EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

PEMS testing of light-duty vehicles: EC JRC developments

Institute for Environment and Sustainability

Presentation Outline

- Objectives of the EC LDV PEMS Test Program
- Design of the program

- Test protocol (PEMS Installation, Testing)
- Test routes

- Test results
- Performance evaluation with on-road data

- Perspectives for the future EU legislation

Objectives of the EC LDV PEMS Test Program

- **Customer: EC DG ENV**
- **To contribute to the establishment of a knowledge and data base on the nature and frequency of different driving situations of road vehicles encountered in real-world driving in the EU, the associated emission levels of pollutants and the associated fuel consumption**
- **To contribute to the development of criteria for the testing of motor vehicles other than HDV using PEMS**

Design of the program - Phase 1

- **To develop the general 'recommendations' to install the equipment and to collect the data on board of light-duty vehicles;**
- **To design test routes that encompass the basic set of conditions (city, rural, highway, slope, etc…) that may be encountered by the vehicles;**
- **To evaluate available data processing methods that can potentially be used to either analyze the on-road emissions data or to provide pass-fail information in a type-approval context.**

Design of the program - Phase 2

- To test several vehicles of different technologies on the same reference routes (city, rural, highway, uphill);
- To study the test-to-test repeatability for a given vehicle-route combination, as each vehicle-route;
- To further evaluate the data processing method selected at the end of phase 1;
- To identify potential emissions 'problems' arising when vehicles with different vehicle technologies are driven under real-world conditions.

Test protocol - Phase 2

- To test several vehicles of different technologies on the same reference routes (city, rural, highway, uphill);
- To study the test-to-test repeatability for a given vehicle-route combination, as each vehicle-route combination was tested three times;
- To further evaluate the data processing method selected at the end of phase 1;
- To identify potential emissions 'problems' arising when vehicles with different vehicle technologies are driven under real-world conditions.

Testing: Test Parameters

PARAMETER	MEASUREMENT DEVICE
THC Concentration	Analyzer
CO Concentration	Analyzer
CO2 Concentration	Analyzer
NOx Concentration	Analyzer
Exhaust Flow Rate	EFM
Exhaust temperature	EFM Temperature Sensor
Vehicle speed	GPS
Vehicle position and altitude	GPS
Acceleration	GPS
Distance traveled	GPS
Elevation	GPS
Ambient humidity	Humidity Sensor
Ambient temperature	Temperature Sensor
Ambient pressure	Pressure sensor

Peculiarities of PEMS LDV Testing

- **Emissions measured from cold start, including cranking**
- **Use of standard commercial fuels**
- **Access to ECU data possible but difficult due to the lack of standardisation: issue for QC/AC of testing**
- **Weight and size of PEMS equipment acceptable but not negligible (70 to 100 kg = 1 person, all PEMS accessories included)**
- **Use of power generators impossible in most cases: the lifetime of the batteries restricts the test durations to roughly 3 hours**

Test vehicles (as off December 2007)

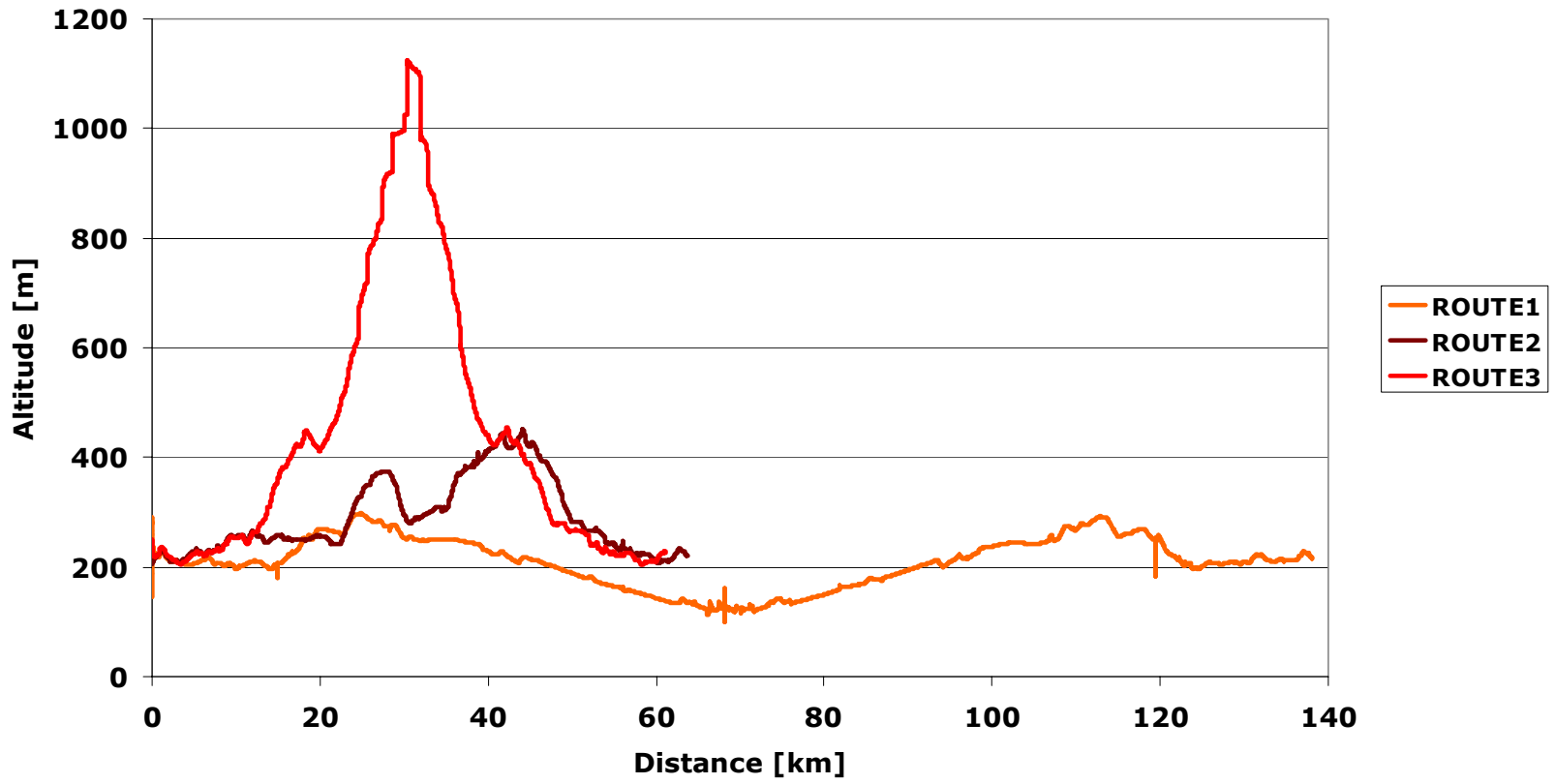
	PHASE 1		PHASE 2			
	DIESEL		HYBRID	DIESEL	GASOLINE	
VEHICLE BRAND AND TYPE	Fiat Scudo JTD	VW T5 TDI	Toyota Prius	Renault Clio	Ford CMAX	Renault Clio
ENGINE CAPACITY [LITRE]	2.0	2.5	1.8	1.5	1.8	1.2
AFTER-TREATMENT SYSTEM	Oxidation catalyst only – No DPF	Oxidation catalyst only – No DPF		Oxidation catalyst only – No DPF		
EMISSIONS STANDARDS	EURO 3 Class II	EURO 4 Class II	EURO 4	EURO 4	EURO 3	EURO 4

Mileage range: 5000 - 80000 km

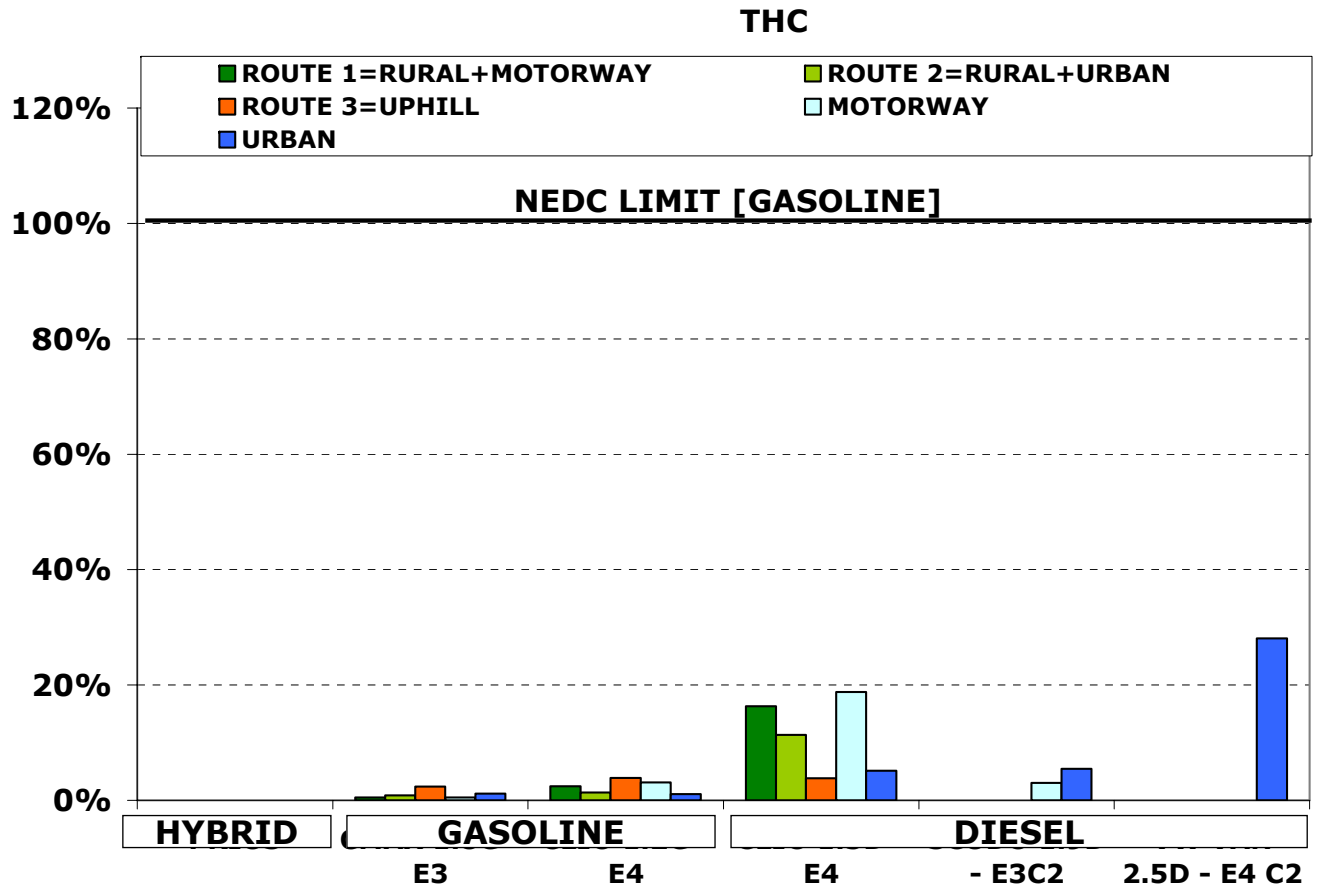
Test routes

	ROUTE 1			ROUTE 2			ROUTE 3		
Section	**Rural**	**Mot.**	**TOTAL**	**Rural**	**City**	**TOTAL**	**Rural**	**Uphill**	**TOTAL**
Distance [km]	35	100	**135**	51	10	**61**	50	10	**60**
Approx. ver. Speed [km/h]	50	90	**65**	40	25	**35**	45	30	**40**

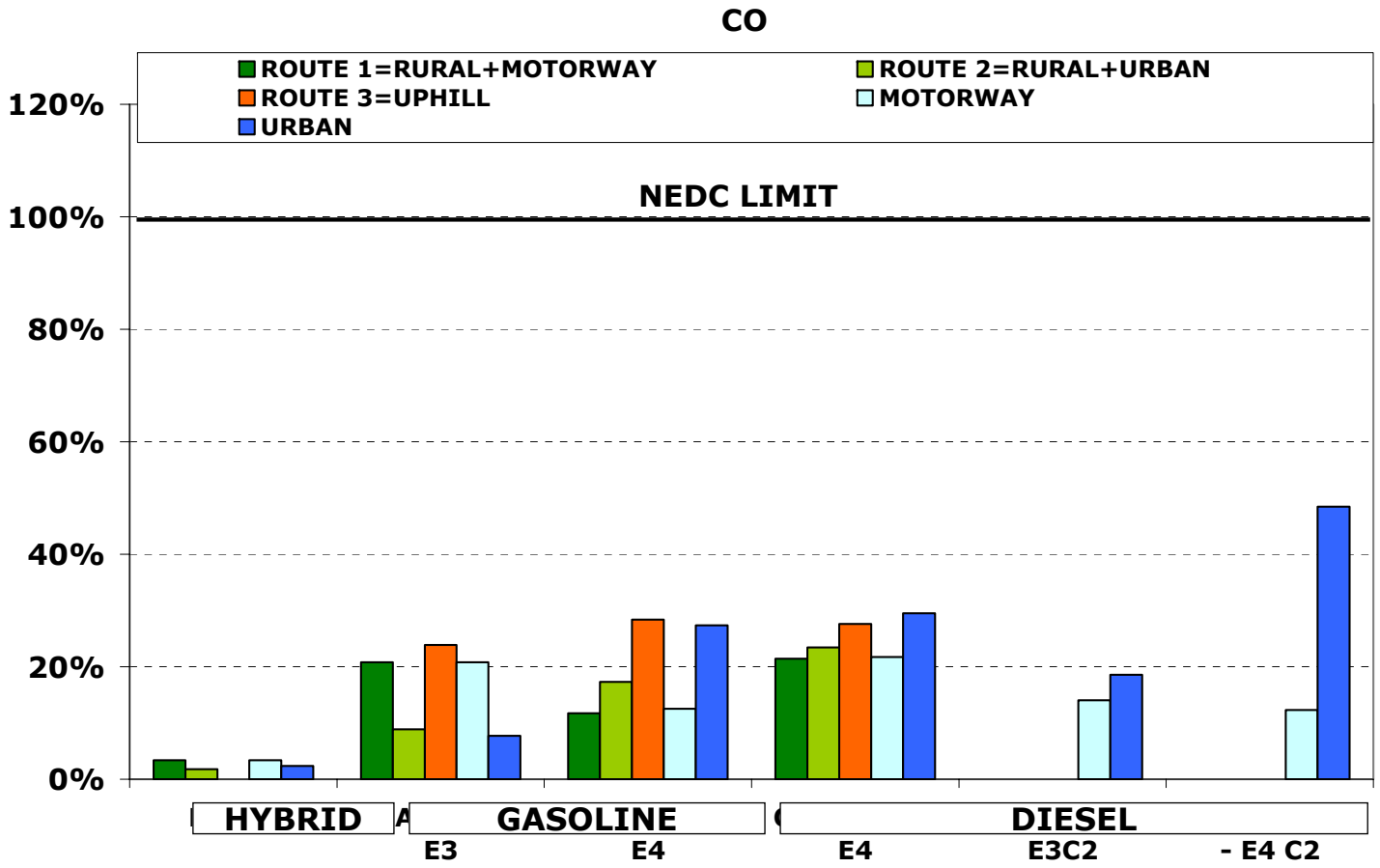
Test routes: GPS Altitude Profiles



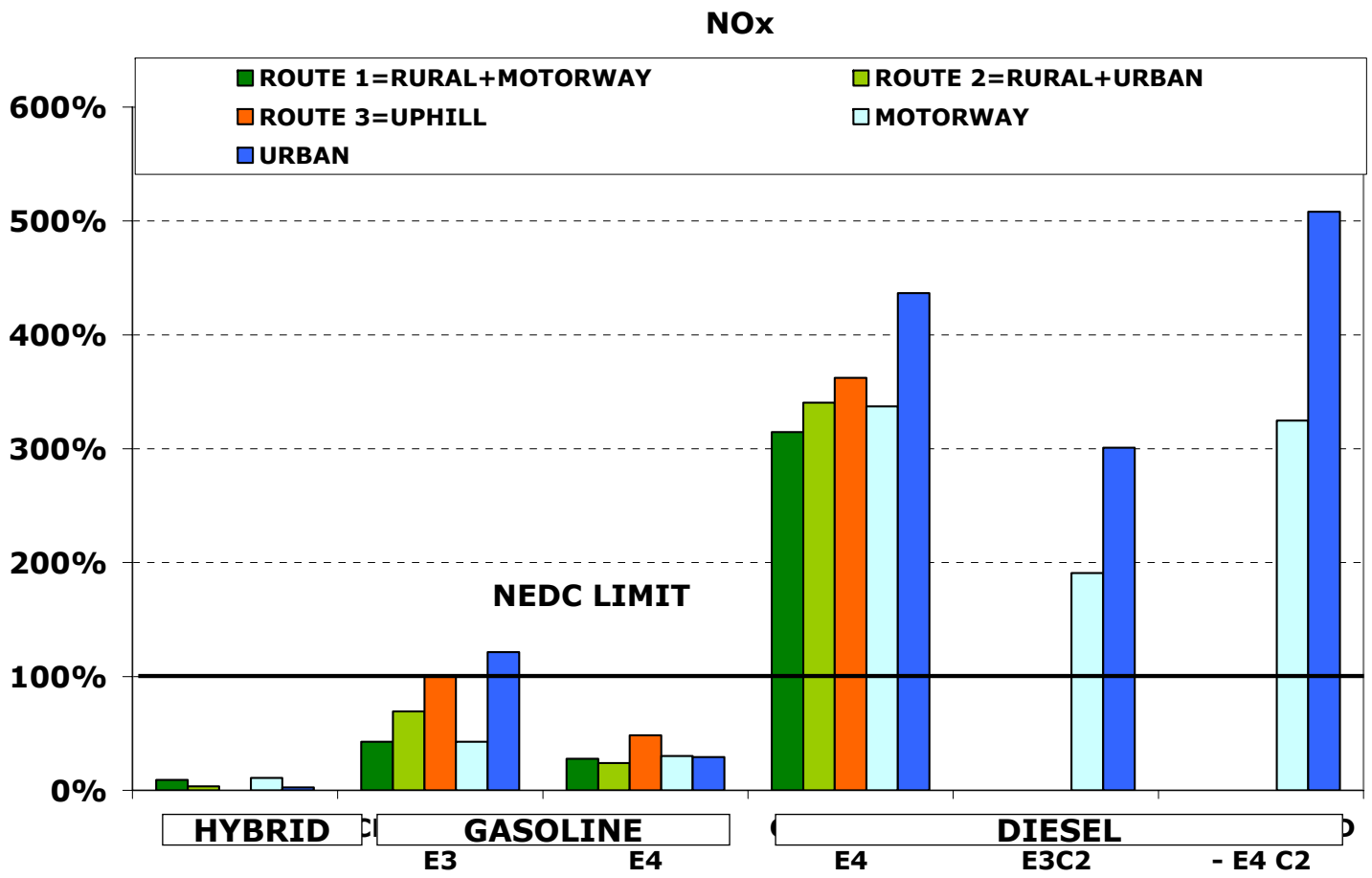
Test results - Complete trips - THC



Test results - Complete trips - CO



Test results - Complete trips - NOx

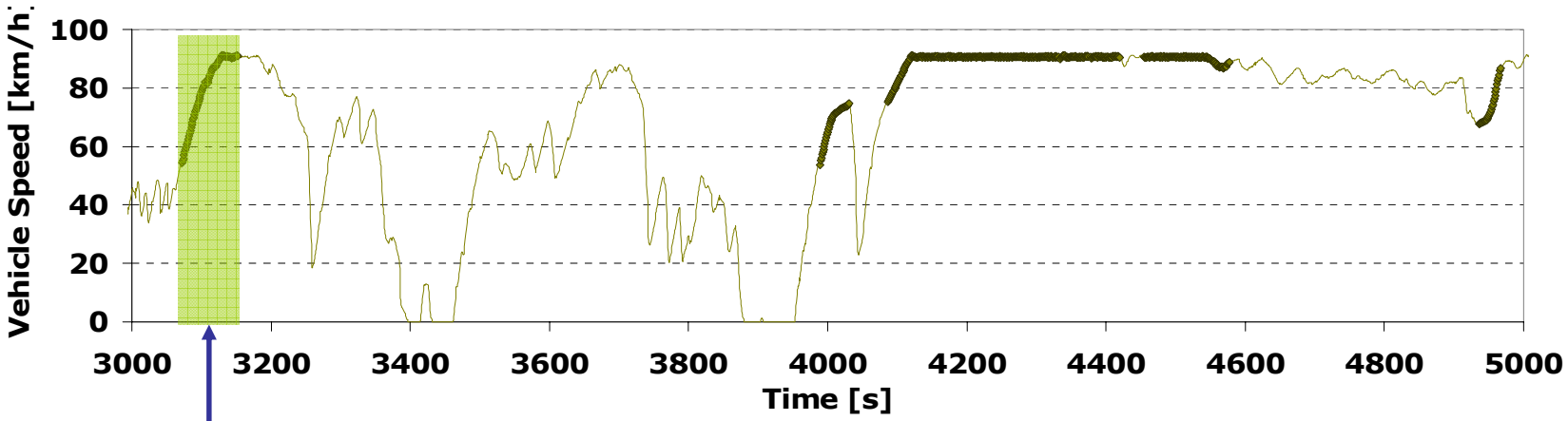


How to evaluate the on-road emissions data…?

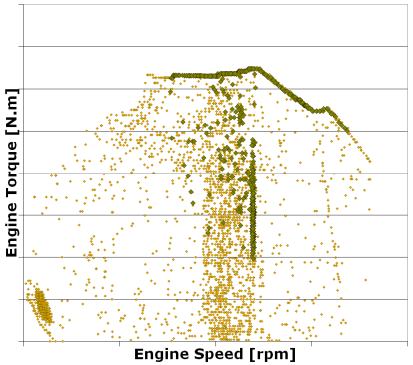
- To characterize in-use emissions
- To consider most of if not all operating patterns
- To damp short effects (peaks) by determining suitable averaging durations
- To select averaging lengths that are representative for the engines

Data Evaluation: US Legislation

- Not-To-Exceed (US-NTE) Standards for On-Highway Trucks (Heavy-Duty) and Non-Road Mobile Machinery



>30s in Control Area = Event

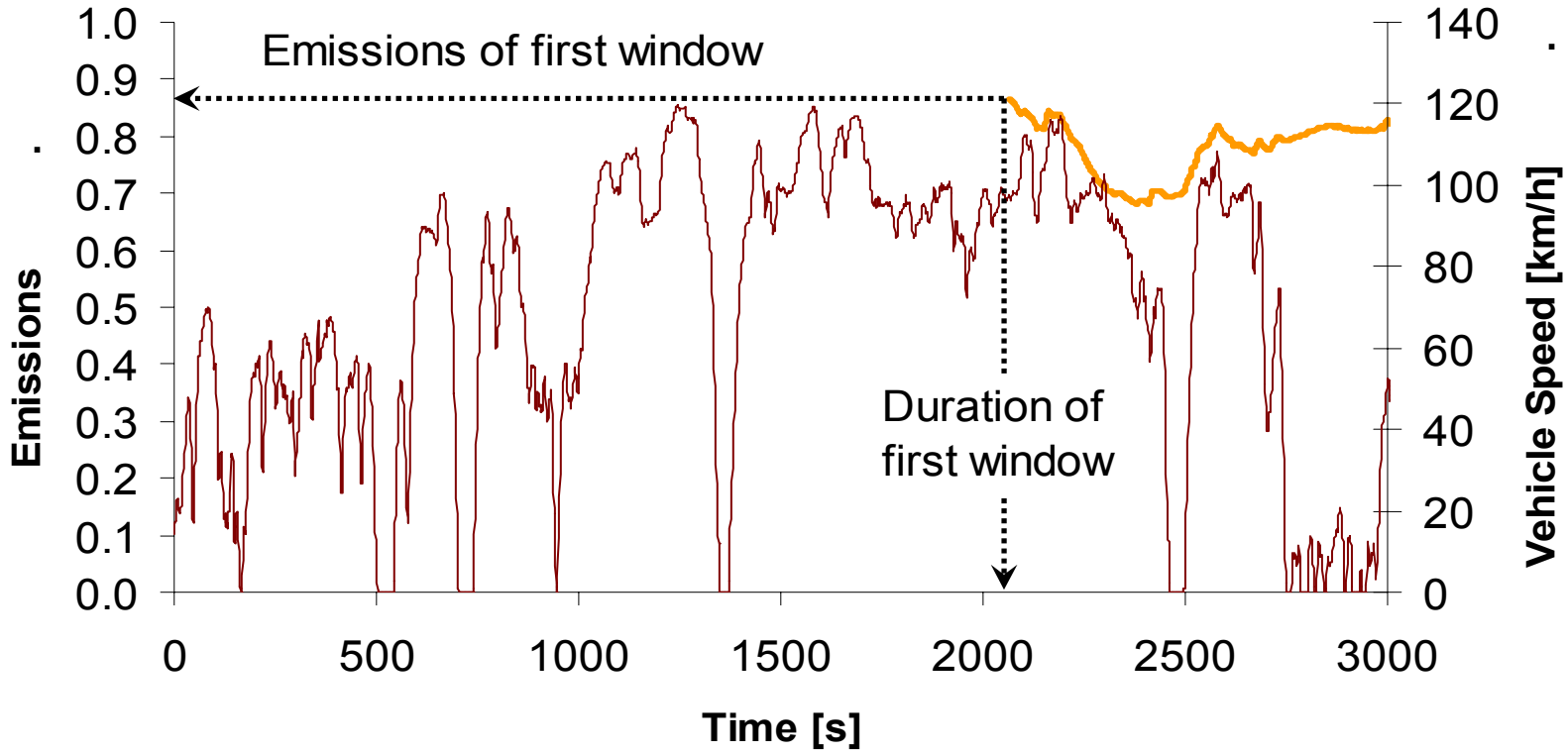


Data evaluation: Future EU HDV Legislation

- **Averaging window principle: moving average, using a reference value to define the size of the averaging window.**

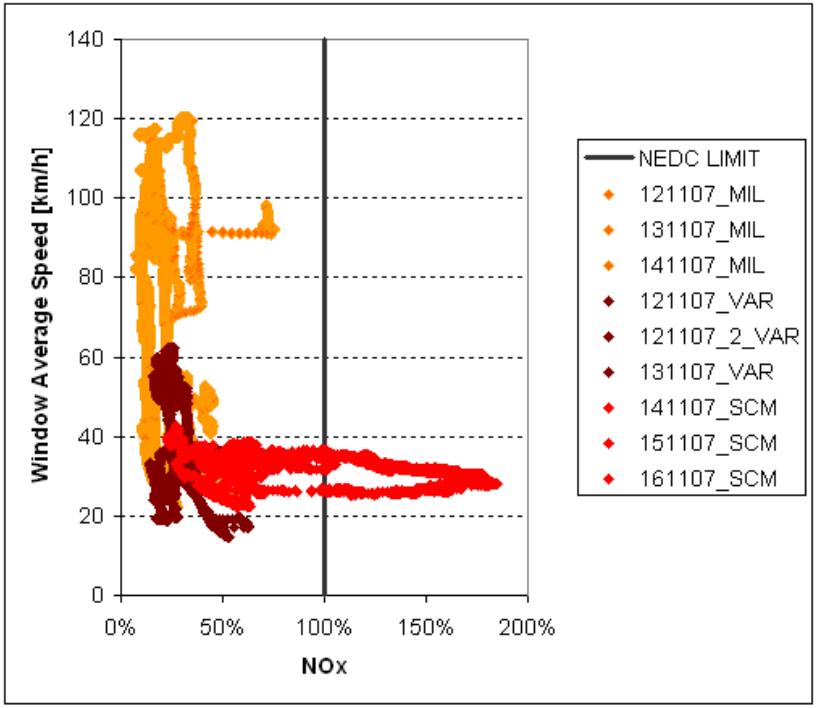
- **Unlike US-NTE, all the data is accounted for.**
- **The reference quantity is obtained from the applicable certification test procedure.**
- **The reference quantity is currently work for HDV.**
- **The possibility to use a CO2 mass instead of work is being evaluated.**

Data evaluation: Future EU HDV Legislation

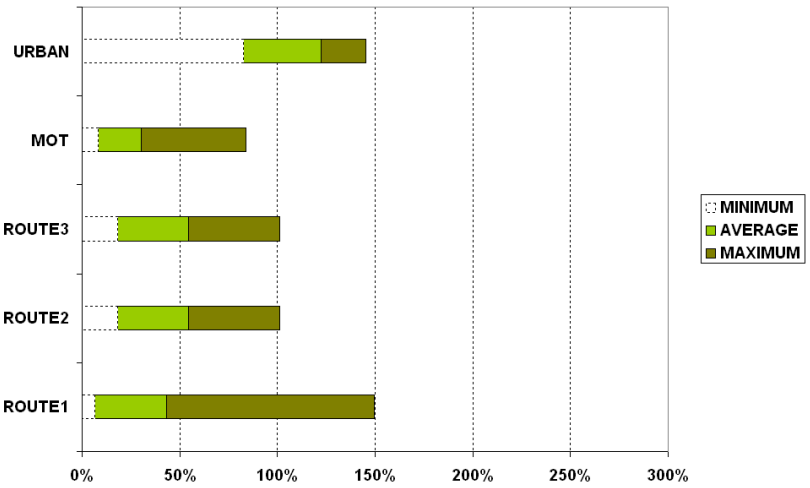


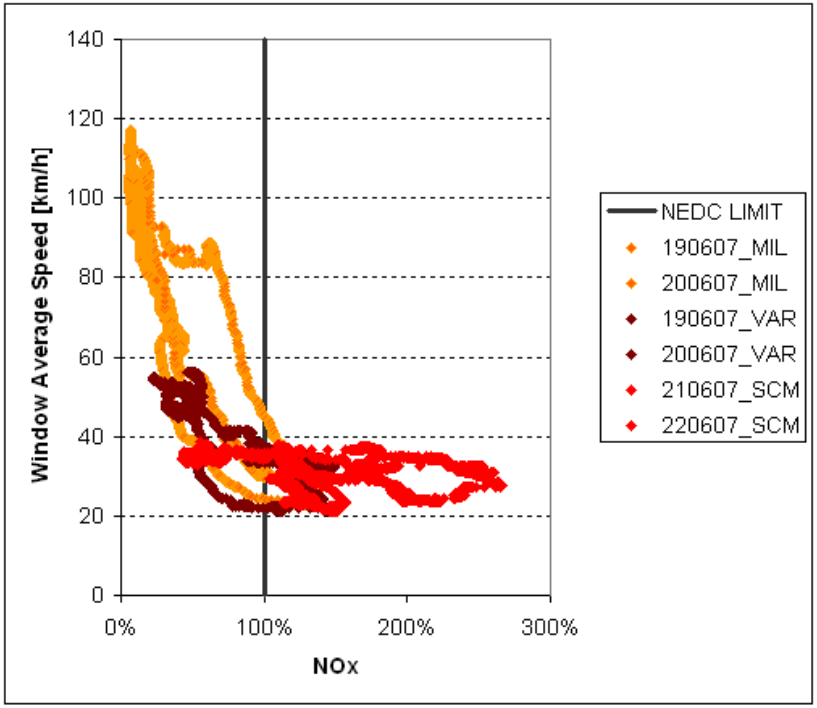
Data Evaluation: Averaging window based on a reference CO2 mass

- **Light-Duty Gasoline Vehicle**
- **Illustration of the averaging window method**
- **Reference CO2 mass from NEDC cycle**

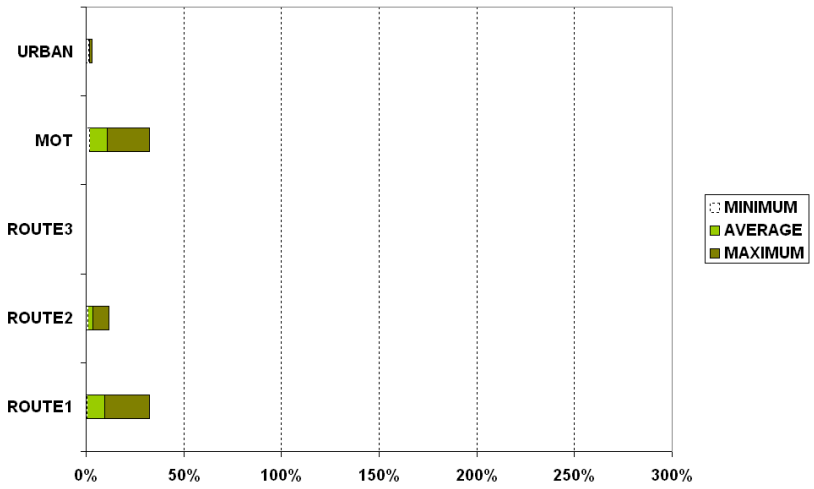


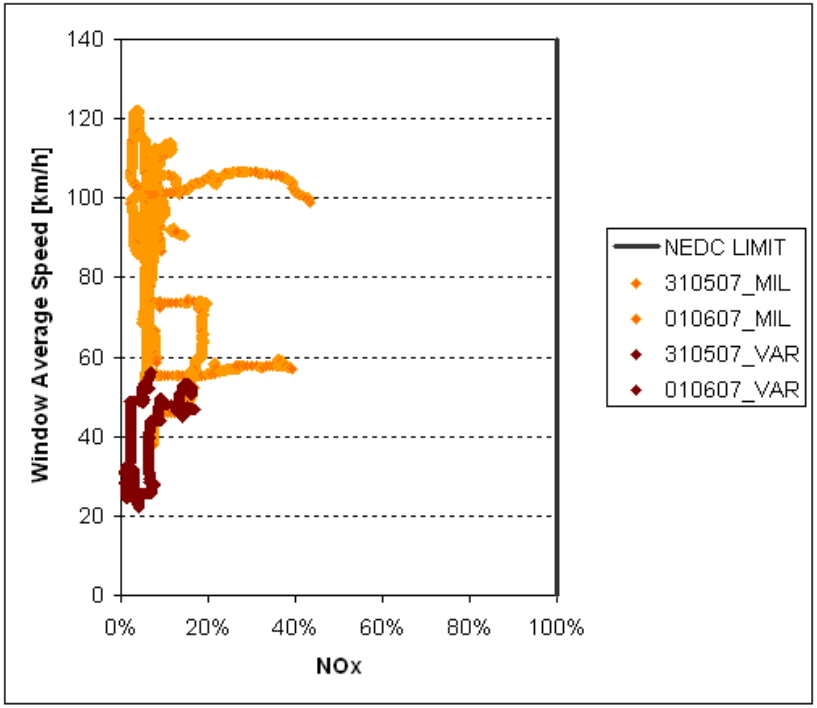
Data Evaluation: CO2 Averaging window NOx - EURO3 Gasoline



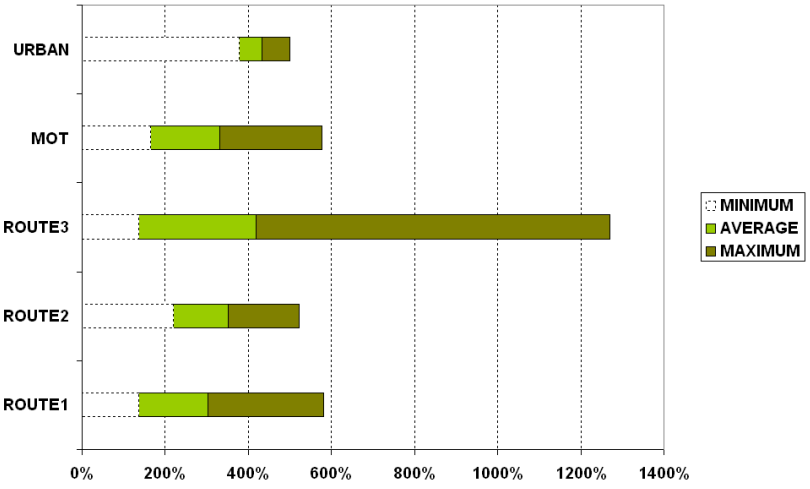


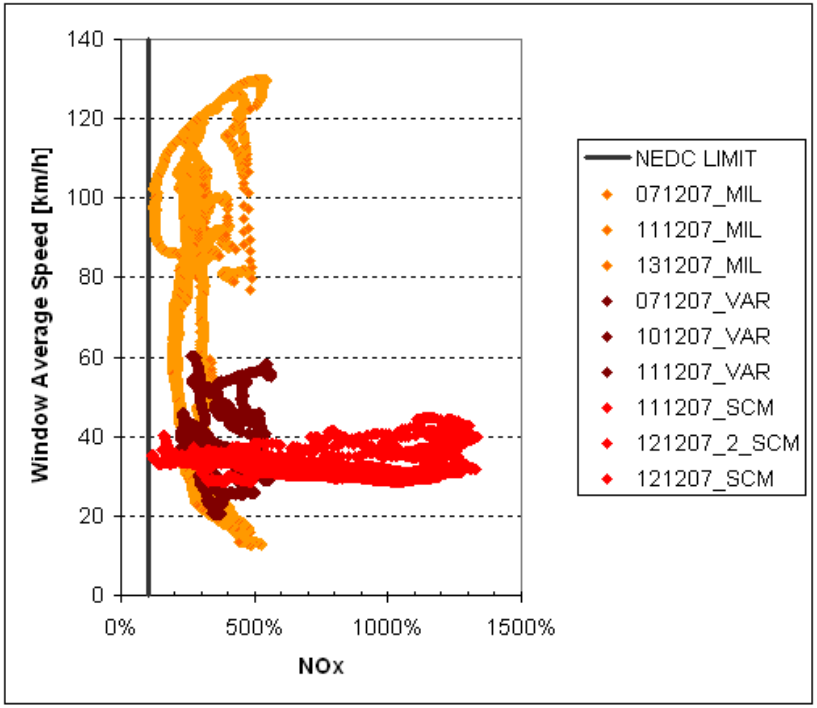
Data Evaluation: CO2 Averaging window NOx - EURO4 Gasoline-Hybrid





Data Evaluation: CO2 Averaging window NOx - EURO4 Diesel





Conclusions (1)

- A laboratory test cycle (NEDC or other) is unlikely to provide an efficient in-use emissions control, as it represents only a limited set of ambient and operating conditions.

- The current emissions laboratory test procedures are not fully appropriate for the future combinations (engine-after treatment-fuel-power train) technologies, as they may only 'capture' a small part of their real usage:

  - Hybrids
  - Multi-mapping of engines
  - Etc...

Conclusions (2)

- In-use testing with PEMS is one of the solutions to check engines and therefore to keep in-use emissions below a certain level under all normal ambient and geographic conditions"

- **Limitations**
  - For LDV, simultaneous testing of gaseous and PM emissions difficult with the current equipment size
  - Comparison of emissions and fuel consumption from different vehicles possible but difficult.

- **Advantages**
  - View on the real vehicle emissions...!

Perspectives for the future EU legislation

PEMS

Light-Duty →

Feasibility study:
- Control of In-Use emissions from EURO6 Standards

Heavy-Duty →

Almost Ready:
- In-Service Conformity for EUROV and IV Standards
- Control of In-Use emissions from EUROIV Standards

Non-road Engines →

Being prepared:
- In-Service Conformity for Future Standards (NRMM stage IV, Application of HDV developments)

Thank you for your attention…