KUALA LUMPUR 2012 WORLD GAS CONFERENCE

IGU

25th world gas conference

"Gas: Sustaining Future Global Growth"

Impact of hydrogen admixture to natural gas on installed gas appliances

By: Dr. Petra Nitschke-Kowsky, E.ON Ruhrgas

Date: 7th June 2012

Venue: WOC 5

Patron

IGU
INTERNATIONAL GAS UNION
UNION INTERNATIONALE DU GAZ

Host

MALAYSIAN Gas ASSOCIATION

Host Sponsor

PETRONAS
reimagining energy

Overview

Global Target

- Hydrogen admixture is an important option for greening natural gas
- Technical questions on the whole chain of transport, distribution and utilization are to be solved.

Specific Task:

- Investigation of the behavior of gas appliances operated with hydrogen admixture to Natural Gas
  - Characteristics of Hydrogen and Mixtures
  - Theoretical approach
  - Lab tests of appliances with different burner types
  - Results and conclusions

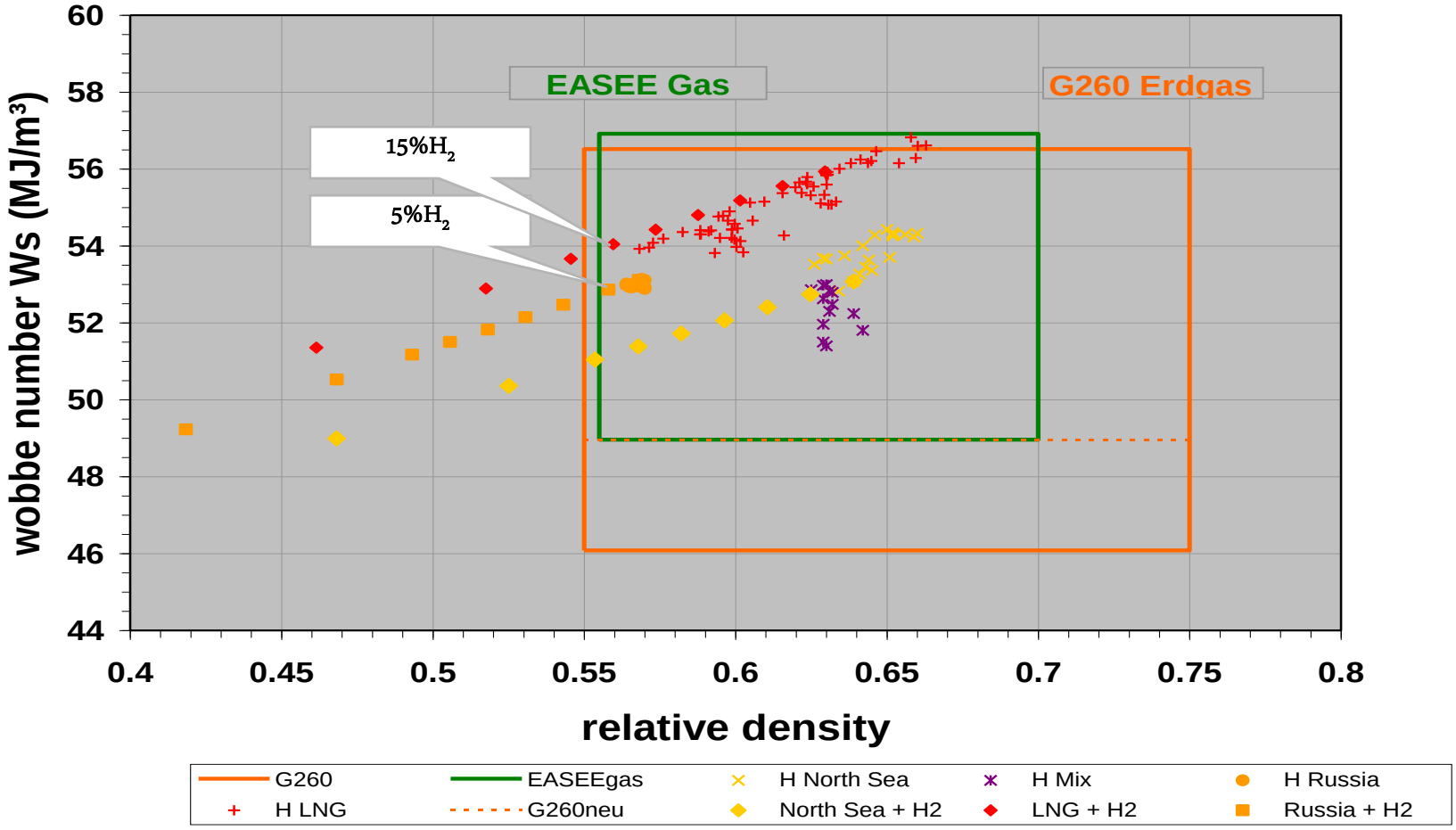
Properties of Hydrogen compared to Natural Gas

Gases (0°C/0°C, 1013 mbar)	Hydrogen H_2	Methane CH_4	Ethane C_3H_6	Natural Gas H (North Sea)
Gross calorific value Hs (MJ/m³)	12,7	39,9	70,3	41,9
Relative Density d	0,07	0,56	1,04	0,63
Wobbe Number Ws MJ/m³	48,3	53,5	68,7	53,0
Air Requirement Lo (m³/m³)	2,4	9,5	16,9	10,1
Maximum Flame Velocity (cm/sec)	346	43	49	43

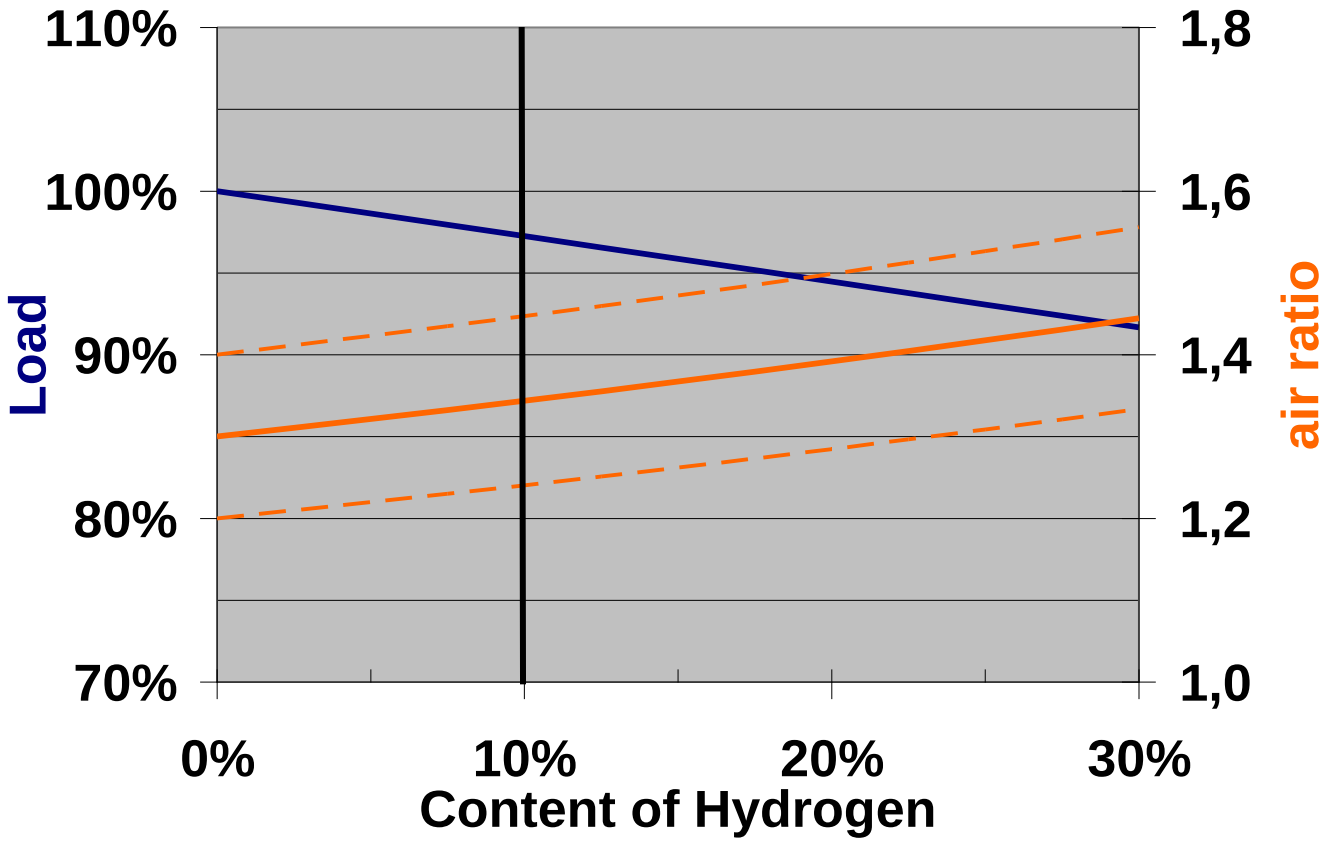
Characteristic values are important for:

- H_s: measurement of consumption, billing
- W_s: load deviation, air ratio, flame stability
- L_0: air ratio, flame stability
- V: flame stability
- d: gas composition, flue gas composition

Natural Gas Qualities in Europe
pure and with admixture of Hydrogen



The Influence of H_2-Admixture on Load and Air Ratio



Load:

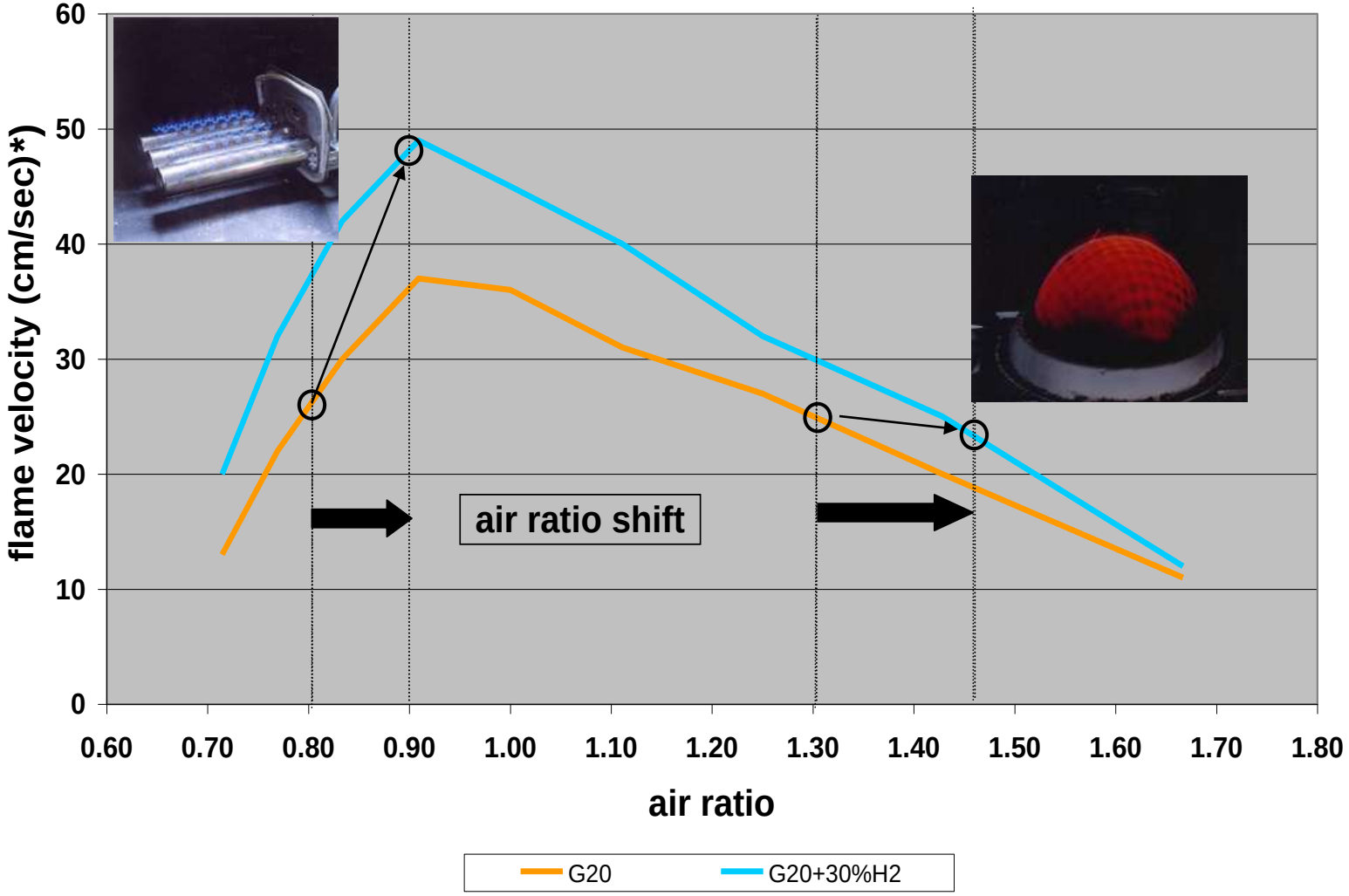
$$\dot{Q}_2 = \dot{Q}_1 \times \frac{W_2}{W_1}$$

Air ratio:

$$\lambda_2 = \lambda_1 \times \frac{l_1}{l_2} \times \sqrt{\frac{d_2}{d_1}}$$

$$\lambda_2 \approx \lambda_1 \times \frac{W_1}{W_2}$$

The Influence of H_2-Admixture on Flame Velocity for different burner types



*)NATURALHY, ICHS2007, De Vries, Florisson, Tiekstra, KEMA, Groningen, NL

Appliance Tests in the lab of E.ON Ruhrgas

Appliances:

1 atmospheric boilers
2 condensing boilers
2 condensing boilers with SCOT control
1 micro CHP Stirling

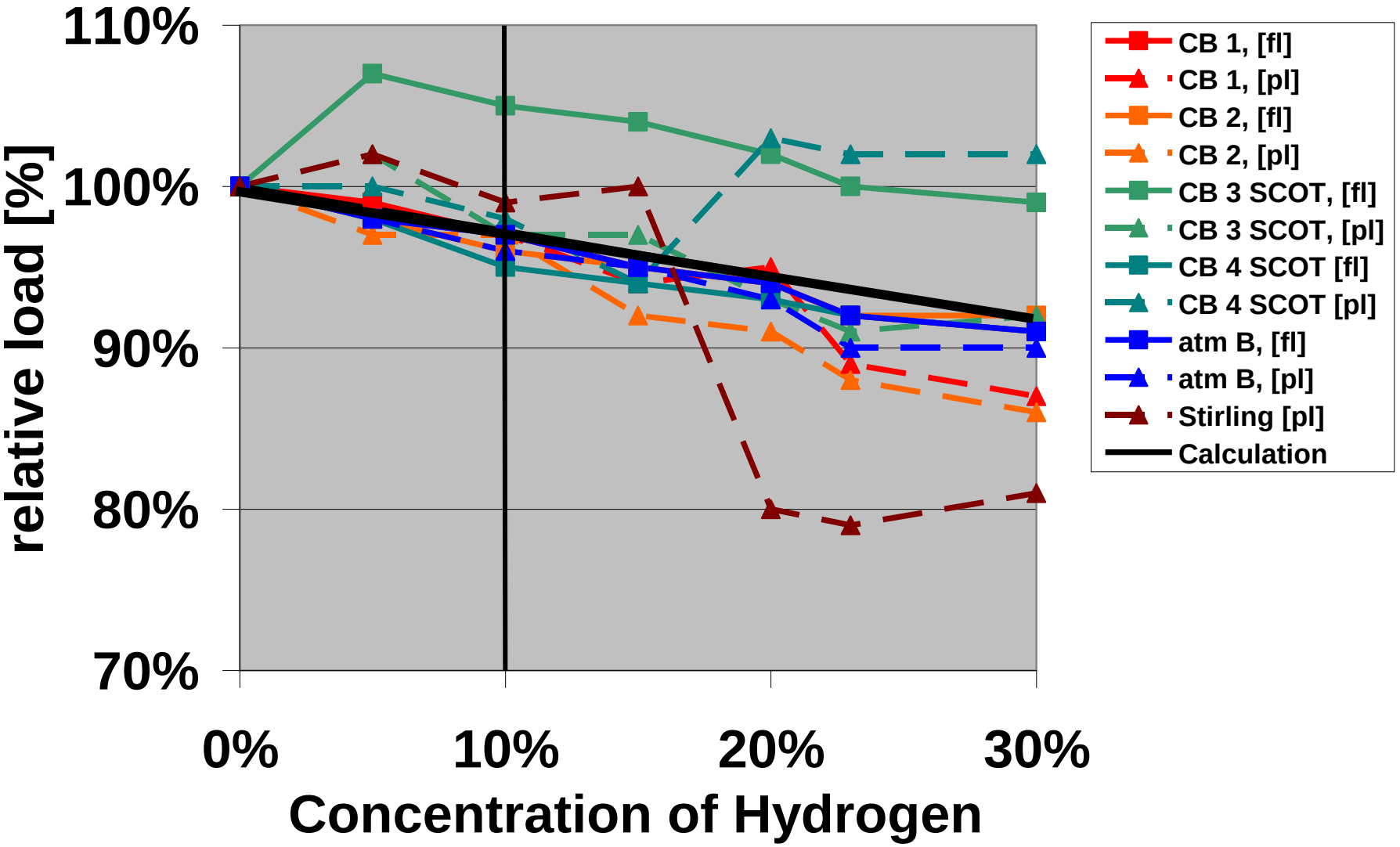
Control of flame stability

safe operation
CO emission curve
cold ignition test

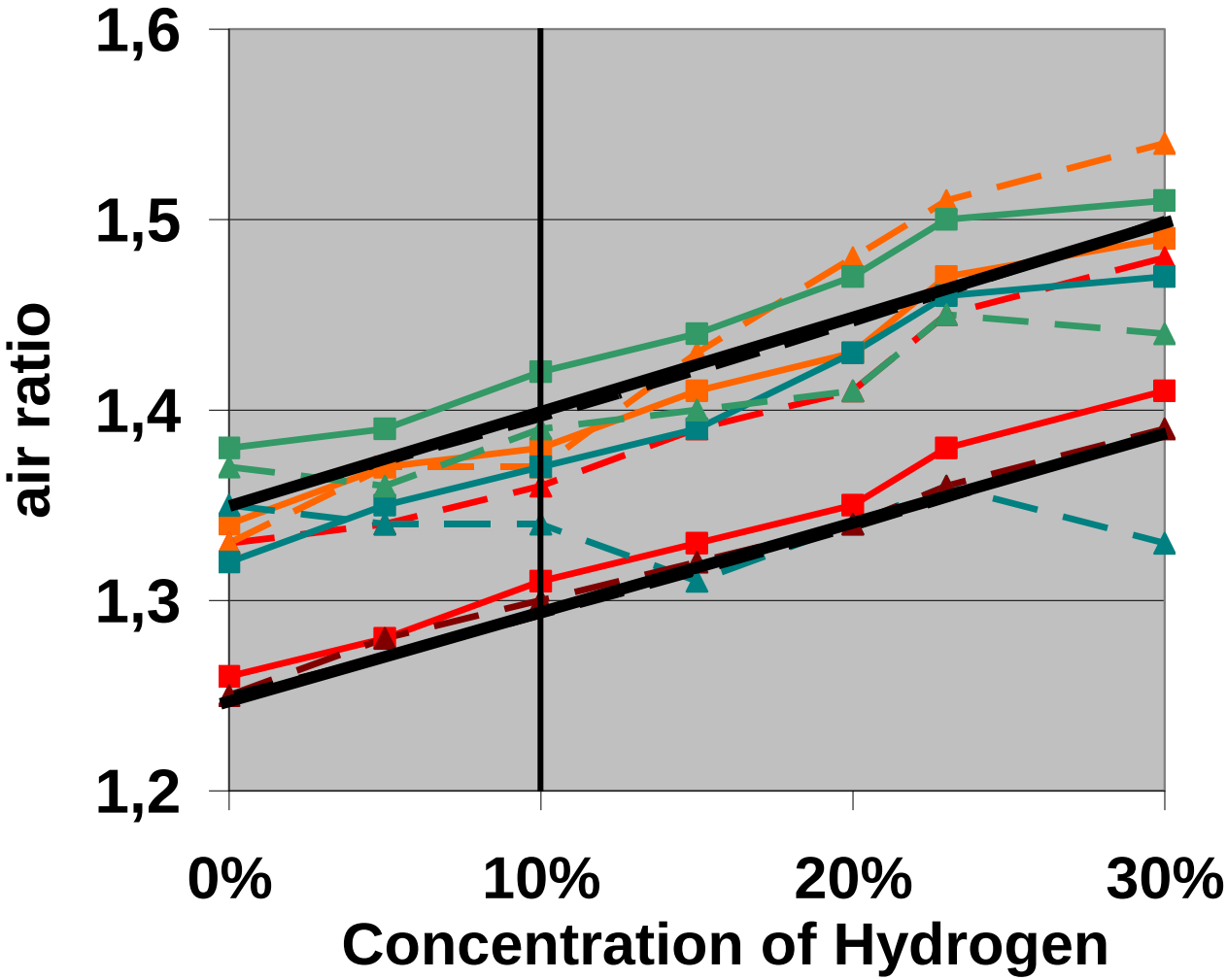
Measurement of

load
efficiency
NO_x emissions

Results of all appliances:
Relative Load with increasing concentration of H_2

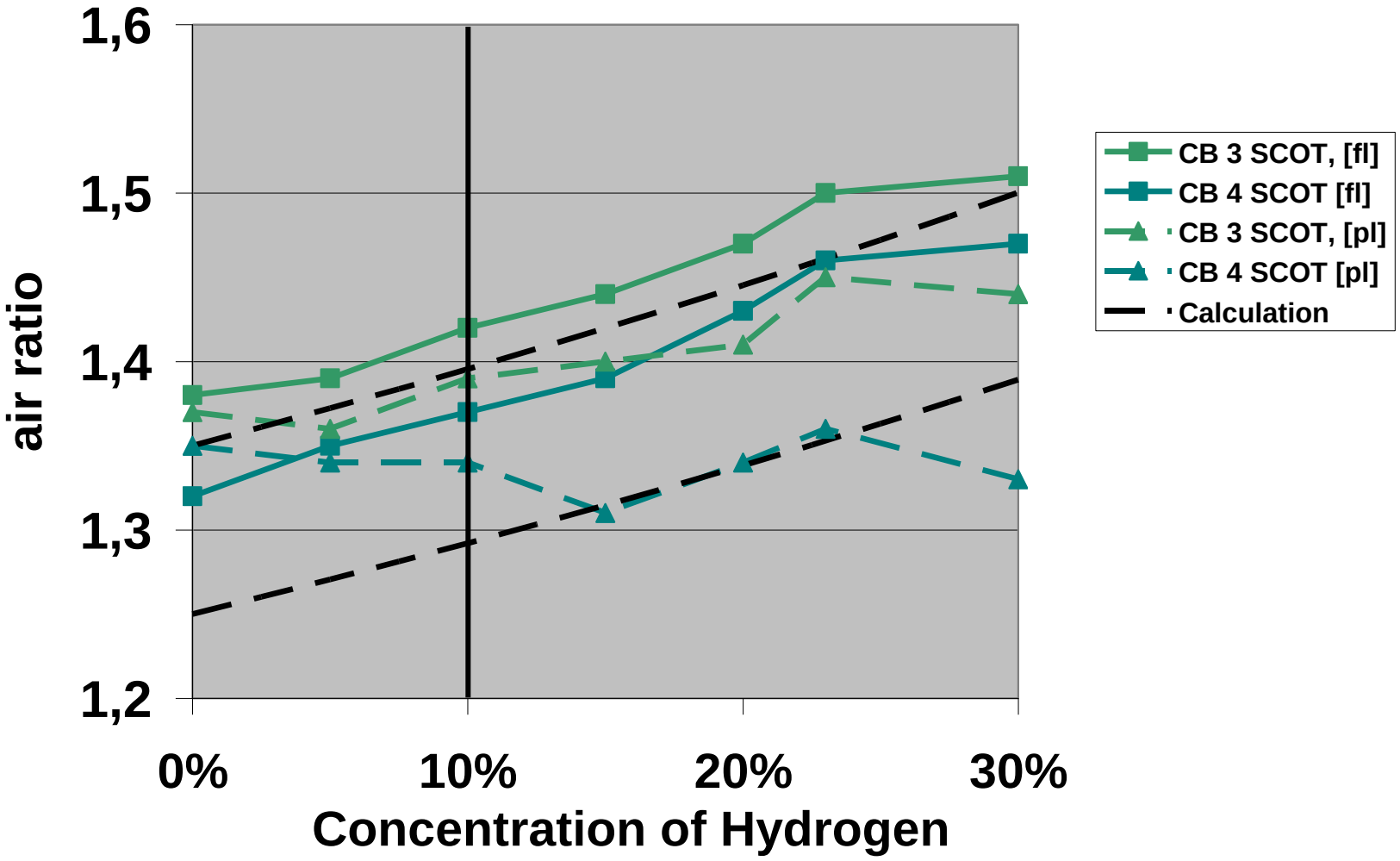


Results of all appliances:
Air ratio with increasing concentration of H_2

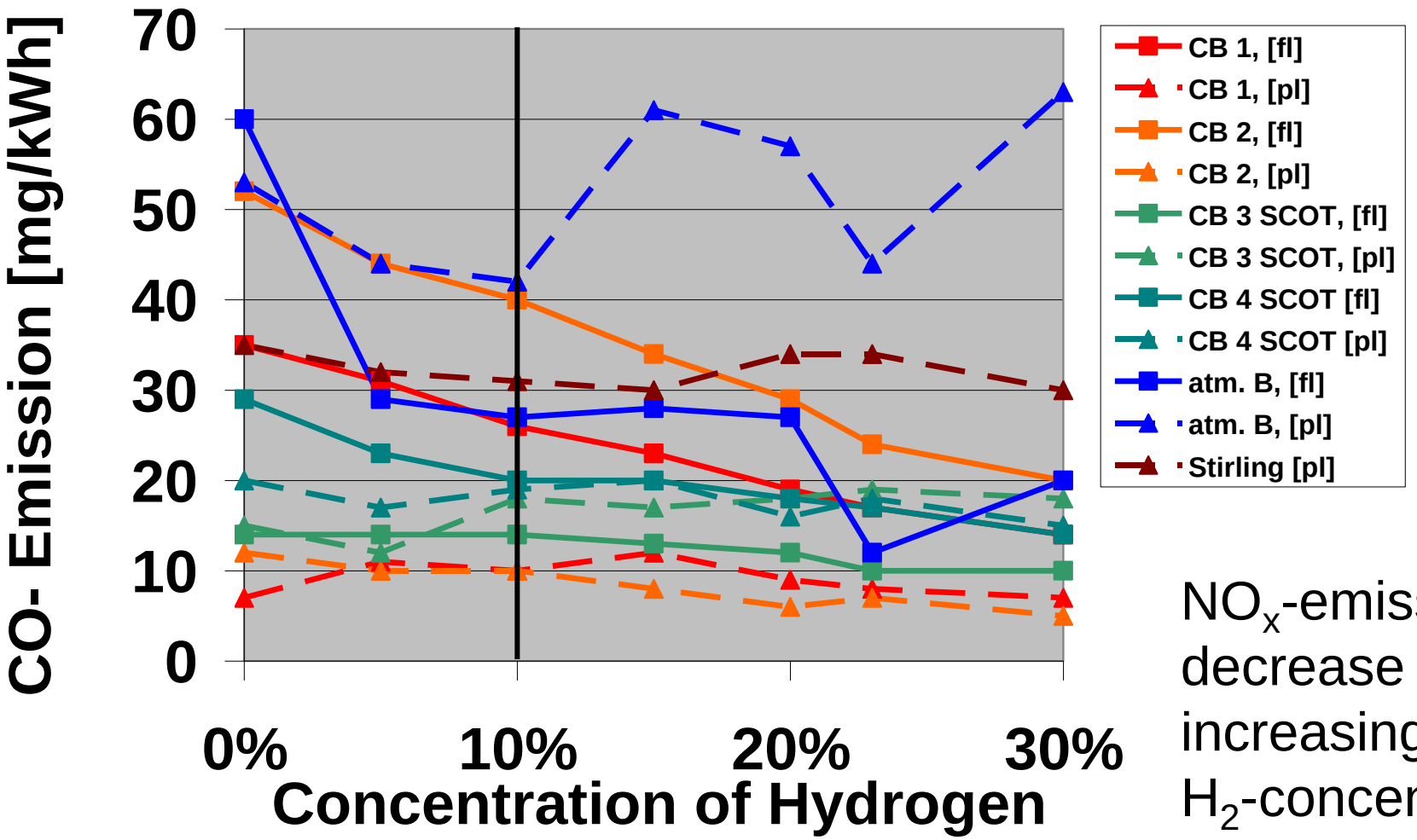


Cold start with 30% H_2 possible for all appliances

Results of SCOT controlled appliances: Air ratio with increasing concentration of H_2



Results on all appliances:
CO-Emission with increasing concentration of H_2



NO_x-emissions decrease with increasing H_2-concentration

Next step: Field test in an existing distribution grid

Distribution grid selected:

128 gas clients

commercial client (CHP)

gas consumption max. 140m³/h

single supply point

existing gas control station

hydrogen injection in preparation

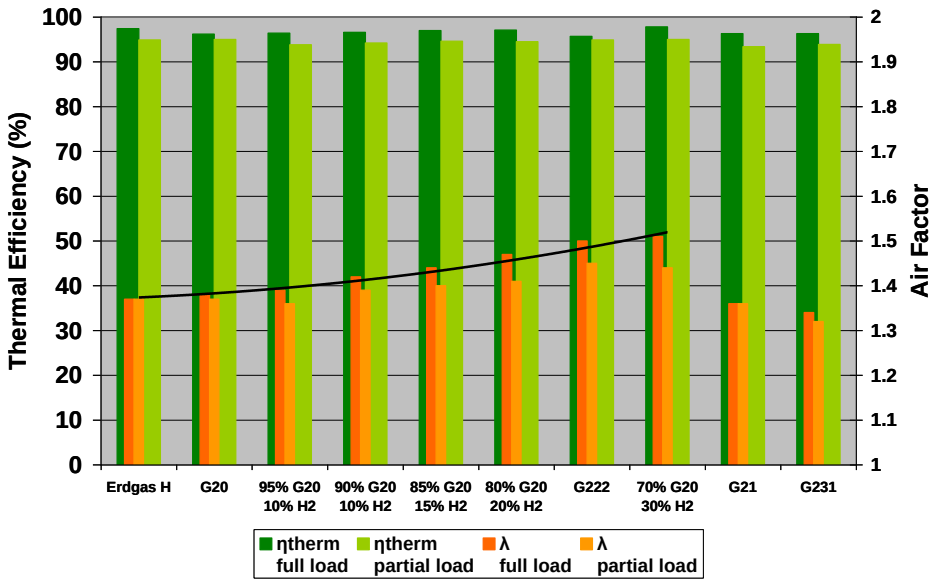
Klanxbüll and Neukirchen in Germany

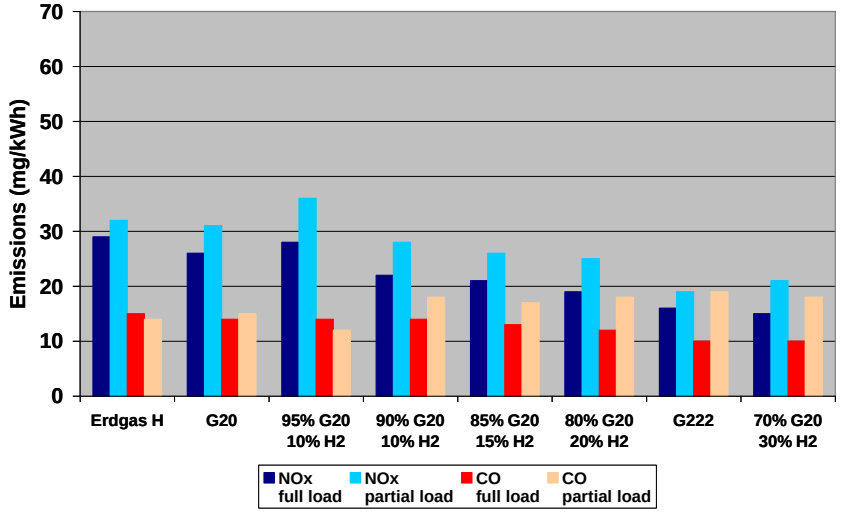
Summary

- **No major problems up to 10% of hydrogen admixture.**
  - No increase of CO, stable flame, cold ignition possible
  - Increasing air ratio (predictable) of about 0.05
  - Decreasing load less than 5%
- **Above 10% admixture first problems are observed.**
  - Initial rise of CO at atmospheric burners
  - Increasing air factors may provoke noise
  - Decreasing load more than 5%
  - Electric efficiency for micro CHP decreases
- **Combustion Control behavior has to be optimized.**
- **Further lab tests on different appliances are needed.**
- **Further tests in existing distribution grids are needed.**

Thanks for your Attention

Results on a typical condensing boiler with combustion control





Results:

- No CO-increase
- Stable flame,
- Cold ignition possible
- No effect on efficiency,

But:

- Combustion control does not correct the airfactor

Appliances investigated on the test stand at E.ON Ruhrgas

2 atmospheric boilers	rib burner, flat water cooled burner
2 condensing boilers	perf. flat ceramic burner perf. cylindric metal burner
2 condensing boilers combustion control	Half spheric metal mesh burner perf. flat metalic burner
1 Mikro CHP Stirling	
1 commercial boiler	Jet burner

Deviation of characteristic values with increasing admixture of hydrogen