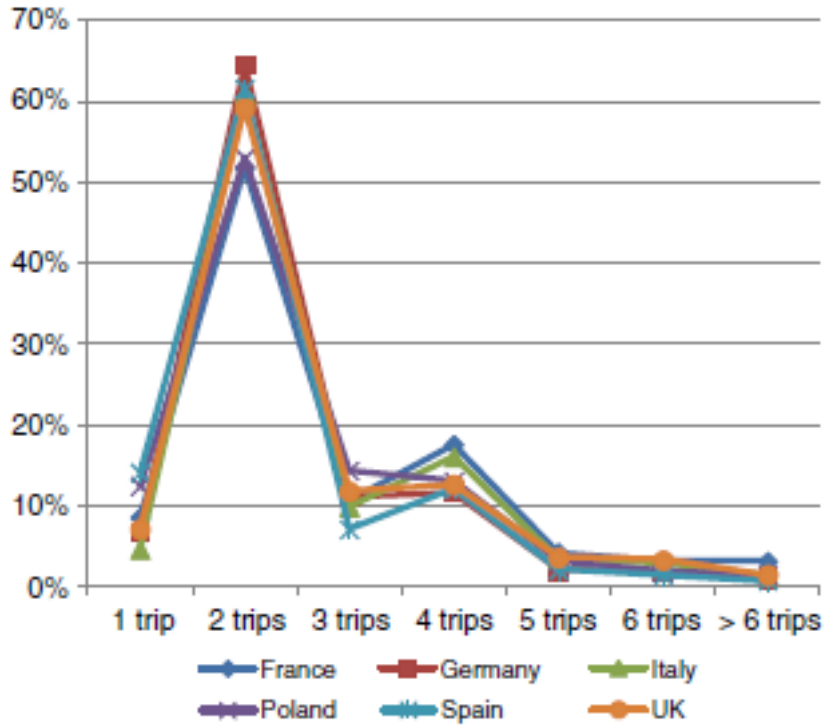
The importance of tackling cold-start RDE

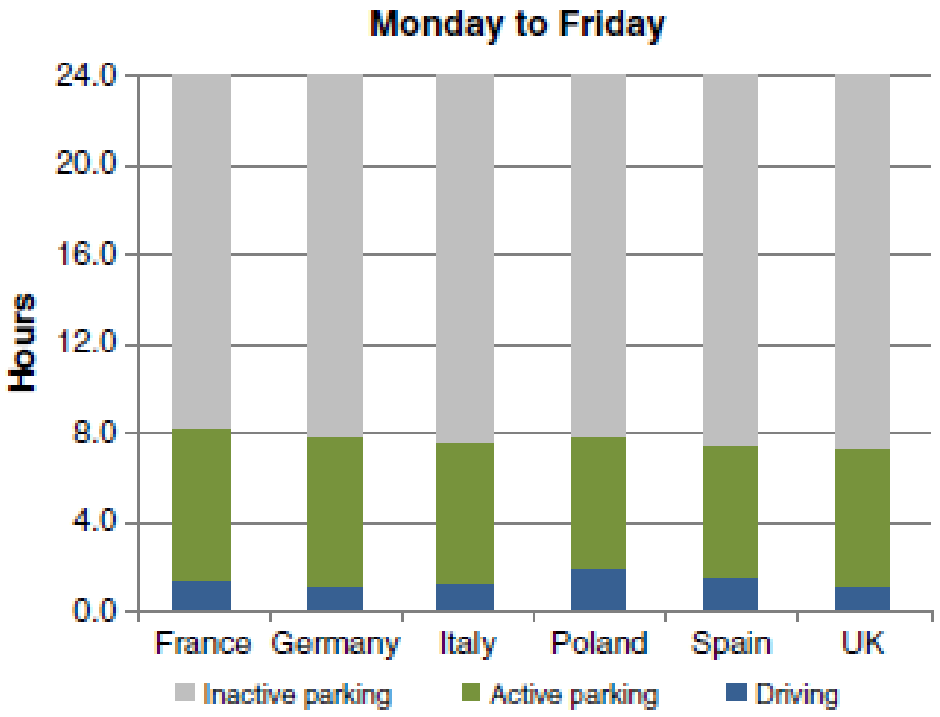
AECC Technical seminar on RDE PN

4 July 2016

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 NOx 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 NOx CF<1.5	SCR on DPF
√ 6	2015	Diesel	Series NOx CF<1.5	SCR on DPF
√ 7	2015	GDI	Series NOx and PN CF<1	With GPF
√ 8	2016 ongoing	GDI	Series + Demonstrator	Without GPF With GPF

√ Analysis with latest version of EMROAD and CLEAR done

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 NOx Trap
DPF: Diesel Particulate Filter

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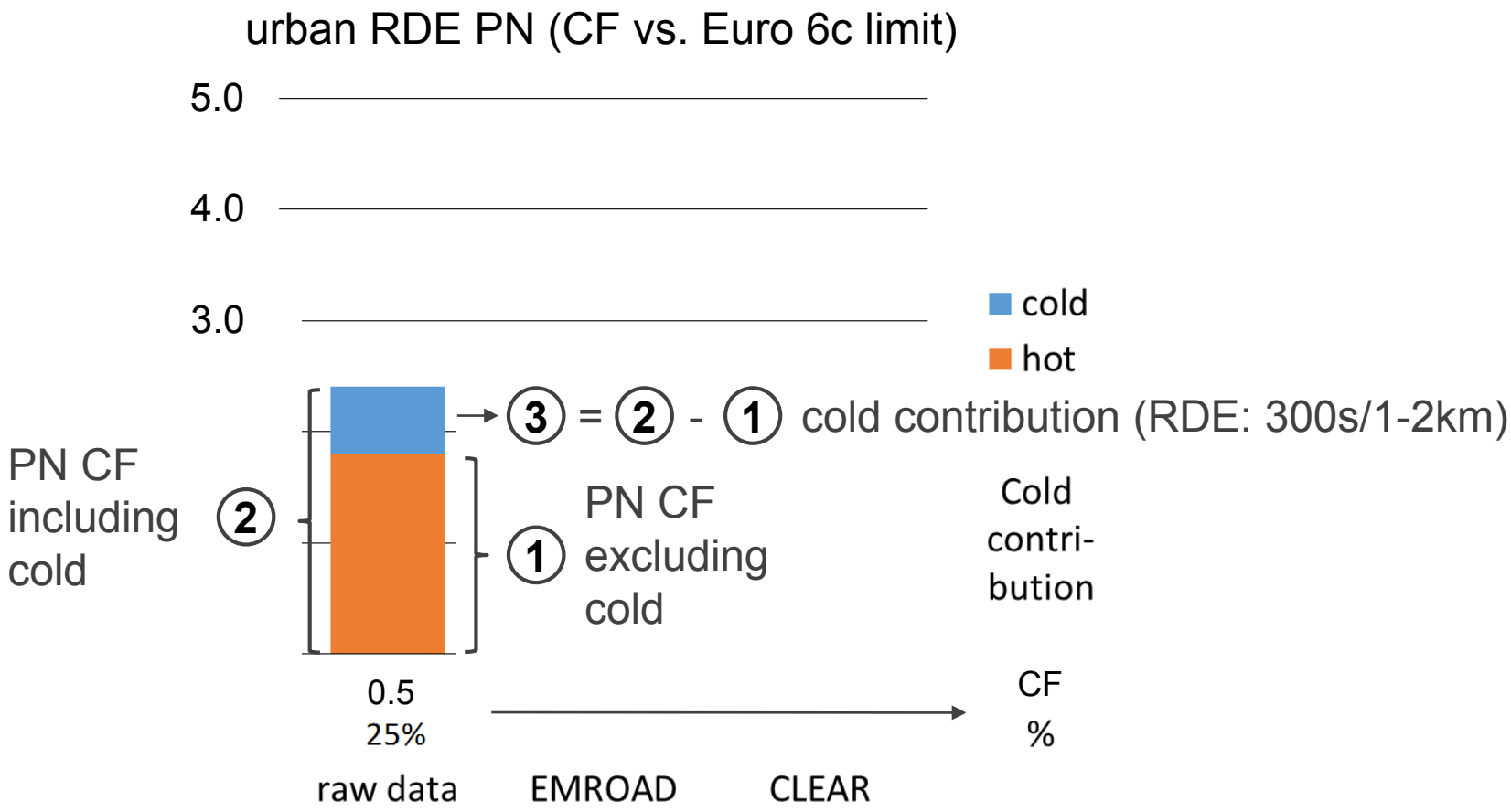
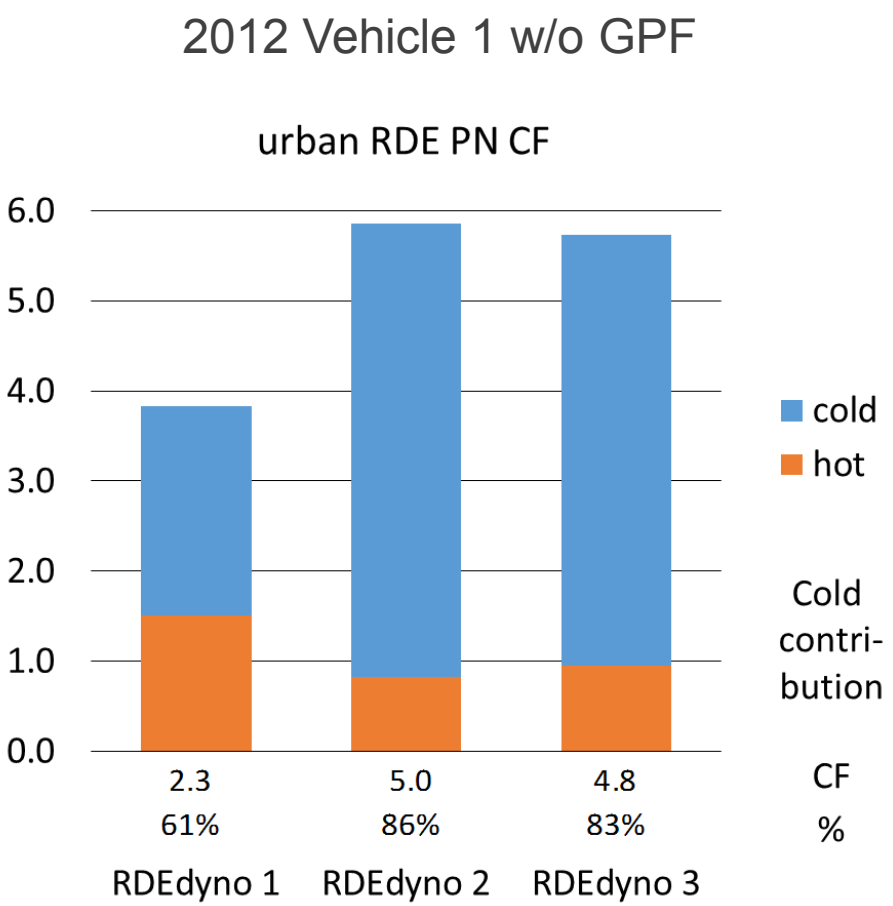
Cold-start RDE analysis

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



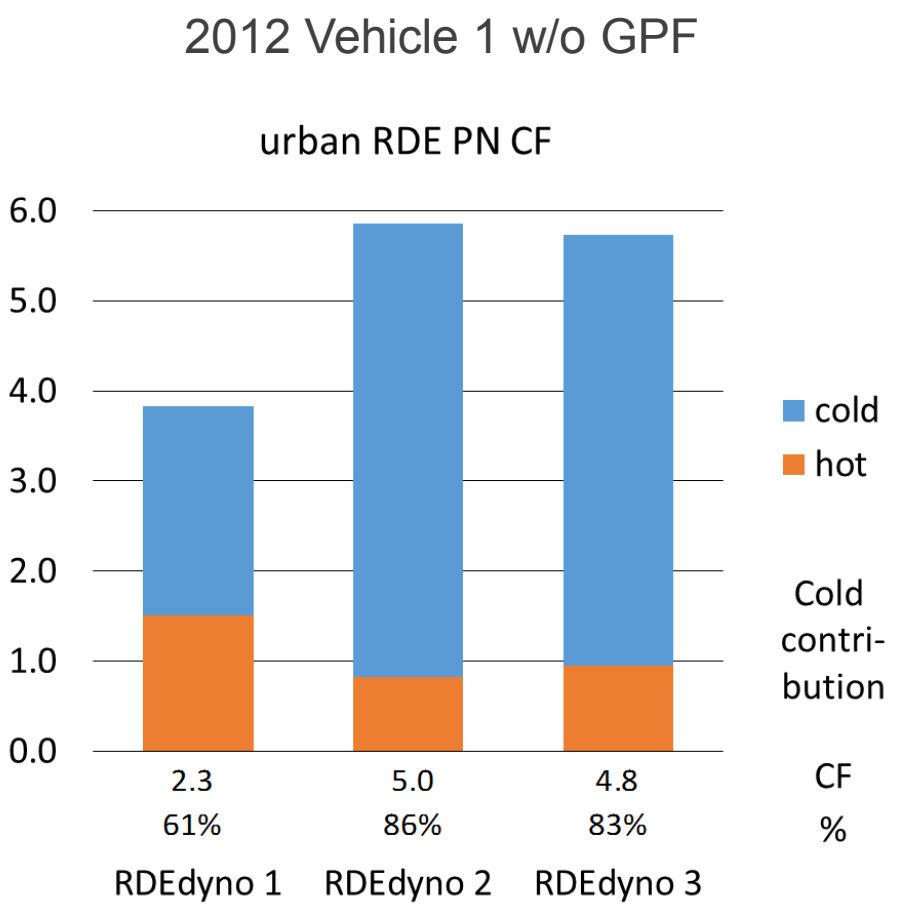
Impact on GDI PN

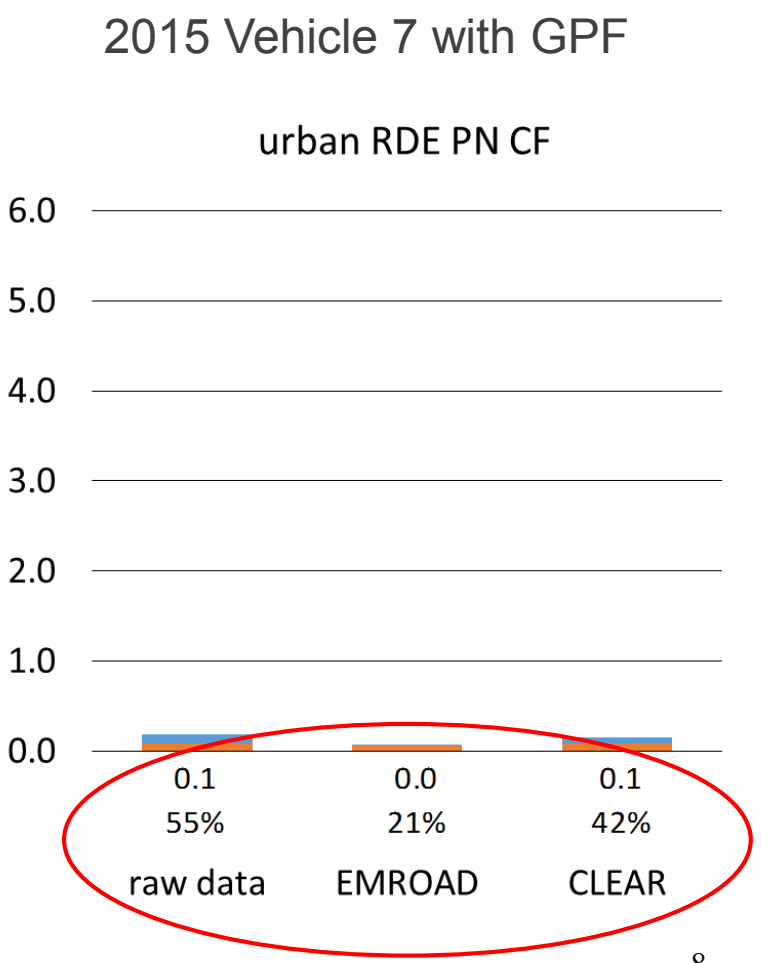
- Significant cold-start contribution (up to 86% for 2012 vehicle)



Impact on GDI PN

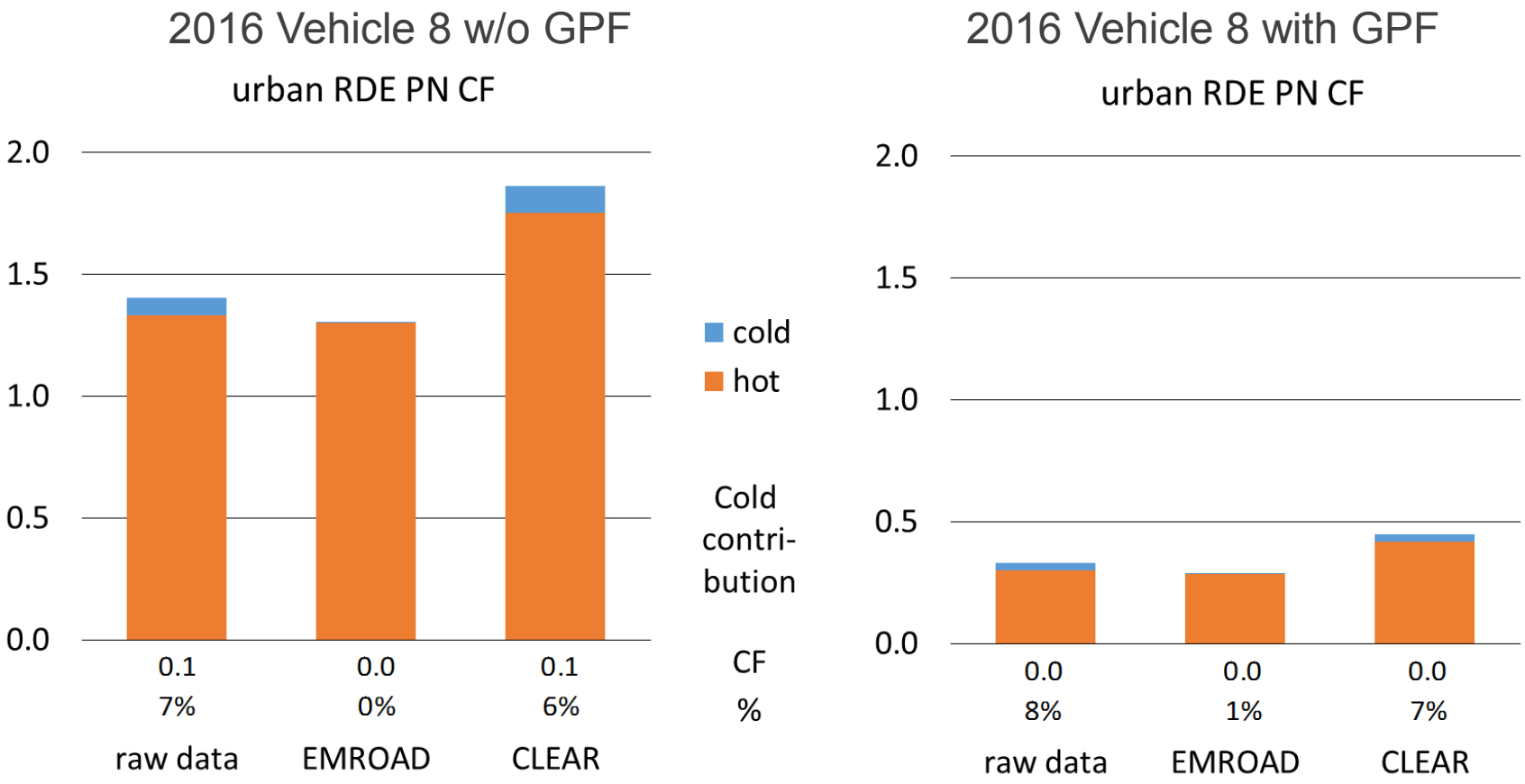
- Significant cold-start contribution (up to 86% for 2012 vehicle)
- RDE raw ~ CLEAR > EMROAD





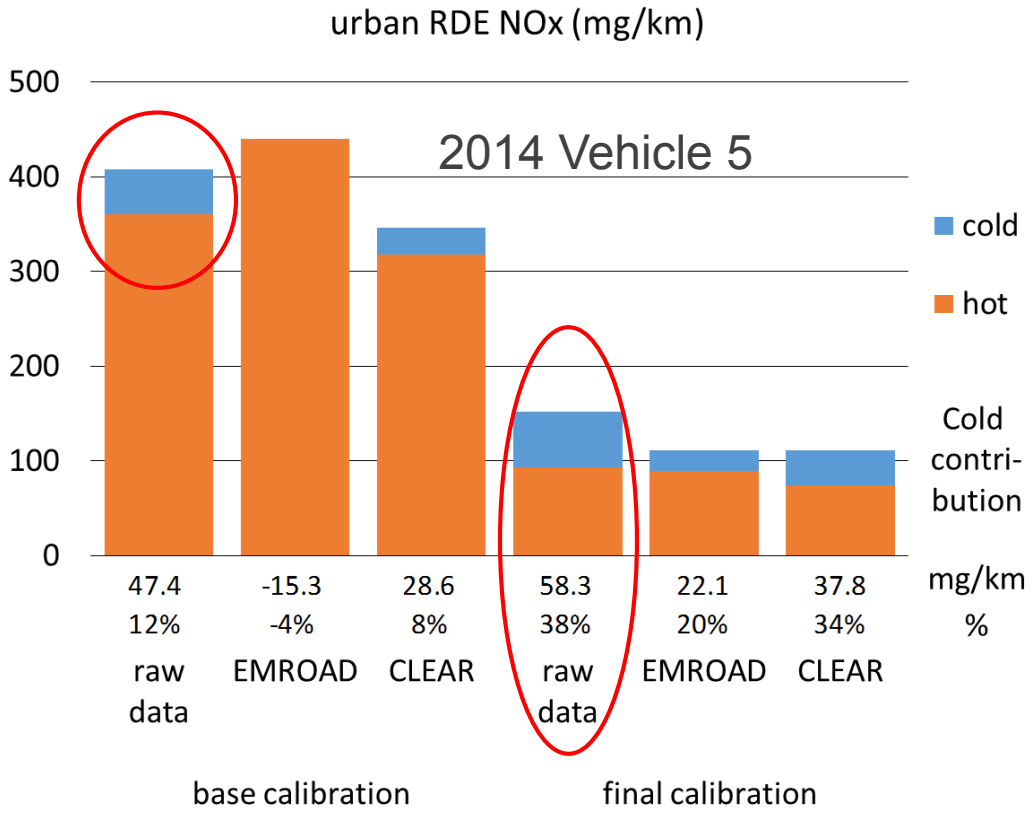
Impact on GDI PN

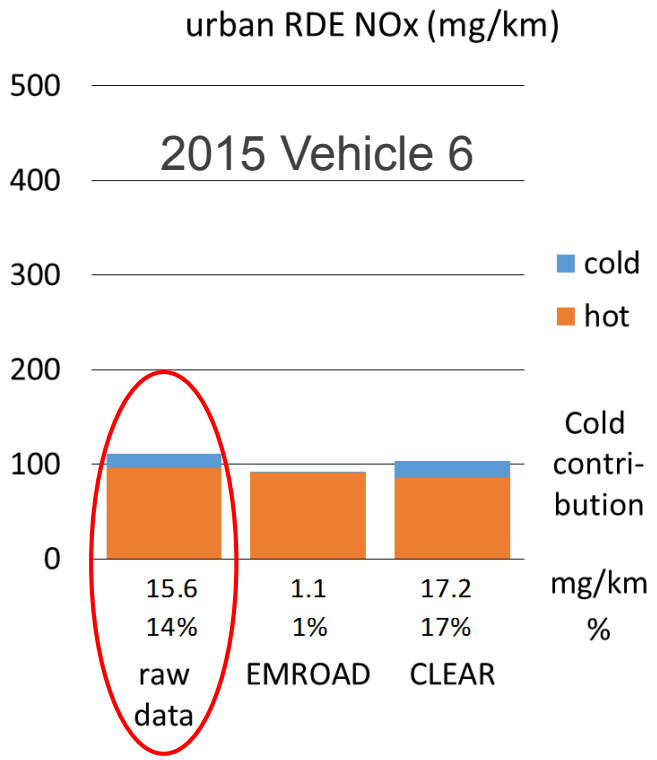
- State of the art GDI
  - Can have well controlled cold-start emissions (7% share)
  - GPF results in emissions below Euro 6c limit



Impact on diesel NOx

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





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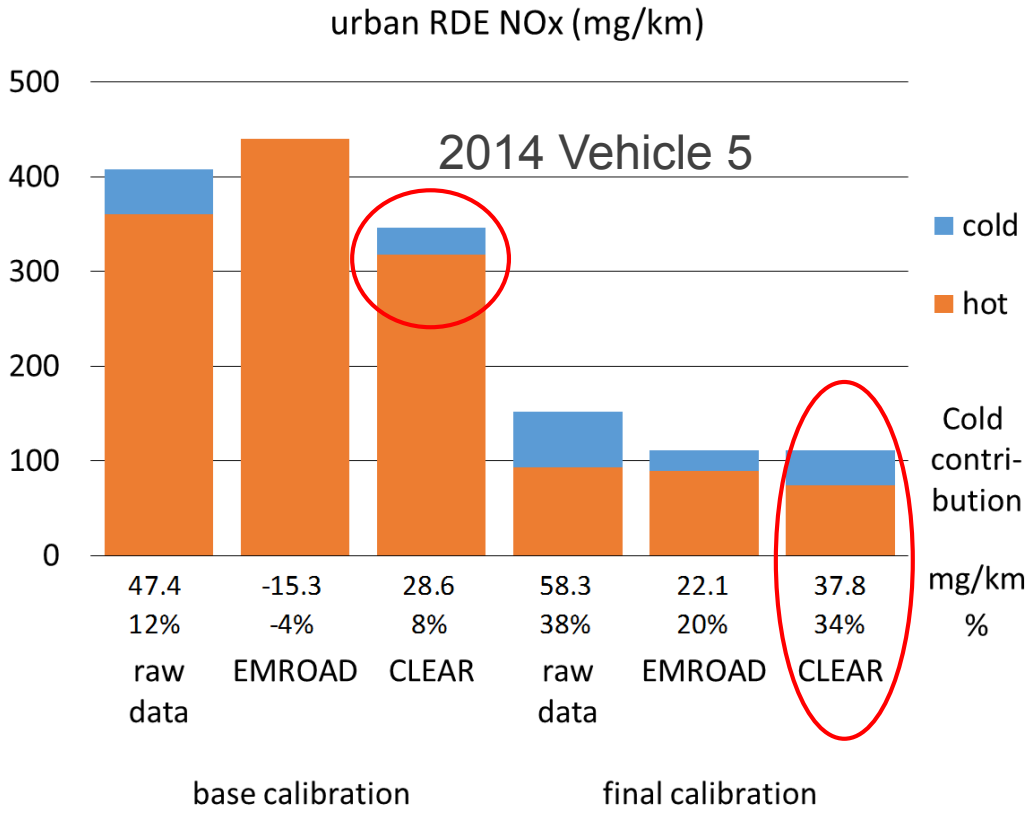
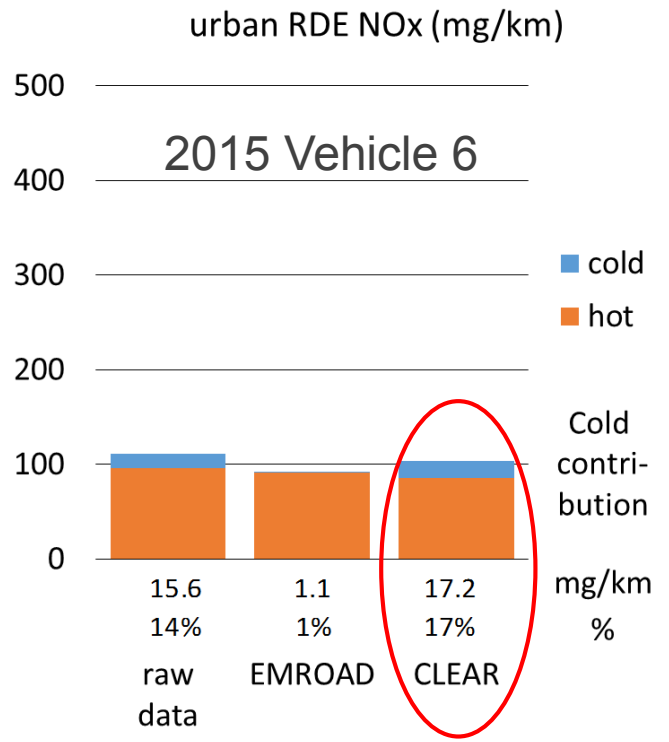
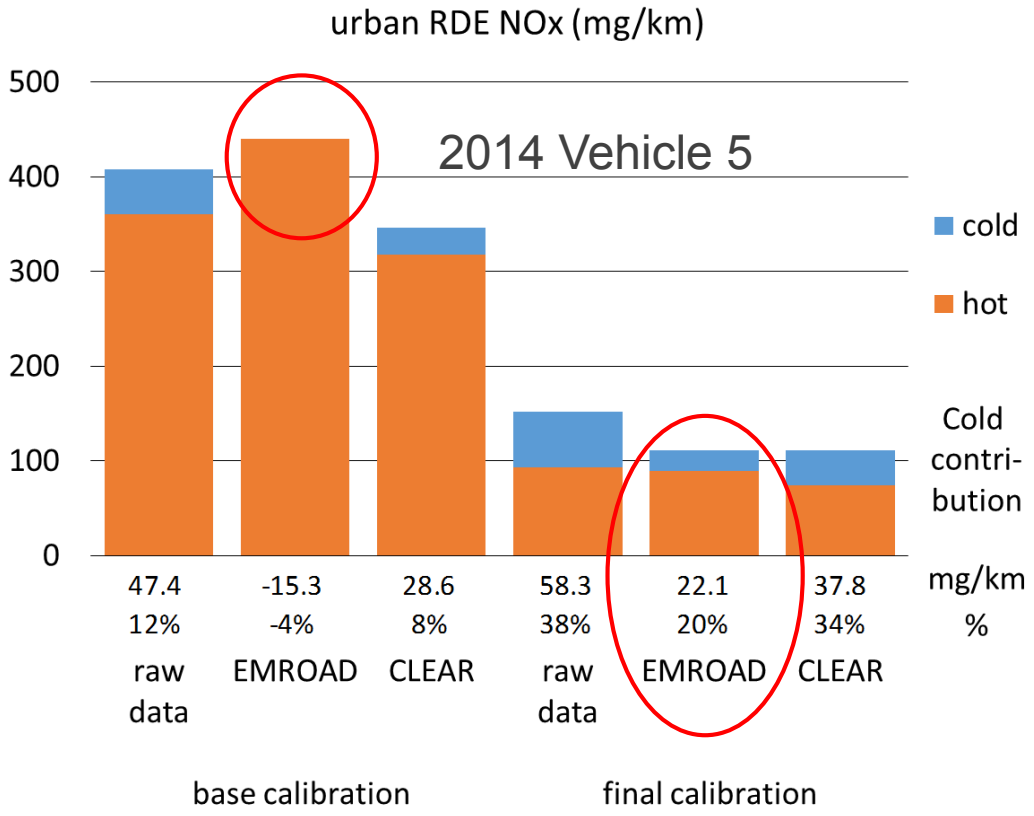
- Significant cold-start contribution in raw urban data (up to 38%)
- RDE raw ~ CLEAR

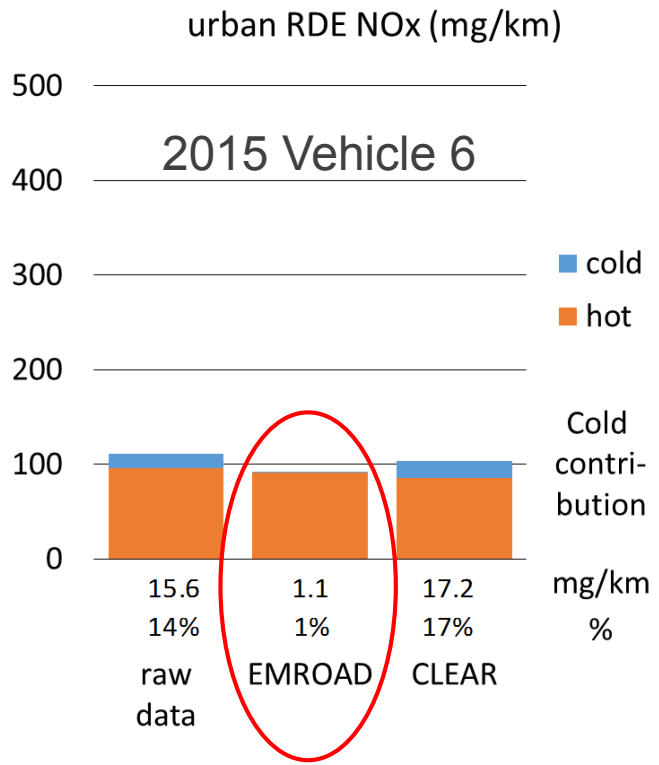




Impact on diesel NOx

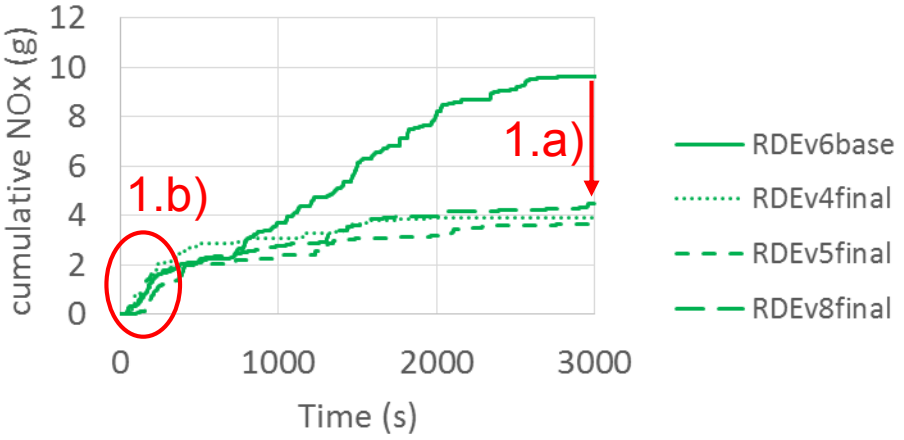
- Significant cold-start contribution in raw urban data (up to 38%)
- RDE raw ~ CLEAR > EMROAD
- Extra analysis on 2014 vehicle 5 data

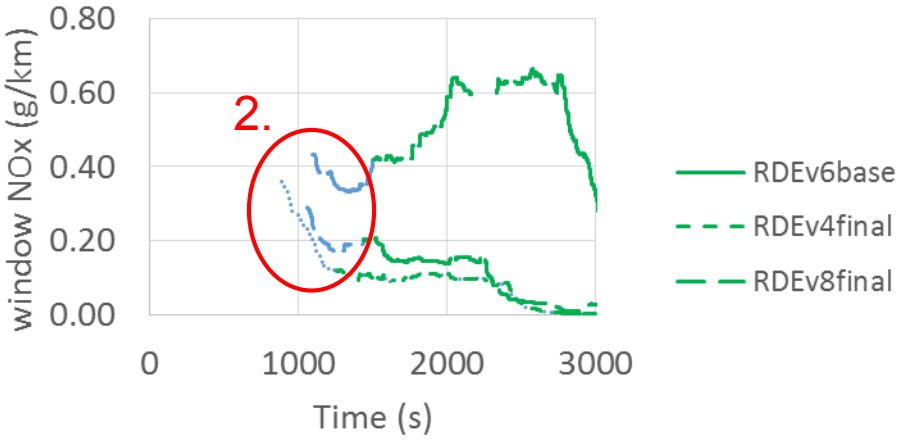




Impact on diesel NOx

- 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_{urban} = 8 km
  - d_{urban} = 23 km
  - d_{urban} = actual driven $RDE_{hot,urban}$

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

normalised hot

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

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

normalised hot

$w = x[km]/d[km]$:

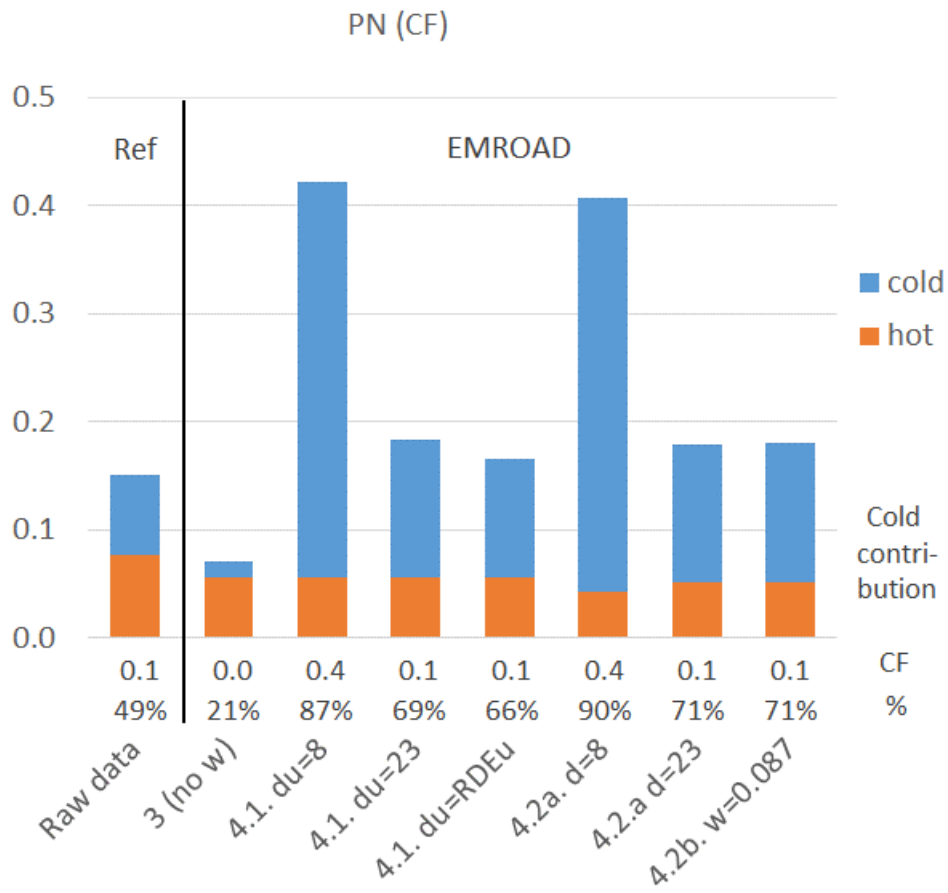
reference distance

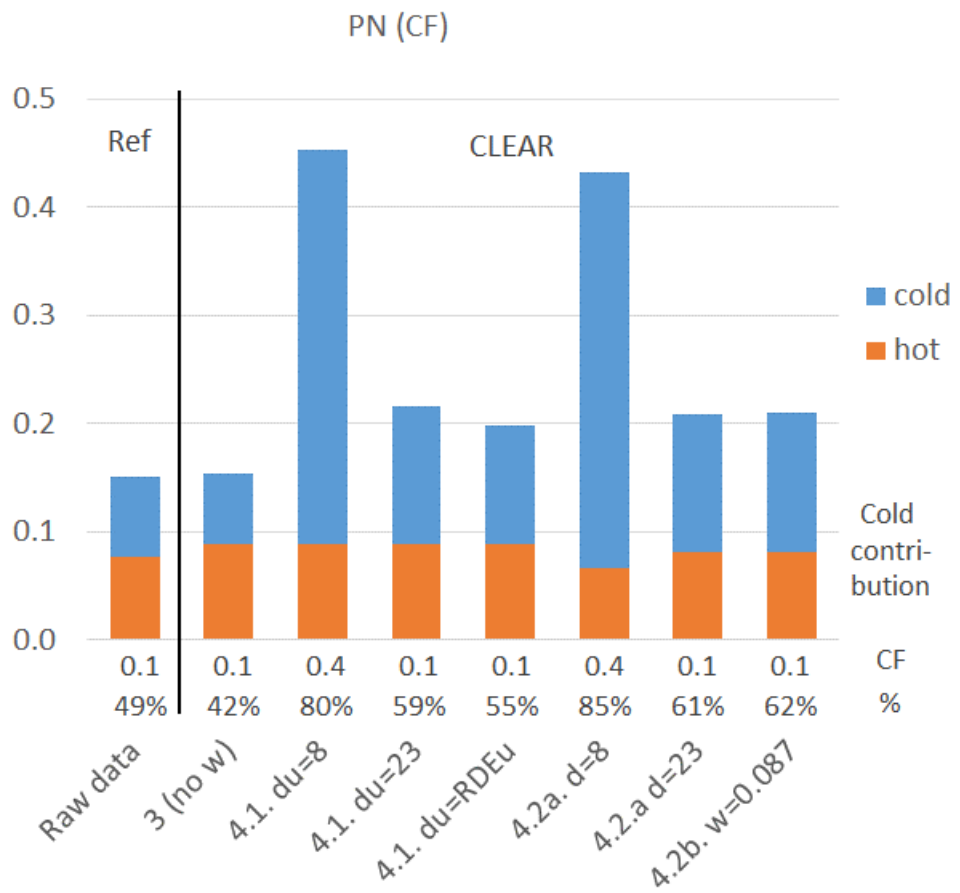
actual distance (4.2.a)
fixed distance (4.2.b)

- Option 4.2.b: with fixed factor w

GDI PN (2015 Vehicle 7 with GPF)

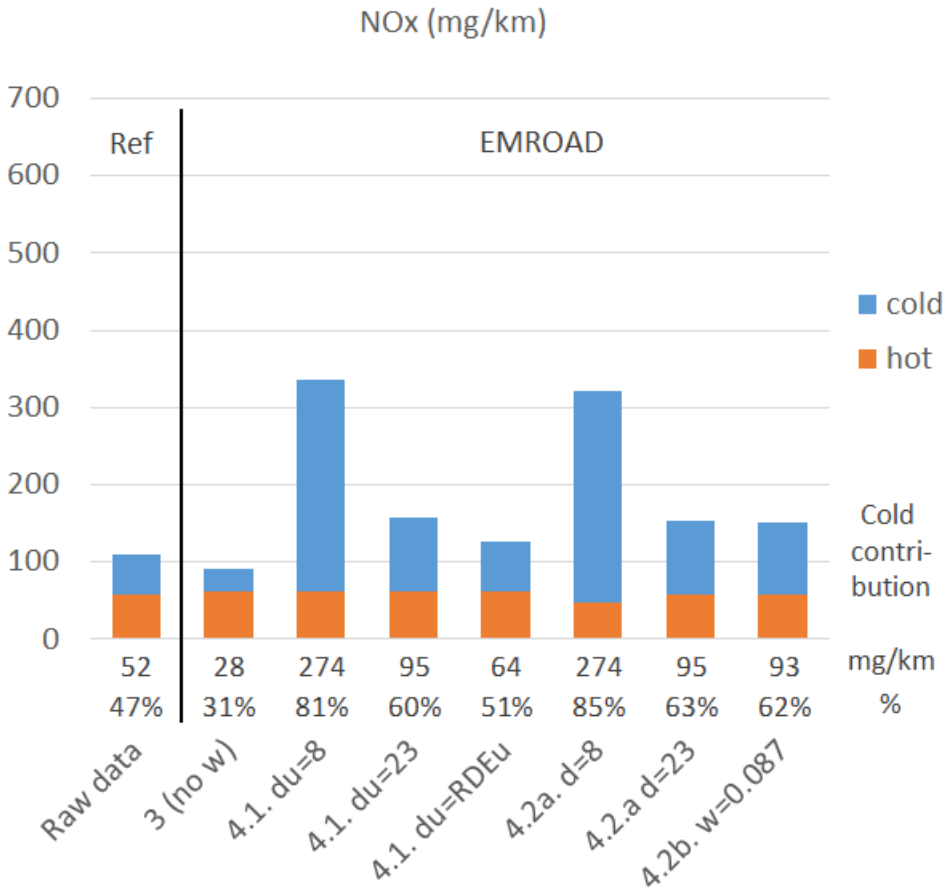
- Reference is raw data, without normalisation
- All weighing options increase contribution of cold-start emissions vs. raw data

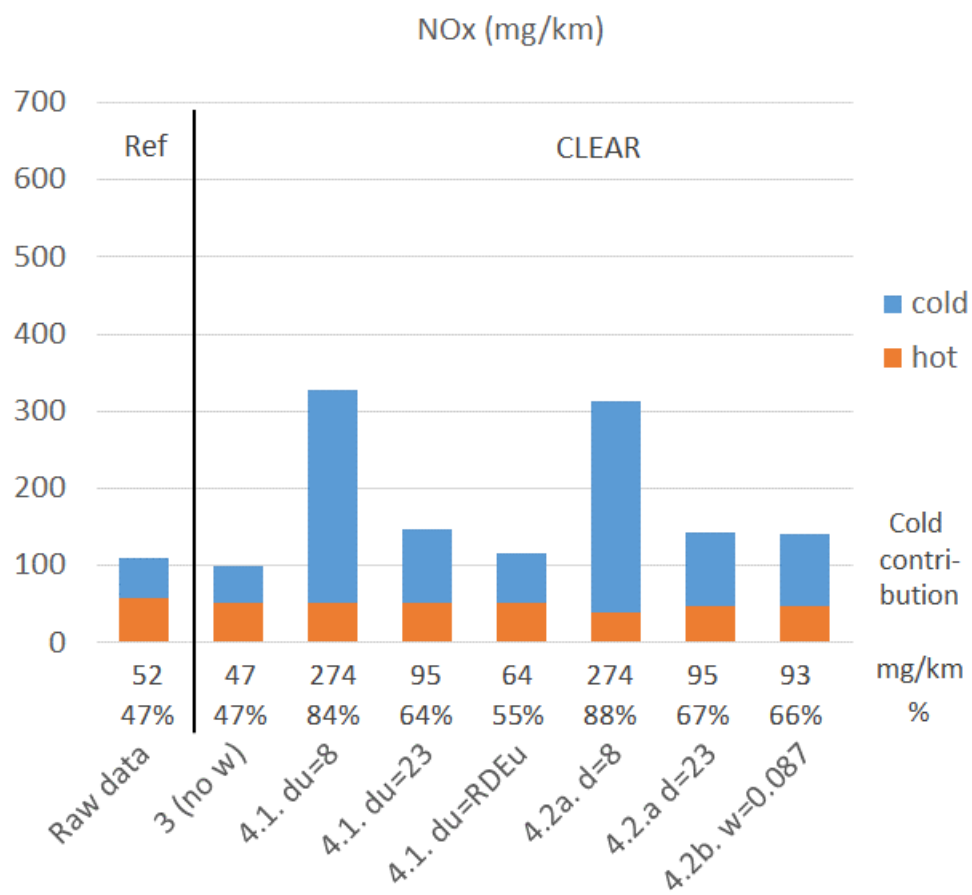




Diesel NOx (2014 Vehicle 5 final calibration)

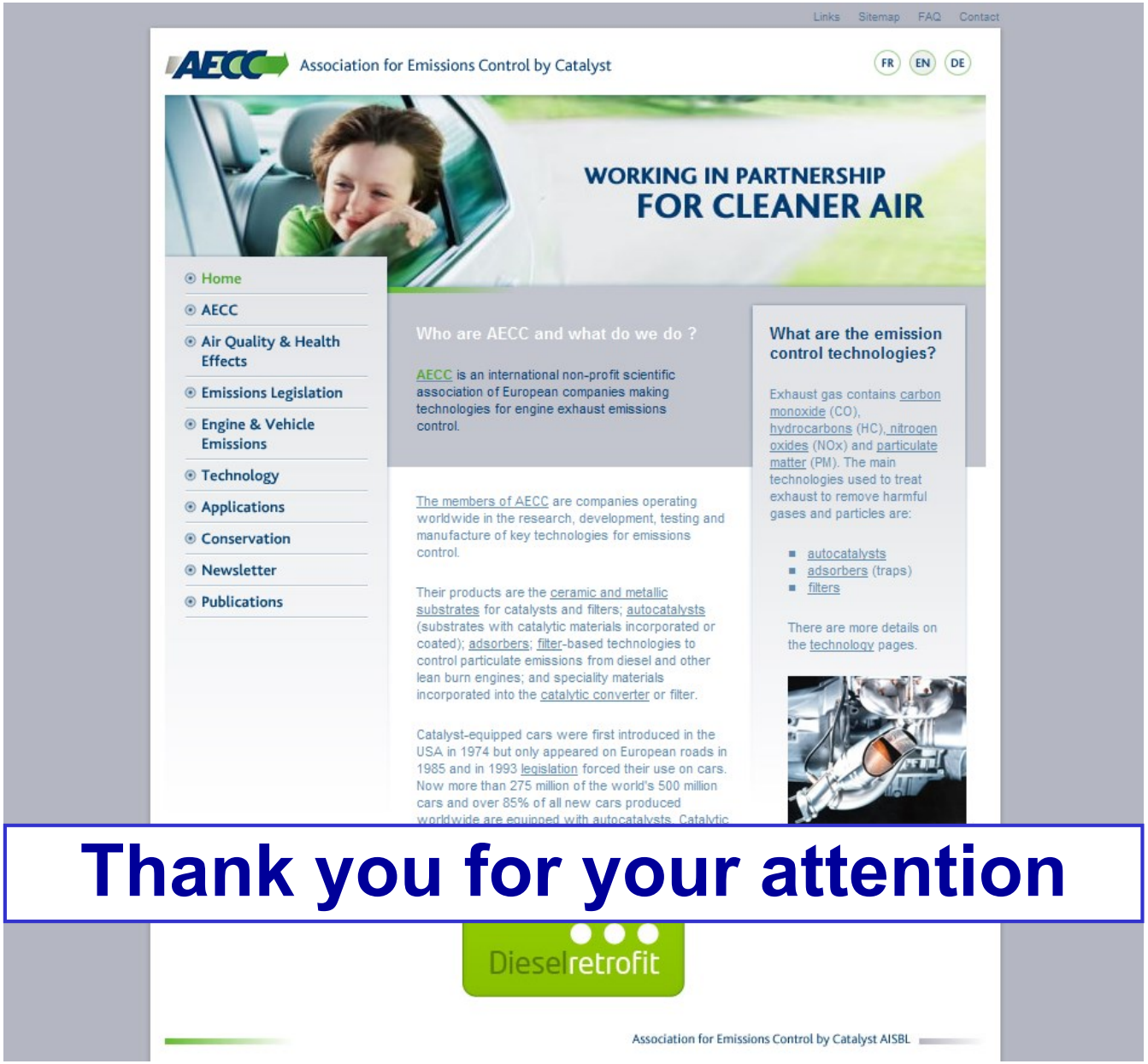
- Reference is raw data, without normalisation
- All weighing options increase contribution of cold-start emissions vs. raw data





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.



Thank you for your attention

AECC Association for Emissions Control by Catalyst AISBL