *Distribution of CO_2 emissions (g/km) as function of the window relative positive acceleration in the speed bin 15-25 Km/h.*



Results

- *Averaging reference distance = ECE 15 length, 4.052 km.*
- *Average road grade between -0.25% and 0.25%.*
- *Speed bin 15-25 Km/h.*
- *Comparison between dyno emissions and on-road emissions*



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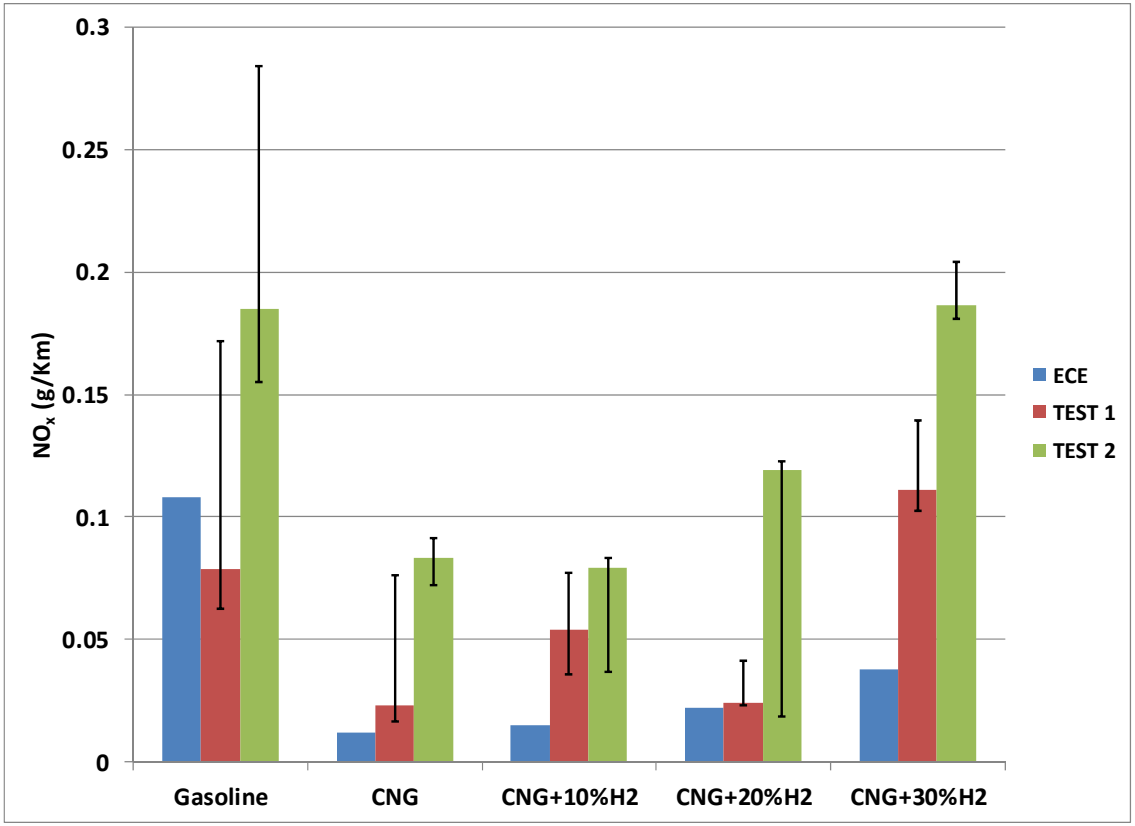

Conclusions: methodology

- *Indicators proposed for a systematic data binning method*
- *RPA was found to be a good indicator to explain the variability in the CO_2 emissions at constant road grade and speed*
- *The averaging window method provides an efficient way to link emissions and average operating characteristics*

Conclusions: results

- *Use of hydrogen blends effectively reduce on-road CO_2 emissions*
- *NOx emission generally increase as the hydrogen content in the blend increases*
- *Largest spread of CO_2 results in bins corresponding to the largest RPA spread.*

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