Aftertreatment Challenges for CNG as an Automotive and Engine Fuel

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Emission Controls Manufacturers Association

Who are we

- We are a non-profit Association, representing thirteen manufacturers of exhaust aftertreatment for mobile & stationary sources. We are comitted to collaboratively lead India towards Cleaner Air.

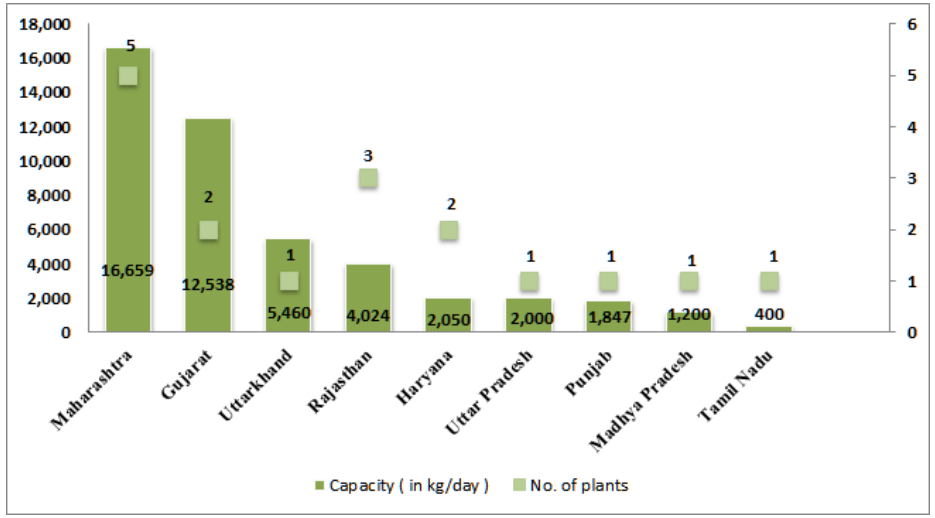
- We work with the Industry, Government Regulators, Oil Companies and the Public at large, to be a credible source of knowledge on emission control and we strive to increase awareness in emissions management by providing relevant technical solutions for this.

- We achieve this through assimilation of technologies, providing and disseminating knowledge enabling emission control. We hold Seminars and Conferences, pertaining to reducing pollution from automotive and powertrain exhaust sources

Prelude

- CNG as a fuel for automotive and stationary engine use is expected to grow in future.
- There are various reasons for this and not just the depletion of the fossil-fuel pool but also the abundance of CNG and the possibility for generating Bio-CNG from bio-waste.

Presently, there are seventeen Bio-CNG plants operational in India, with a combined capacity of 46,178 kg per day



Source Renewabkes Watck -https://bit.ly/2P4Koc4

- The perception of CNG as cleaner than other fossil and bio-fuels works in its favour.
- However as norms for emissions remain fuel neutral and become more stringent, CNG too needs exhaust aftertreatment tailored to specific requirements.

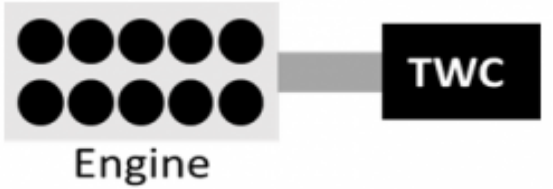
What is CNG

Gas Species	Concentration (vol. %)
Methane (CH_4)	90.0 ± 1.0
Ethane (C_2H_6)	4.0 ± 0.5
C_3 and Higher	2.0 ± 0.3
C_6 and Higher	0.2 max
Oxygen (O_2)	0.5 max
Inert Components (CO_2 and N_2)	3.5 ± 0.5
Hydrogen (H_2)	0.1 max
Carbon Monoxide (CO)	0.1 max
Sulfur (S)	16 ppm max

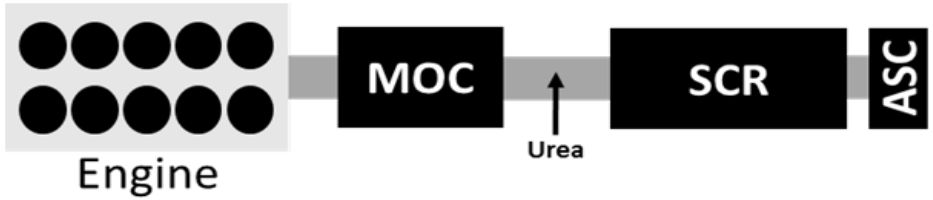
Major Green House GAS EMISSION
& Tough Species to Oxidise

Major Poisoning element for Catalyst

CNG Engine After Treatment System (ATS)

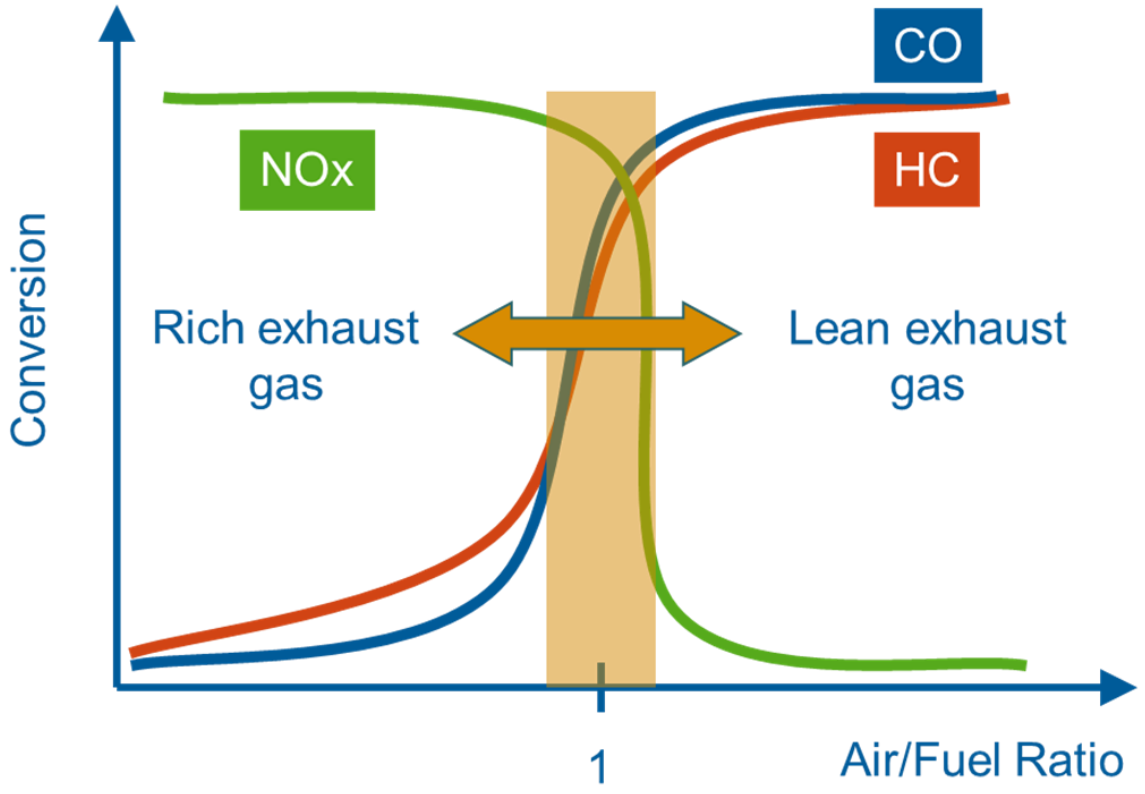


Emission conversion of Stoichiometric CNG engine can be carried out with a three-way catalyst (TWC)



Lean-burn conditions in CNG combustion requires more complex ATS to clean exhaust gases. Methane oxidation catalyst (MOC) converts CO and CH4 emissions and provides small quantities of NO2 for a selective catalytic reduction (SCR). The SCR converts NOx emissions with NH3 to N2 and H2O. An ammonia slip catalyst (ASC) prevents NH3 emission

CNG Operation & Challenges

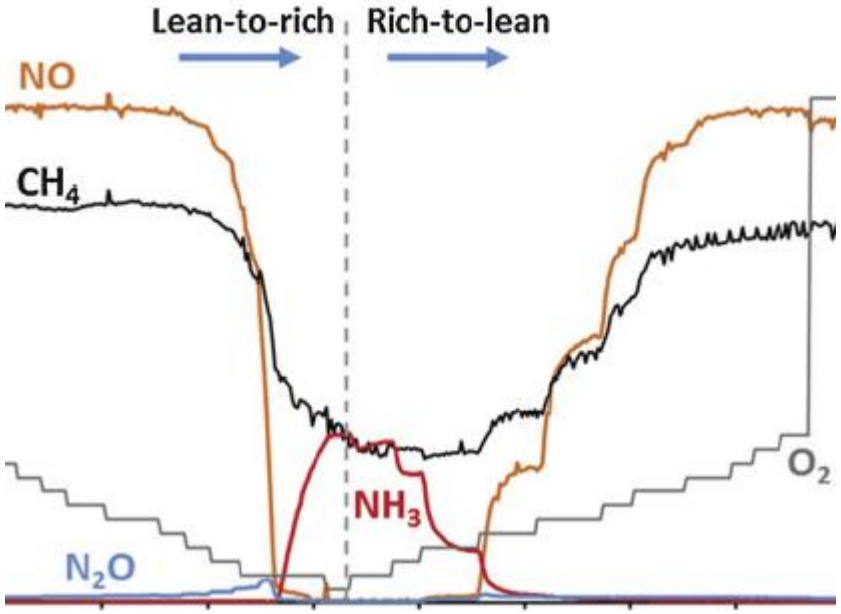


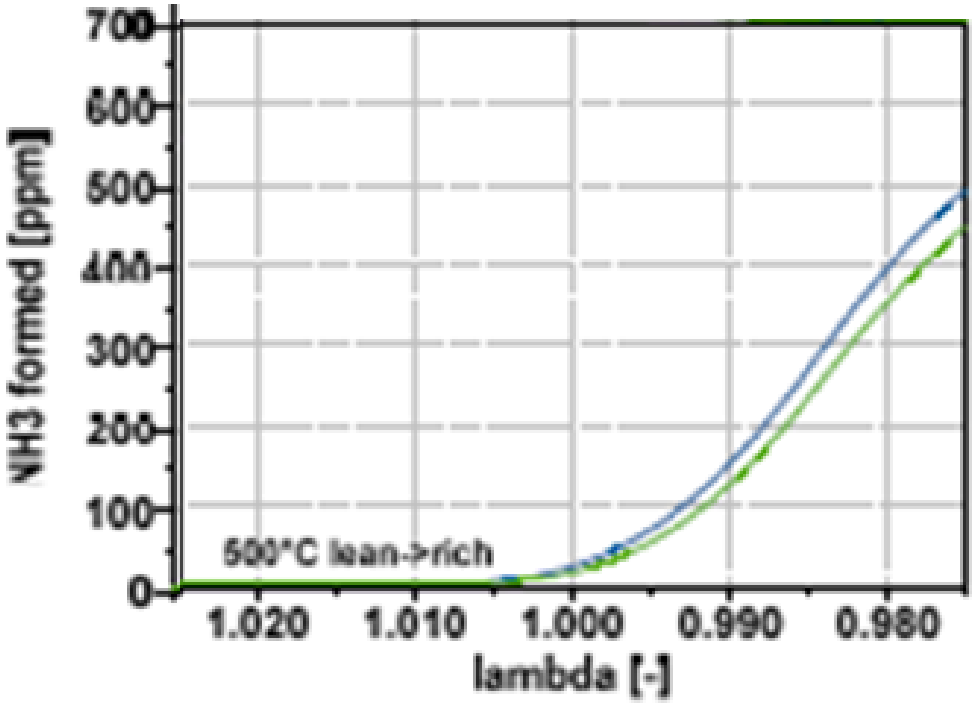
Major Challenges:-

- For BEST Conversion of all Species CNG must operate with Narrow band of Lambda window
- CH4 (GHG) is tough to oxidise if this window is wide
- $CH_4 + 2O_2 = CO_2 + 2H_2O$—Needs a Lot of Energy
- NOx control is more efficient with rich side and optimum lambda
- NH3 formation (For HD-CNG) is challenging during Lean-rich cycle
- OSC stability & Response

NH3-Challenges

2 NO+4 CO+2 H2O+H2→2 NH3+4 CO2
2 NO+5H2→2 NH3+2 H2O



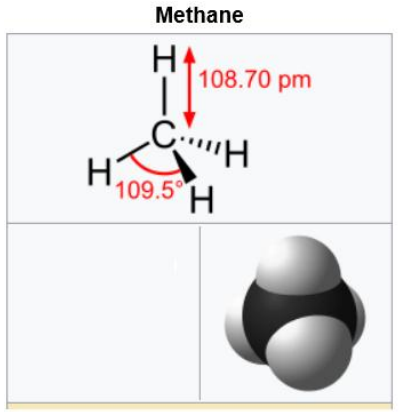


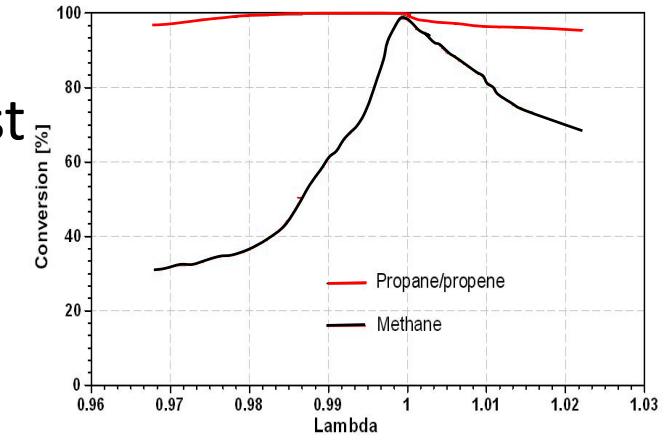
→ high Rh amount needed
→ calibration is crucial, good fit between calibration and catalyst needed

Pic. Ref: Applied Catalysis A, General 552 (2018) 30–37

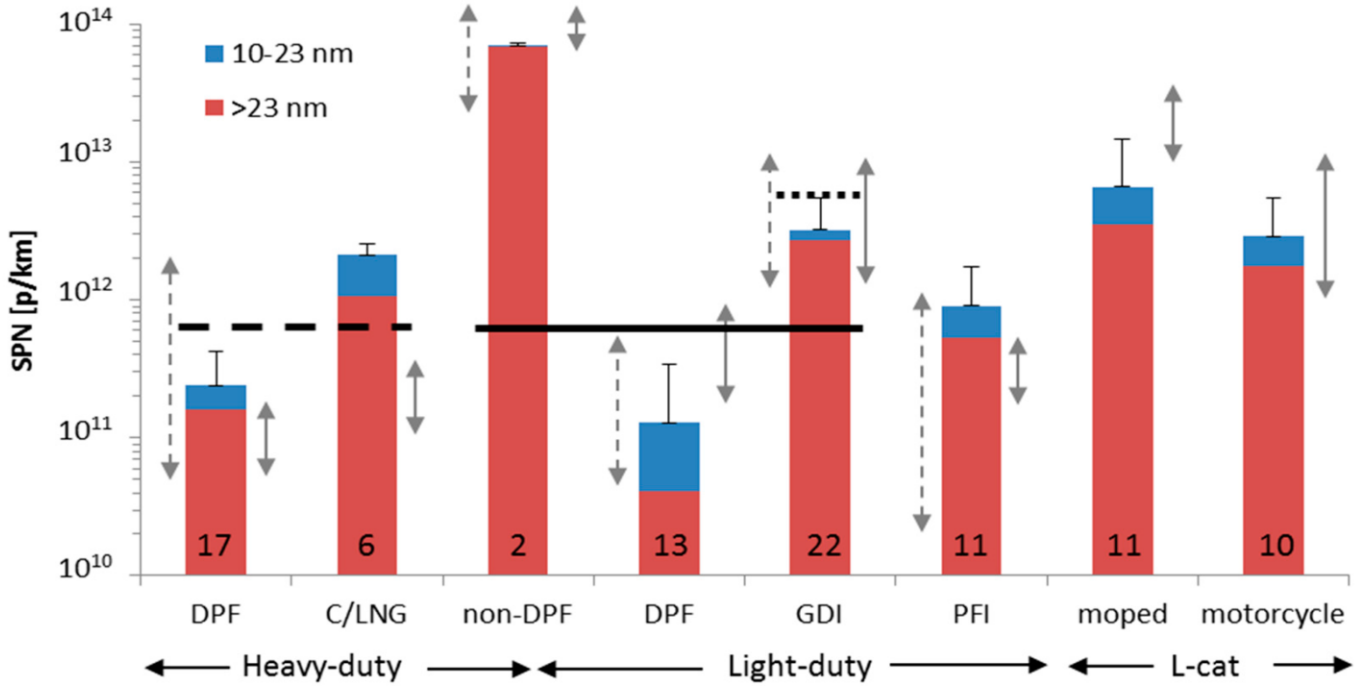
CH4-Challenges

- Lower exhaust gas temperature (compared to gasoline)
  → lower light-off necessary
- Trend from natural aspirated to turbo charged engines
  → even lower exhaust temperature
- λ = 1 – lambda window narrower due more complex methane molecule structure
  → high Pd amount needed
  → calibration is crucial, good fit between calibration and catalyst needed





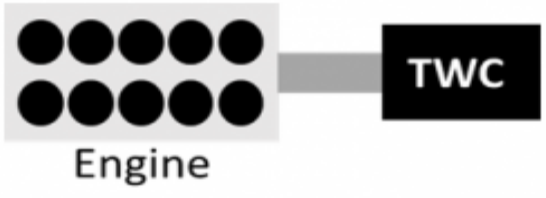
PN Challange

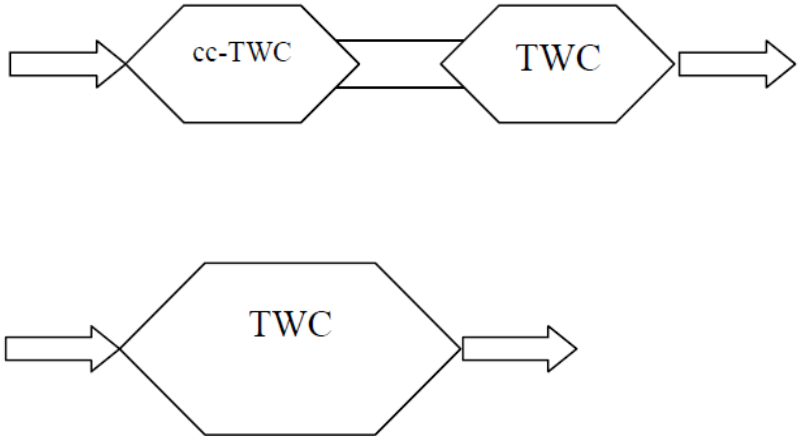


Overview of emission levels of different current vehicle categories. Dashed arrows on the left of the bars show reported range of an older SPN review [35]. Arrows on right shows suggested emission factors based on [68]. Error bars show one standard deviation (only positive side) for the number of vehicles shown in each bar. Horizontal lines give the European regulated SPN limits for SPN >23 nm. Note that for the GDIs of this figure the limit was 6×10^{12} p/km (dotted line). The dashed line shows a limit of 6×10^{11} p/km. However, the SPN limit applies only to heavy-duty engines (not vehicles) and is expressed in p/kWh. All tests at temperatures around 23 °C.

Ref: Int. J. Environ. Res. Public Health **2018**, 15, 304; doi:10.3390/ijerph15020304

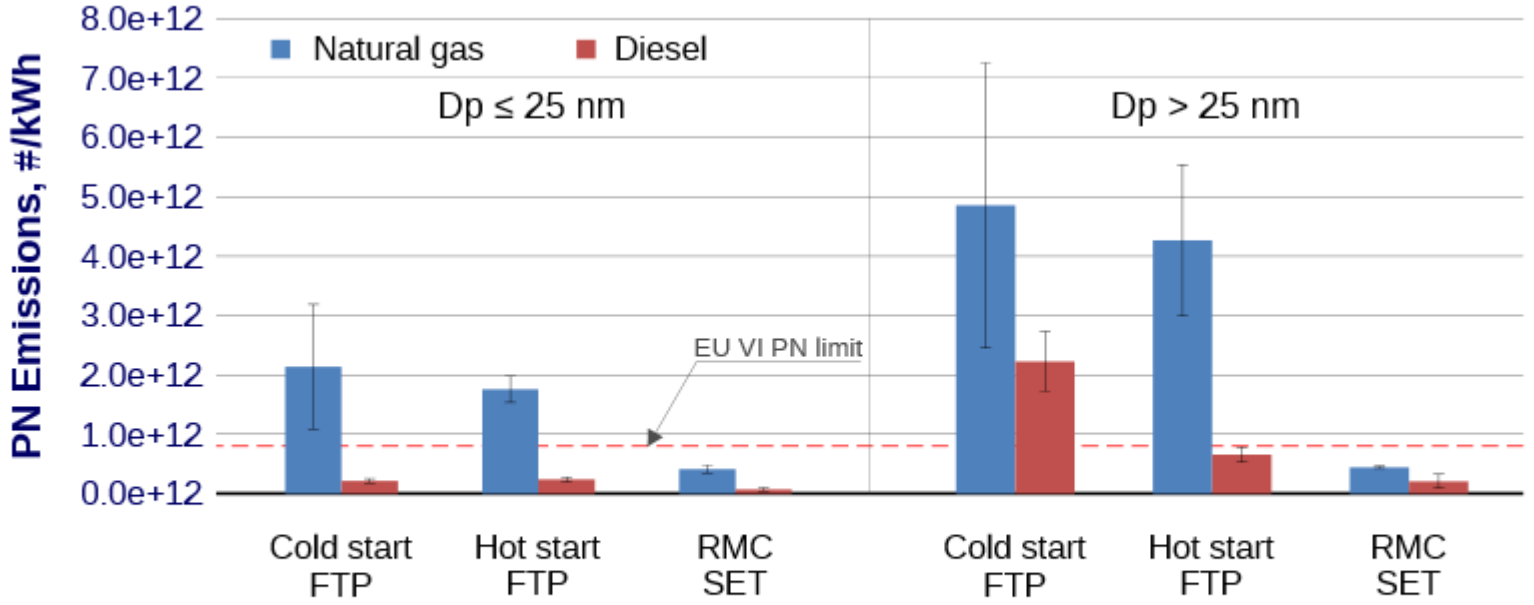
After Treatment for Particulate Control



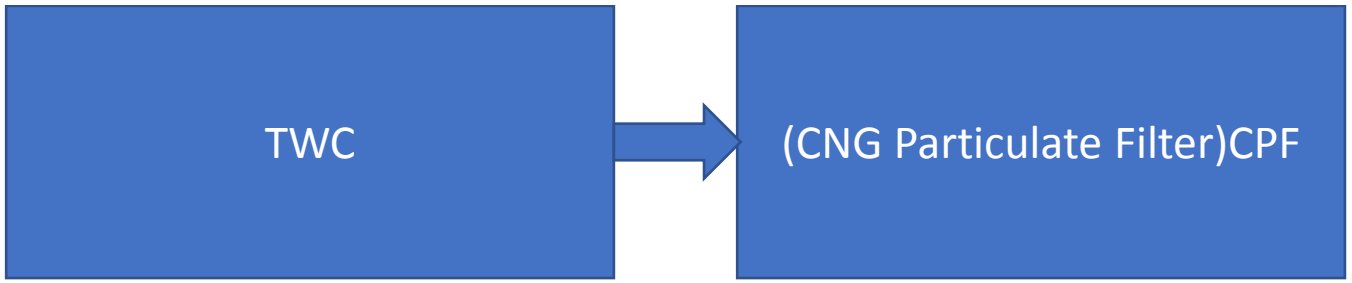


(CNG Particulate Filter)CPF

After Treatment Layout-For PN Reduction



3. Solid PN emissions from a CNG engine and a diesel engine with a DPF for particles below and above 25 nm



Our Member Companies

THANK YOU