

# Real-world NOx emissions of Stage V NRMM

Joachim Demuynck, Dirk Bosteels, AECC

GEME meeting • Brussels • 20 September 2024



# AECC is now the Association for Emissions Control and Climate

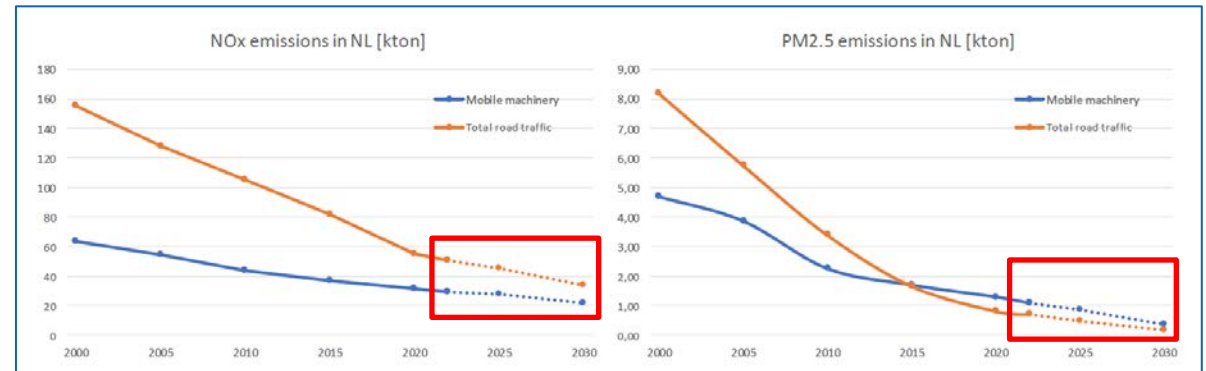
- AECC expands its scope
  - Air quality and **climate** requirements
  - Mobile and **stationary** emissions sources
  - Sustainable **components and systems**, including
    - Catalysts
    - Filters
    - Adsorbers
    - Fuel cells
    - Electrolysers
- AECC is listed in EU Transparency Register (# 78711786419-61) and has consultative status with the UN Economic and Social Council (ECOSOC)



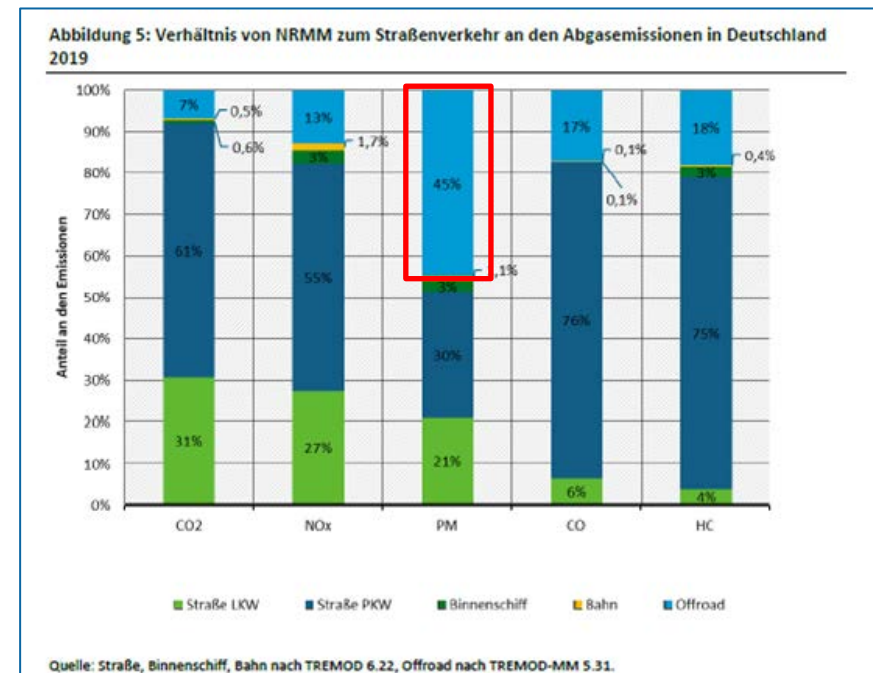


# Increasing contribution of NRMM to air quality impact

➤ In the Netherlands, [GRPE presentation](#), 2023



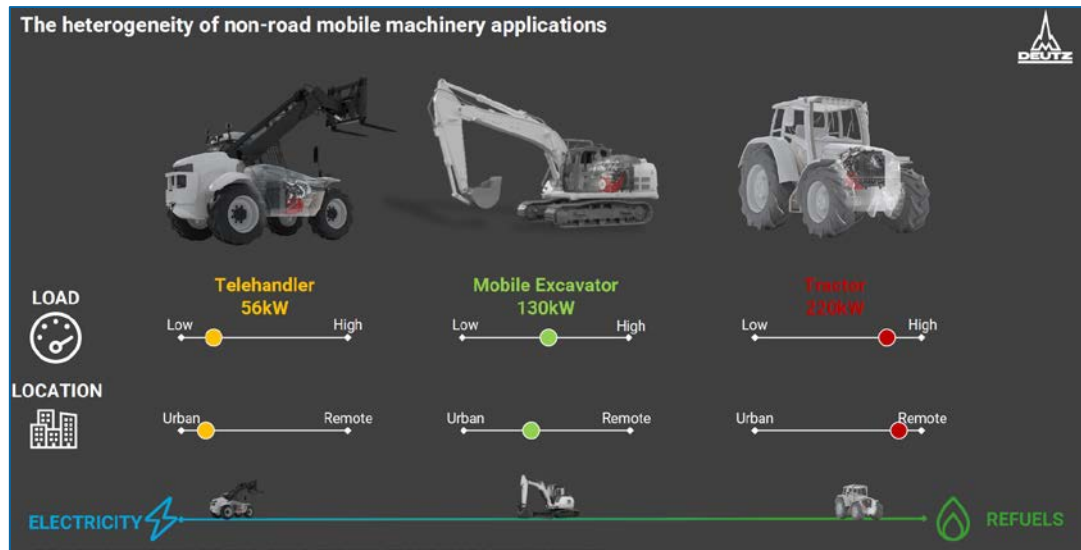
➤ In Germany, [UBA report](#), 2023



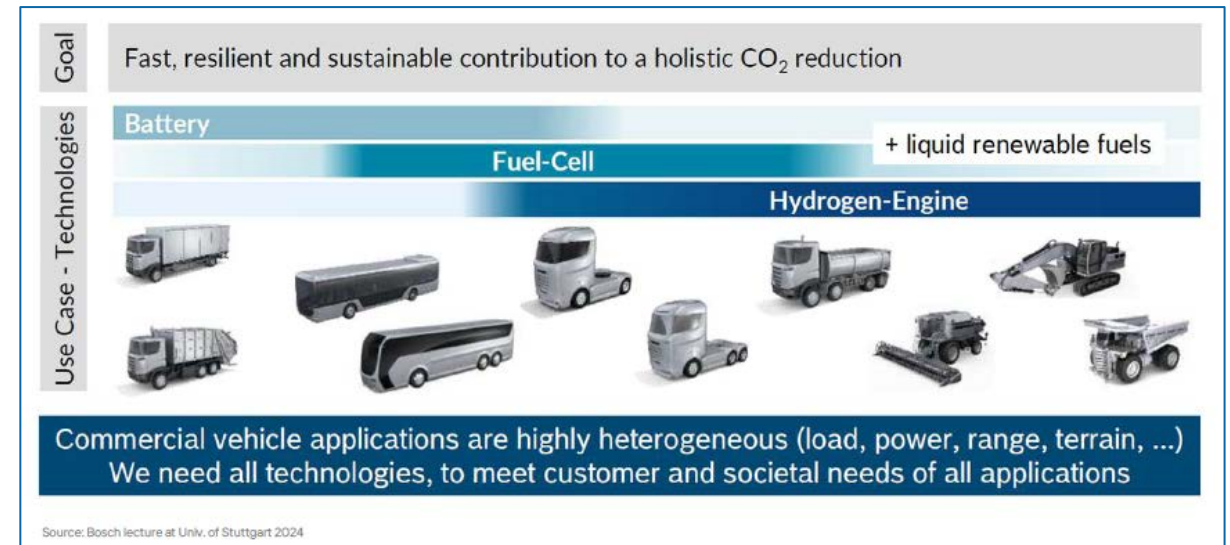


# All powertrain technologies needed towards net-zero CO<sub>2</sub>

- Internal Combustion Engine (ICE) remains key for the NRMM use cases
- Different sustainable renewable fuels are investigated to reduce the carbon footprint



Deutz, Baden-Baden, 2024

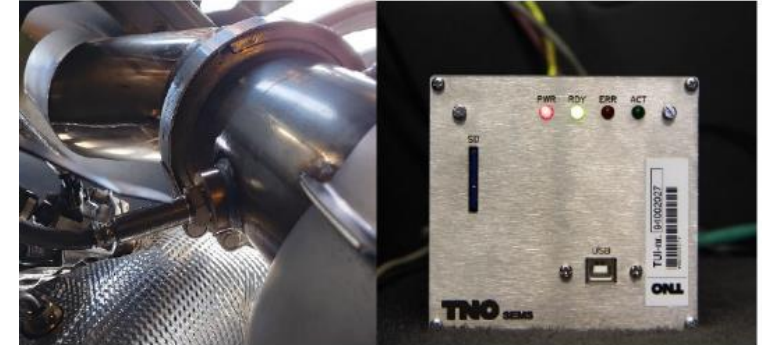
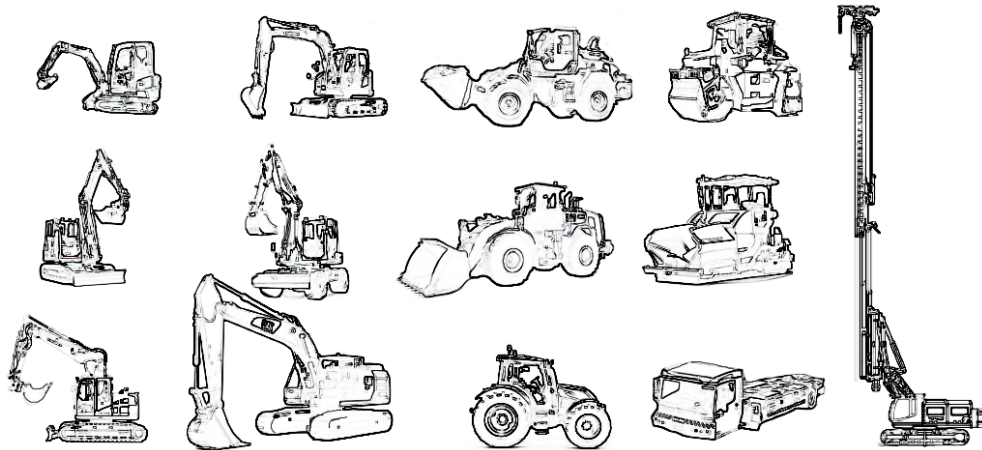


Bosch, lecture at Univ. Stuttgart, 2024



# Scope and objective of the NRMM study

- Investigate NO<sub>x</sub> emissions of NRMM during operation in the field
- Database of 13 Stage IV and V machines
  - Available data from projects of the Dutch Ministry of Infrastructure and Water Management
  - SEMS measurements done by TNO during daily operation in the Netherlands on range of categories
  - AECC asked TNO to apply new analysis on entire database



Further details available in: R. Vermeulen, et al.; [“Real-World NO<sub>x</sub> emissions of Stage V NRMM”](#), Transport and Air Pollution Conference, 2023

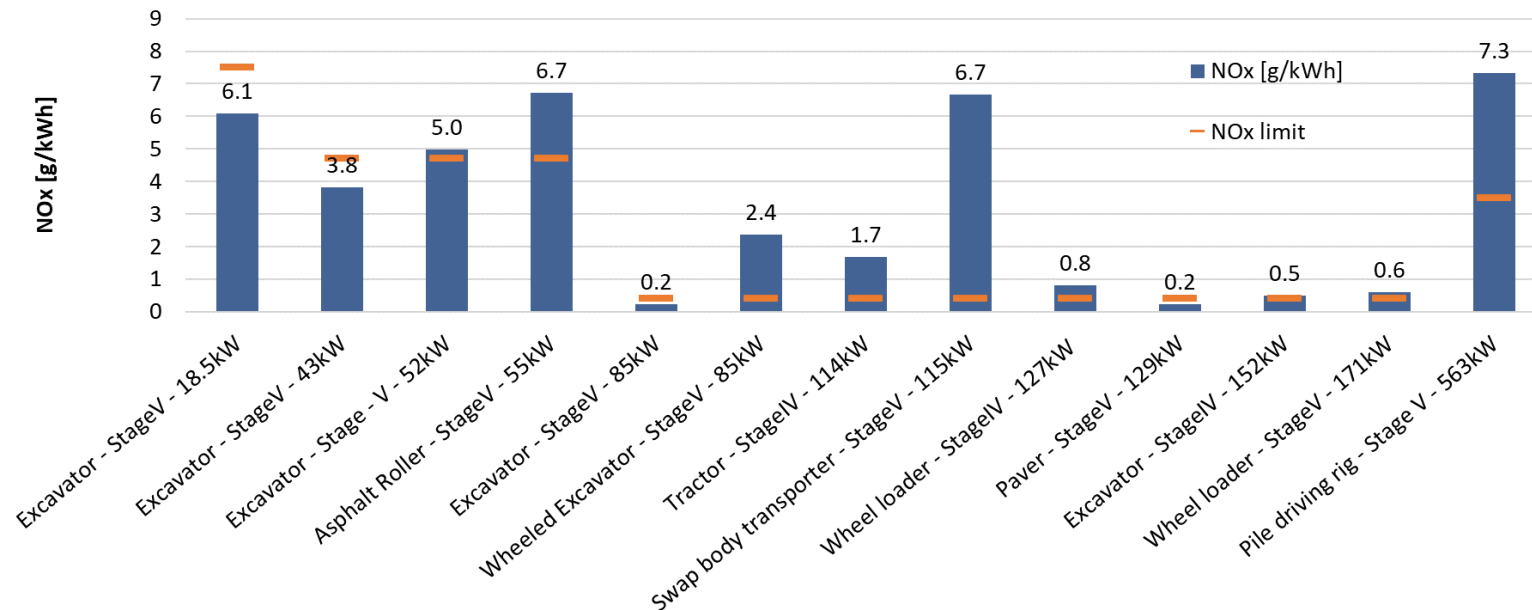
SEMS: Smart Emissions Measurement Systems





# A large variation is observed in real-world NOx emissions

- Main category NRE-v-5 and NRE-v-6
  - 4 machines with average NOx emissions below or around the limit set for the engine cycle
  - 4 machines with significantly higher average NOx emissions
- NOx emissions are around the higher engine cycle limit for the lower power categories
- The example of the high-power category (pile driving rig) shows high NOx emissions





# Investigation of distribution of emissions

➤ Application of Moving Average Window (MAW) post-processing methodology

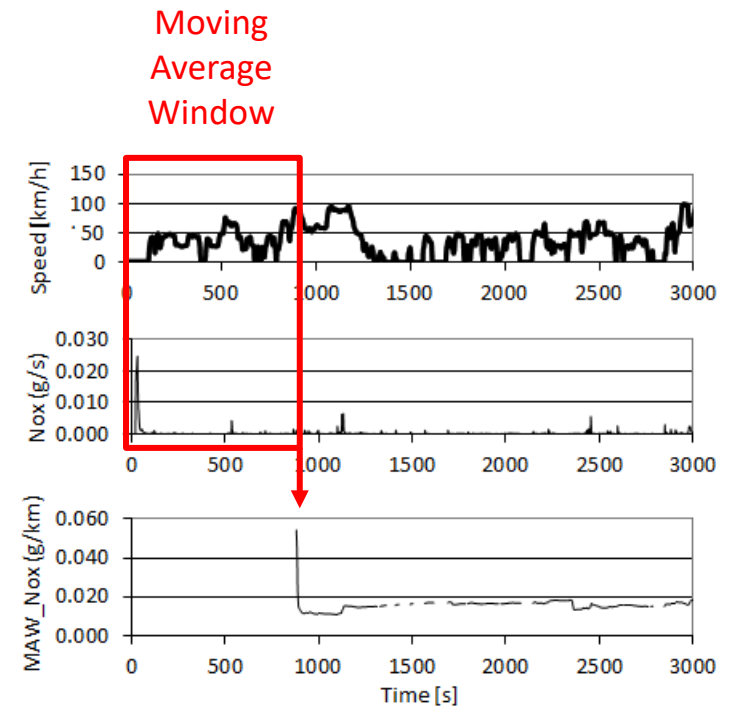
➤ According to In-Service Monitoring procedures

➤ Invalid data

- Non-working events
  - For example, for  $< 10\%$  power, cold-start,  $< -7\text{ }^{\circ}\text{C}$ , ...
  - Merging of short working events
  - Take off after long non-working event
- Invalid MAW if average power  $< 20\%$

➤ Valid data

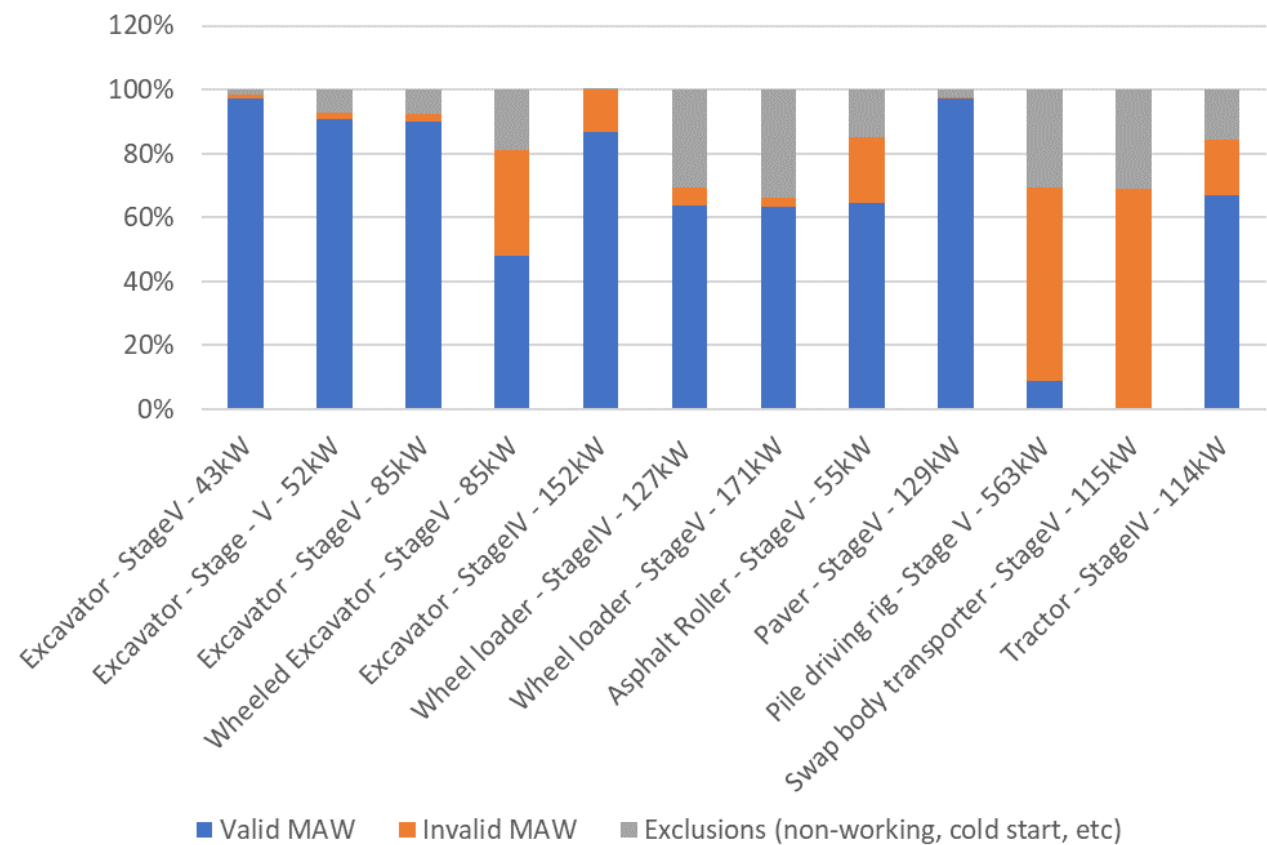
- Remaining valid windows
- Should be  $> 50\%$  of MAWs





# Investigation of distribution of emissions

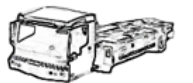
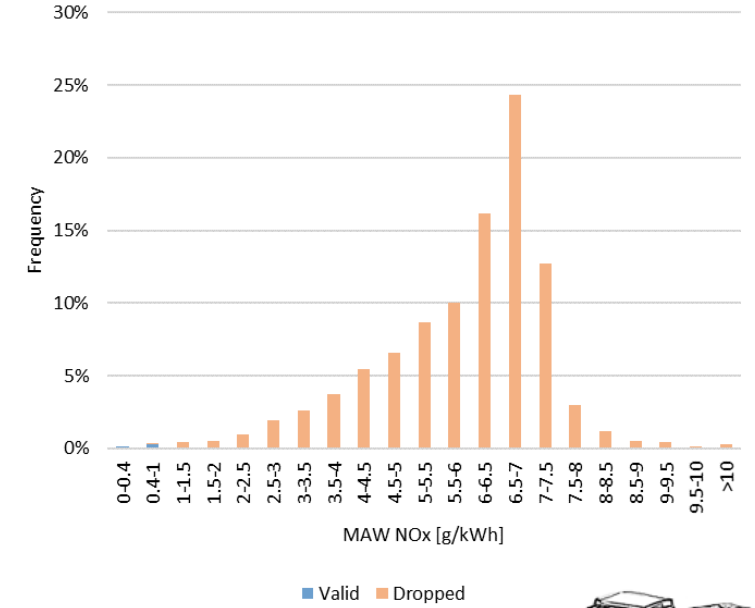
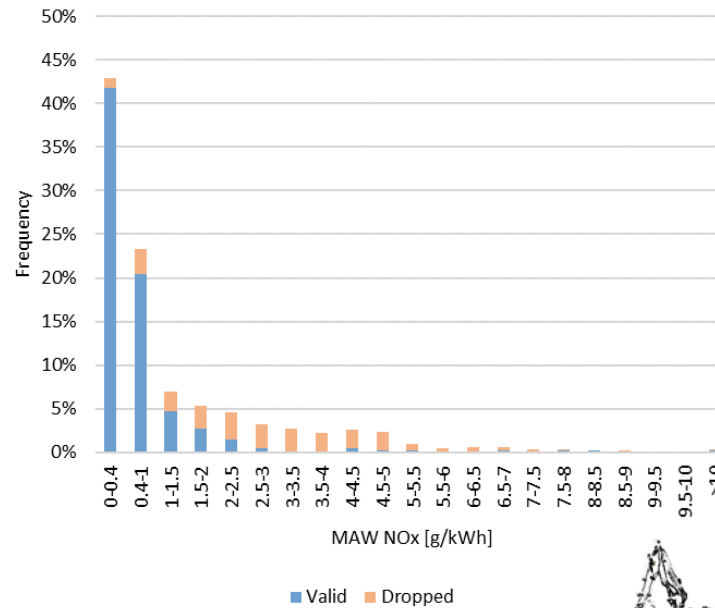
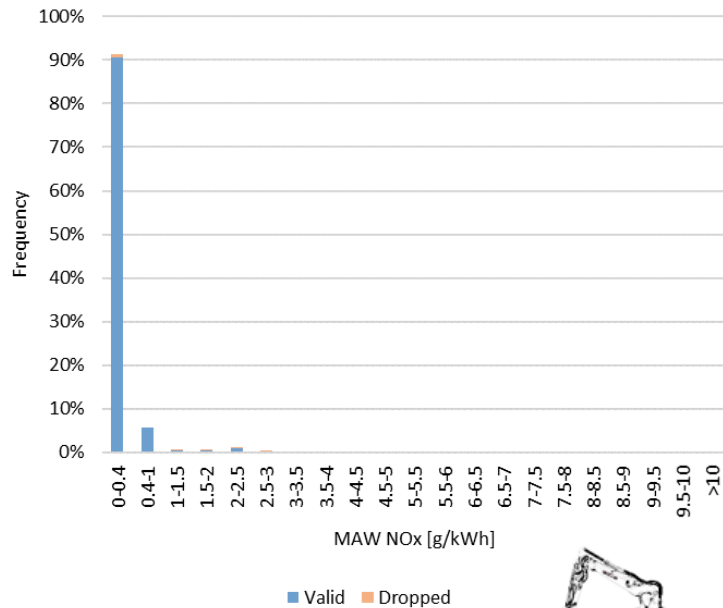
➤ Excluded data can be significant for some applications investigated





# A large variation is observed in real-world NOx emissions

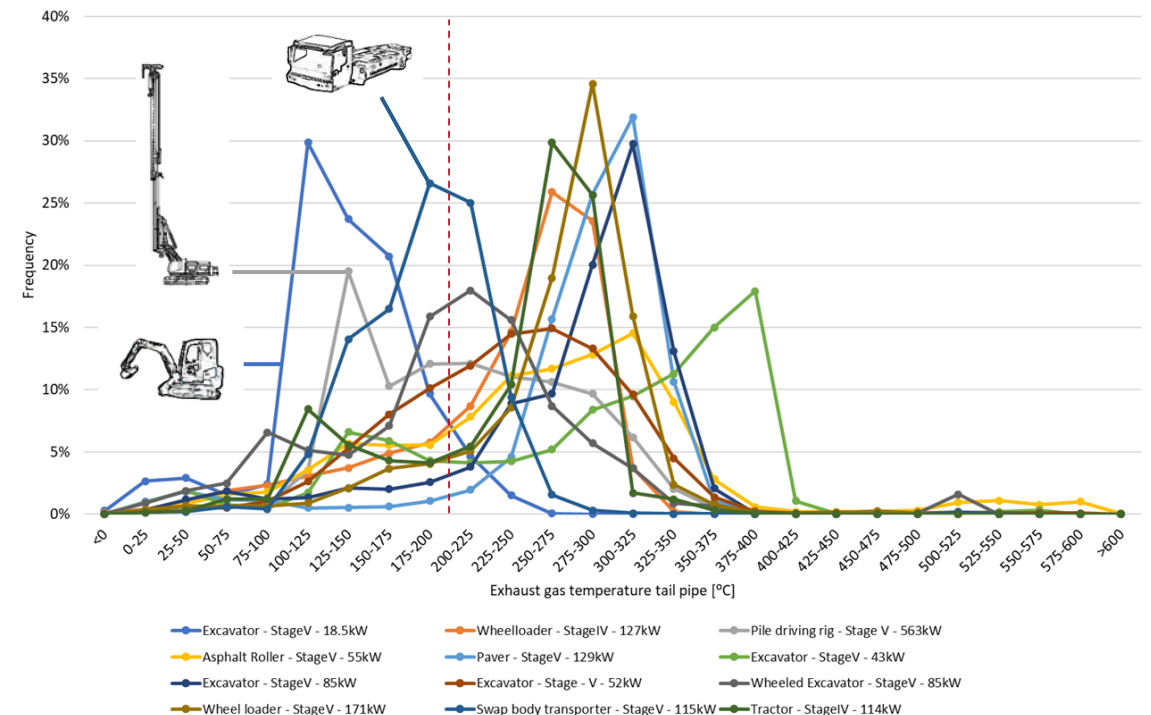
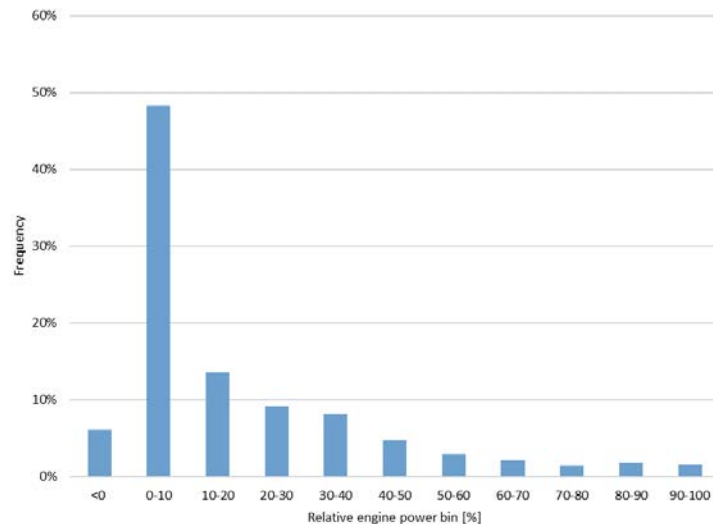
- 3 examples from the database to illustrate
  - Majority of valid MAWs is below 1 g/kWh
  - Distribution can have a tail of emissions up to 10 g/kWh
- Nearly all data from the transporter is not considered by the monitoring provisions





# Potential root causes for higher NOx emissions

- Some applications with higher emission limits are not equipped with SCR
- Significant amount of low engine power operation
  - 68% of data < 20% of rated power
  - 37% of data < 200 °C exhaust gas temperature (no or limited urea dosing)





# Summary and outlook

- There are many NRMM types and their use pattern varies significantly
- A large variation is observed in real-world NO<sub>x</sub> emissions
  - Average emissions can be below the limit but were significantly above in several examples
  - Distribution of emissions shows significant amount of high emission events
- NRMM regulation does not consider a substantial share of the real working conditions
- Future-proof ICE concept requires zero-impact pollutant and net-zero GHG emissions
  - Transition to CO<sub>2</sub>-neutral fuels needed to achieve net-zero CO<sub>2</sub> emissions
  - Potential emission control solutions for zero-impact pollutant emissions
    - NO<sub>x</sub> abatement with improved performance at low load operation
    - Introduction of SCR & DPF for low and high-powered diesel engines
  - AECC committed to support review of Stage V regulation with data from test projects



# THANK YOU



[www.aecc.eu](http://www.aecc.eu)



[@AECC\\_eu](https://twitter.com/AECC_eu)



[AECC EU](https://www.linkedin.com/company/aecc-eu)



[AECC eu](https://www.youtube.com/channel/UCv8v8v8v8v8v8v8v8v8v8v8)

