

# Ricardo-AEA

## COPERT 4 emission factors for Euro 6 diesel cars used in the NAEI and in the Emission Factors Toolkit

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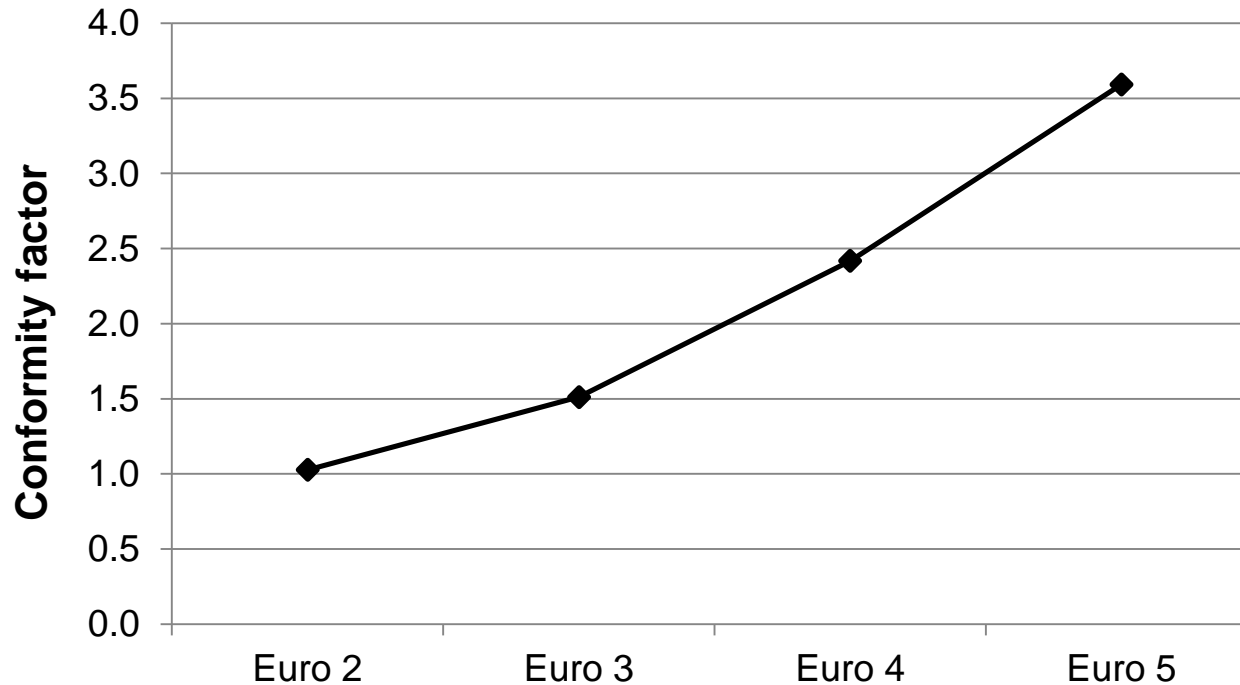
APRIL (Air Pollution Research in London) Meeting – 24 February 2015

- Background
  - Road transport emission modelling approach used in the UK National Atmospheric Emissions Inventory (NAEI) and in the Emission Factors Toolkit (EFT)
  - NO<sub>x</sub> performance of diesel cars (up to Euro 5)
  - How will Euro 6 be delivered for diesel cars?
- NO<sub>x</sub> emission factors for Euro 5/6 diesel cars (and LGVs) used in the current NAEI and EFT
- Comparison of the current NAEI/EFT NO<sub>x</sub> factors with the updated factors from COPERT 4 v11.0
- Summary and conclusions

- Both the NAEI and the EFT use an emission modelling approach and emission factors consistent with those recommended by the **COPERT 4 methodology** “*Computer Programme to Calculate Emissions from Road Transport*”
- COPERT 4 is a model and database of vehicle emission factors developed on behalf of the European Environment Agency
  - It is used widely by other Member States to calculate emissions from road transport
  - Part of the EMEP/EEA Air Pollutant Emissions Inventory Guidebook
- The COPERT emission factors are represented as equations **relating emission factor in g/km to average speed** of the vehicle in the drive cycle
- The scientific development of the COPERT 4 model is managed by the European Commission’s Joint Research Centre, drawing input from e.g.
  - European Research Group on Mobile Emissions (ERMES) work programme

# Real-World NO<sub>x</sub> Emission Factors for Diesel Cars – Conformity Factors

- A Conformity Factor is the ratio of measured 'real-world' emission factor to the Type Approval Limit value
- Conformity factors have been increasing with successive Euro standards

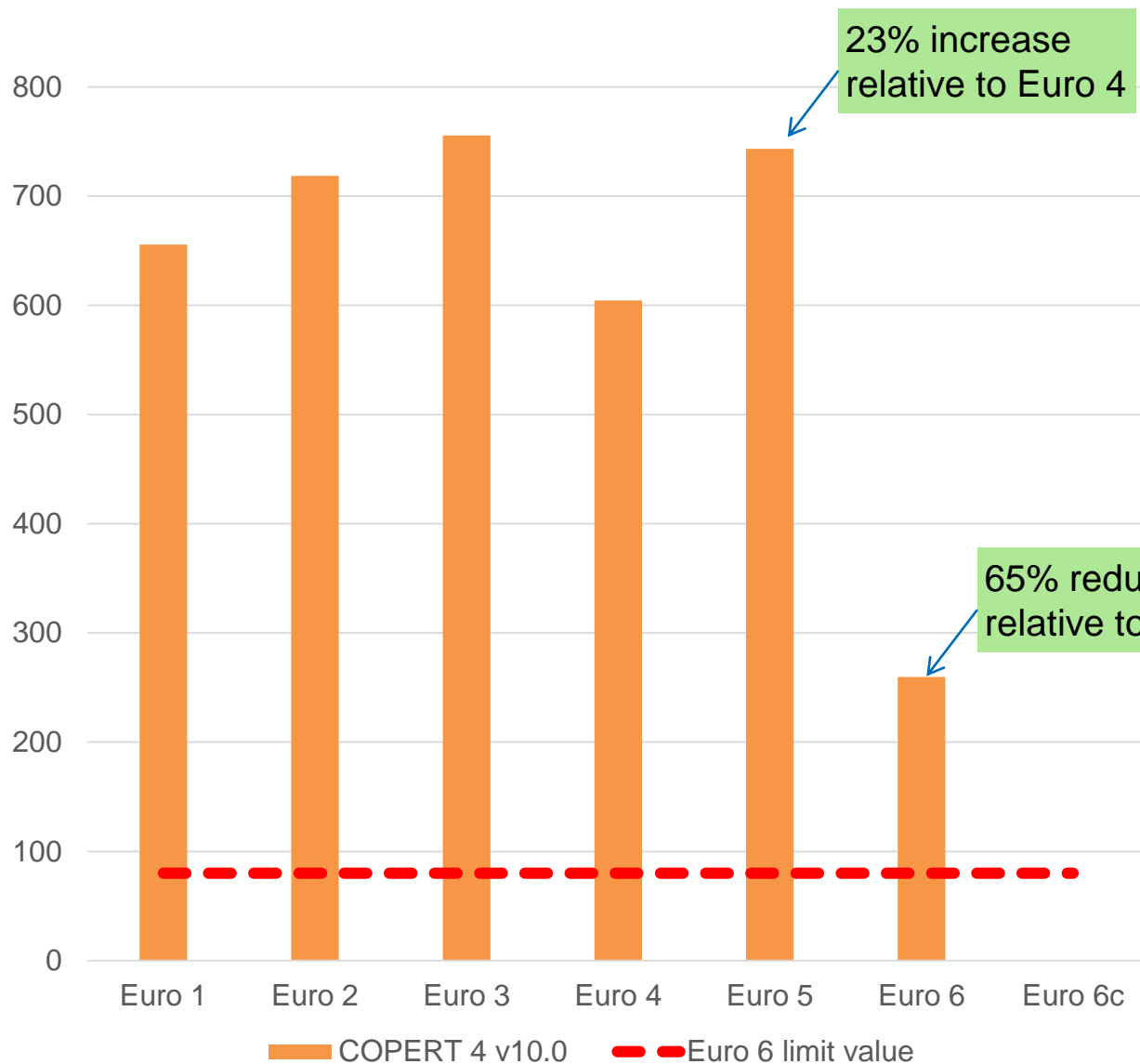


- EC 715/2007 Regulation Limit value for NO<sub>x</sub> is **80 mg/km** for Euro 6
  - 180 mg/km for Euro 5, so implies a 56% reduction
- Flexibility built into EC Regulation: Article 14, para 3:
  - “The Commission shall keep under review the procedures, tests and requirements referred to in Article 5(3) as well as the test cycles used to measure emissions. If the review finds that these are no longer adequate or no longer reflect real world emissions, they shall be adapted so as to adequately reflect the emissions generated by real driving on the road.”
- Euro 6 will be delivered in two stages:
  - 2015 – Euro 6
  - 2018 – Euro 6c
  - Same limit value, different test procedures
- Real Driving Emissions (RDE) legislation for Euro 6c based on Portable Emission Measurement systems (PEMS) to bring reductions in real-world emissions

# Euro 5/6 NO<sub>x</sub> EFs for Diesel Cars in Current NAEI and EFT

- Latest version of NAEI (with emission data up to 2013) and EFT (v6.0.2) are based on
  - **COPERT 4 v10.0** (released in November 2012)
- Compared to the previous version (COPERT 4 v9.0), changes were made to **Euro 5/6 diesel cars only**
  - Based on measurements and initial results collected in the ERMES database at the time
  - Euro 5 (24 vehicles)
  - Euro 6 (8 vehicles) – Note these early Euro 6 models are of advanced emission control technology
- For diesel cars, the COPERT 4 v10.0 NO<sub>x</sub> emission factors imply
  - Euro 5: 23% higher than Euro 4
  - Euro 6: 65% lower than Euro 5
  - **Does not include Euro 6c**

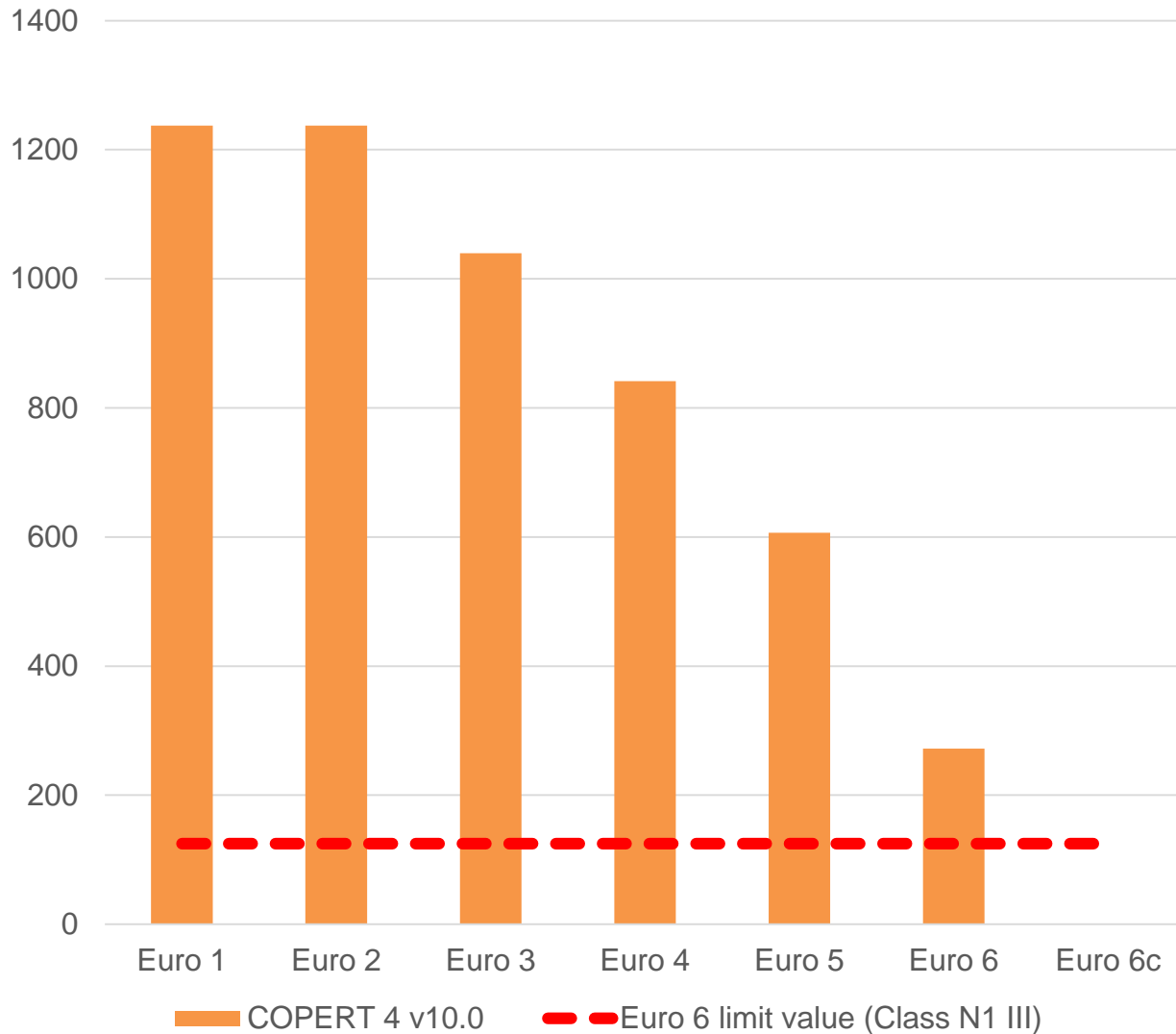
# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel Cars – Urban



● **COPERT 4 v10.0 → current NAEI / EFT**

● No Euro 6c

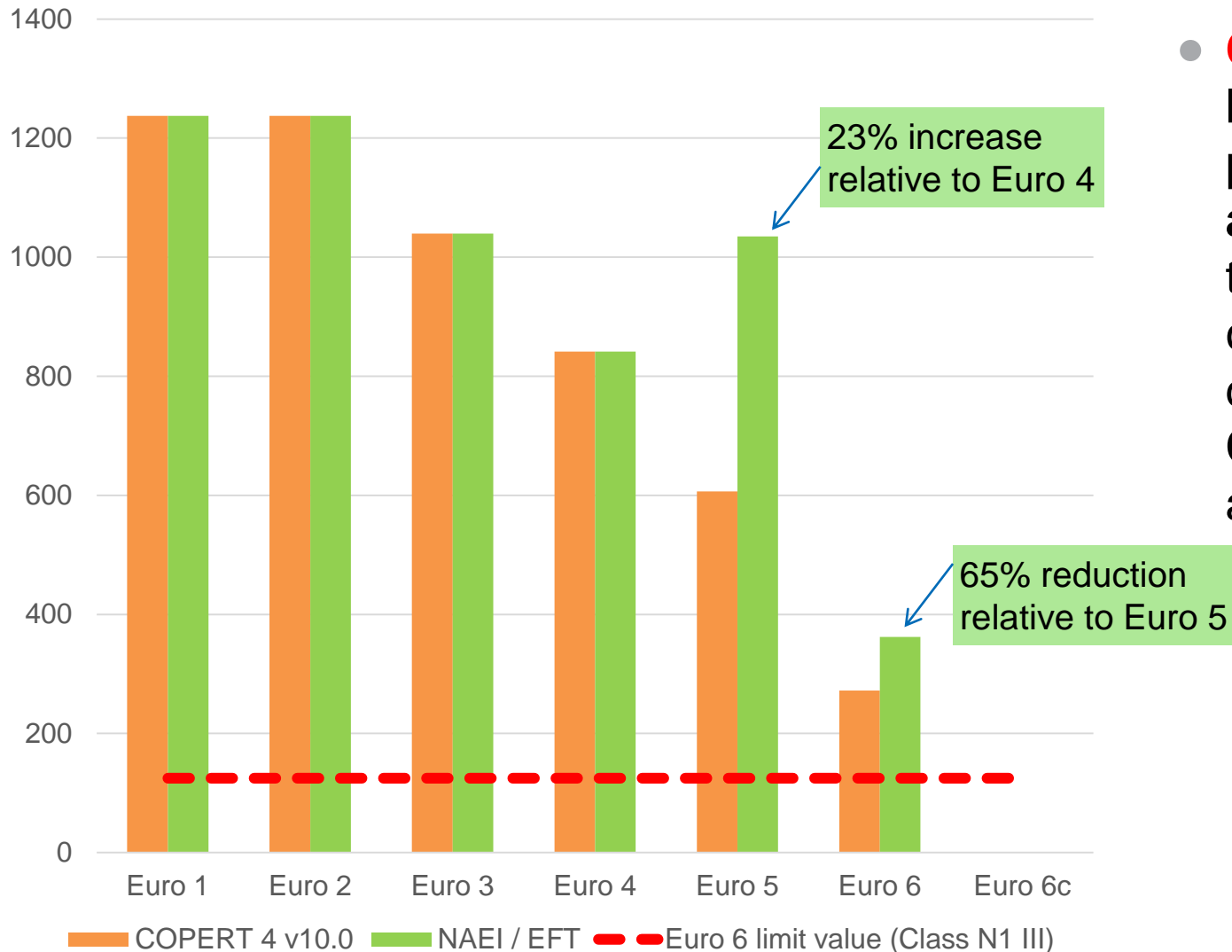
# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel LGVs – Urban



- COPERT 4 v10.0
  - 28% reduction from Euro 4 to Euro 5
  - 55% reduction from Euro 5 to Euro 6
  - Based on relative change in limit values
- No Euro 6c



# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel LGVs – Urban

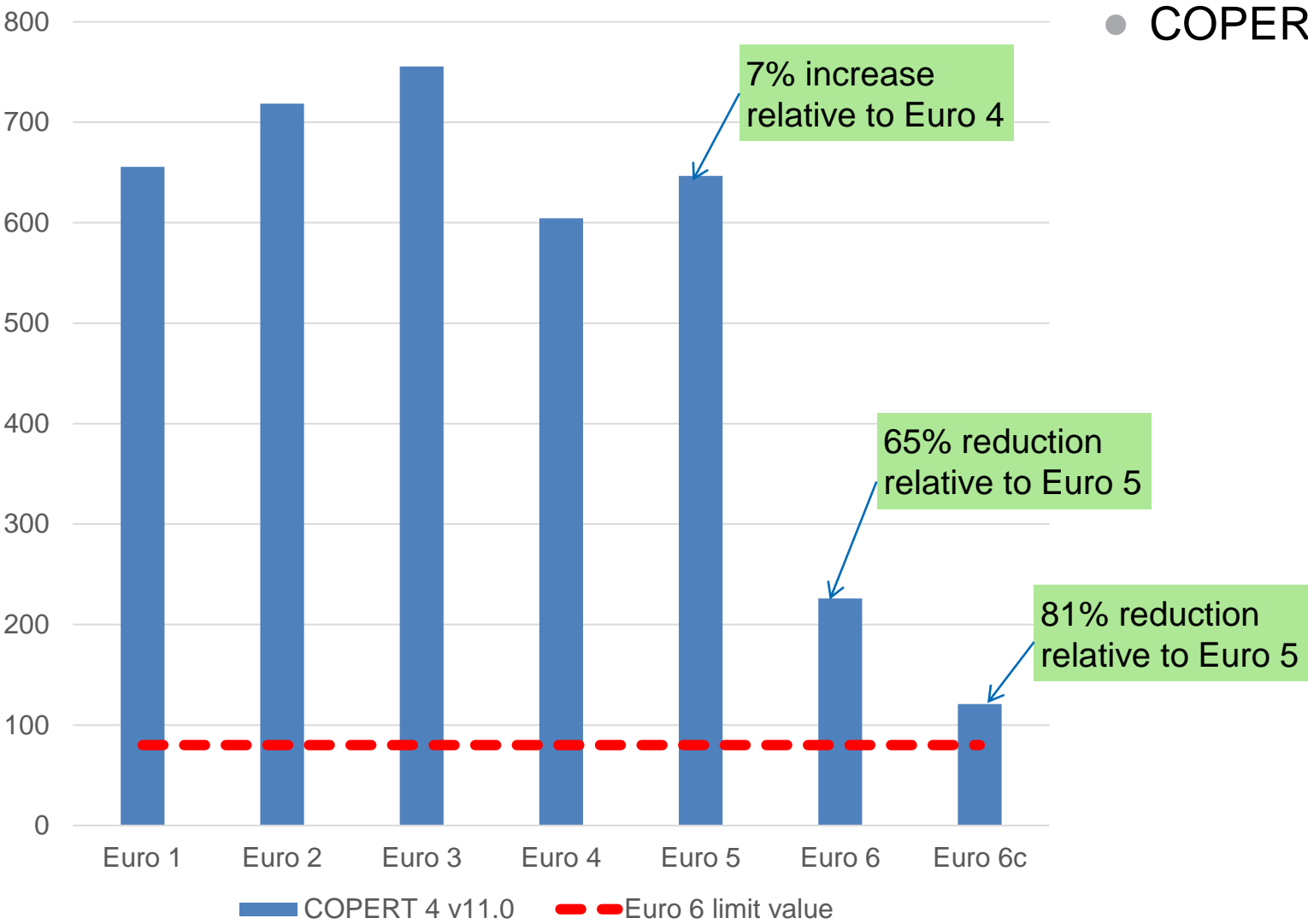


- **Current NAEI / EFT** have adopted a **precautionary approach** - assumed the same Euro 5 and 6 changes factors for diesel cars (made in COPERT 4 v10.0) apply to diesel LGVs

- Released in September 2014
- Updated emission factors for Euro 5/V, 6/VI vehicles (cars, LGVs, HGVs and buses), including NO<sub>x</sub>, PM, HC, CO, NH<sub>3</sub>, N<sub>2</sub>O and NO<sub>2</sub>
- Based on data from the latest version of the Handbook Emission Factors for Road Transport (**HBEFA version 3.2**) – the new COPERT equations were produced by applying regression analysis on the given HBEFA data

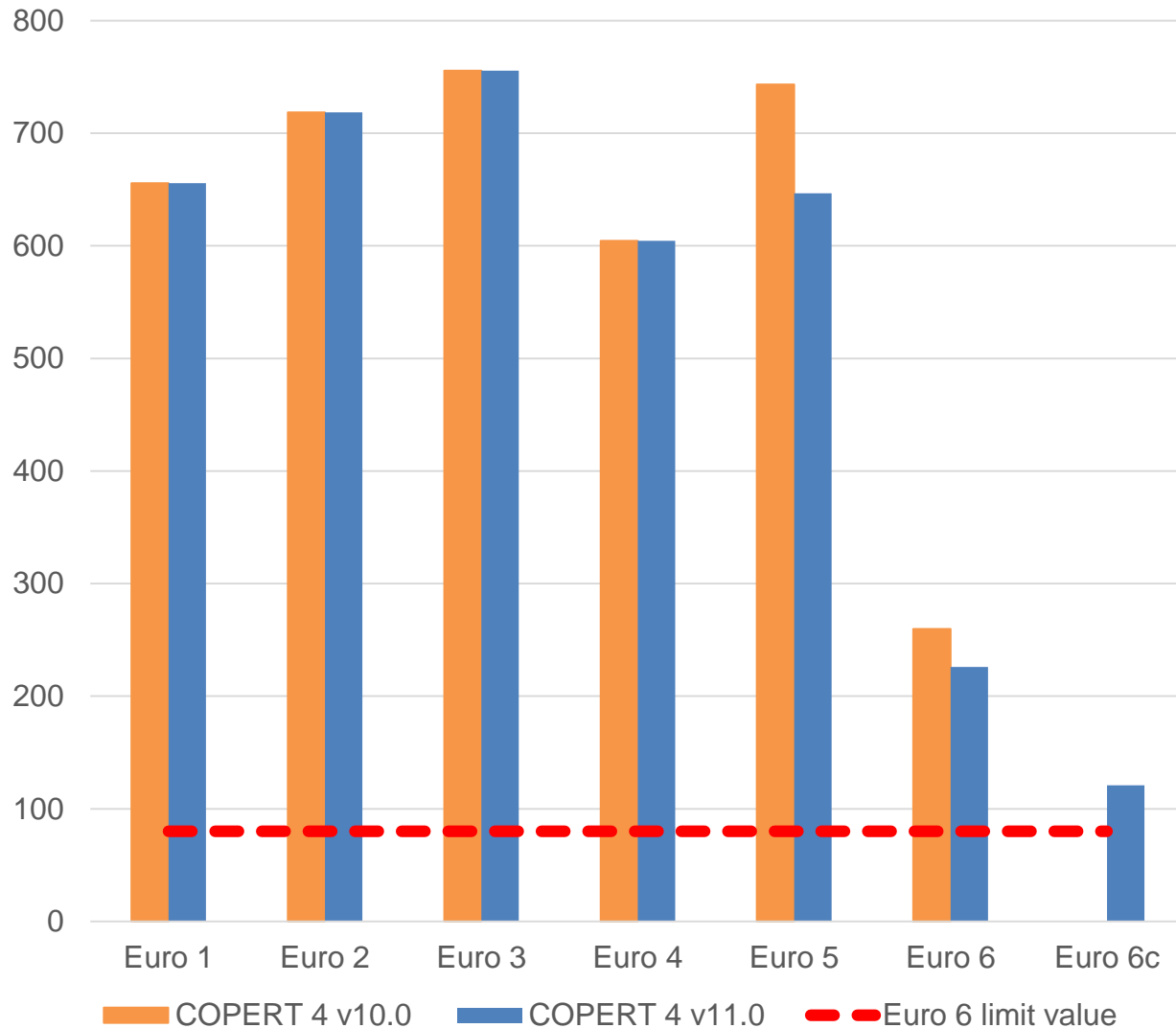
- The emission factors in **HBEFA version 3.2**
  - The work was coordinated within the ERMES group
  - Emission factors developed for Euro 5 and Euro 6a,b based on real-world tests and then processed through vehicle simulation model (PHEM)
  - Number of measured **diesel cars**:
    - Euro 5 (50 vehicles)
    - Euro 6 (19 vehicles – Note the Euro 6 vehicle models tested belong to the “premium class” and so there are questions on the representativeness of the vehicles sampled so far)
- **Including factors for Euro 6c**
  - No in-service Euro 6c vehicles available for testing – factors based on ERMES prognosis of likely technology approaches required to conform with RDE testing procedures

# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel Cars – Urban

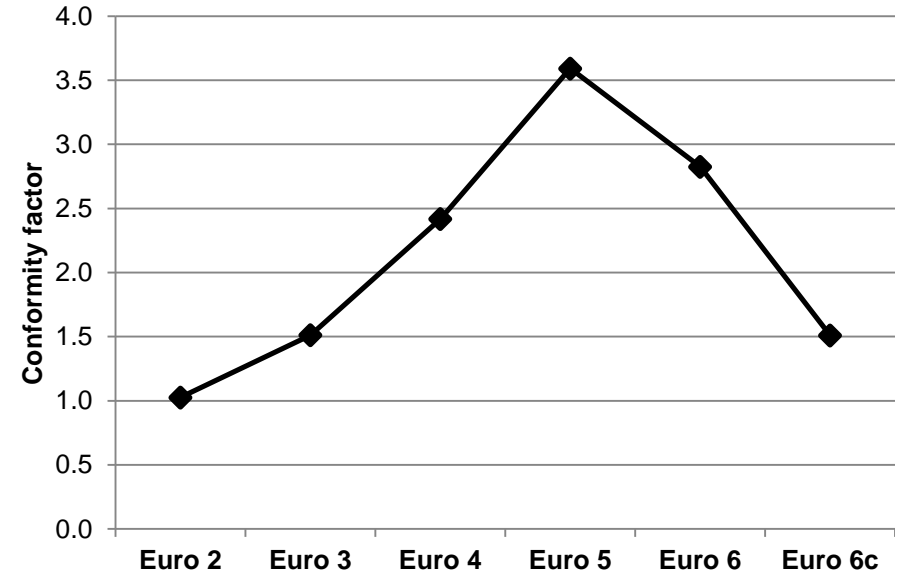
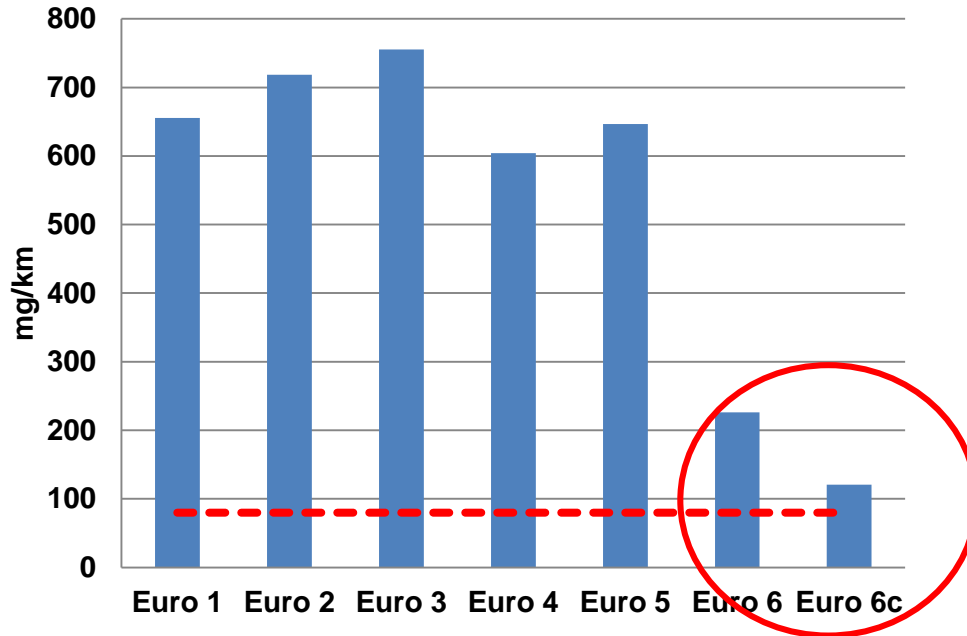


● COPERT 4 v11.0

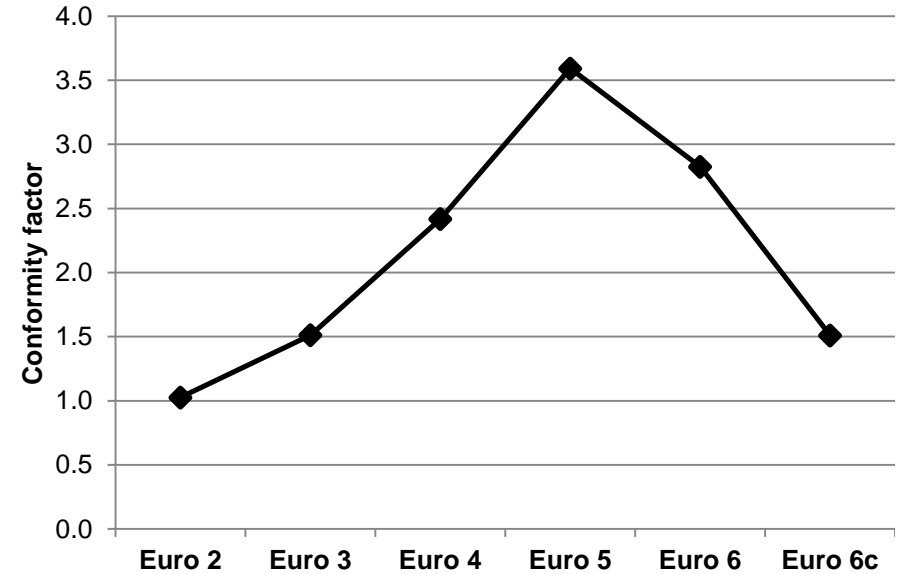
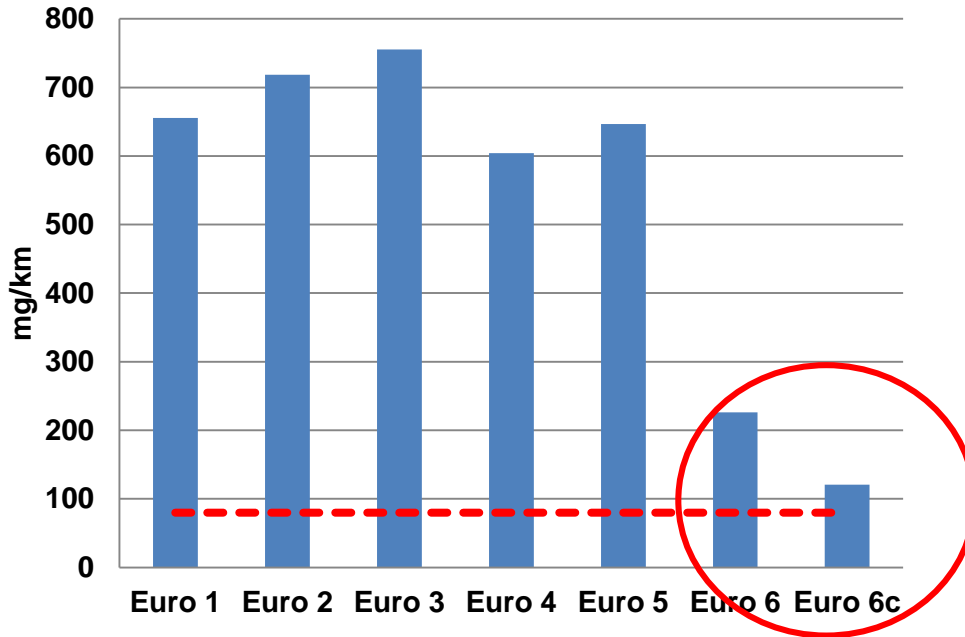
# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel Cars – Urban



- COPERT 4 v10.0 → current NAEI/ EFT (Orange bars)
- COPERT 4 v11.0 (Blue bars)
  - **Lower** NO<sub>x</sub> EFs for Euro 5/6 diesel cars than the factors used in the current NAEI/EFT
  - Inclusion of Euro 6c

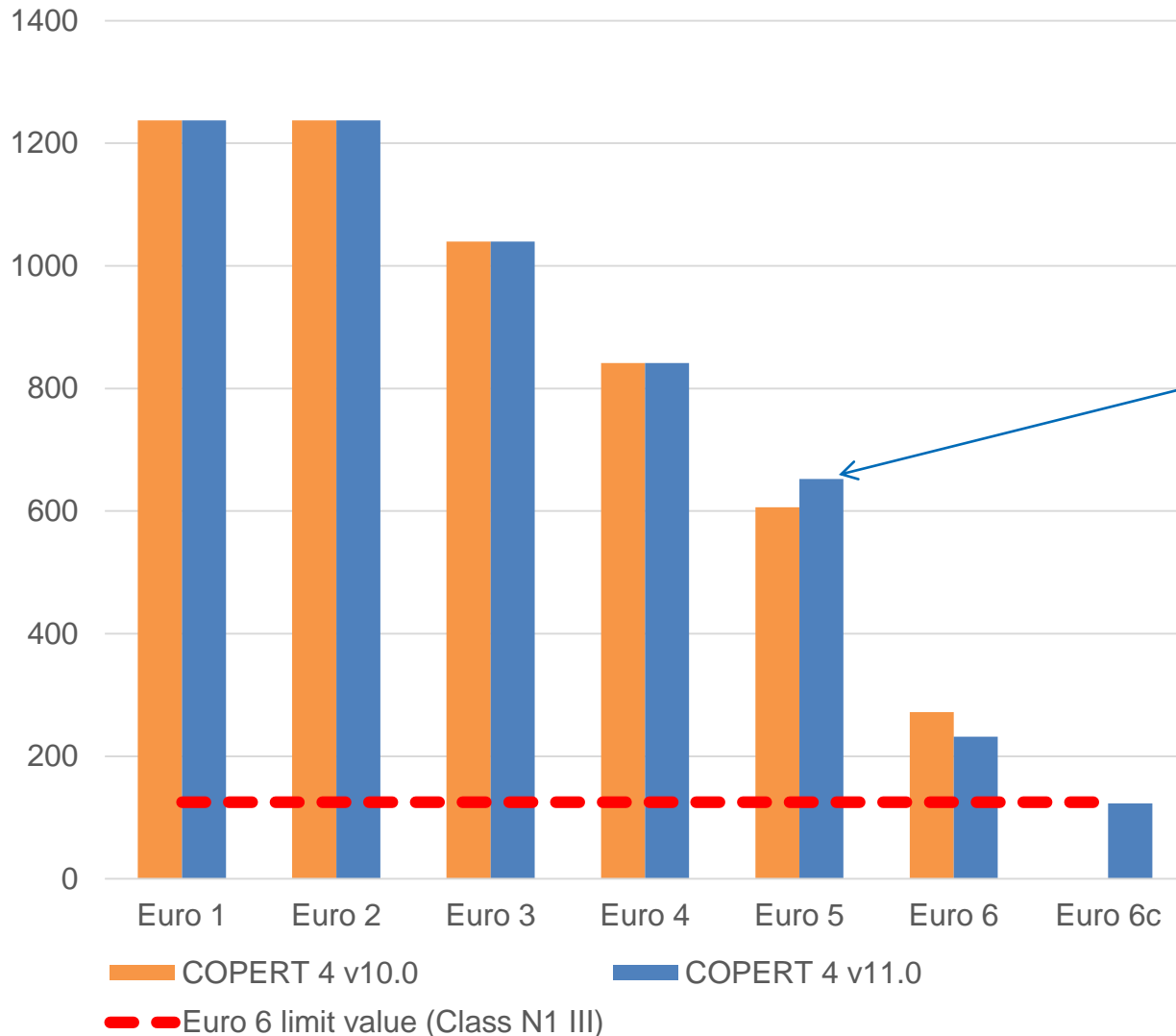


- But are these factors weighted by samples including 'premium class' models?
- Some studies on PEMS data analysis show much higher Euro 6 emissions, with Conformity Factors as high as 7!
- Emissions outside the NEDC regulatory test cycle vary considerably between car models, reflecting different technological approaches by manufacturers to achieve the more stringent limit value



- No in-service Euro 6c vehicles available for testing – factors based on ERMES prognosis of likely technology approaches required to conform with RDE testing procedures
- Time will tell !

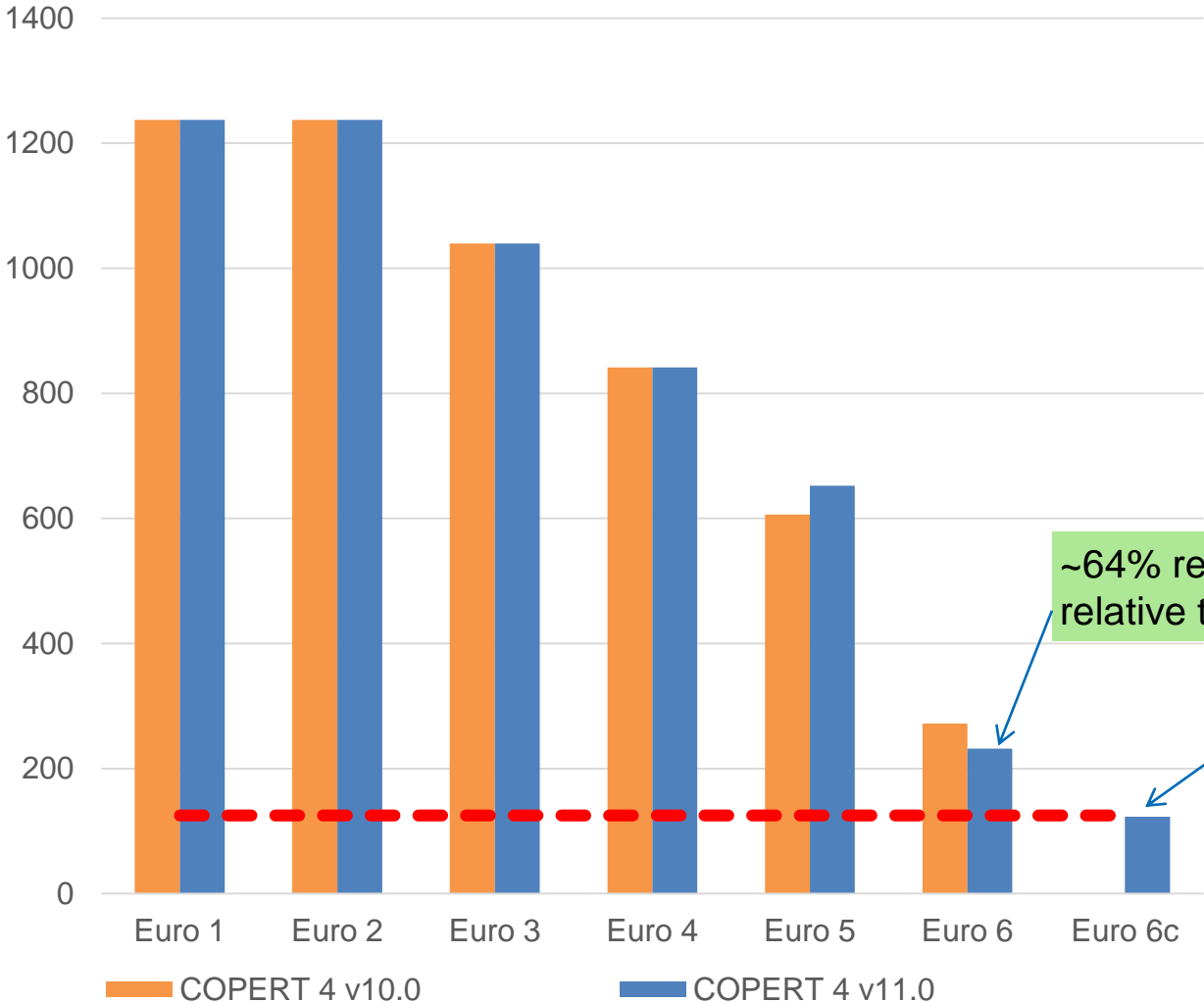
# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel LGVs – Urban



- The available test data for LGVs however is much smaller than for passenger cars.
- New test data (4 vehicles?) for Euro 5 suggest lower reduction from Euro 4 to Euro 5 (22% instead of 28% as implied by the relative change in limit values)



# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel LGVs – Urban



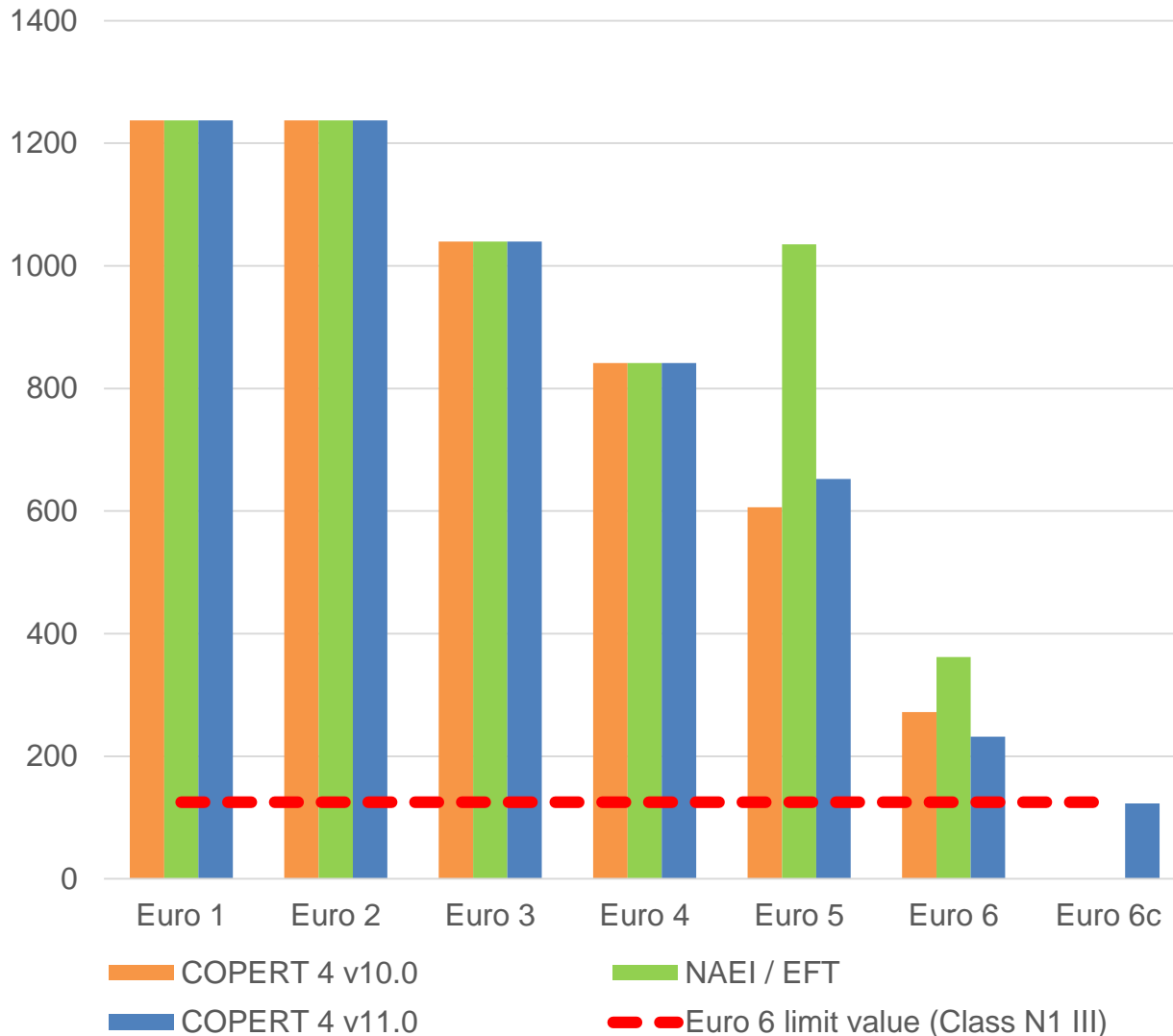
- No EURO 6 LGVs test data were available, COPERT 4 v11.0 / HBEFA version 3.2 assumed the same relative changes between EURO 5 and EURO 6 for diesel cars apply to diesel LGVs

~64% reduction relative to Euro 5

81% reduction relative to Euro 5

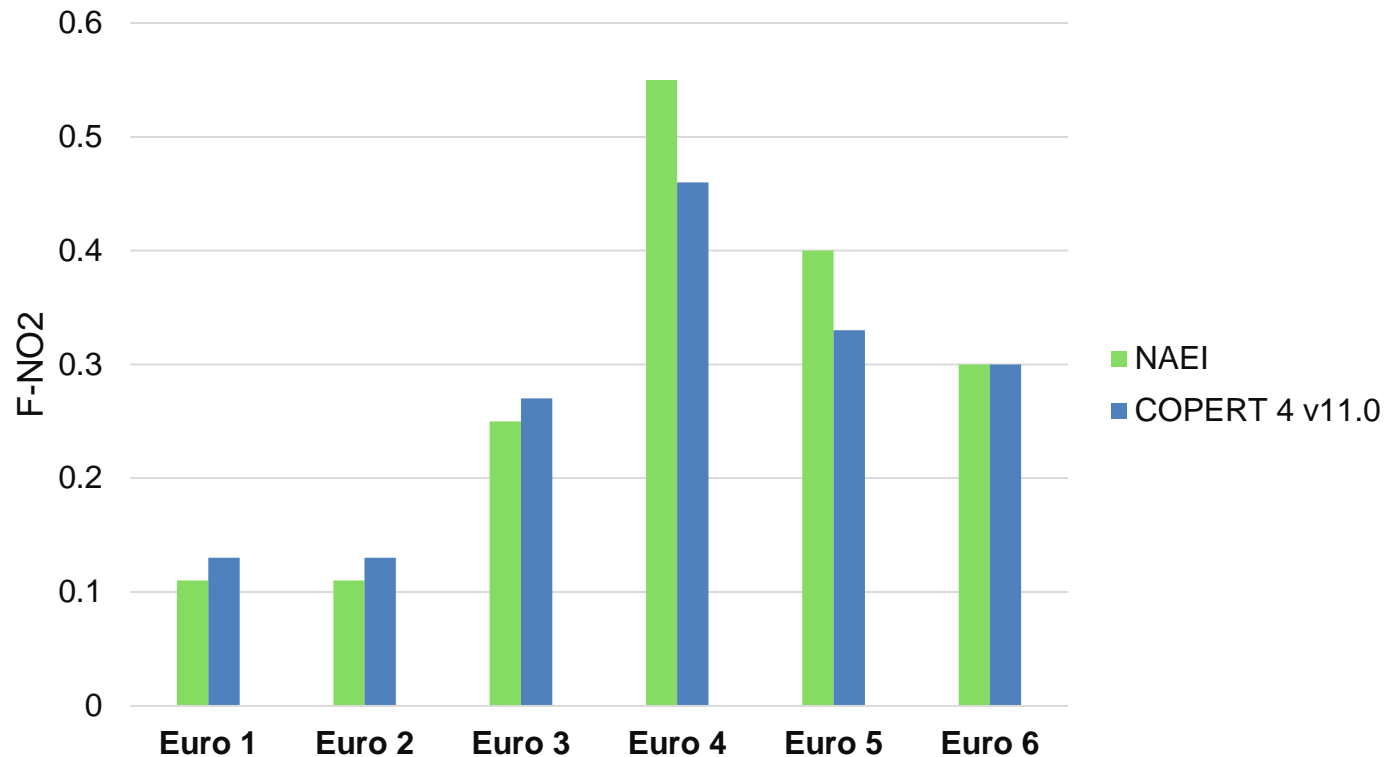
■ COPERT 4 v10.0      ■ COPERT 4 v11.0  
- - - Euro 6 limit value (Class N1 III)

# NO<sub>x</sub> Emission Factors (mg/ km) for Diesel LGVs – Urban



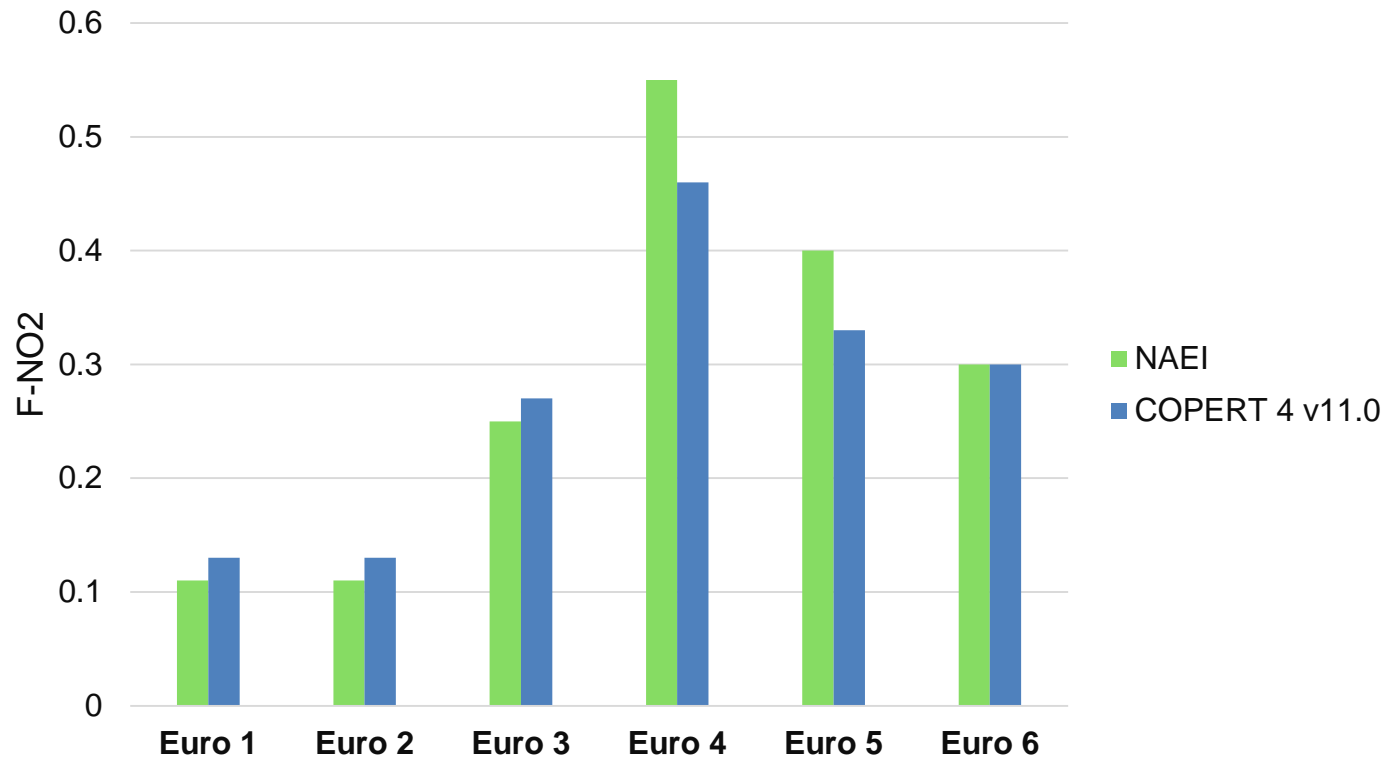
- COPERT 4 v11.0 (Blue bars)
  - **Lower** NO<sub>x</sub> EFs for Euro 5/6 diesel LGVs than the factors used in the current NAEI/EFT
  - Inclusion of Euro 6c

# Primary NO<sub>2</sub> Factors for Diesel Cars



- Primary NO<sub>2</sub> factors are highly variable – very dependent on technology and exact configuration of the exhaust aftertreatment system
  - Use of an LNT may lead to f-NO<sub>2</sub> values of above 40%, while use of SCR limits f-NO<sub>2</sub> to a moderate 10-20% in real world conditions.
  - If a catalysed DPF follows the SCR, this could increase f-NO<sub>2</sub> to levels to up to 50%.

# Primary NO<sub>2</sub> Factors for Diesel Cars



- Much uncertainty on f-NO<sub>2</sub> for Euro 6
- The actual average value will depend on the share of each aftertreatment configuration to the total vehicle fleet.
- COPERT 4 v11.0 assumes SCR to be the dominant deNO<sub>x</sub> technology with some 70% of SCRs preceding the DPF and 30% of SCRs following the DPF.

# Summary and Conclusions (1)

- Diesel cars: poor NO<sub>x</sub> performance up to Euro 5
- Euro 6 will be delivered in 2 stages
  - Early Euro 6 generally show reductions in NO<sub>x</sub> but initial evidence is highly variable
    - Different technological approaches – NO<sub>x</sub> is technology dependent (so for modelling and impact assessments, simply knowing the Euro standard is not enough!)
    - Uncertainty on representativeness of emission factors developed for Euro 6
  - Euro 6c (2018 - ) should deliver improvements to real-world emissions, because of RDE test procedure, but only time will tell

- Primary NO<sub>2</sub> emissions
  - Seem to have stabilised across recent Euros?
  - A wide range of possible values for f-NO<sub>2</sub> exists for diesel Euro 6 cars
  - Highly dependent on technology and its configuration
  - The actual average value will depend on the share of each aftertreatment configuration to the total vehicle fleet
  - Proposed limits on f-NO<sub>2</sub> factors for Euro 6 should help
- Euro 6 performance of diesel LGVs even more uncertain due to lack of current evidence, but would expect trends to be similar to diesel cars

# Thank you!

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