

# RDE MEASUREMENTS OF A GDI WITHOUT AND WITH A GPF

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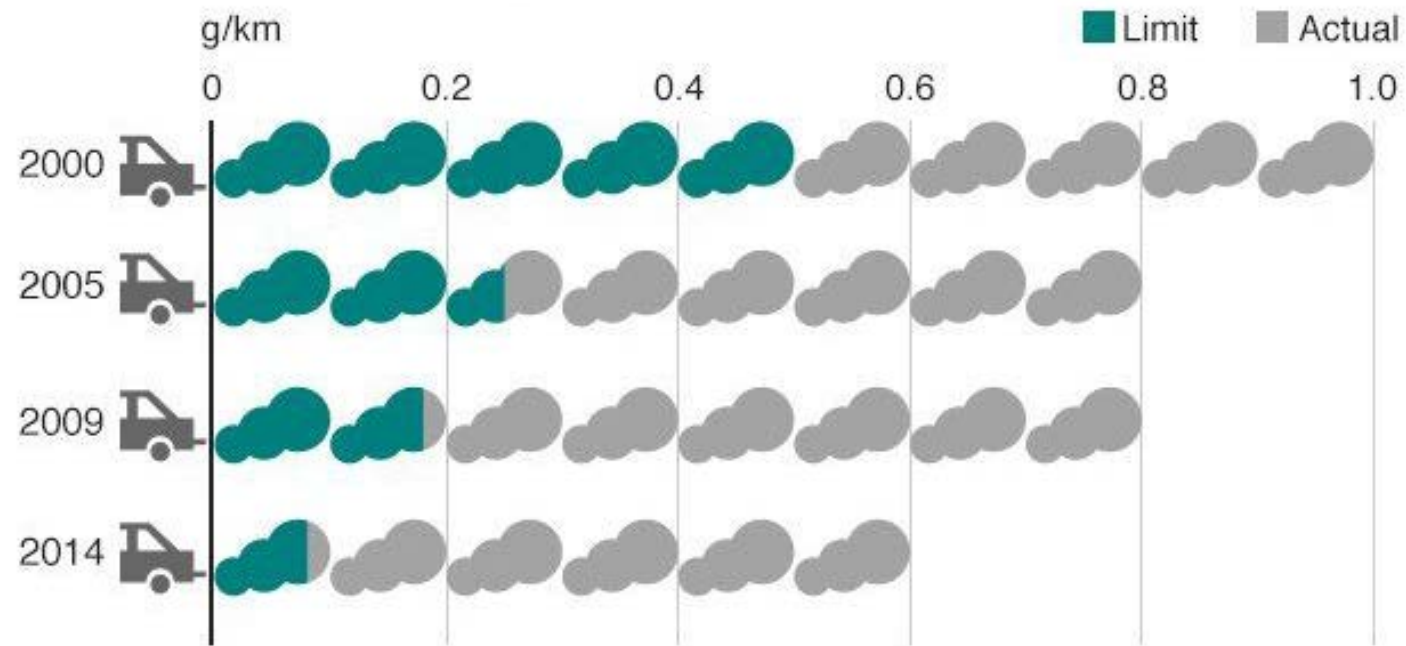
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J. Andersson; Ricardo Consulting Engineers Ltd.

full paper: <https://www.aecc.eu/wp-content/uploads/2017/04/Real-world-emissions-measurements-of-a-GDI-vehicle-without-and-with-GPF.pdf>



# EU RDE legislation to close the gap between lab and real-world emissions



Source: the ICCT

# EU RDE legislation to close the gap between lab and real-world emissions

- Not To Exceed limit (NTE) = Euro 6 limit x Conformity Factor (CF)
  - CF defined for NO<sub>x</sub> and PN
  - CF applies to urban part and total trip

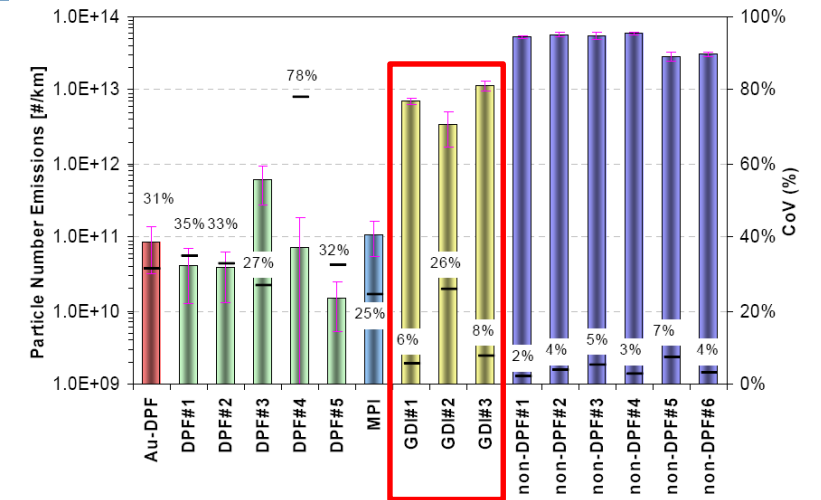
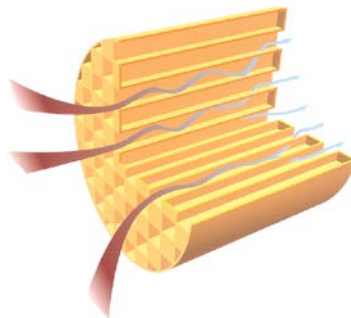
	2016				2017				2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
RDE monitoring phase	NT																															
NO <sub>x</sub> CF requirements					NT				Euro 6-dTEMP NO <sub>x</sub> CF = 2.1				All				NT				Euro 6d				All				NO <sub>x</sub> CF2 = 1.0 + 0.5 error margin			
PN CF requirements					NT				All				PN CF = 1.0 + 0.5 error margin																			

- RDE boundary conditions define normal driving
  - Route specifications
  - Ambient conditions
  - Driving dynamics
- RDE legislation being finalised

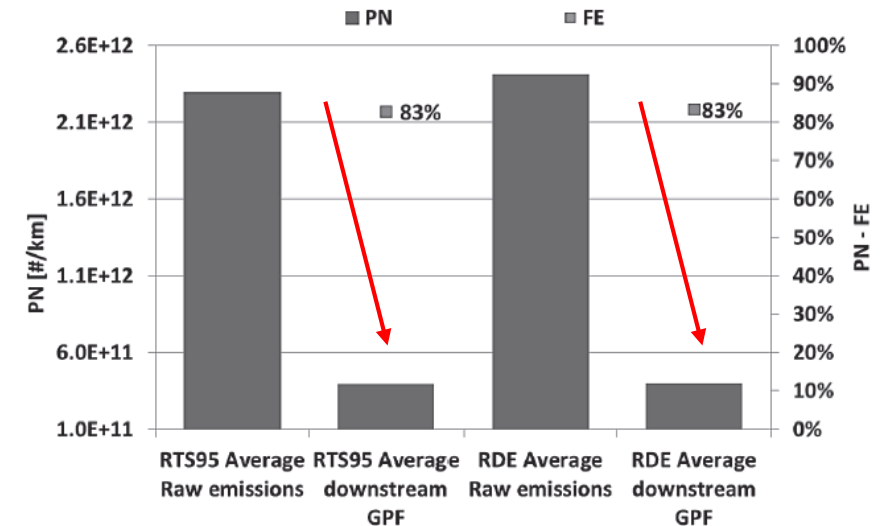
NTE: Not To Exceed      NT: New Type Approval  
 CF: Conformity Factor    All: All new vehicles

# The GDI particle RDE issue

- CO<sub>2</sub> legislation promotes fuel-efficient Gasoline Direct Injection (GDI) in the EU
- Particles emitted by DI gasoline vehicles reported higher than Euro 6c limit of  $6 \times 10^{11}$  #/km, especially under real driving conditions
- Gasoline Particulate Filters (GPF) are an effective route to reduce the number of ultrafine particles under all driving conditions



Source: PMP Inter-Laboratory Correlation Exercise Final Report

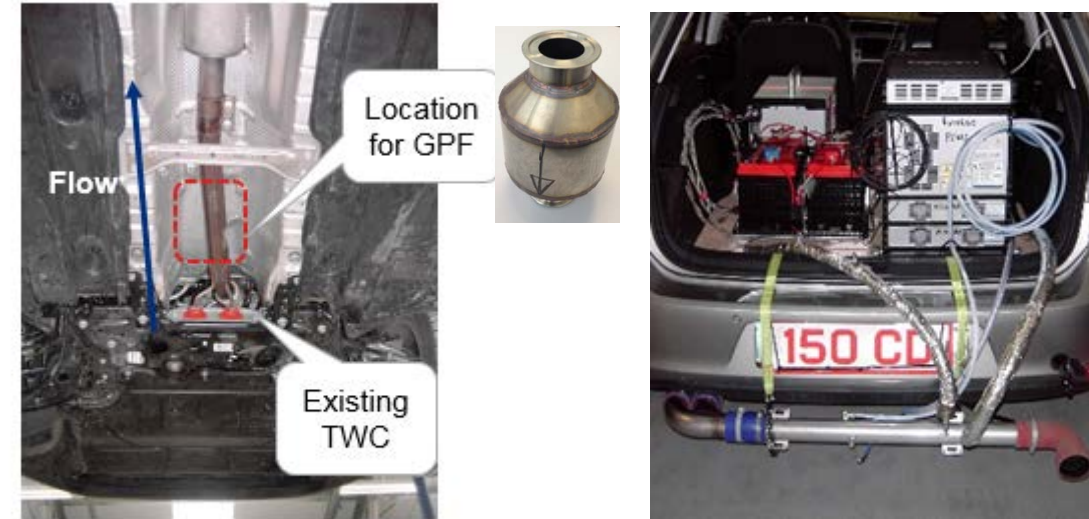


Source: AECC member

- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

# Test programme set-up

- Vehicle
  - C-segment, 1.4l engine
  - Market representative GDI technology; Euro 6b certified
  - Original configuration w/o GPF
  - Add coated GPF demonstrator underfloor
- HORIBA PEMS equipment
  - Gaseous PEMS (CO<sub>2</sub>, CO, NO<sub>x</sub>)
  - PEMS-PN demo unit
- Parameters to evaluate
  - fuel type & quality
  - driving dynamics (RDE on dyno)
  - cold ambient temperature (RDE on dyno)
  - sub-23nm PN
- Test matrix

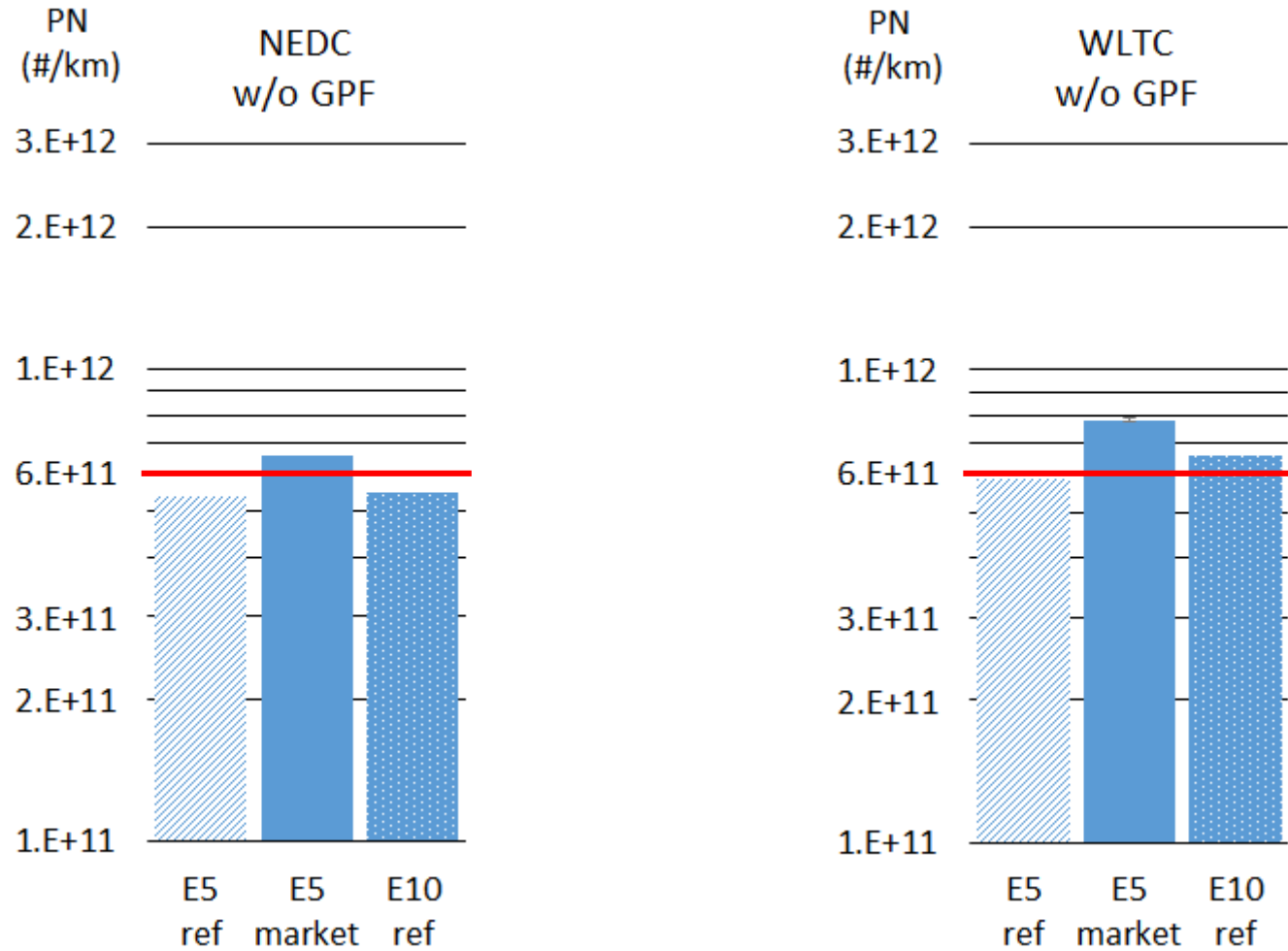


Underfloor view

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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# PN results w/o GPF are below Euro 6c limit on NEDC and WLTC with E5 ref fuel, but go above limit with other fuels

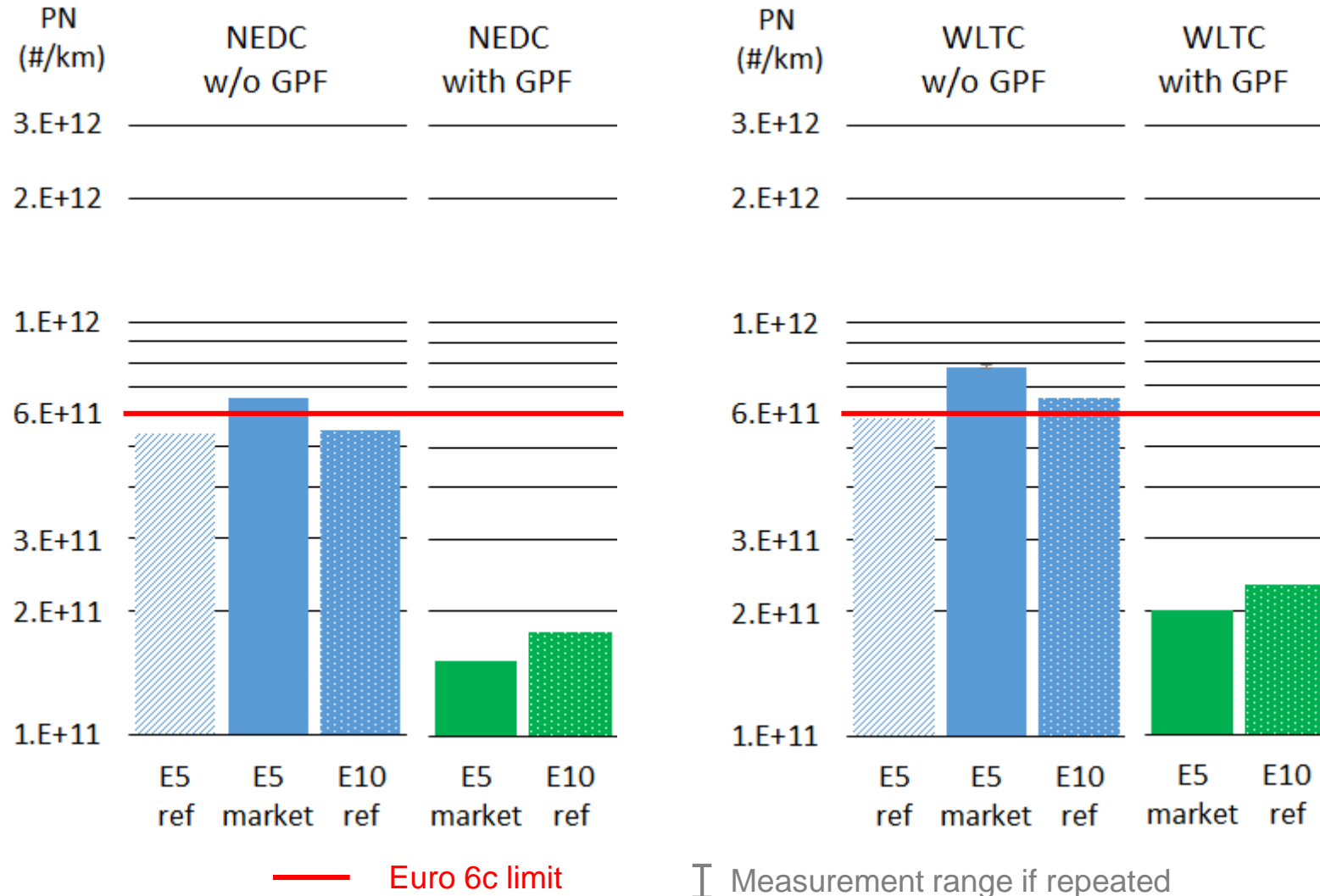


— Euro 6c limit

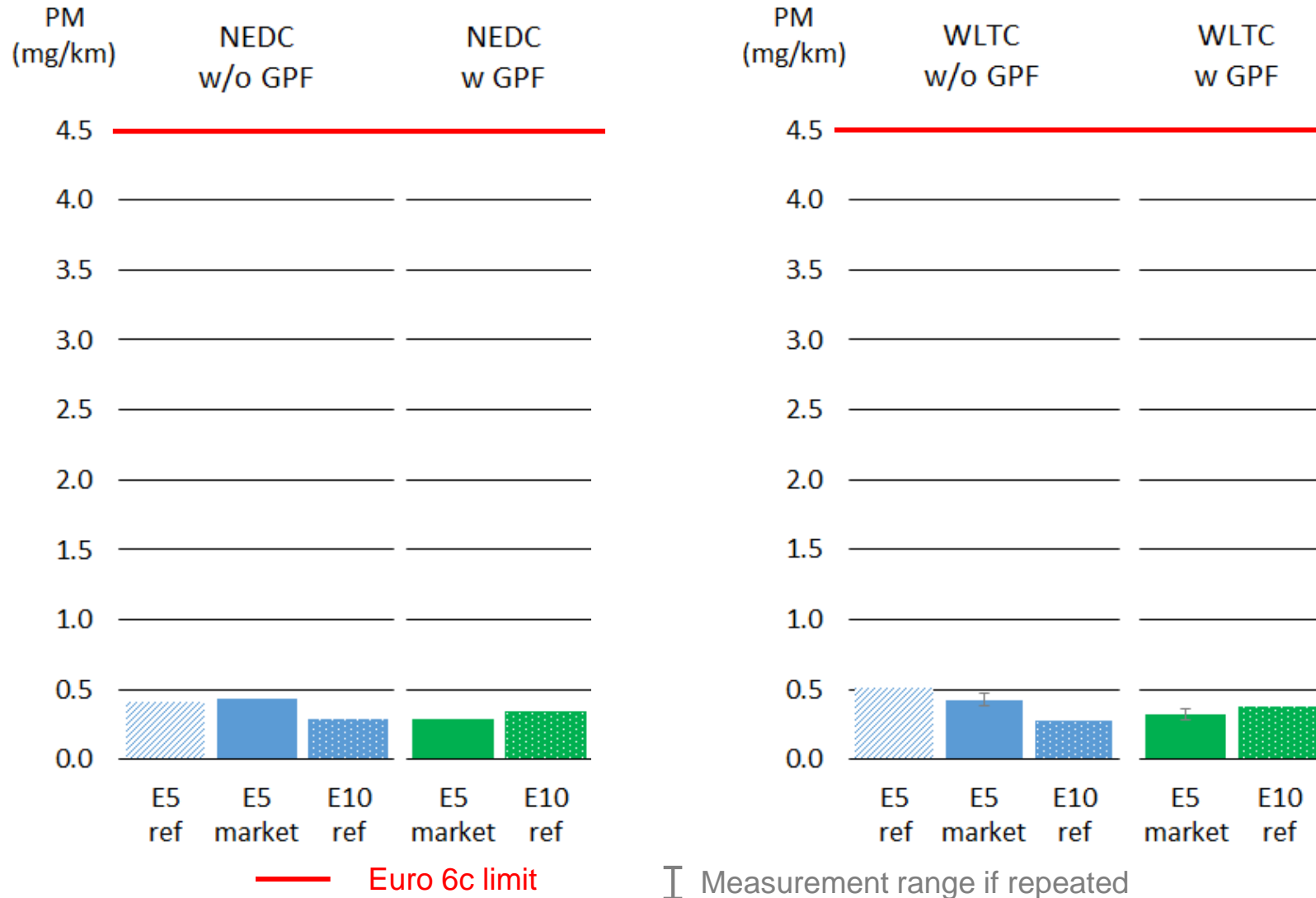
I Measurement range if repeated



# PN results with GPF stay below Euro 6c limit on NEDC and WLTC

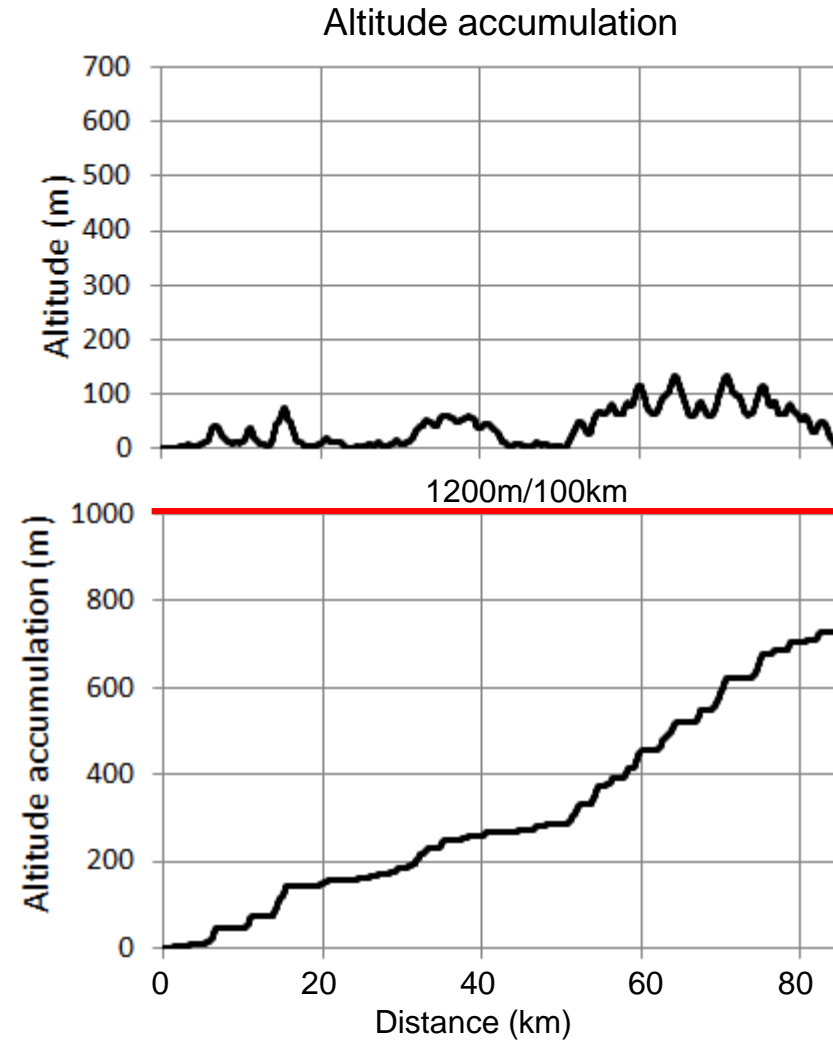
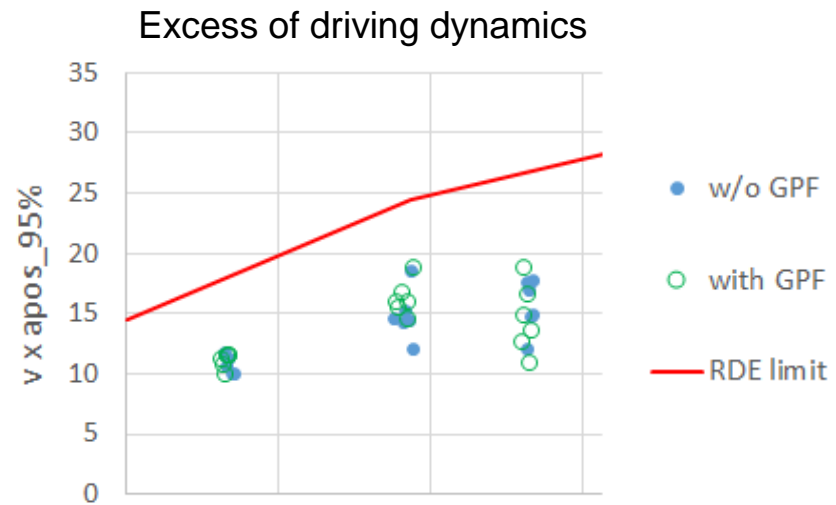
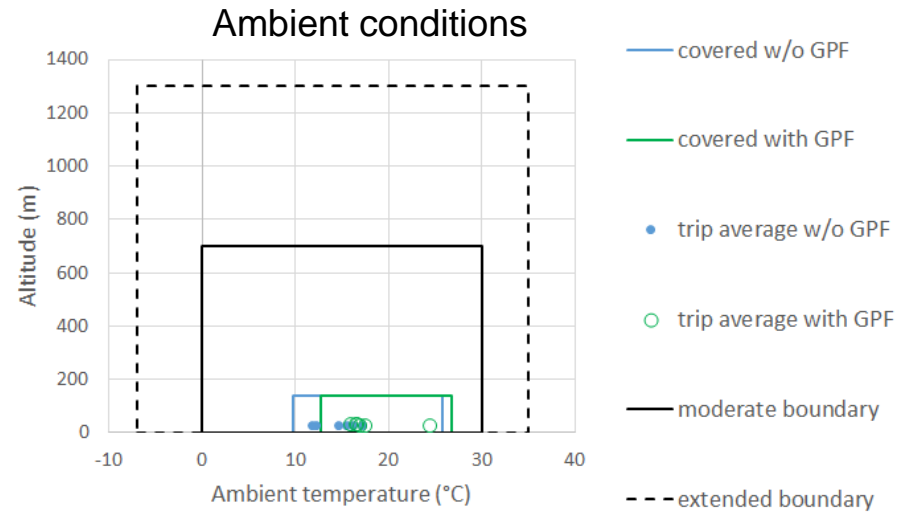


# PM emissions are well below Euro 6c limit on NEDC and WLTC, no measurable difference between two vehicle configurations

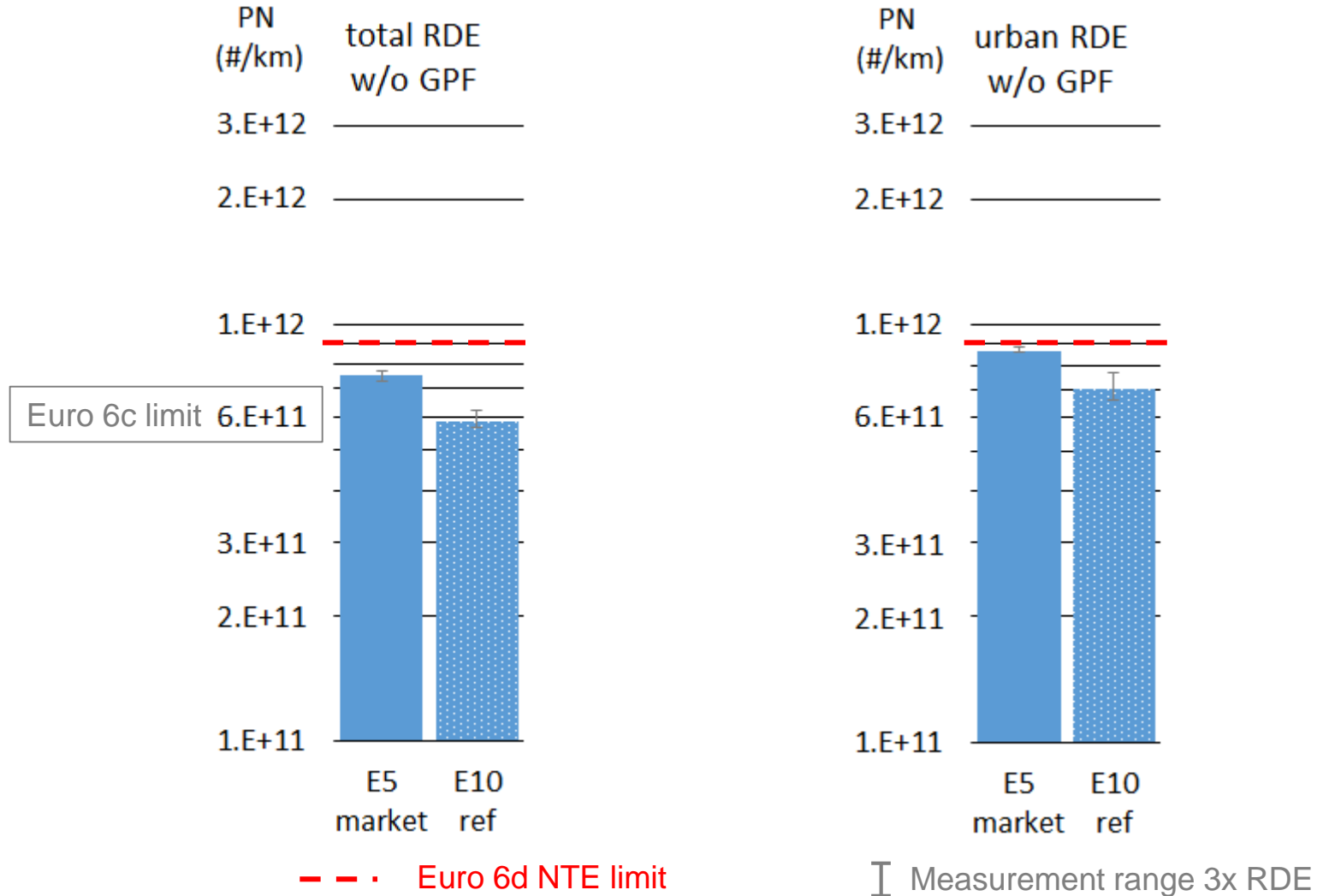


- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- **Real-Driving Particulate Emissions (RDE)**
  - On the road
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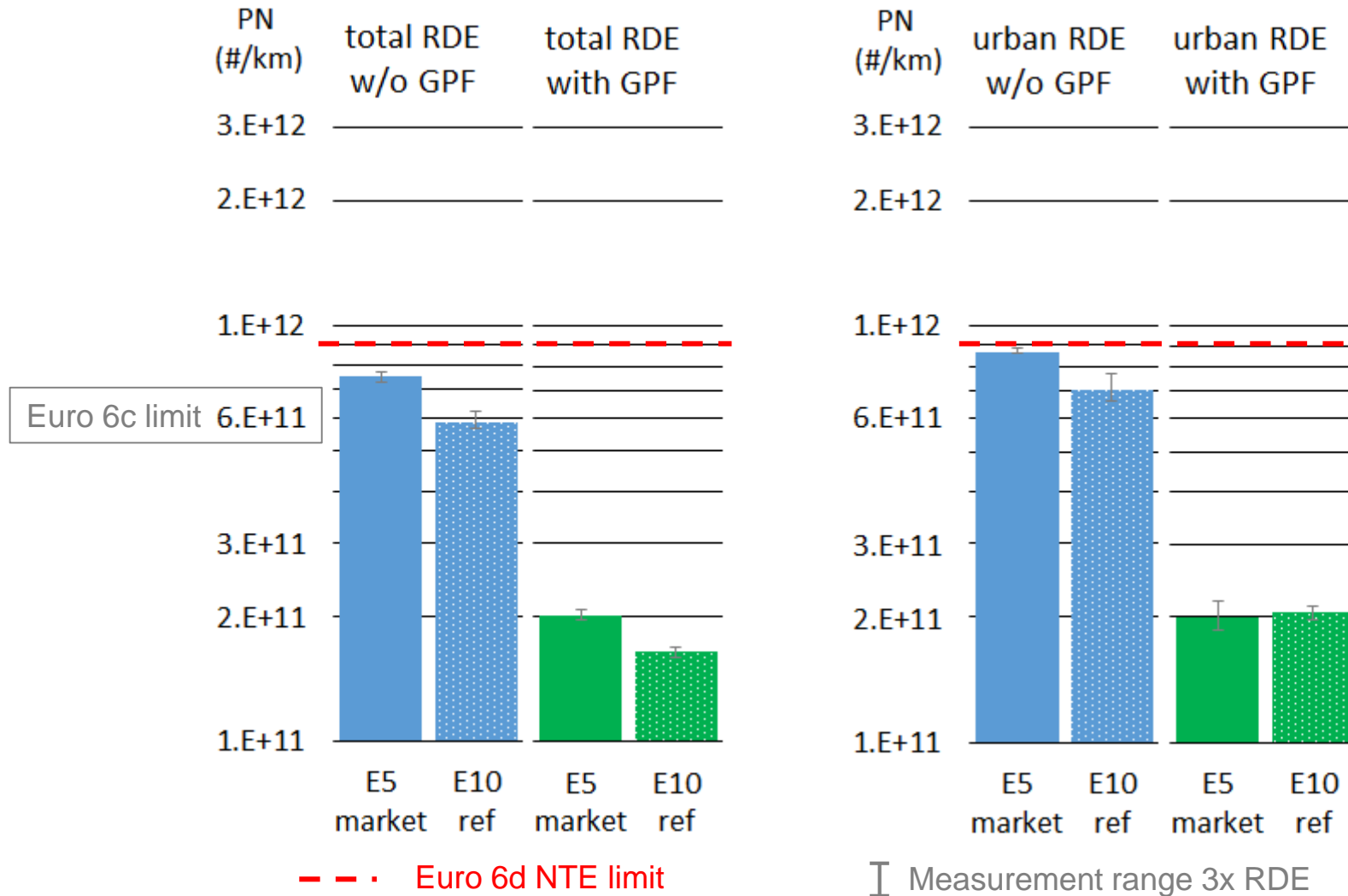
# Measured data are within the RDE boundary conditions



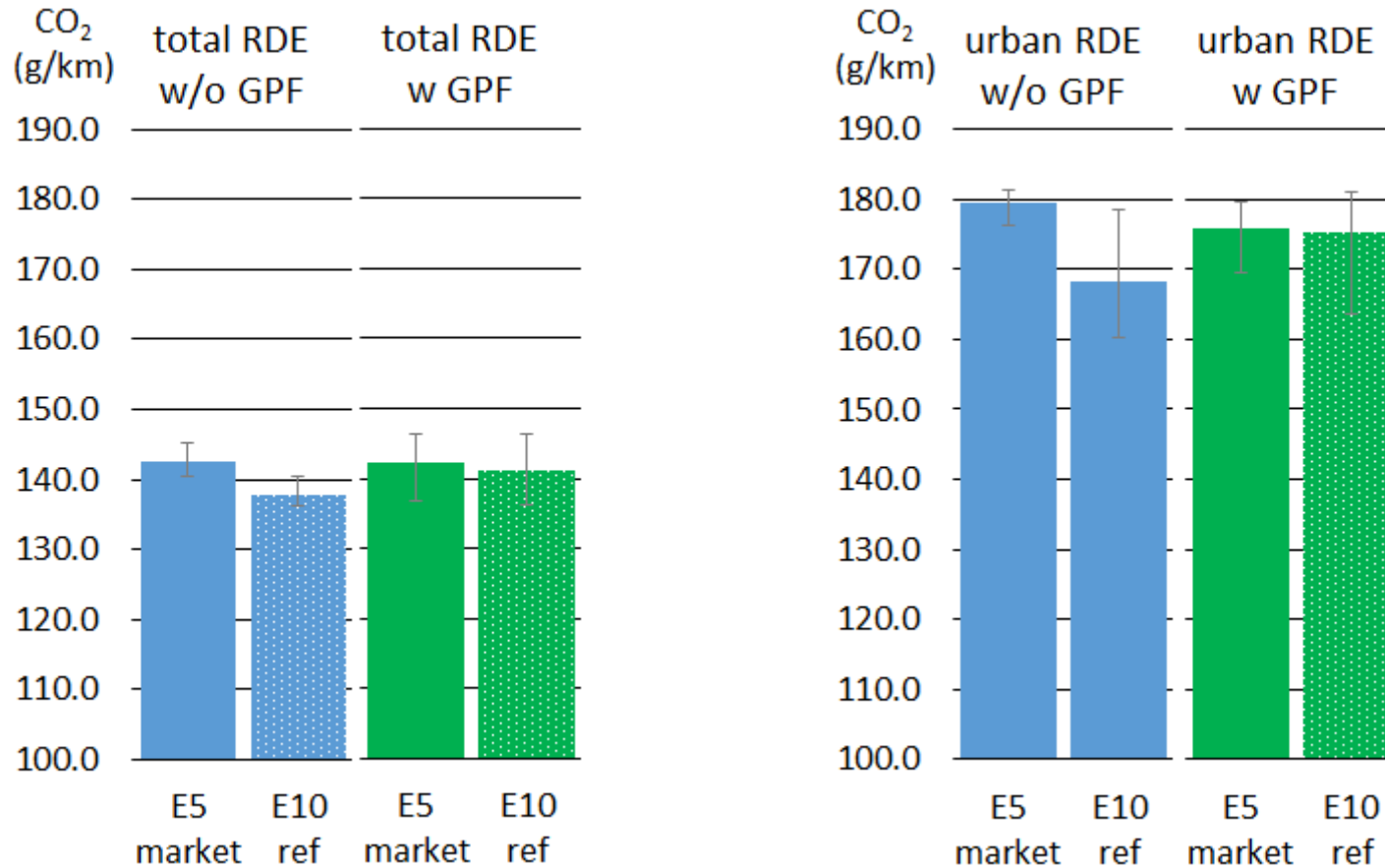
# PN results w/o GPF increase towards Euro 6d NTE limit on the road



# PN results with GPF are well below Euro 6d NTE limit on the road



# No CO<sub>2</sub> penalty was measured for the GPF on the road



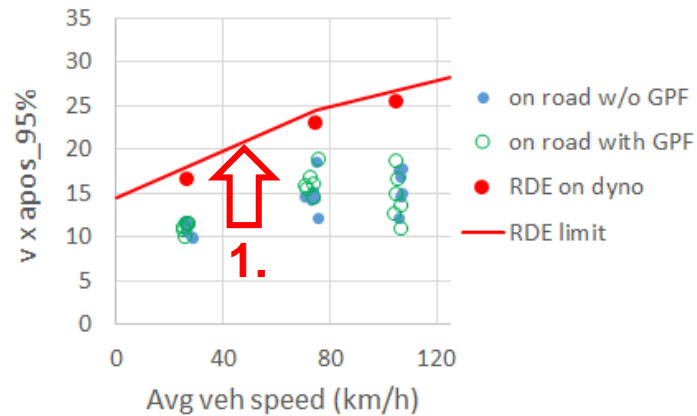
I Measurement range 3x RDE

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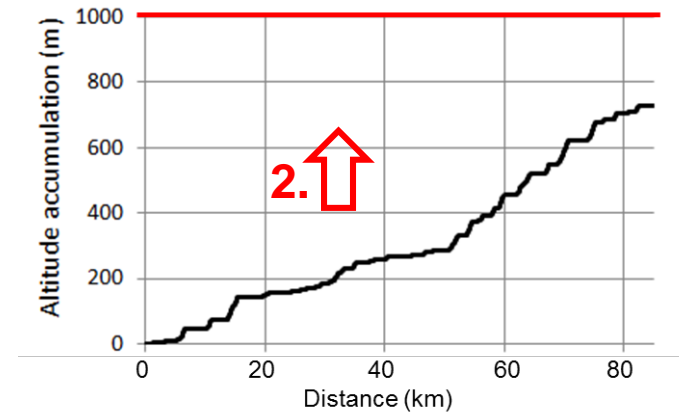


# RDE on dyno to investigate impact of going towards RDE boundary conditions

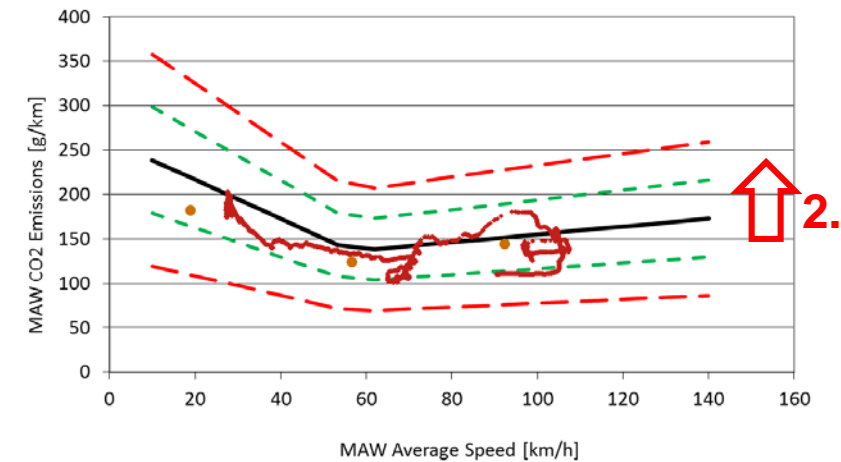
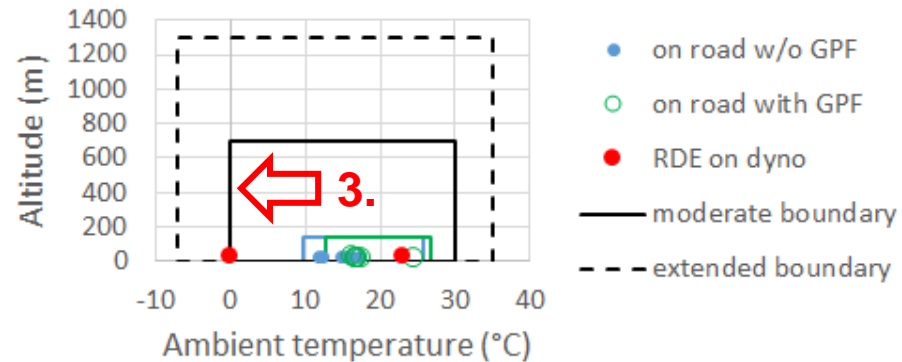
## 1. Change accelerations



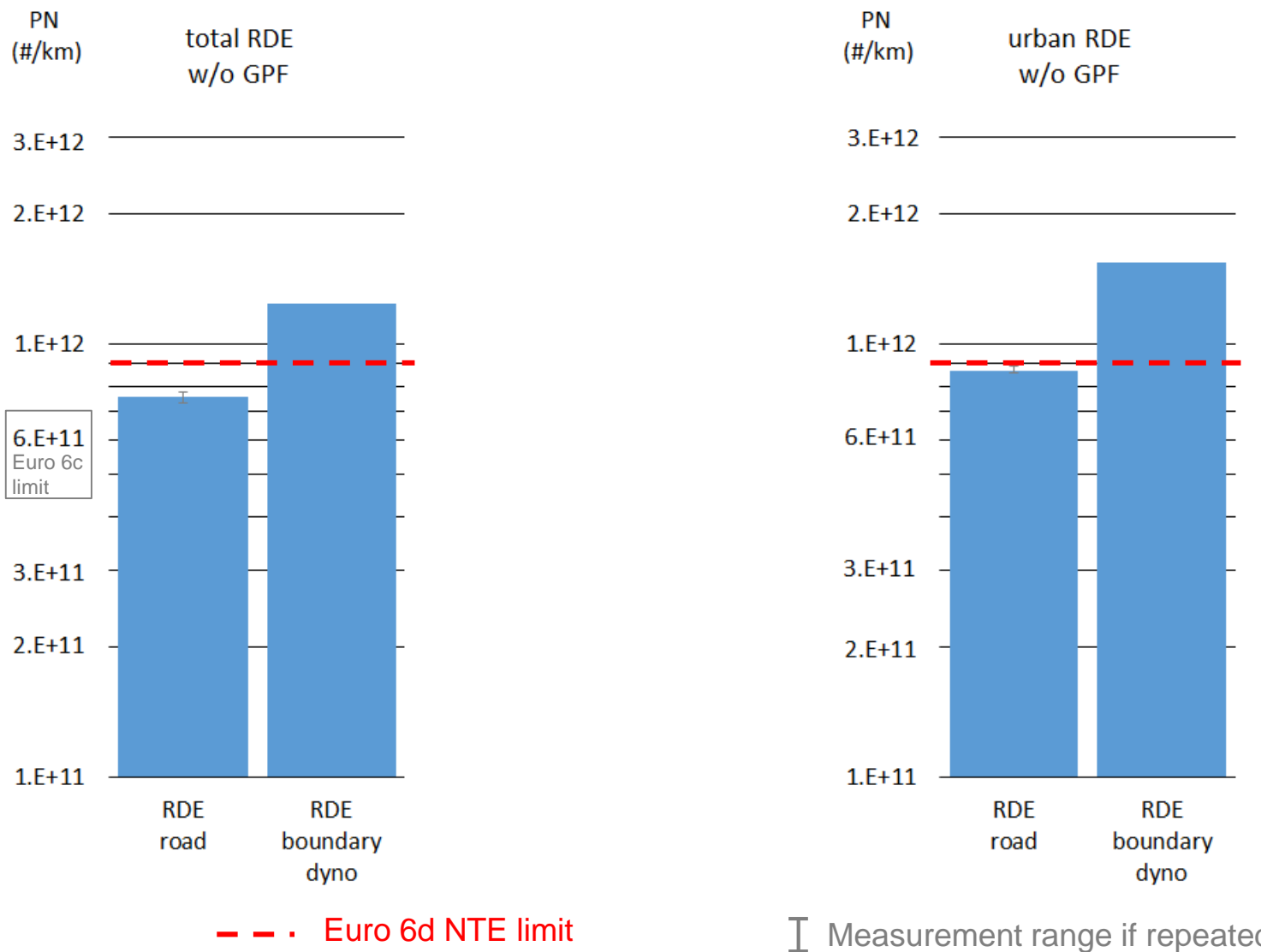
## 2. Change dyno load



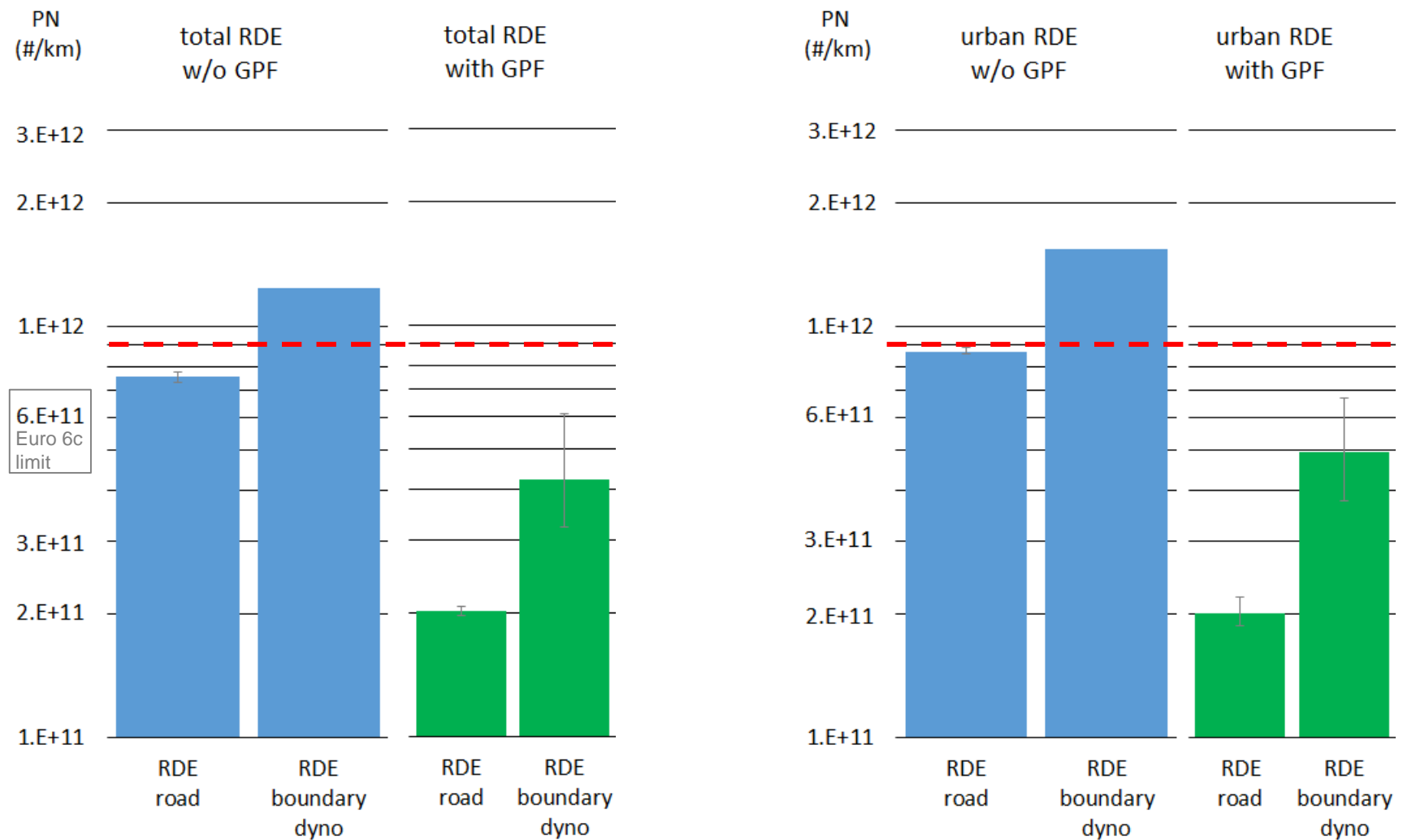
## 3. Change ambient temperature



# PN results w/o GPF increase above Euro 6d NTE limit towards RDE boundary conditions



# PN results with GPF remain below Euro 6d NTE limit towards RDE boundary conditions

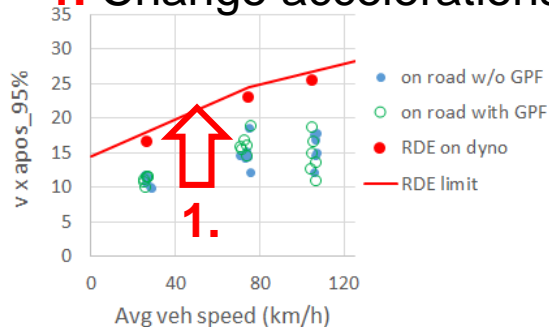


--- Euro 6d NTE limit

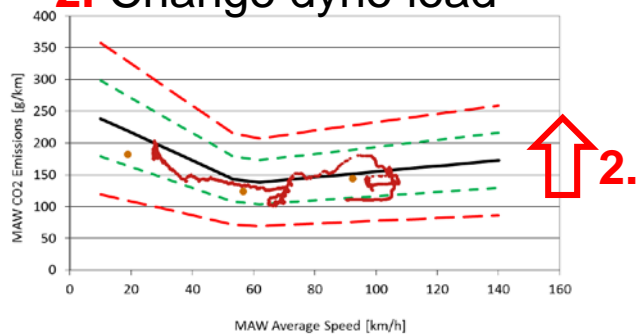
I Measurement range if repeated

# All PM results remain significantly below 4.5 mg/km towards RDE boundary conditions

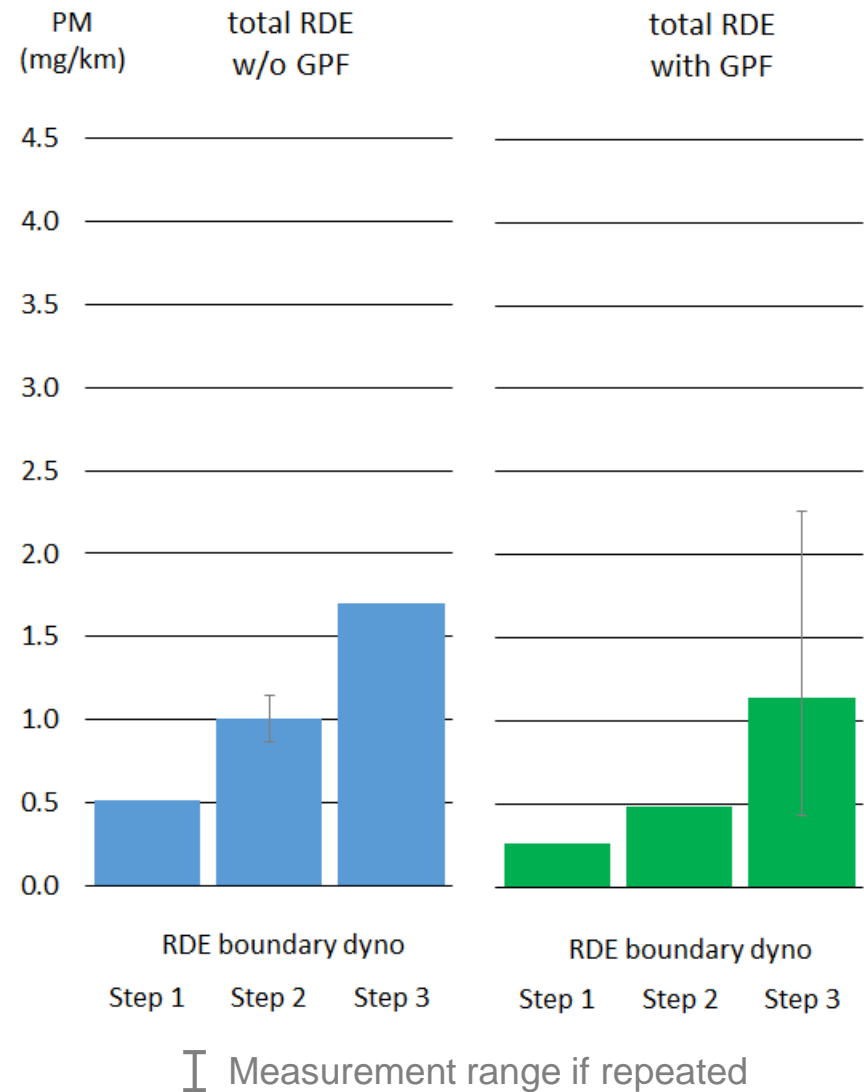
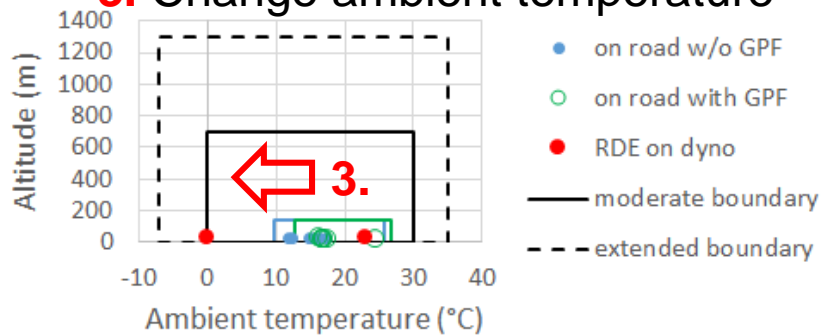
## 1. Change accelerations



## 2. Change dyno load



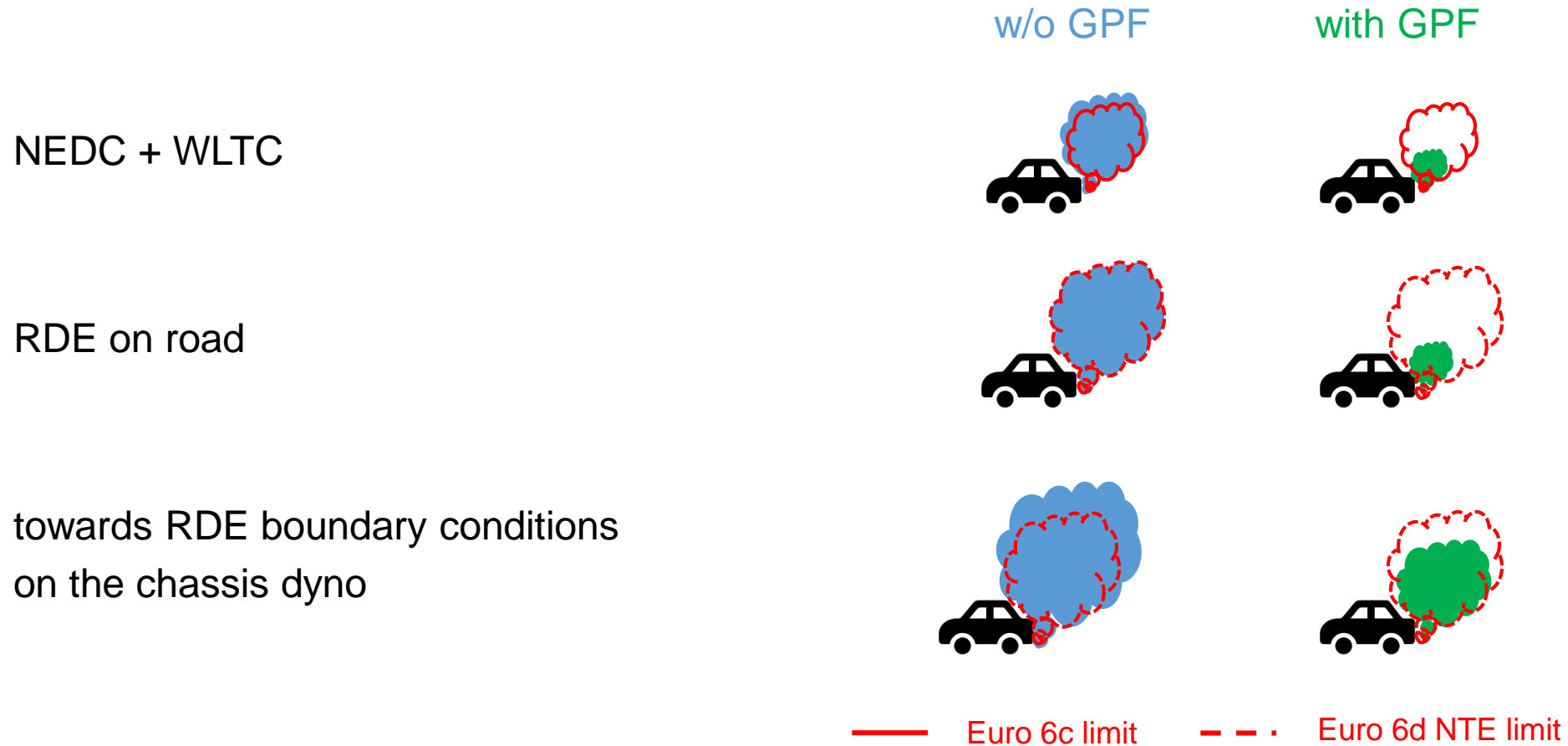
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# Conclusion

RDE PN emissions from a Euro 6b GDI vehicle were measured with and without a GPF



# Thank you for your attention!

- Acknowledgements
  - AECC members for funding and supporting
  - Concawe for working in partnership
  - Ricardo for testing and data analysis
  
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