AECC project on real-world GDI PN Emissions

AECC Technical seminar on RDE PN

4 July 2016

Content

- Test programme set-up

- Emissions on regulatory test cycles (NEDC and WLTC)

- Real-Driving Emissions (RDE)
  - On the road
  - On the dyno: impact of boundary conditions

- Conclusion

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Test programme set-up

- Objective: investigate NOx & PN RDE without and with GPF

- At Ricardo in cooperation with Concawe

- Vehicle
  - C-segment, 1.4l engine
  - Market representative GDI technology targeting Euro 6c → only Euro 6b available
  - Original configuration w/o GPF
  - Add coated GPF demonstrator underfloor

- HORIBA PEMS equipment
  - Gaseous PEMS (CO_2, CO, NOx)
  - PEMS-PN demo unit

Flow

Location for GPF

Existing TWC

Underfloor view

150 CD

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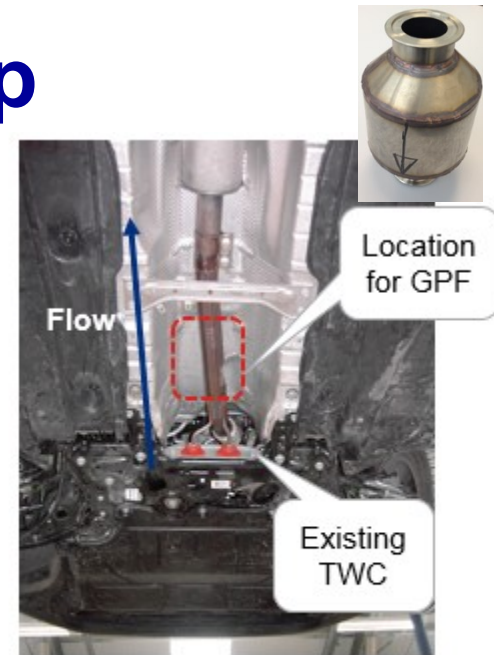
Test programme set-up

- Identified parameters to evaluate
  - fuel type & quality
  - cold-start PN
  - driving dynamics (RDE on dyno)
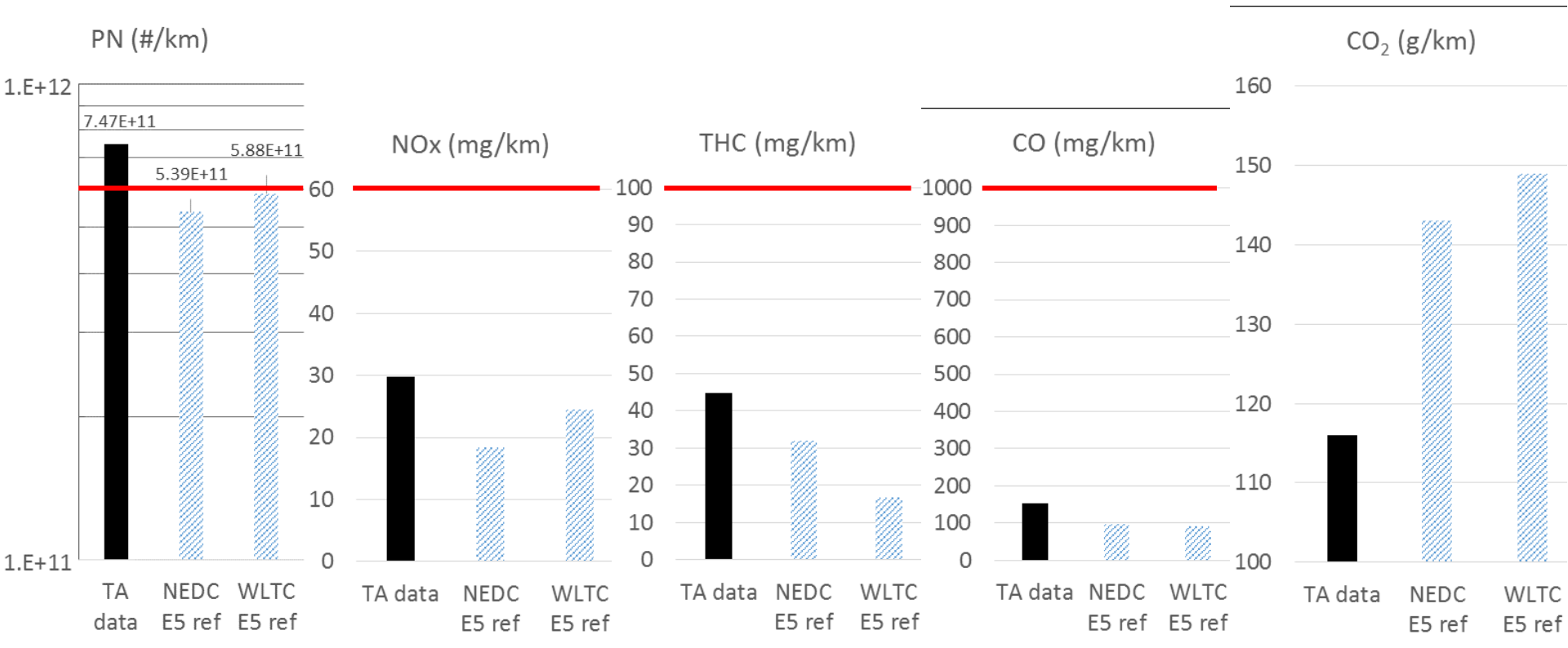 - cold ambient temperature
  - <23nm PN

- Test matrix

Exhaust	Fuel	NEDC + WLTC	RDE on road	RDE on dyno
Original (without GPF)	Ref E5	1x	-	-
	Ref E10	1x	3x	-
	Market E5	1x	3x	6x
With coated GPF	Ref E10	1x	3x	-
	Market E5	1x	3x	6x

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NEDC + WLTC results w/o GPF on E5 ref fuel are below Euro 6c limit

- Data demonstrates that the vehicle is a state of the art GDI

PN (#/km)

1.E+12
7.47E+11
5.88E+11
5.39E+11
1.E+11

TA data | NEDC E5 ref | WLTC E5 ref

NOx (mg/km)

TA data | NEDC E5 ref | WLTC E5 ref

THC (mg/km)

TA data | NEDC E5 ref | WLTC E5 ref

CO (mg/km)

TA data | NEDC E5 ref | WLTC E5 ref

CO_2 (g/km)

TA data | NEDC E5 ref | WLTC E5 ref

—— Euro 6c limit

PN results w/o GPF go above Euro 6c limit on other dyno tests
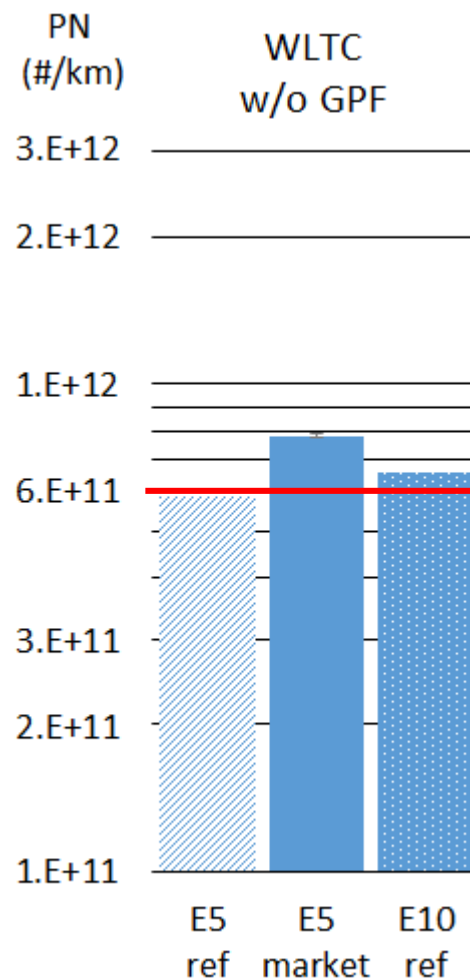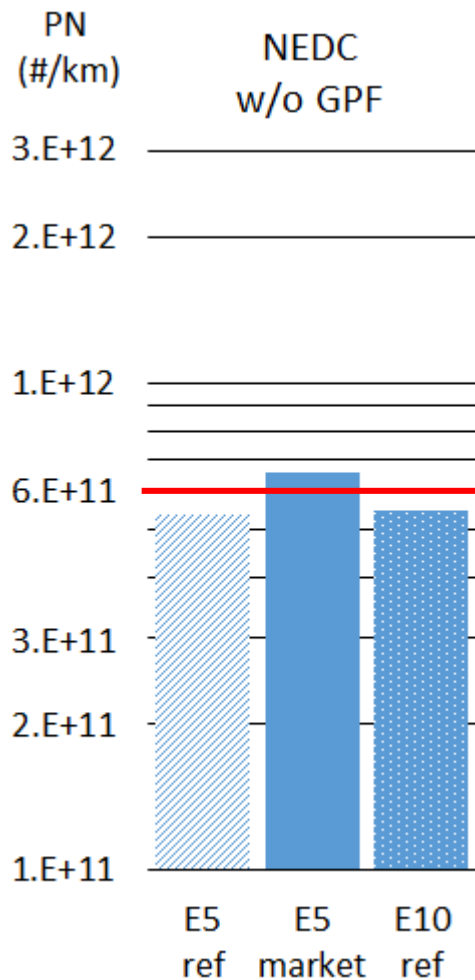
Euro 6c limit

⊥ Measurement range if repeated

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PN results with GPF are below Euro 6c limit on all dyno tests
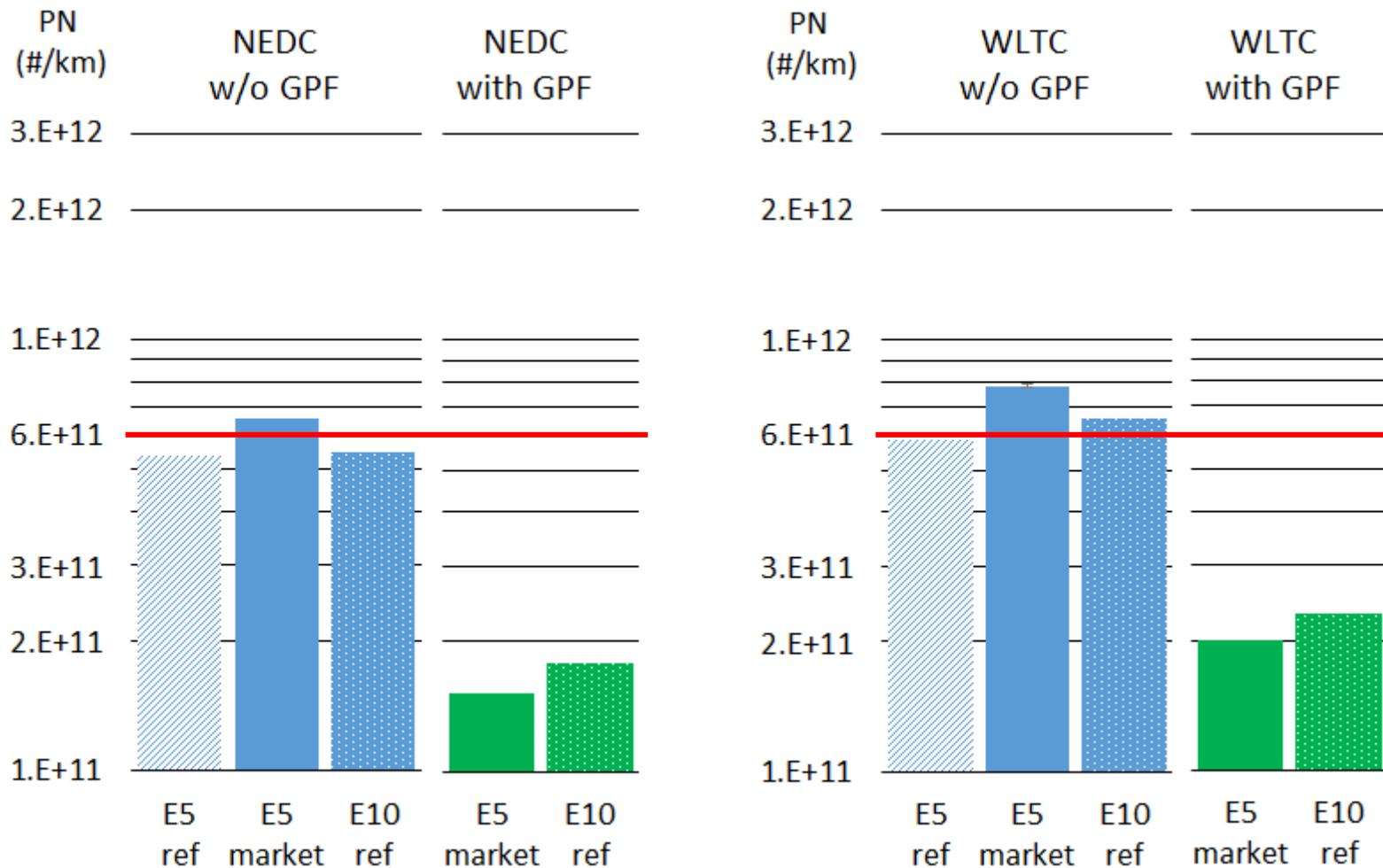
Euro 6c limit

Measurement range if repeated

Association for Emissions Control by Catalyst AISBL

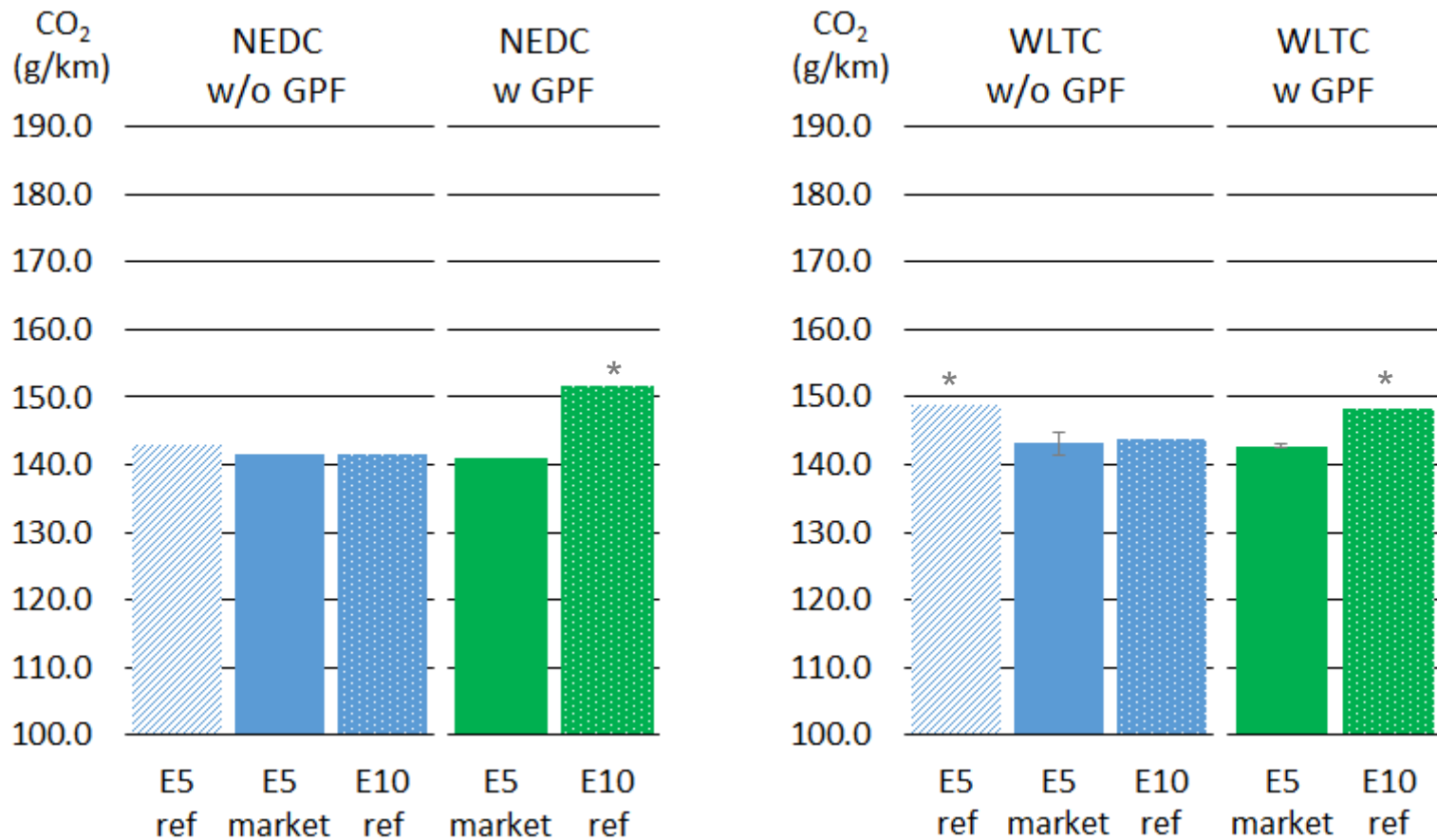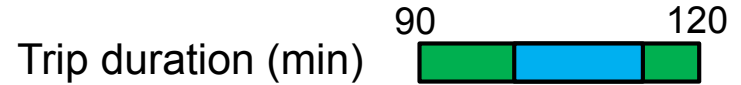# Other pollutants are below Euro 6c limit on all dyno tests w/o and with GPF
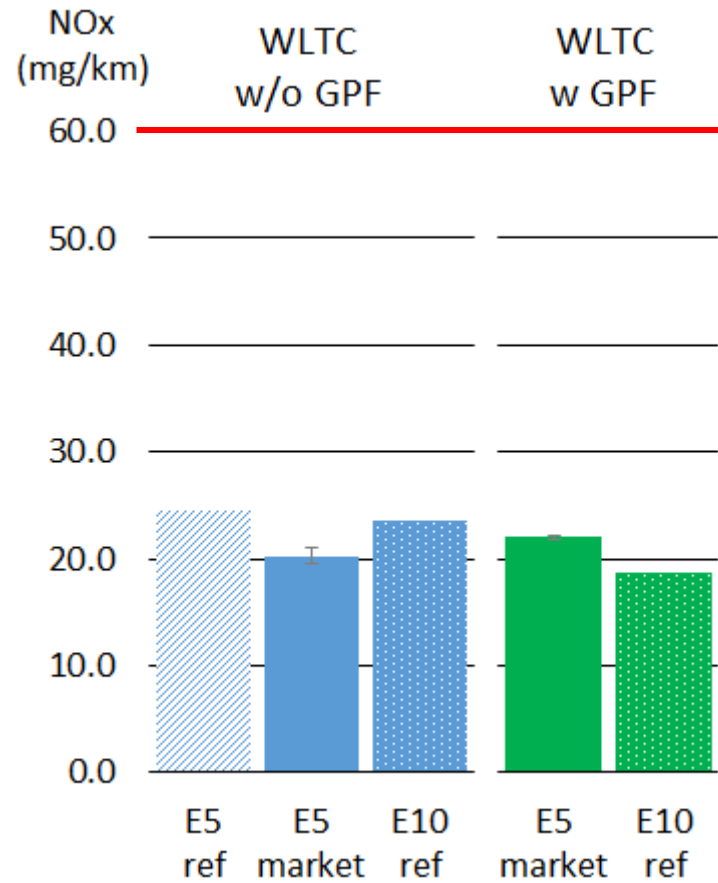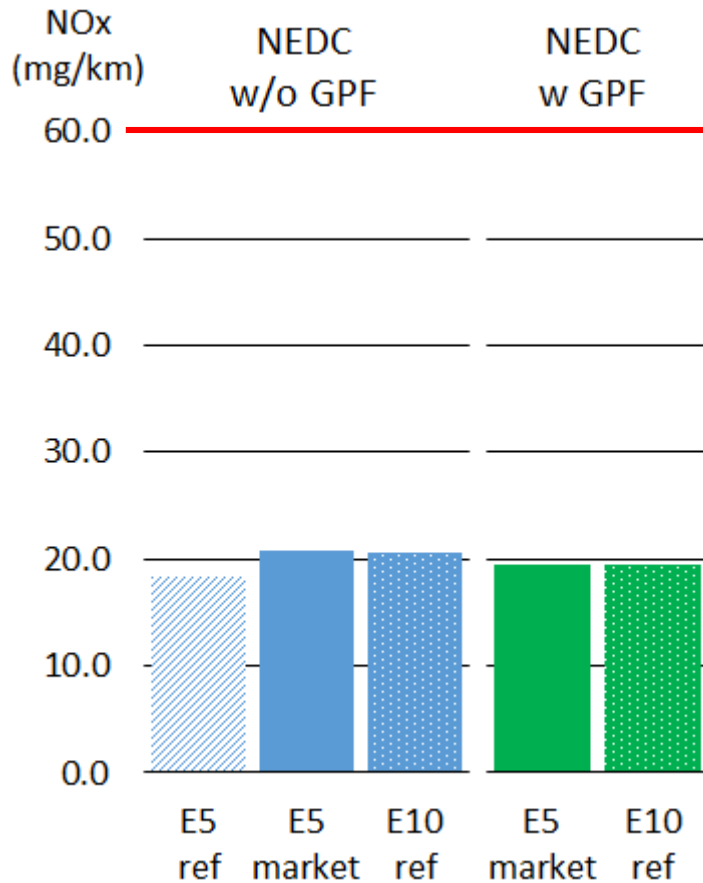
Euro 6c limit

Measurement range if repeated

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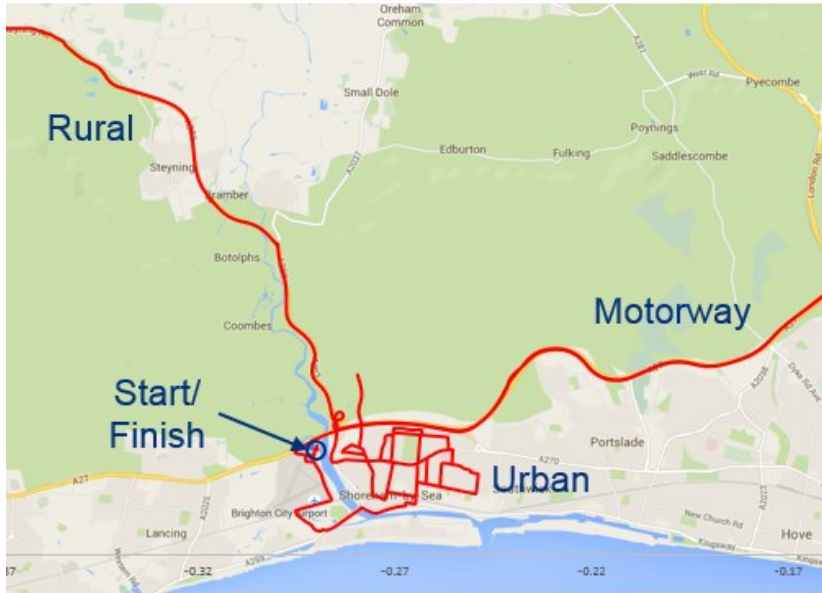# No CO$_2$ penalty was measured for the GPF on NEDC and WLTC

* Start & Stop impact

Measurement range if repeated

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RDE route is within the requirements

RDE Cycle Route from GPS

Rural

Motorway

Start/Finish

Urban

Trip duration (min)   90   120

Distance share (%)
(>16 km)

urban (<60km/h)   29   44

rural (>60 & <90km/h)   23   43

motorway (>90km/h)   23   43

Urban requirements

Average speed (km/h)   15   40

Time share of stops (%)   6   30
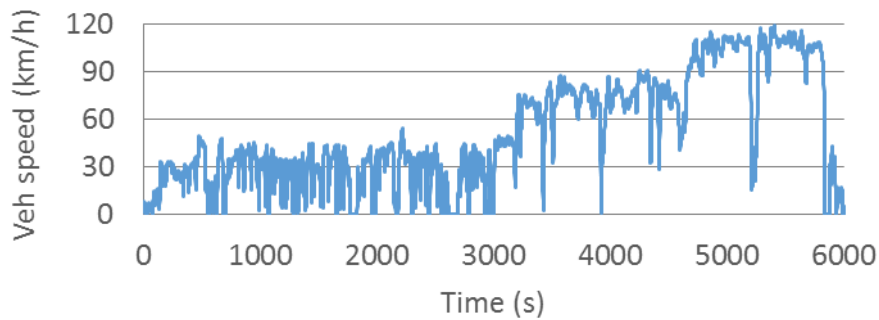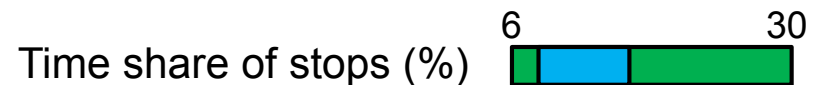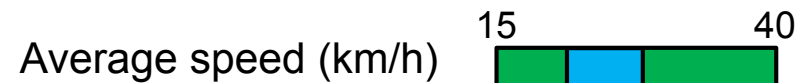
Allowable tolerance   AECC tests

Measured data is within moderate environmental boundary conditions

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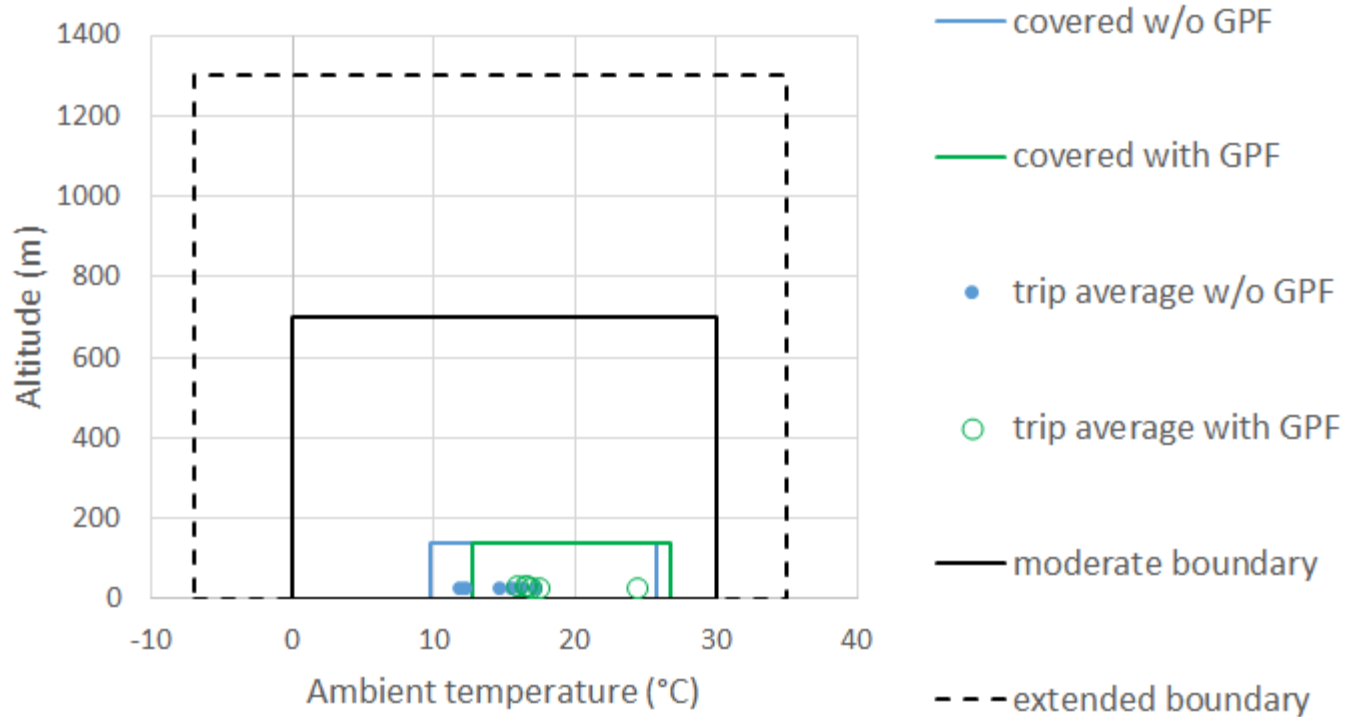
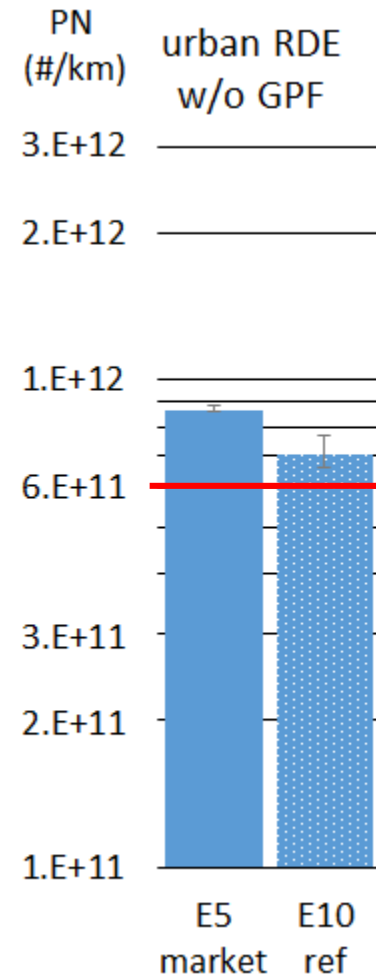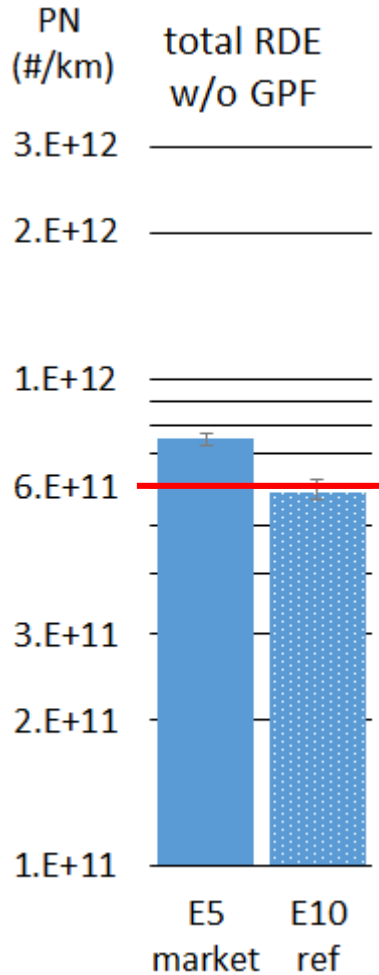# Measured data is within
the dynamic boundary conditions

Excess or absence of driving dynamics
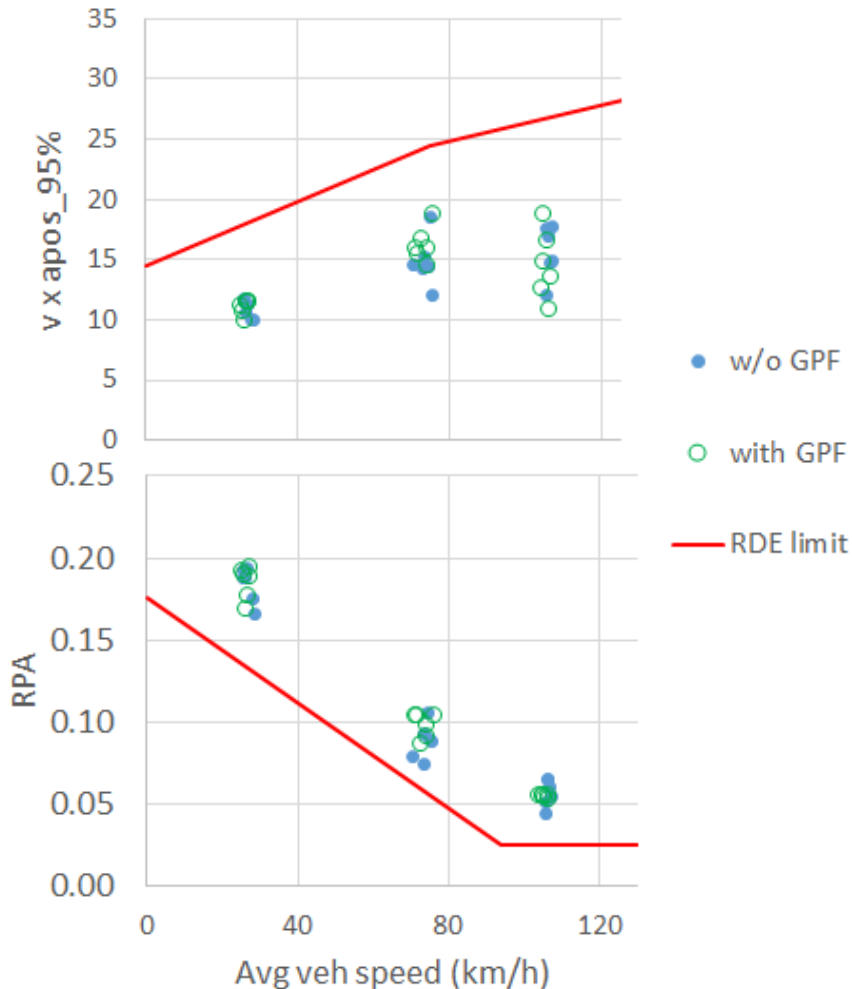
Altitude accumulation
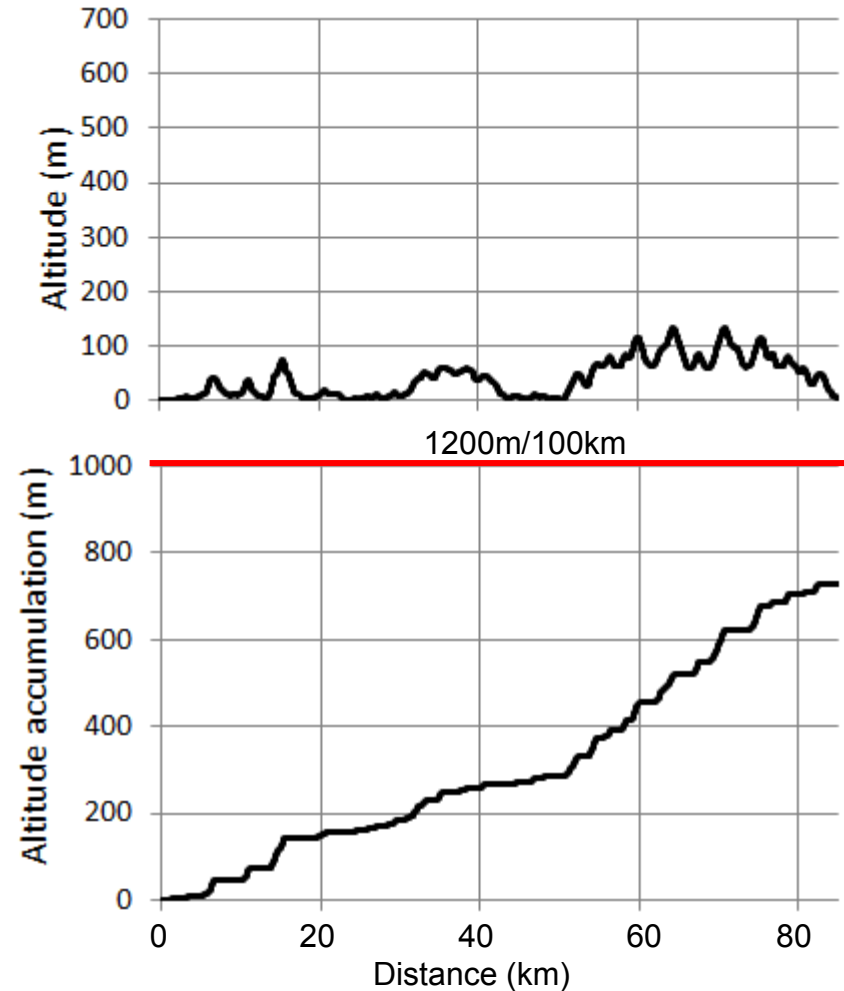
1200m/100km

14
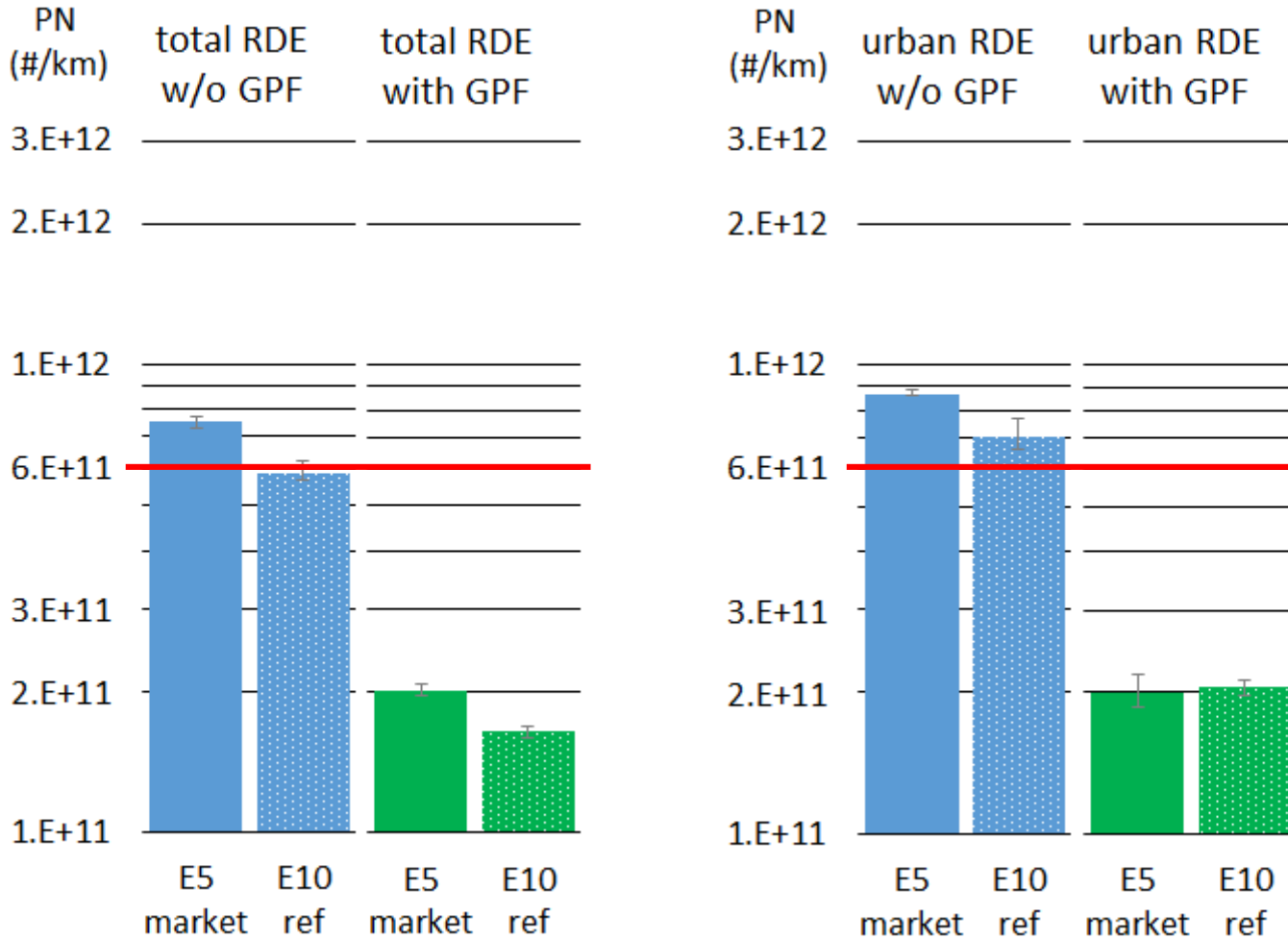
PN results w/o GPF further increase above Euro 6c limit on the road

PN (#/km) total RDE w/o GPF

3.E+12
2.E+12
1.E+12
6.E+11
3.E+11
2.E+11
1.E+11

E5 market   E10 ref

PN (#/km) urban RDE w/o GPF

3.E+12
2.E+12
1.E+12
6.E+11
3.E+11
2.E+11
1.E+11

E5 market   E10 ref

* Raw data, no exclusion/ normalisation

——— Euro 6c limit   ⊥ Measurement range 3x RDE

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PN results with GPF are well below Euro 6c limit on the road

PN (#/km) — total RDE w/o GPF, total RDE with GPF, urban RDE w/o GPF, urban RDE with GPF

* Raw data, no exclusion/ normalisation

—— Euro 6c limit
⊥ Measurement range 3x RDE

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RDE normalisation tools have a different impact

PN (#/km)

total RDE w/o GPF — total RDE with GPF — urban RDE w/o GPF — urban RDE with GPF

Categories (left to right within each group): raw data, EM ROAD, CLEAR

— Euro 6c limit

⊺ Measurement range 3x RDE

* data on E5 market

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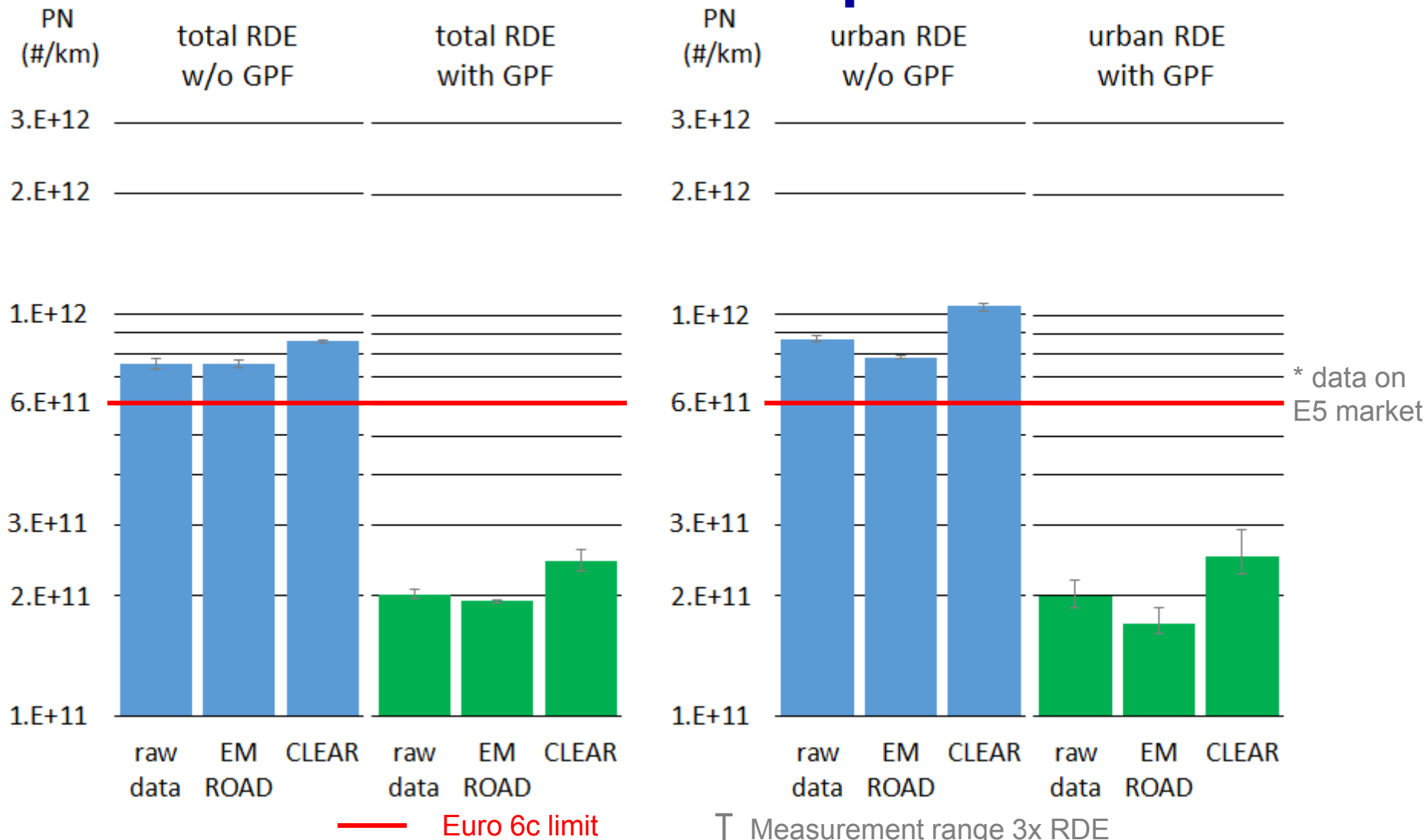
No CO$_2$ penalty was measured for the GPF on the road
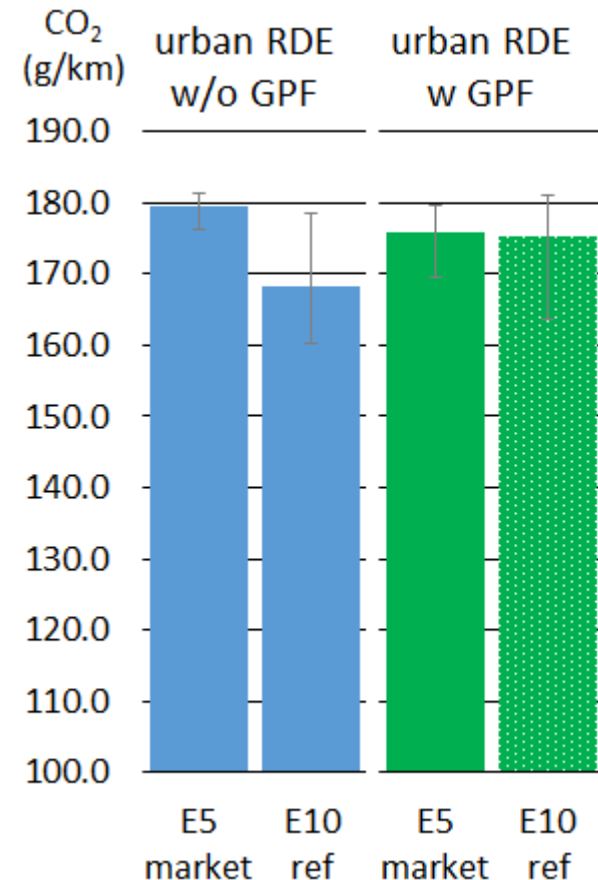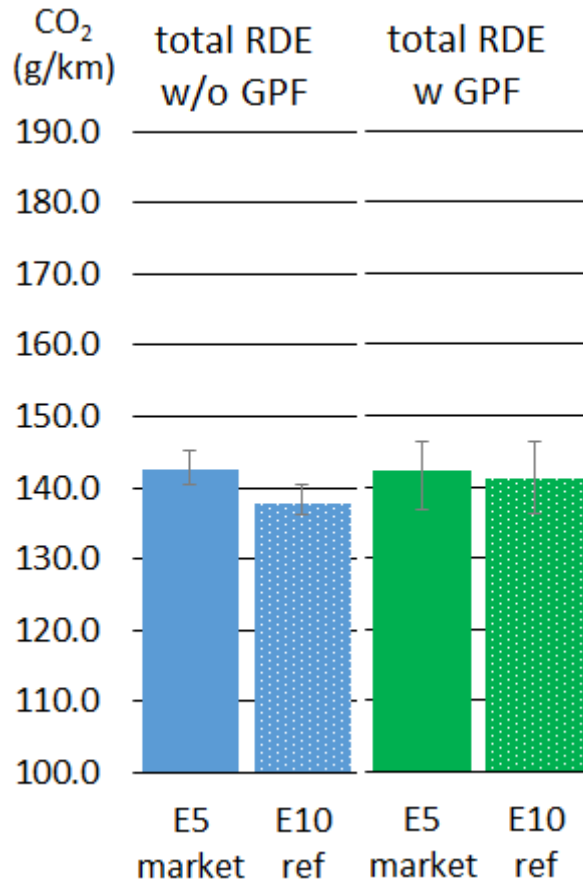
Measurement range 3x RDE

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RDE on dyno to investigate impact of going towards RDE boundary
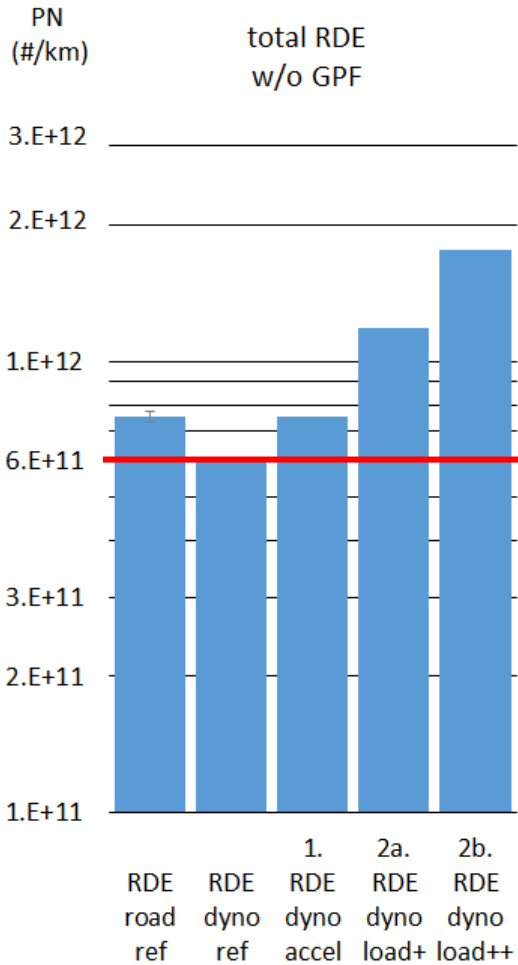
1. Change accelerations
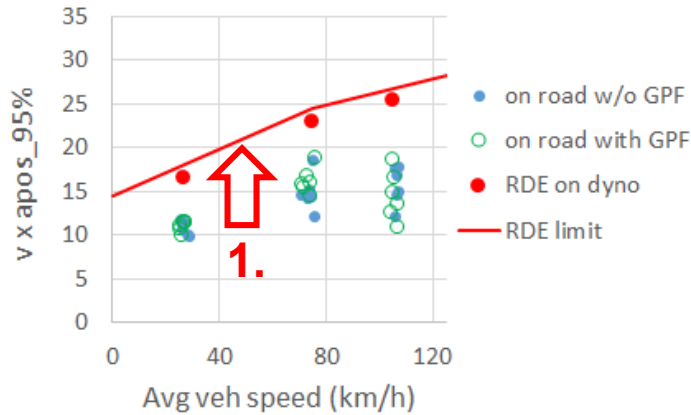
2. Change dyno load
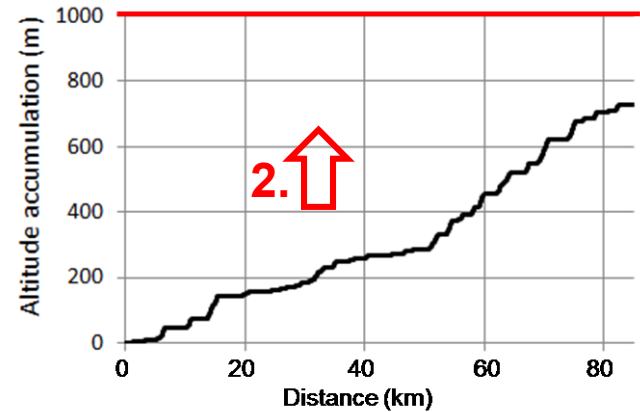
3. Change ambient temperature

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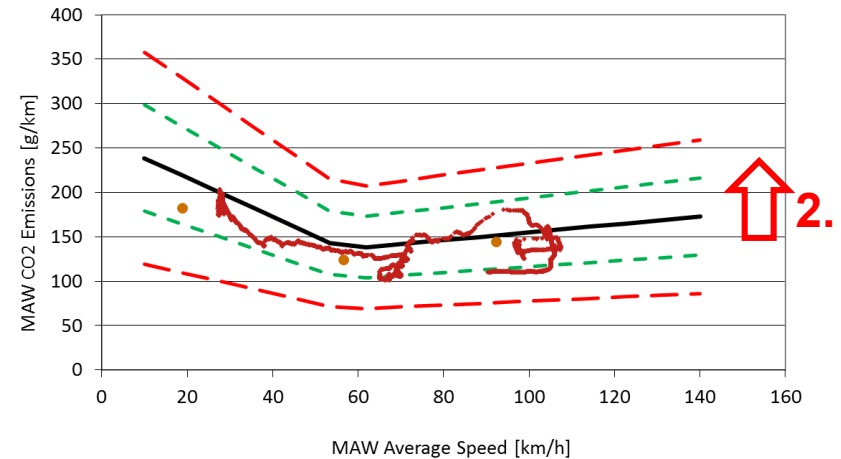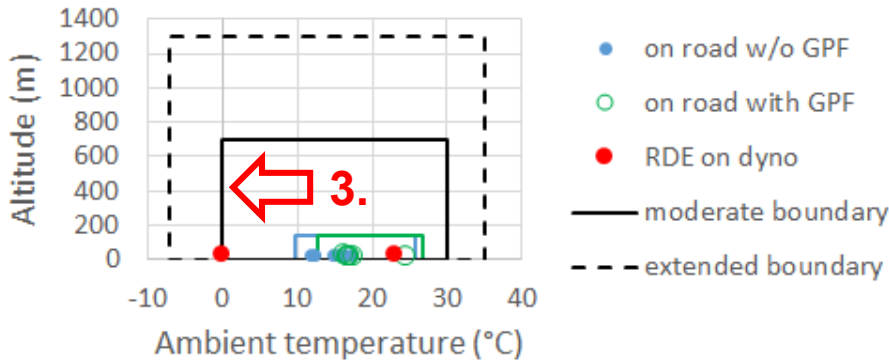
PN results w/o GPF further increase above Euro 6c limit towards RDE boundary
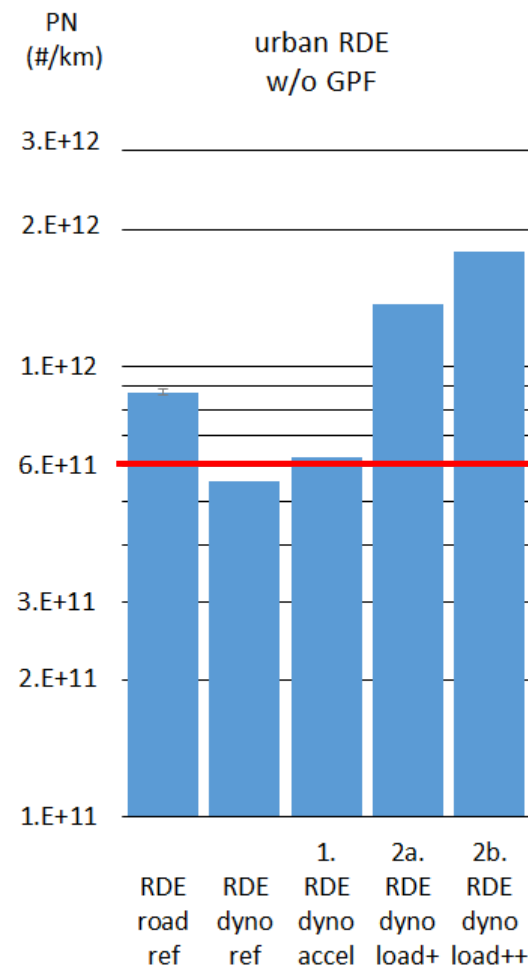
PN results with GPF remain below Euro 6c limit on all tests

Euro 6c limit — Measurement range 3x RDE

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Conclusion

- The programme demonstrated that a GPF enables GDI PN emissions below Euro 6c limit under all driving conditions

w/o GPF   with GPF

- NEDC + WLTC

Euro 6c limit

- RDE on road

- towards RDE boundary (on chassis dyno)
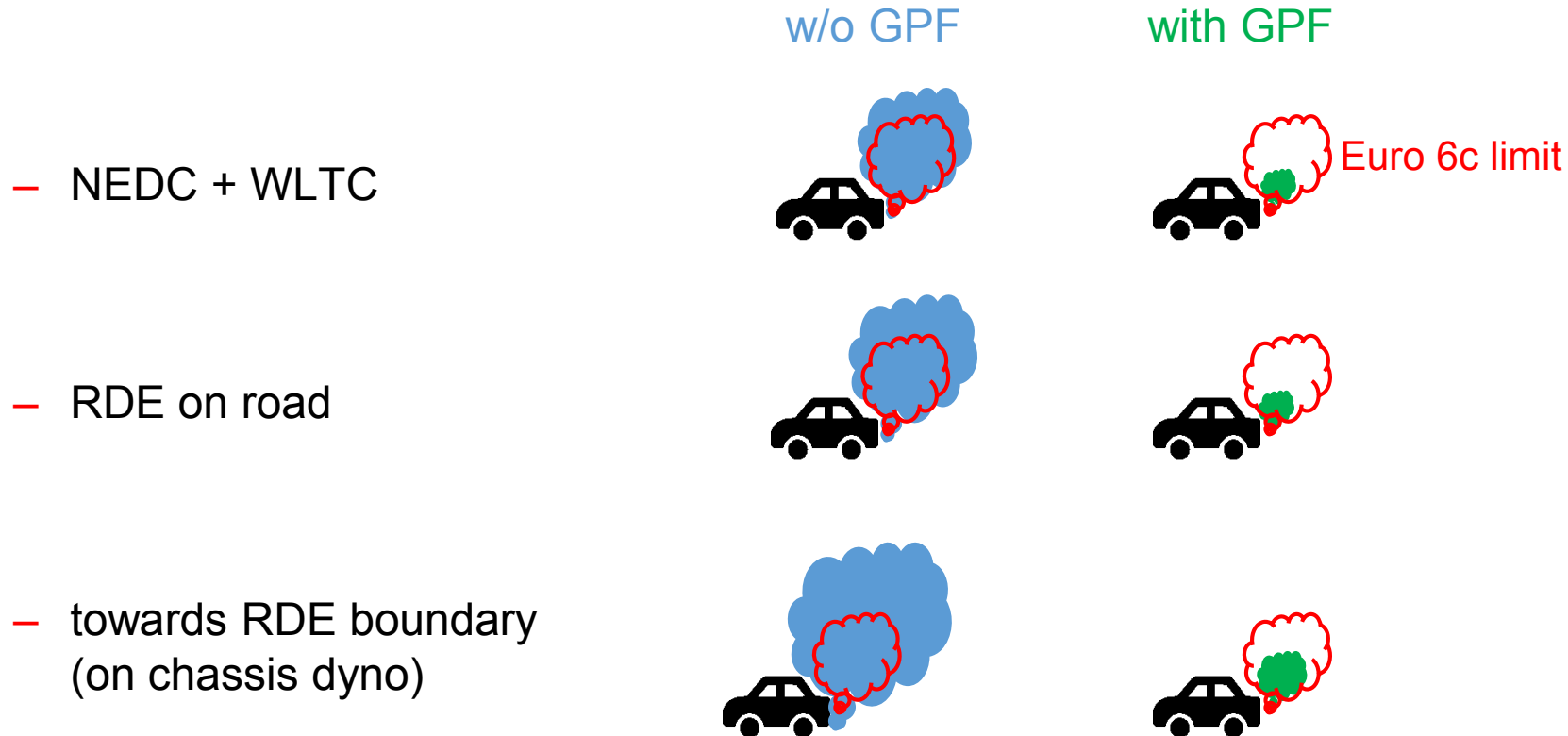
Note: style based on ICCT graphic

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Thank you for your attention