

The importance of tackling cold-start RDE

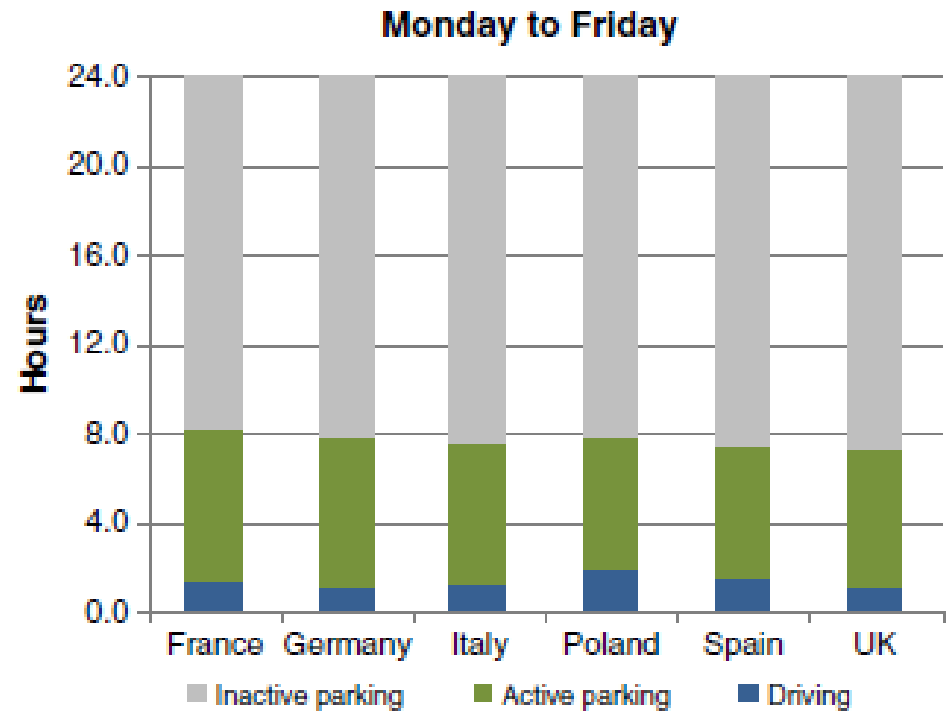
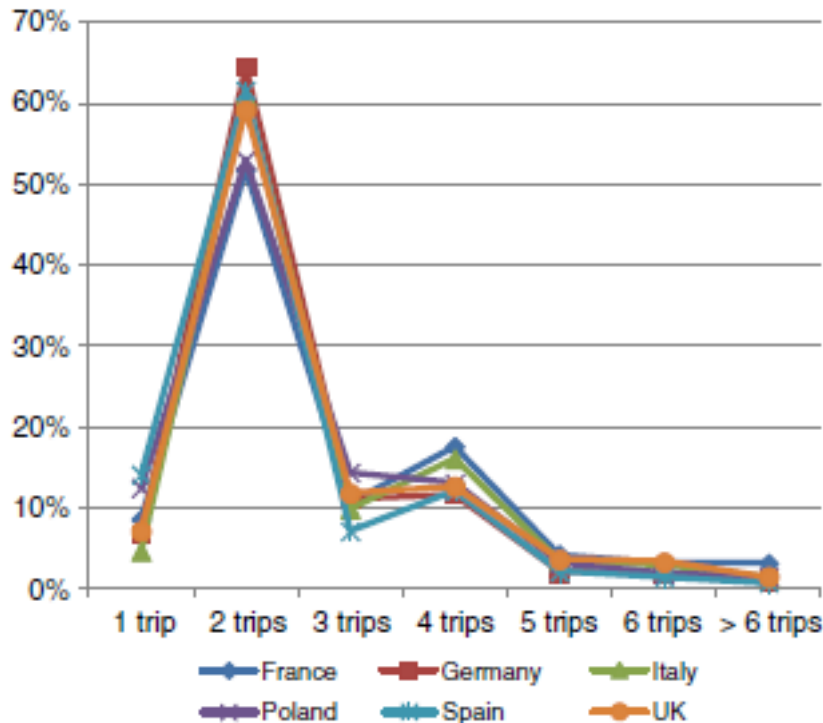
AECC Technical seminar on RDE PN
4 July 2016



Association for Emissions Control by Catalyst AISBL

Cold-start is part of real-world driving

- Cold-start = engine start after soaking to ambient temperature
- EU driving statistics indicate mostly
 - 2 trips per day
 - parking >6hrs in-between trips



Source: JRC report "Driving and parking patterns of European car drivers - a mobility survey" (2012)

Content

- AECC PEMS database
- Cold-start RDE analysis (raw data)
 - Gasoline Direct Injection PN
 - Diesel NOx
- Cold-start RDE weighing options

Overview of AECC PEMS database

- Diesel vehicles → focus on NO_x RDE
- Gasoline vehicles → focus on PN RDE

Vehicle	Year	Type	Series production/ demonstrator	Comment
1	2012	GDI-MPI	Series	Without GPF
2	2013	Diesel	Series	HP+LP EGR
3	2013	Diesel	Series	SCR
4	2013	Diesel	Series	LNT+SCR
✓ 5	2014	Diesel	Demonstrator NO _x CF<1.5	SCR on DPF
✓ 6	2015	Diesel	Series NO _x CF<1.5	SCR on DPF
✓ 7	2015	GDI	Series NO _x and PN CF<1	With GPF
✓ 8	2016 ongoing	GDI	Series + Demonstrator	Without GPF With GPF



GDI: Gasoline Direct Injection
 MPI: MultiPoint Injection
 GPF: Gasoline Particulate Filter
 HP: High Pressure
 LP: Low Pressure
 EGR: Exhaust Gas Recirculation
 SCR: Selective Catalytic Reduction
 LNT: Lean NO_x Trap
 DPF: Diesel Particulate Filter

✓ Analysis with latest version of EMROAD and CLEAR done

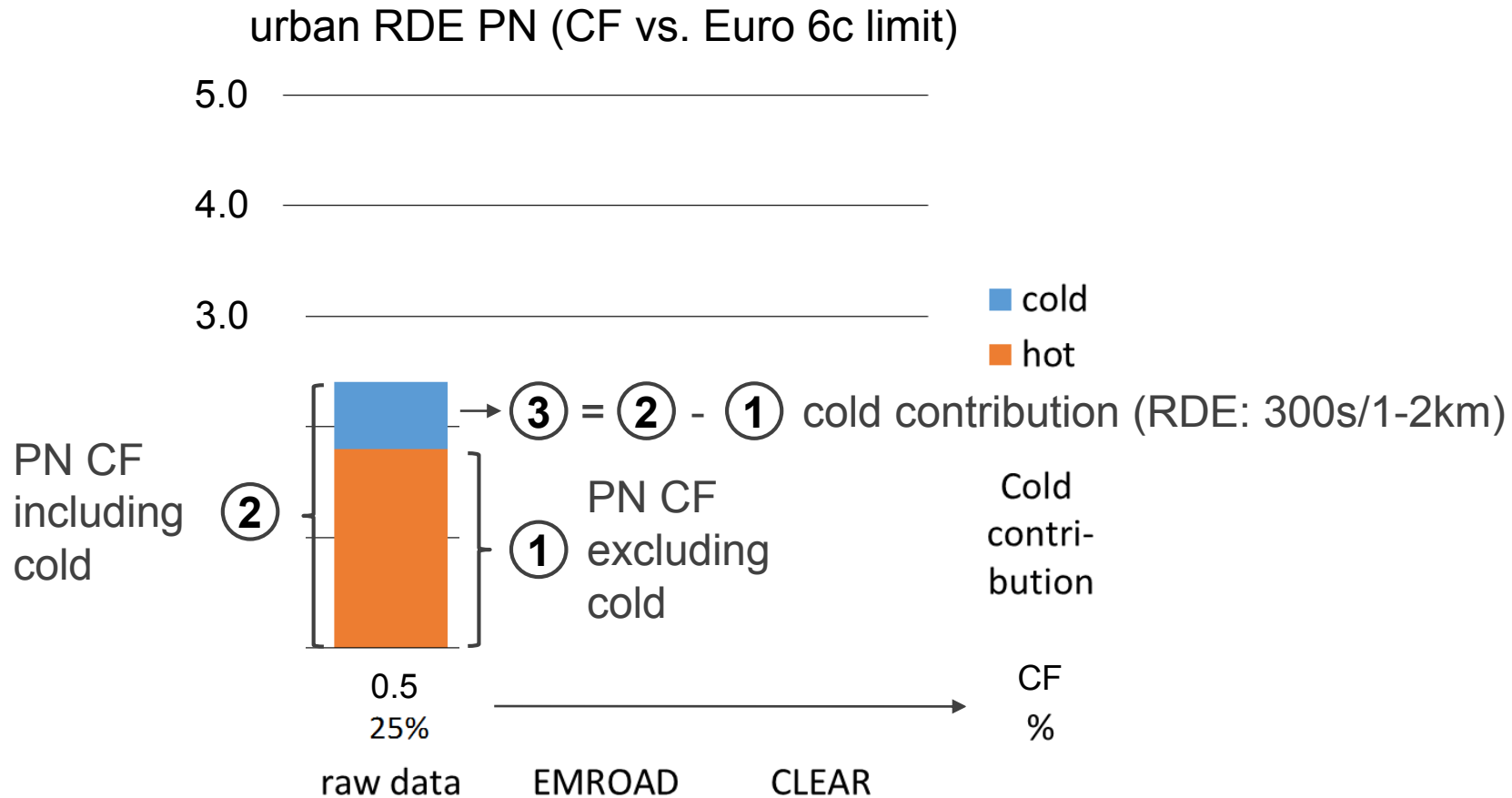


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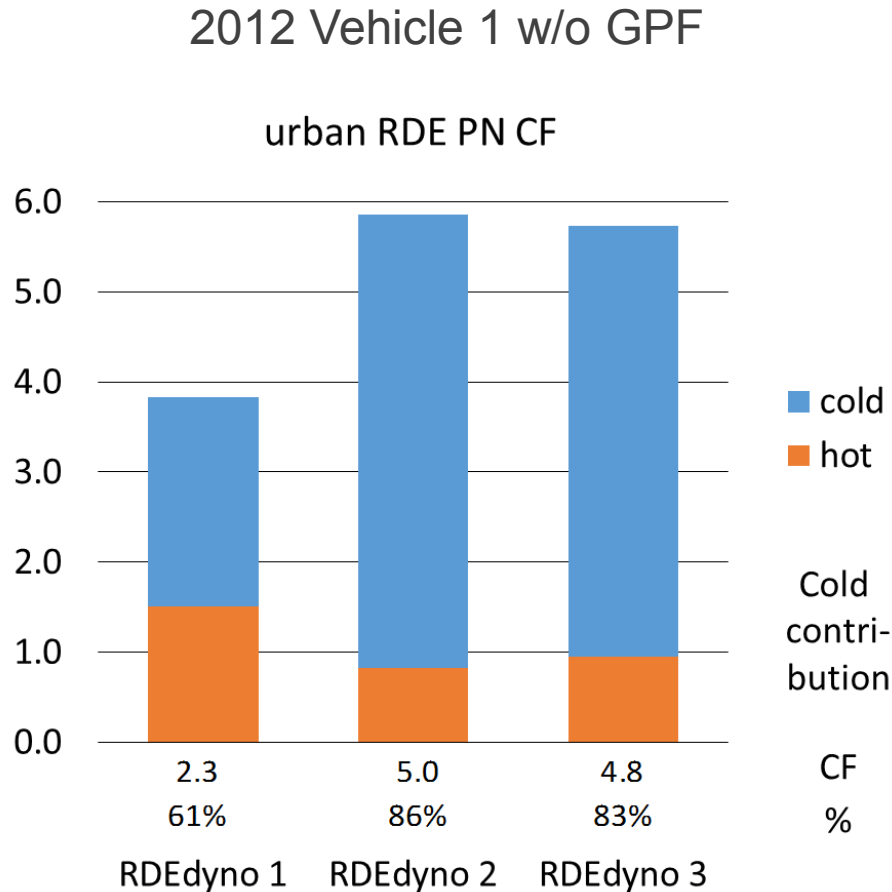
Cold-start RDE analysis

- Impact of currently excluded 5 minutes of cold-start emissions on urban RDE data



Impact on GDI PN

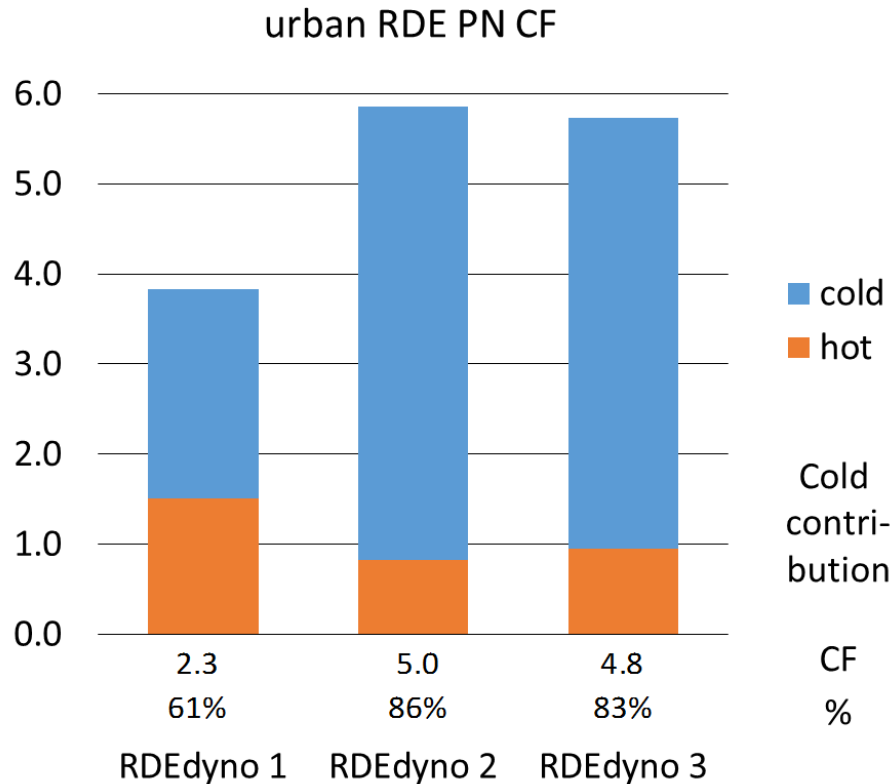
- Significant cold-start contribution (up to 86% for 2012 vehicle)



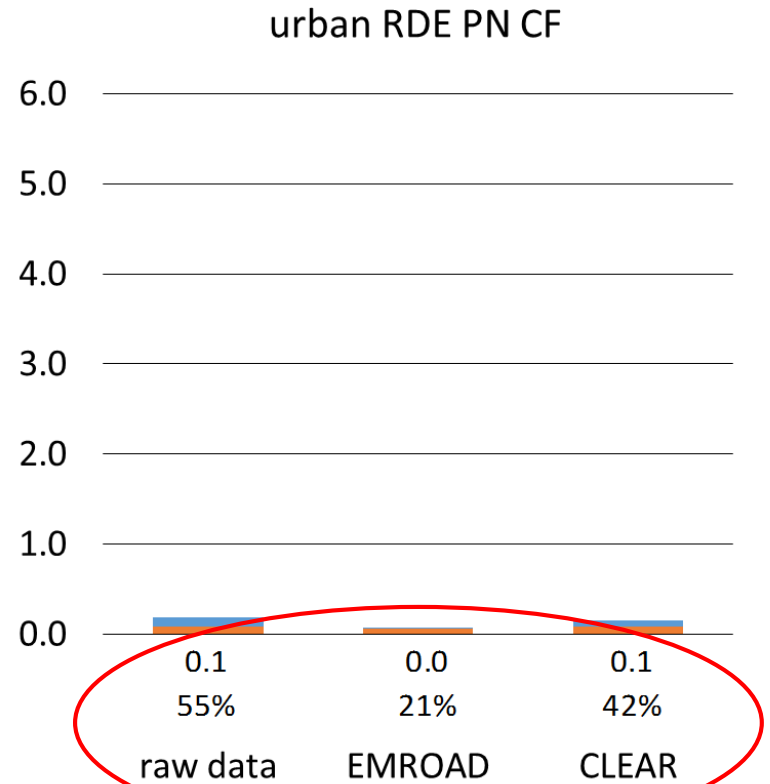
Impact on GDI PN

- Significant cold-start contribution (up to 86% for 2012 vehicle)
- RDE raw ~ CLEAR > EMROAD

2012 Vehicle 1 w/o GPF

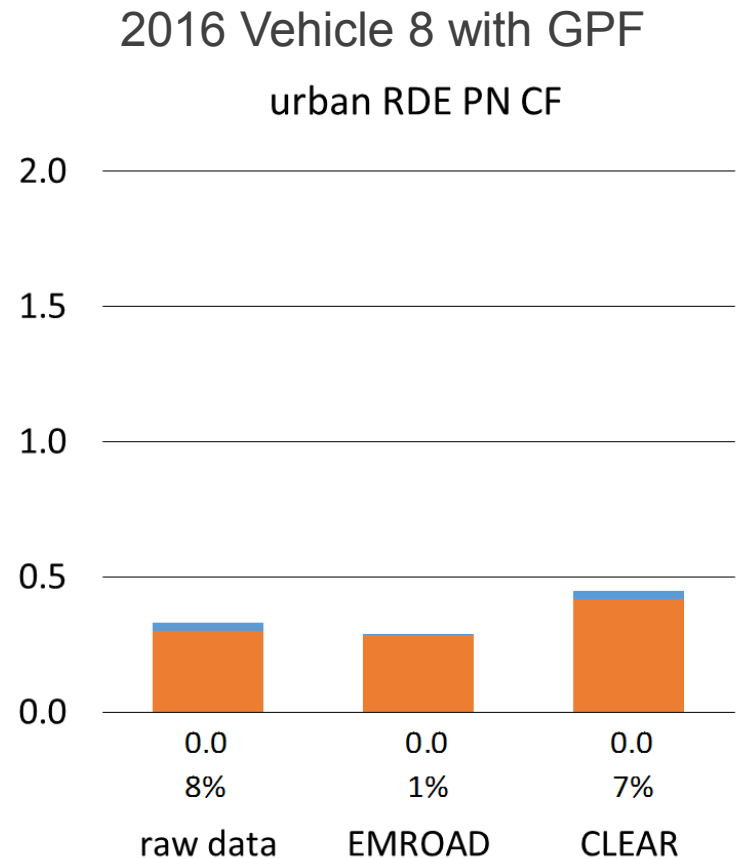
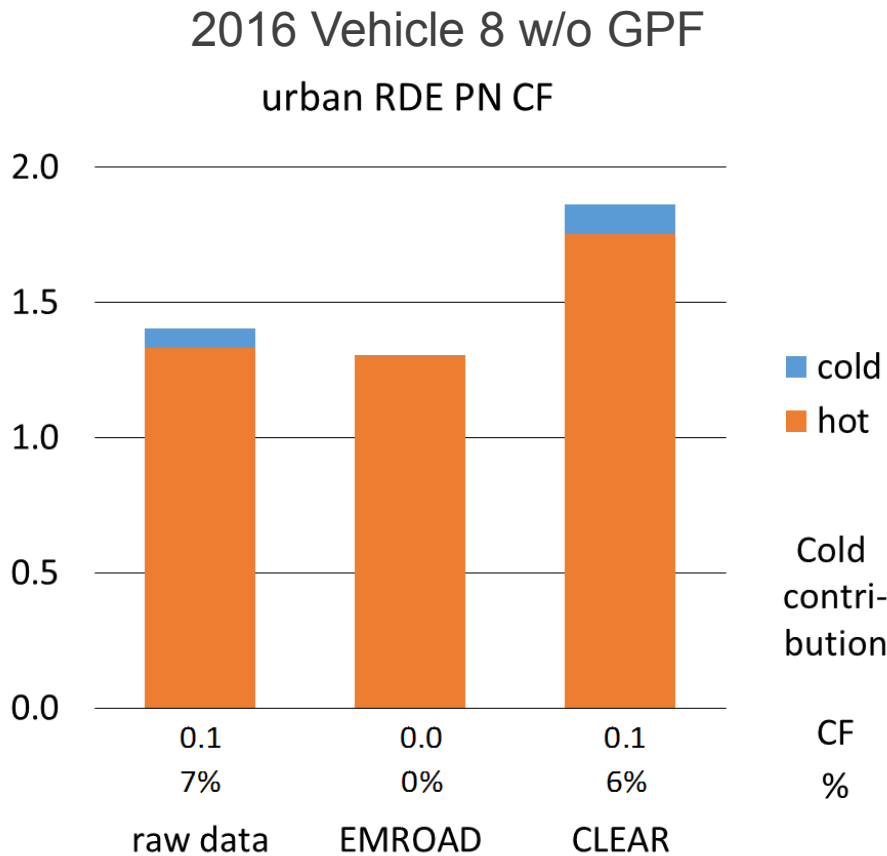


2015 Vehicle 7 with GPF



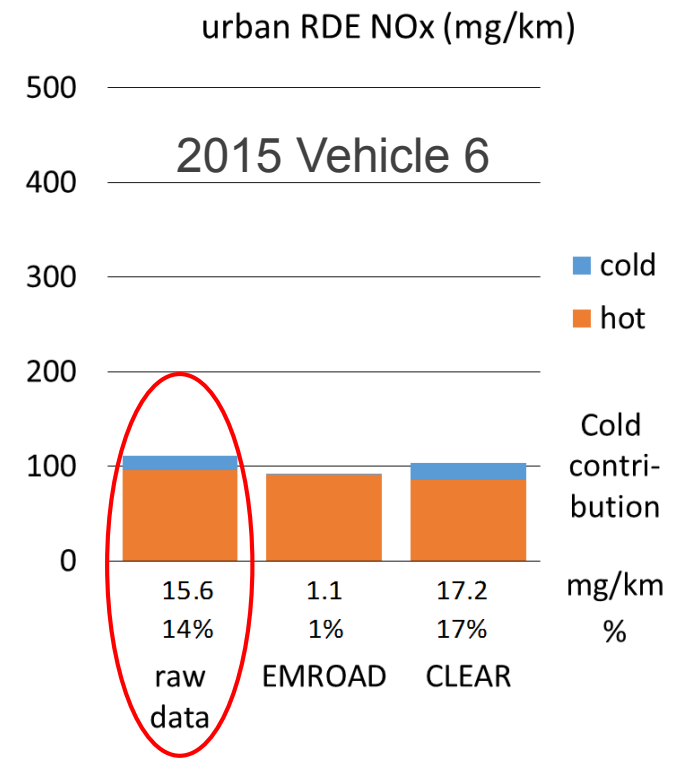
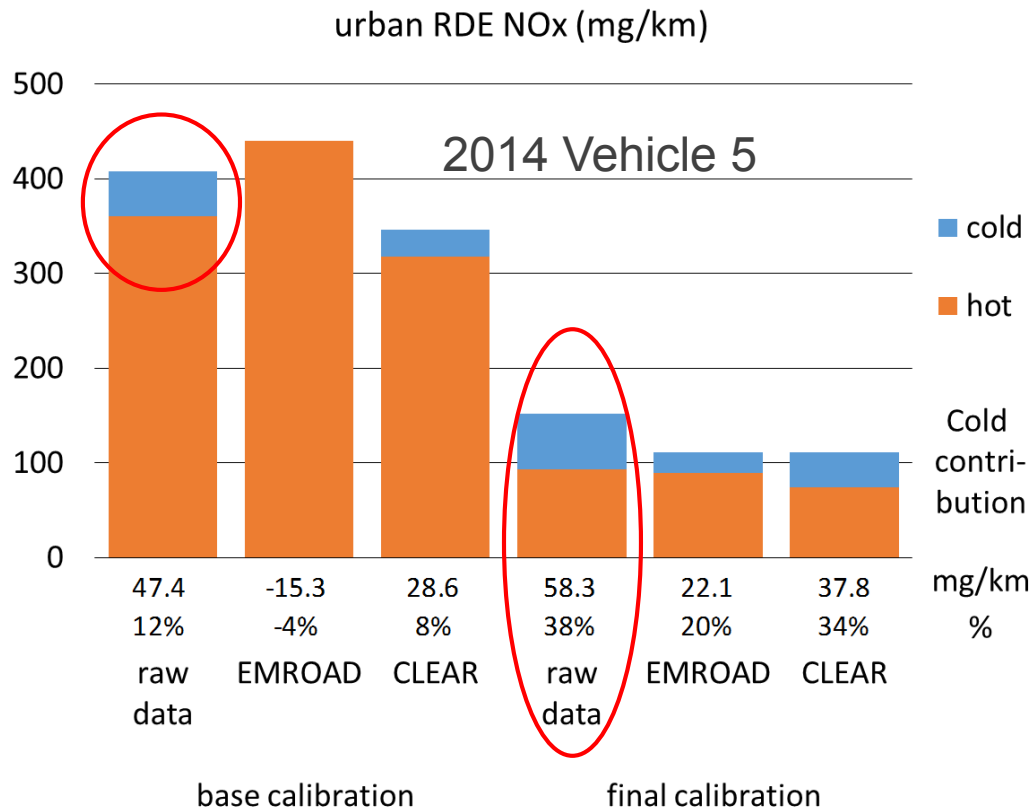
Impact on GDI PN

- State of the art GDI
 - Can have well controlled cold-start emissions (7% share)
 - GPF results in emissions below Euro 6c limit



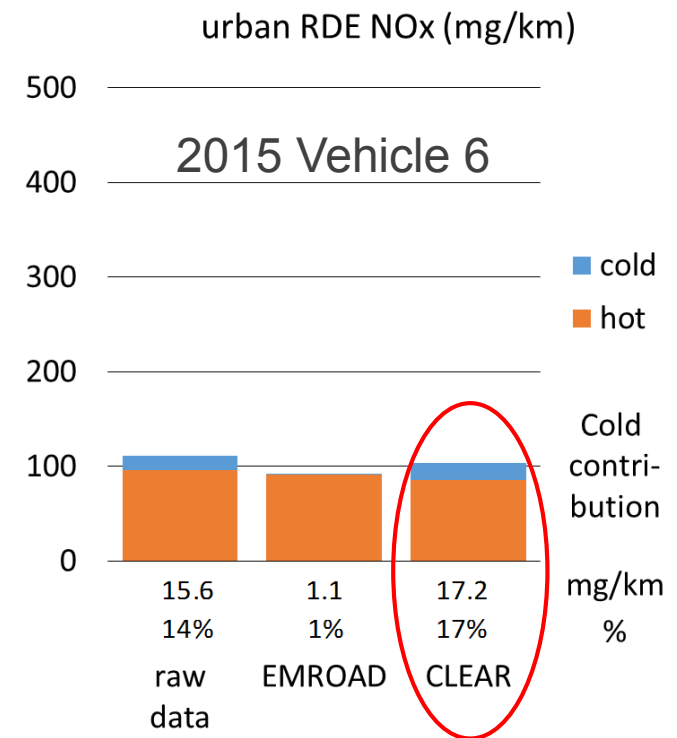
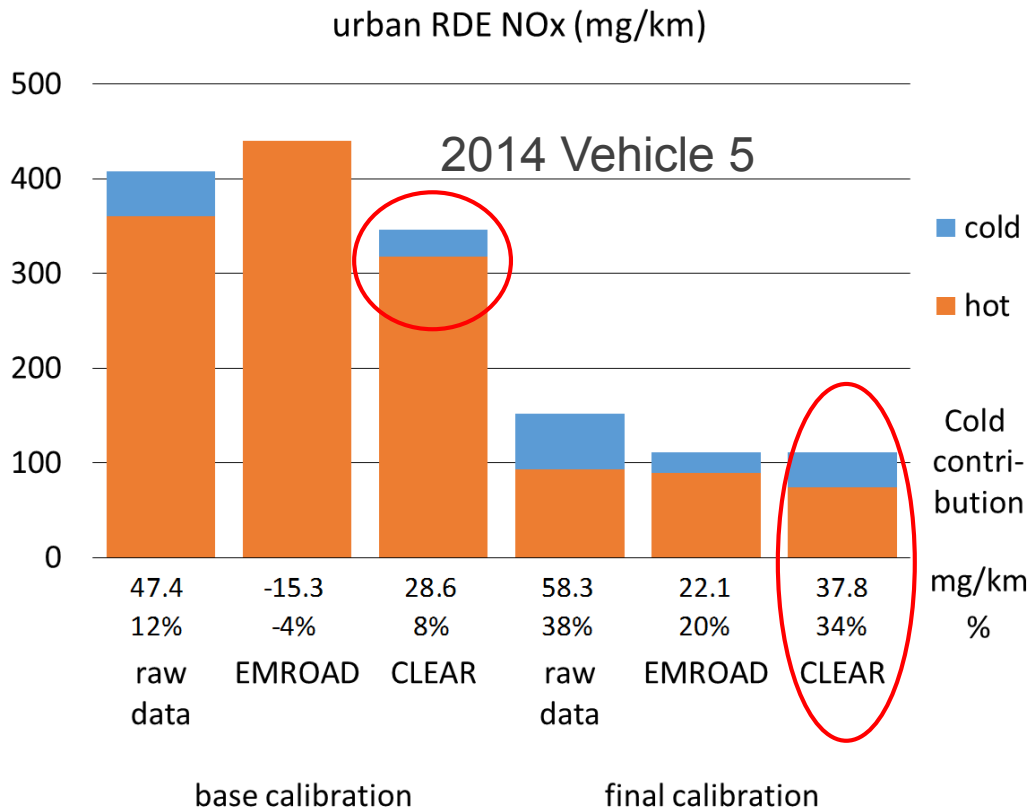
Impact on diesel NOx

- Significant cold-start contribution in raw urban data (up to 38%)



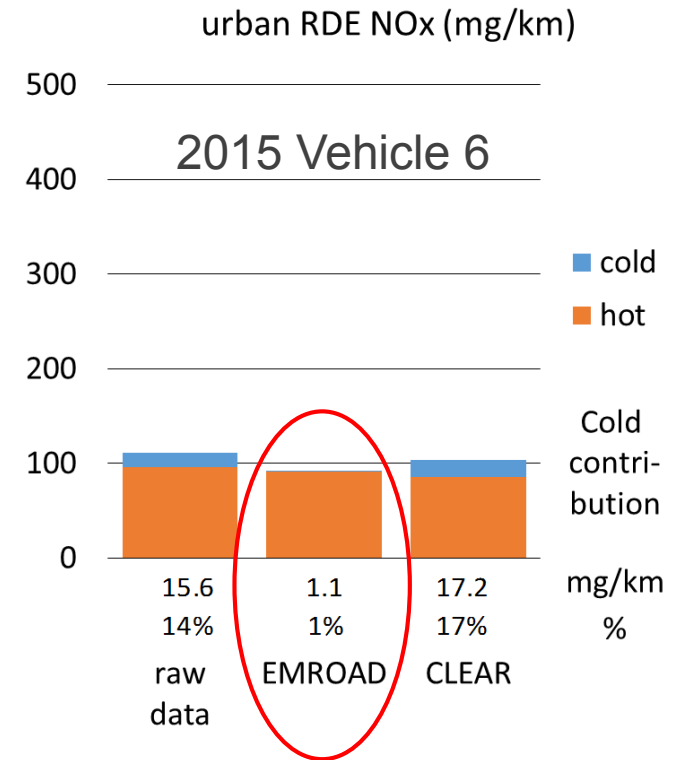
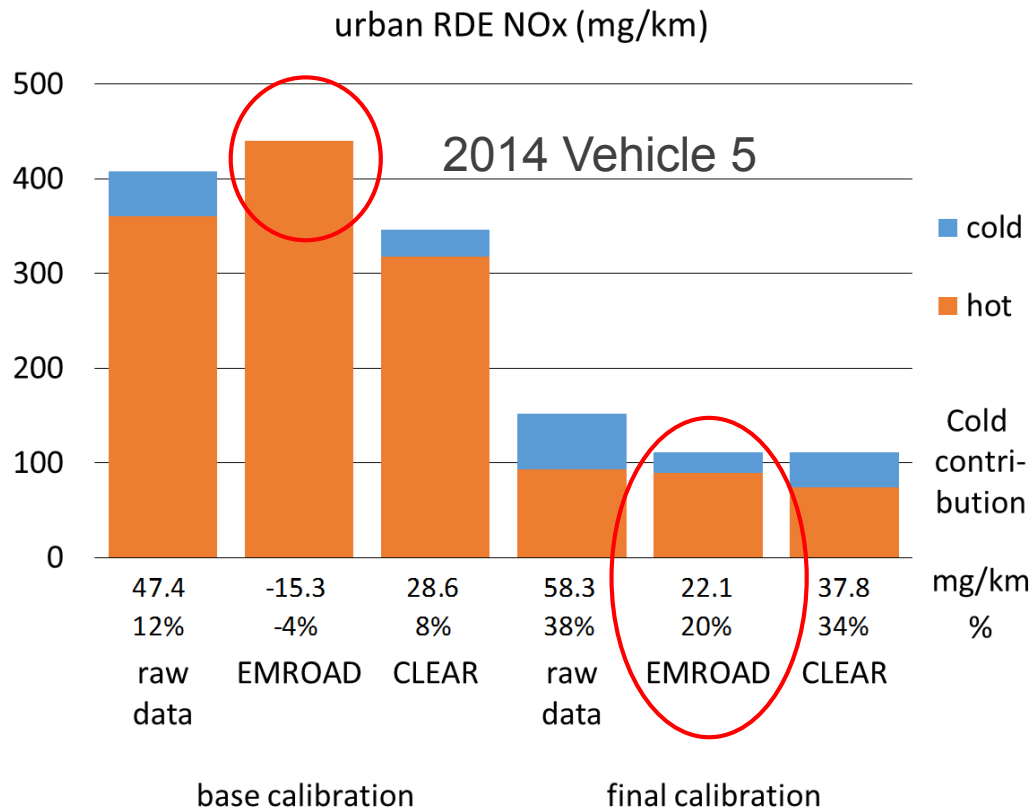
Impact on diesel NOx

- Significant cold-start contribution in raw urban data (up to 38%)
- RDE raw ~ CLEAR



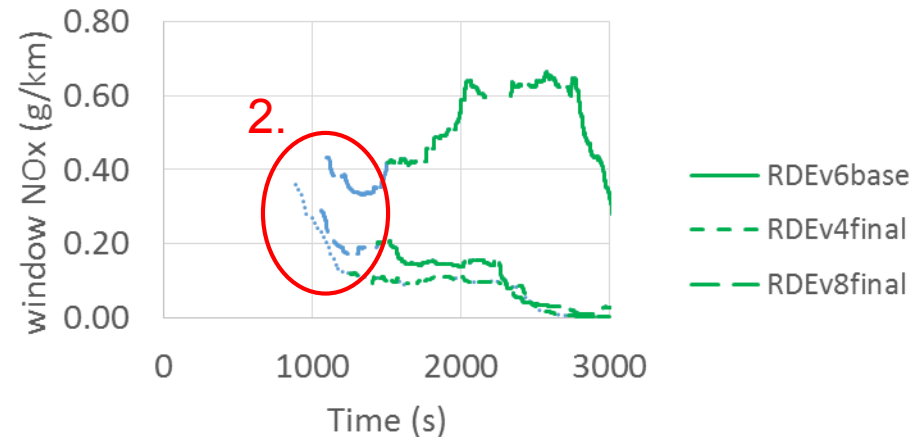
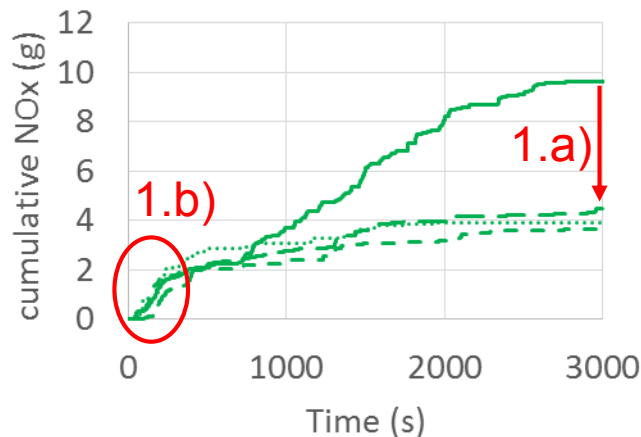
Impact on diesel NOx

- Significant cold-start contribution in raw urban data (up to 38%)
- RDE raw ~ CLEAR > EMROAD
- Extra analysis on 2014 vehicle 5 data



Impact on diesel NOx

- Extra analysis on 2014 Vehicle 5 data
 1. Final calibration showcase of what could happen if cold-start remains excluded
 - a) Overall emissions in urban reduced
 - b) But same NOx ramp during cold-start → contribution increases
 2. Base calibration: NOx of extra cold windows < hot windows → cold-start not significant in EMROAD
Final calibration: NOx of extra cold windows > hot windows → cold-start significant in EMROAD



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Different cold-start weighing options considered in RDE working group

- Option 3: include first 5 minutes w/o additional analysis (results previous slides)
- Option 4.1: weighing of measured mg during first 5 minutes using reference urban distance
 - $d_{\text{urban}} = 8 \text{ km}$
 - $d_{\text{urban}} = 23 \text{ km}$
 - $d_{\text{urban}} = \text{actual driven } RDE_{\text{hot,urban}}$

$$M_{\text{urban}} \left[\frac{\text{mg}}{\text{km}} \right] \approx \frac{m_{\text{cold}} [\text{mg}]}{d_{\text{urban}} [\text{km}]} + RDE_{\text{hot,urban}} \left[\frac{\text{mg}}{\text{km}} \right]$$

normalised hot

- Option 4.2.a: weighing of measured mg/km during first 5 minutes with variable factor w
 - $d = 8 \text{ km}$
 - $d = 23 \text{ km}$

$$M_{\text{urban}} \left[\frac{\text{mg}}{\text{km}} \right] = w \cdot M_{\text{cold}} \left[\frac{\text{mg}}{\text{km}} \right] + (1 - w) \cdot RDE_{\text{hot,urban}} \left[\frac{\text{mg}}{\text{km}} \right]$$

normalised hot

$w = x[\text{km}]/d[\text{km}]$:

reference distance

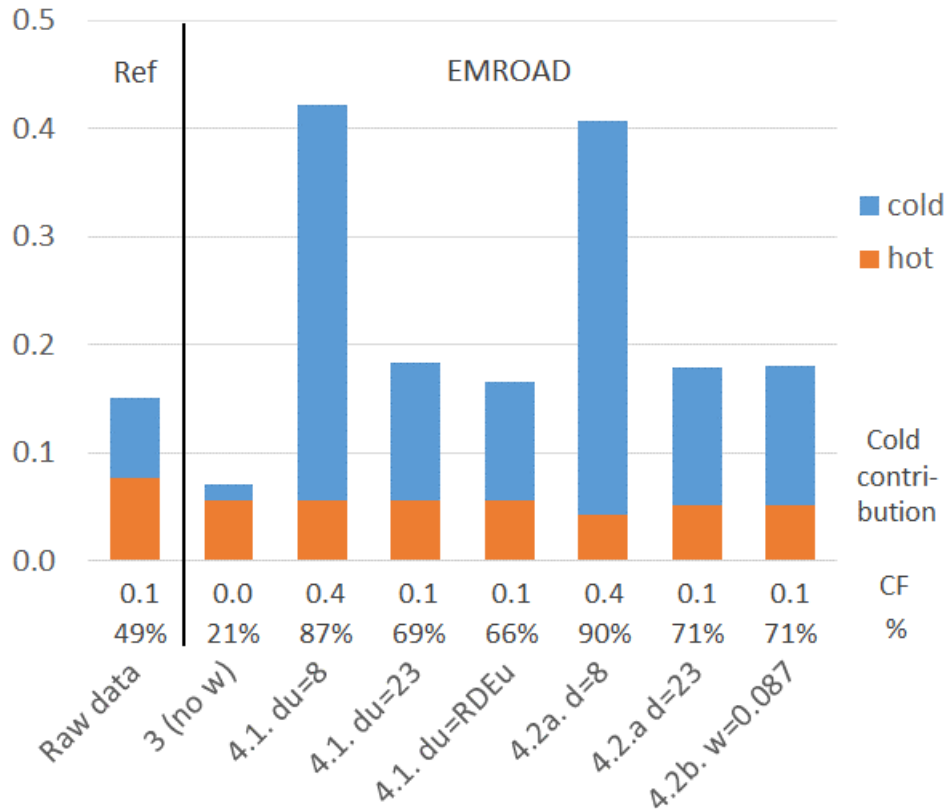
- Option 4.2.b: with fixed factor w

actual distance (4.2.a)
fixed distance (4.2.b)

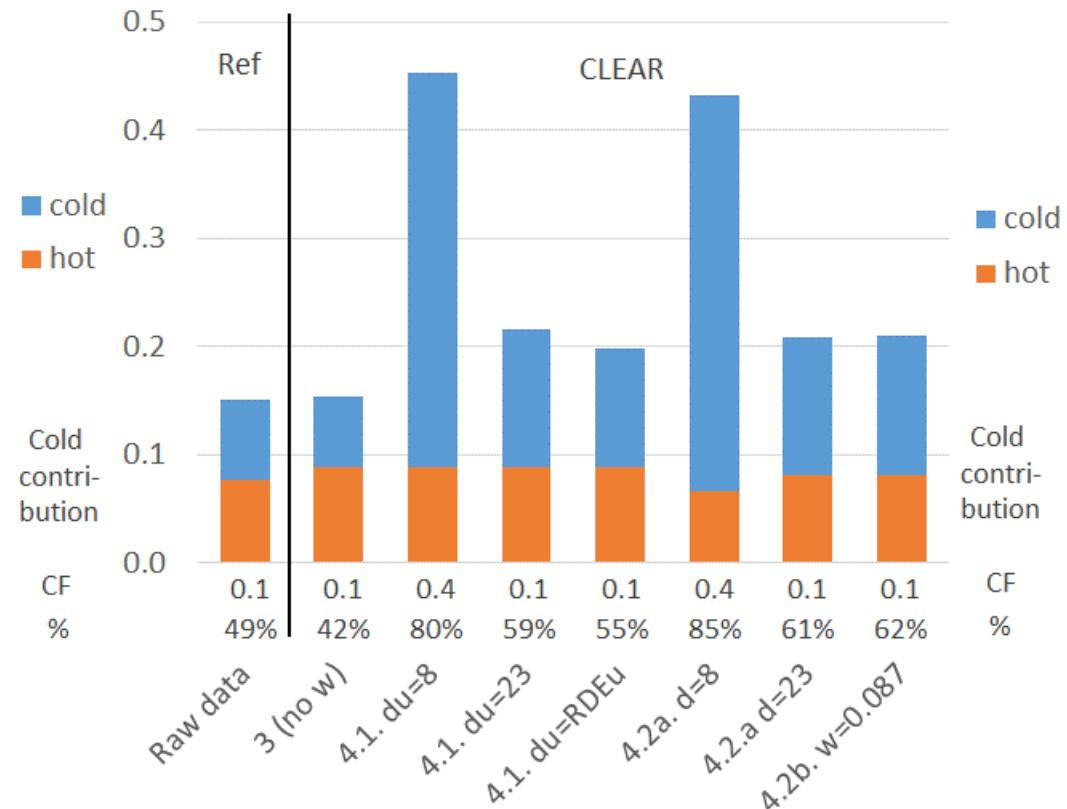
GDI PN (2015 Vehicle 7 with GPF)

- Reference is raw data, without normalisation
- All weighing options increase contribution of cold-start emissions vs. raw data

PN (CF)



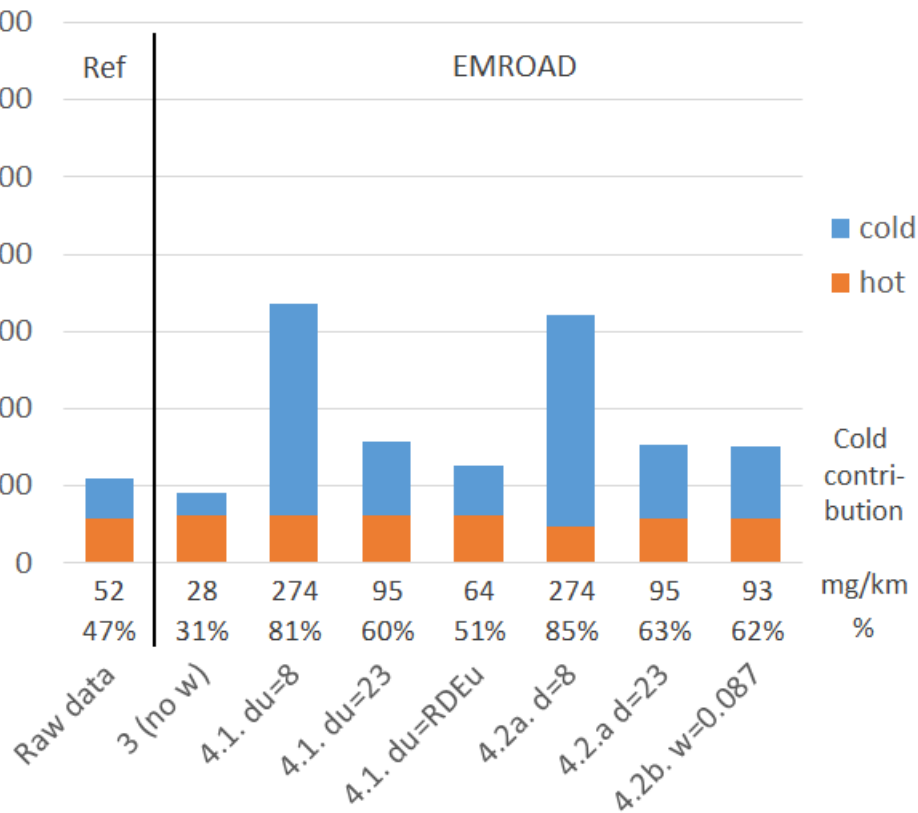
PN (CF)



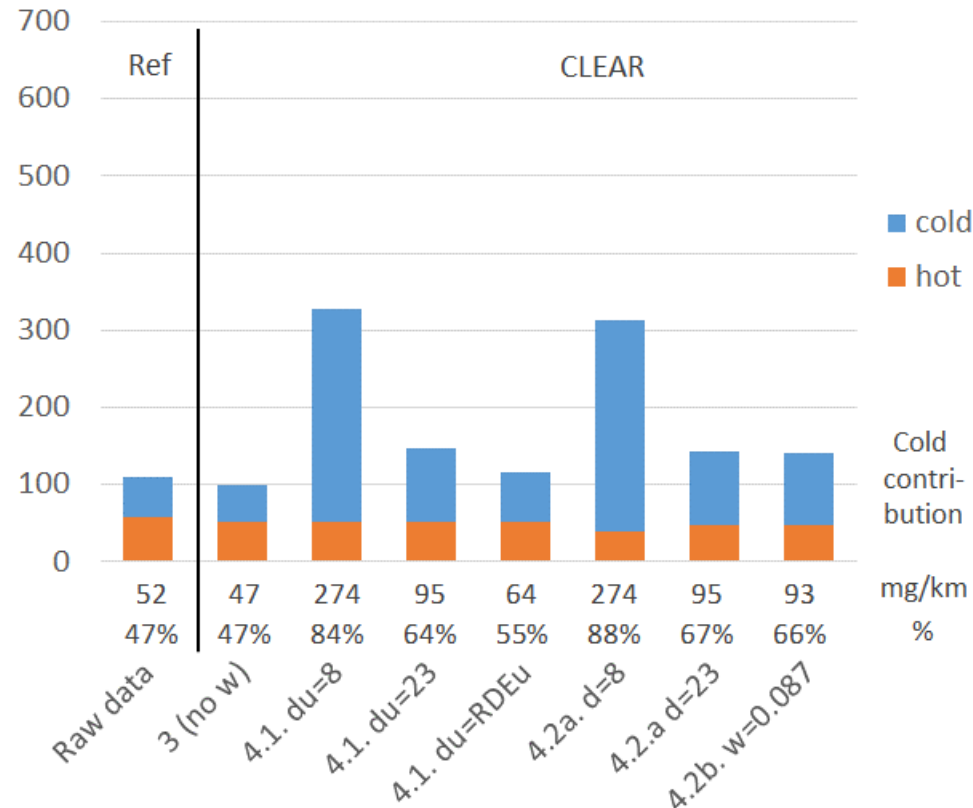
Diesel NOx (2014 Vehicle 5 final calibration)

- Reference is raw data, without normalisation
- All weighing options increase contribution of cold-start emissions vs. raw data

NOx (mg/km)



NOx (mg/km)



Conclusions

- Cold-start is part of real-world driving.
- A significant impact of the first 5 minutes (currently excluded) of cold-start emissions was shown for both GDI PN and diesel NOx.
- Data is limited to construct a robust new procedure within the timeframe of the third RDE regulatory package.
- At this stage, for simplicity and transparency AECC supports the inclusion of cold-start emissions directly in the assessment of RDE emissions in the urban phase without weighing factors.
- Soaking at moderate ambient temperature conditions is appropriate as preconditioning.



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- ⊙ Emissions Legislation
- ⊙ Engine & Vehicle Emissions
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- ⊙ Publications

Who are AECC and what do we do ?

AECC is an international non-profit scientific association of European companies making technologies for engine exhaust emissions control.

The members of AECC are companies operating worldwide in the research, development, testing and manufacture of key technologies for emissions control.

Their products are the ceramic and metallic substrates for catalysts and filters; autocatalysts (substrates with catalytic materials incorporated or coated); adsorbers; filter-based technologies to control particulate emissions from diesel and other lean burn engines; and speciality materials incorporated into the catalytic converter or filter.

Catalyst-equipped cars were first introduced in the USA in 1974 but only appeared on European roads in 1985 and in 1993 legislation forced their use on cars. Now more than 275 million of the world's 500 million cars and over 85% of all new cars produced worldwide are equipped with autocatalysts. Catalytic

What are the emission control technologies?

Exhaust gas contains carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM). The main technologies used to treat exhaust to remove harmful gases and particles are:

- autocatalysts
- adsorbers (traps)
- filters

There are more details on the technology pages.



Thank you for your attention

Dieselretrofit