CO Emissions from Gas Engines Fueled by Producer Gas

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CO Emissions from Gas Engines Fueled by Producer Gas

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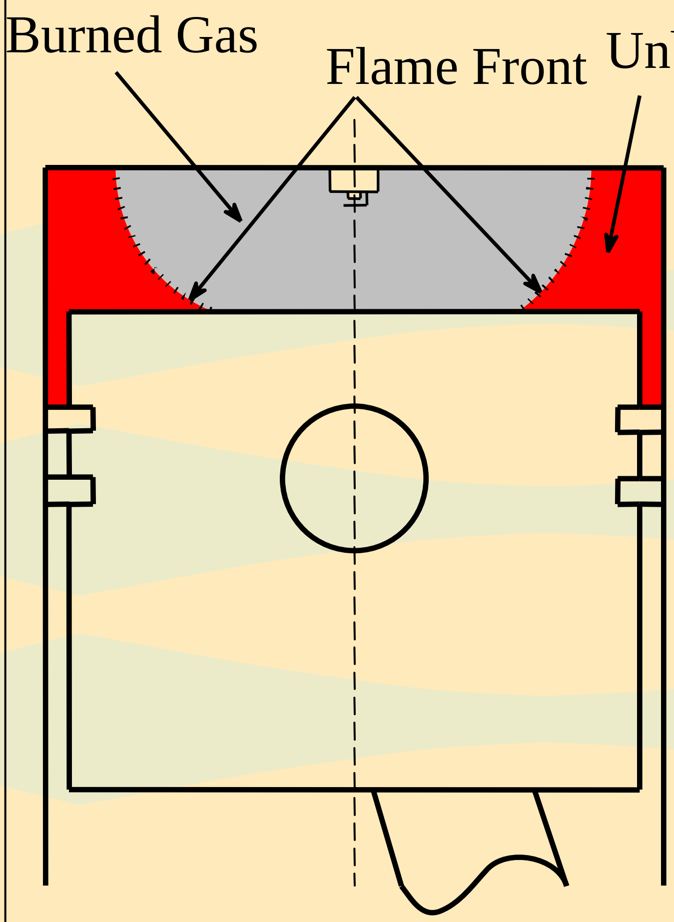
Agenda

- Nature of CO emissions formation in SI gas engines
- Experimental measurements
- Measurements from the Harboøre plant
- CO and global warming
- Conclusion

CO Emissions Formation from SI Gas Engines



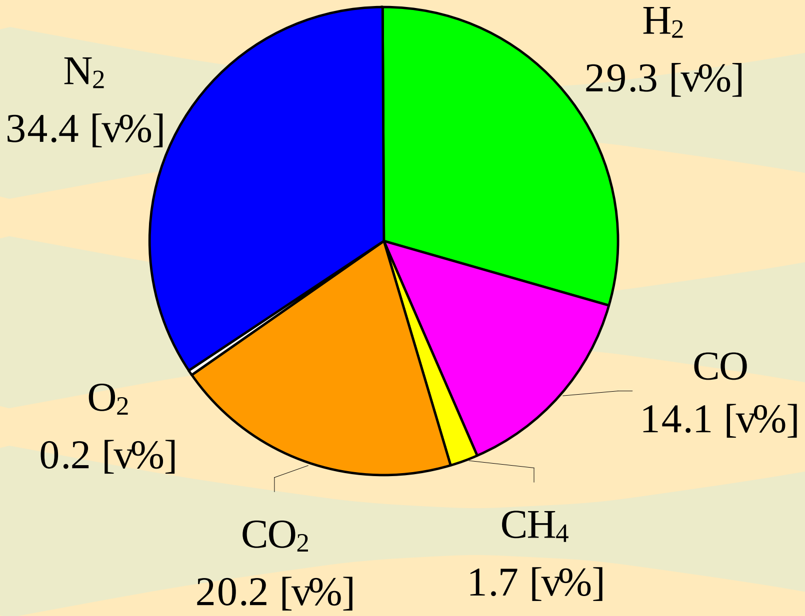
Governing factors:

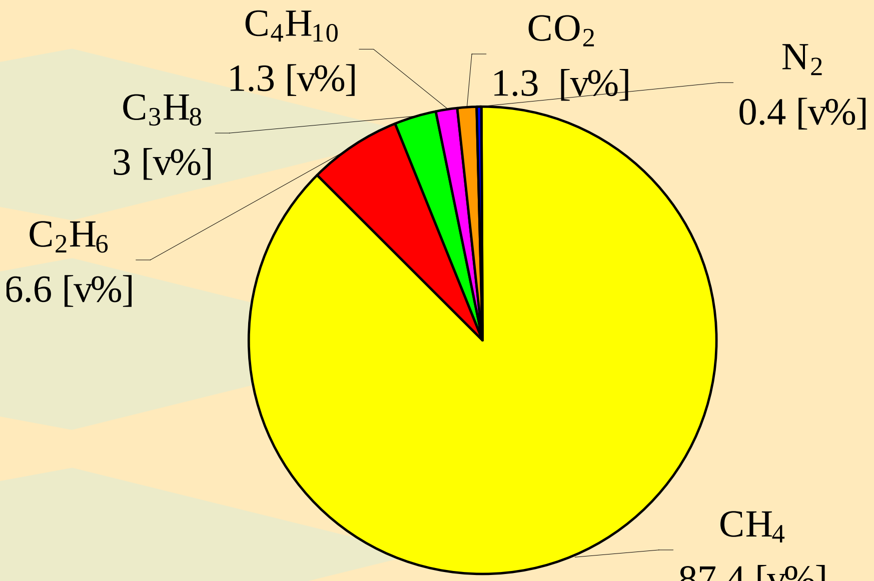
- Air-fuel ratio (λ)
    - Low combustion-end temperature ⇒ $CO + OH \not\rightarrow CO_2 + H$
    - Low flame speed ⇒ quenching of the flame ⇒ UHC or UCO
- Stoiciometric air-fuel ratio:
  NG=11:1 PG=1:1

Data for Test Engines

Engine data	BUKH	NISSAN
Bore	85 mm	108 mm
Stroke	85 mm	126 mm
Compression ratio	12:1	12.5:1
Valve per cylinder	2	2
Intake pressure	0.95 bar	0.70 bar
Ignition timing	MBT	-25 deg
Number of cylinders	1	4

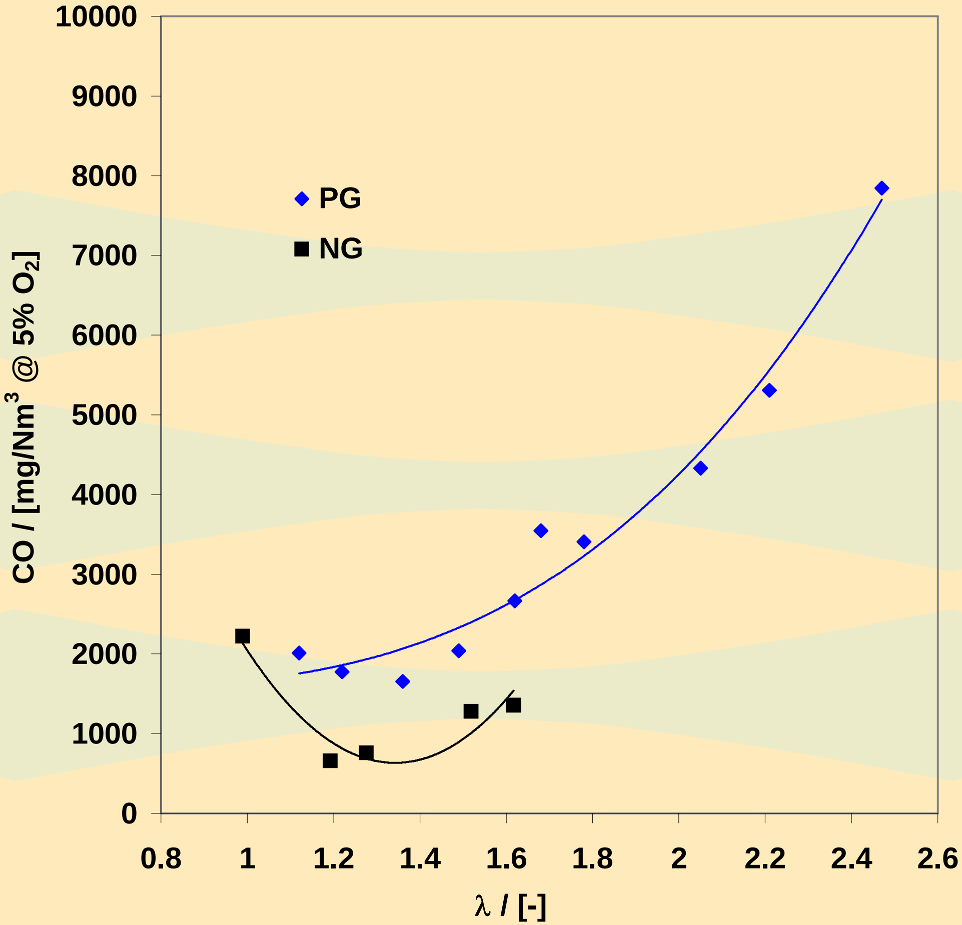
Gas Compositions





CO Emissions

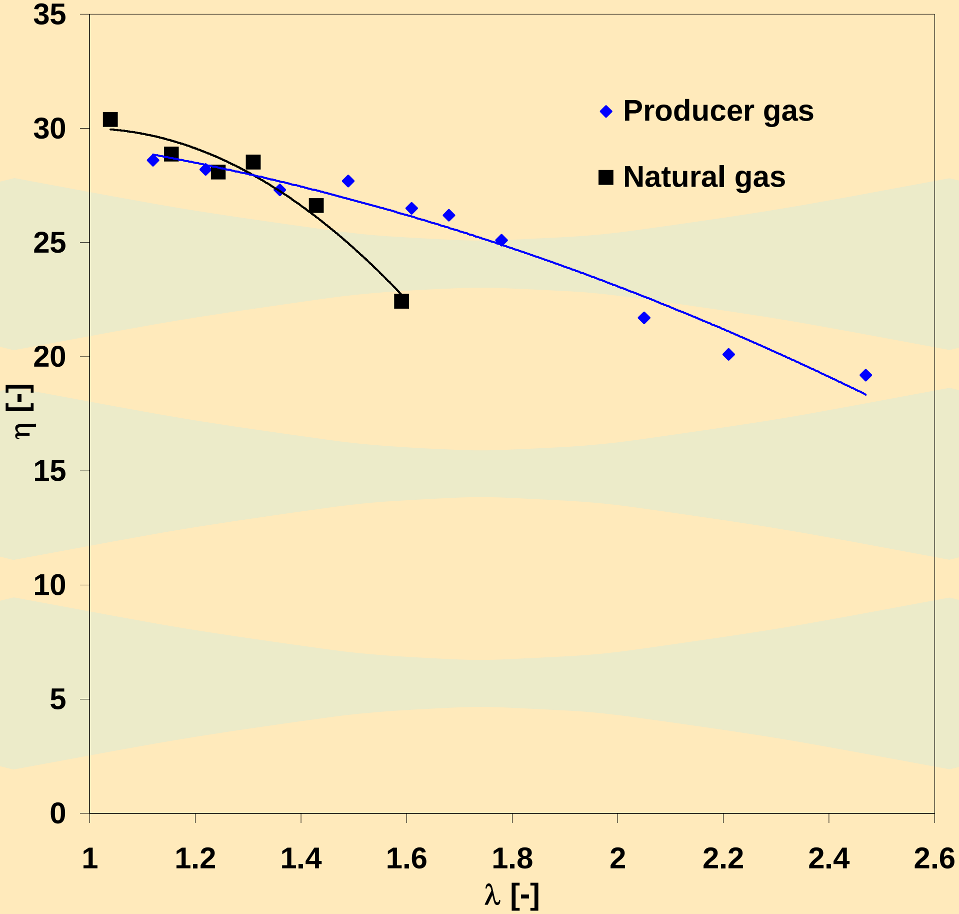
(Bukh)



- Strong λ dependency
- Overall high UCO emissions from PG

Break Efficiency

(Bukh)



- Excellent lean burn fuel
- Stable operation for 1<λ<3

Effect of PG Fuel-CO on CO Emissions

Fuels:

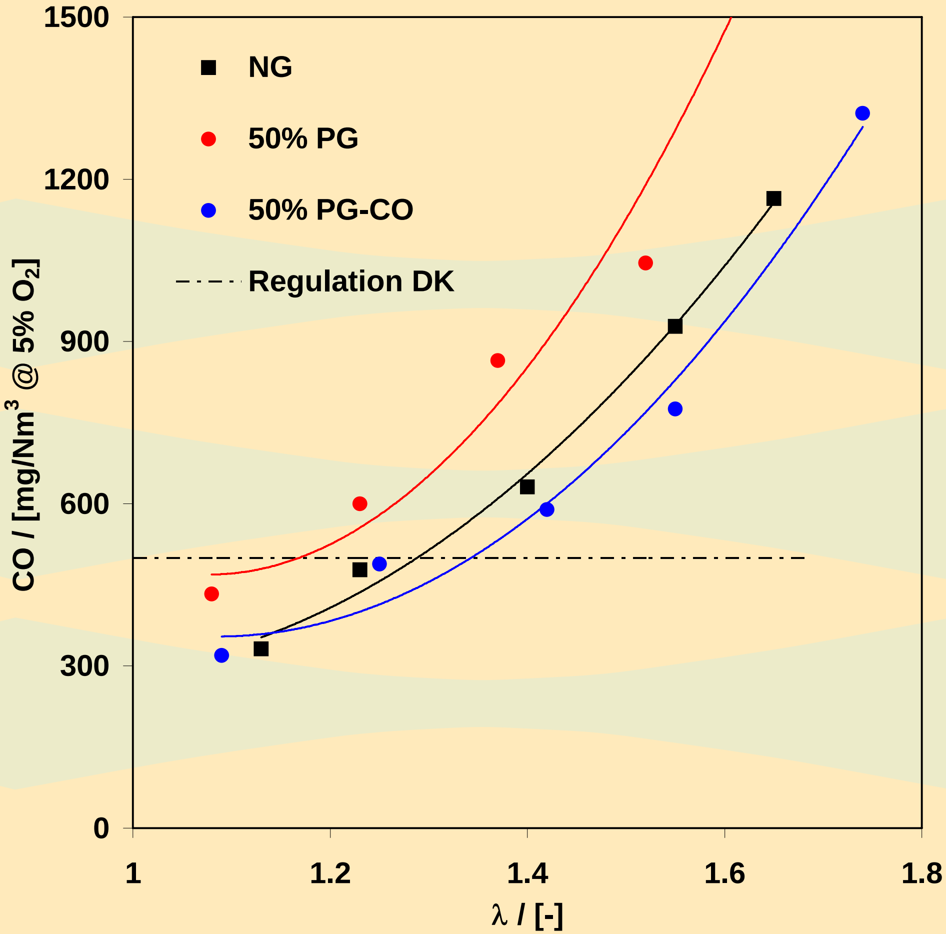
- Natural gas (NG)
- Mixture of 50%Vol. NG and 50%Vol. PG (50% PG)
- Mixture of 50%Vol. NG and 50%Vol. PG where the CO content has been replaced by N_2 (50% PG-CO).

Measurements:

- CO emission
- UHC emission

CO Emissions

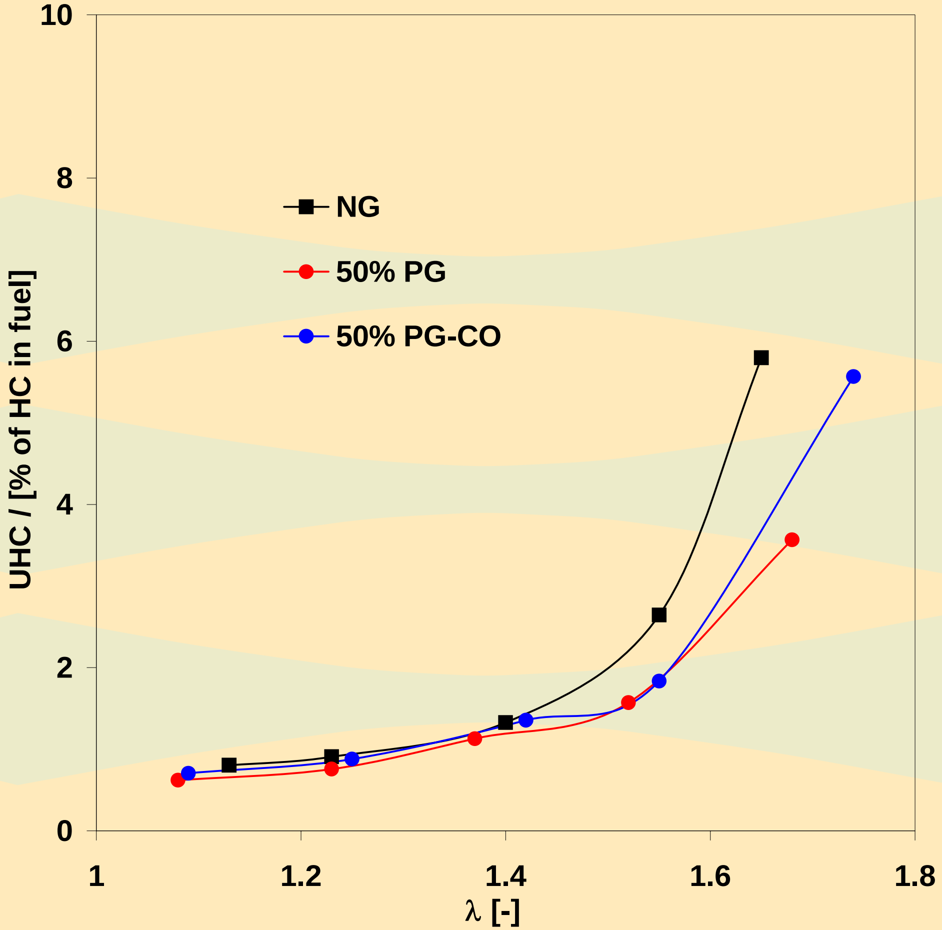
(Nissan)



- Up to 30% higher CO emissions when fueled by 50% PG compared to NG.
- Reduction in emissions when fuel-CO is replaced by N_2.
- Difference due to UCO

UHC Emissions

(Nissan)



- Addition of producer gas increases combustion efficiency at lean conditions.
- CO content has no significant influence on combustion efficiency.
- For λ>1.6 there is an reduction in UHC emissions of more than 50% compared to NG

Measurements from the Harboøre Plant

PAH [$\mu g/Nm^3$, dry]	Before ESP	After ESP	After Engine
Naphthalene	**37,000**	**6,300**	**4.7**
Phenanthrene	**9,800**	**<18**	**1**
Benzo(a)pyrene	**500**	**<35**	**<0.12**
TOTAL PAH	**68,000-70,000**	**6,600-6,800**	**6.4-7.1**

λ	CO (Before)	CO (After)	Reduction
[-]	**[ppm]**	**[ppm]**	**[%]**
2	**1,717**	**413**	**76**

Measurements of PAH and CO emissions for engine #1 at the Harboøre gasification plant in Denmark. Data from Babcock & Wilcox

Vølund R&D Centre - august 2001.

- High CO emissions
- Very low PAH emissions
- Catalytic reduction possible

CO and Global Warming

- CO leads to photochemical production of ozone in the presence of high NO_X concentrations

$$net: CO + 2O_2 + h\nu \Rightarrow CO_2 + O_3$$

- For low NO_x concentrations CO leads to ozone destruction

$$net: CO + O_3 \Rightarrow CO_2 + O_2$$

- O_3 has about the same global warming potential (GWP) as CH_4

Conclusion

- The high CO emissions from engines fueled by producer gas are mainly due to unburned fuel-CO (UCO)
- Combustion efficiency is not influenced by fuel-CO
- High CO emissions do not equal high PAH emissions
- UCO emissions from producer gas engines are comparable to UHC emissions from natural gas engines, both in origin and in GWP
- Separate emissions standards are needed for producer gas engines both for CO and PAH emissions

Questions ???

Wood Gas

The Green Engine Fuel for CHP

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Mass Fraction of Fuel Burned

(Nissan)