Gas- und Wärme-
Institut Essen e.V.

Impact of Changing Natural Gas Quality on Industrial Combustion Processes

IGRC 2014, Copenhagen

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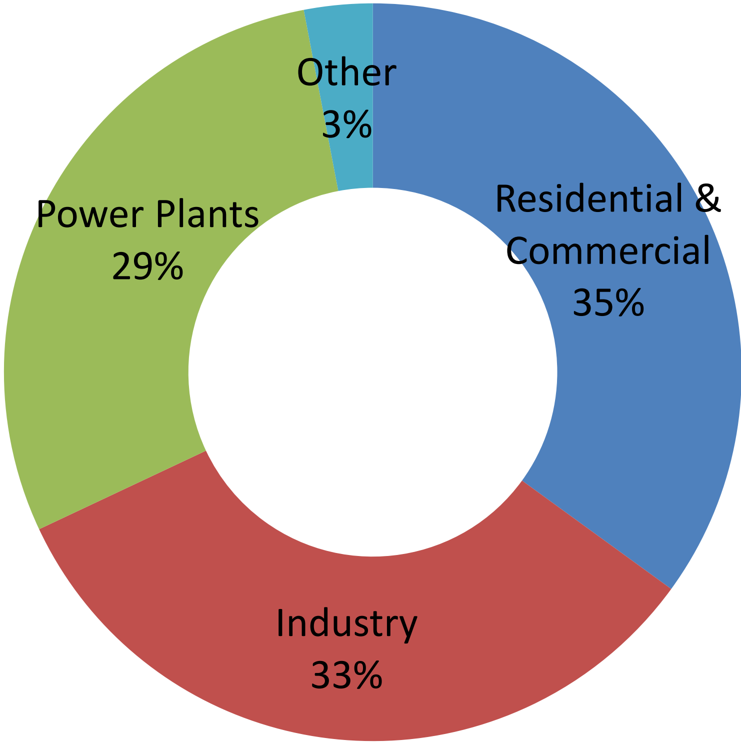
Natural Gas in Industrial Applications

- Industrial applications (excluding power generation) account for about 1/3 of Europe‘s consumption of natural gas.
- Natural gas is the premier means to provide process heat in many industries, from the food industry to high temperature processes in glass, ceramics and metals manufacturing.
- Manufacturing processes have very high demands for efficiency, stability, pollutant emissions and of course product quality. This usually requires a tight control of furnace conditions.
- Constant natural gas qualities are a significant locational advantage when running sensitive thermal manufacturing processes.



Source: EUROGAS

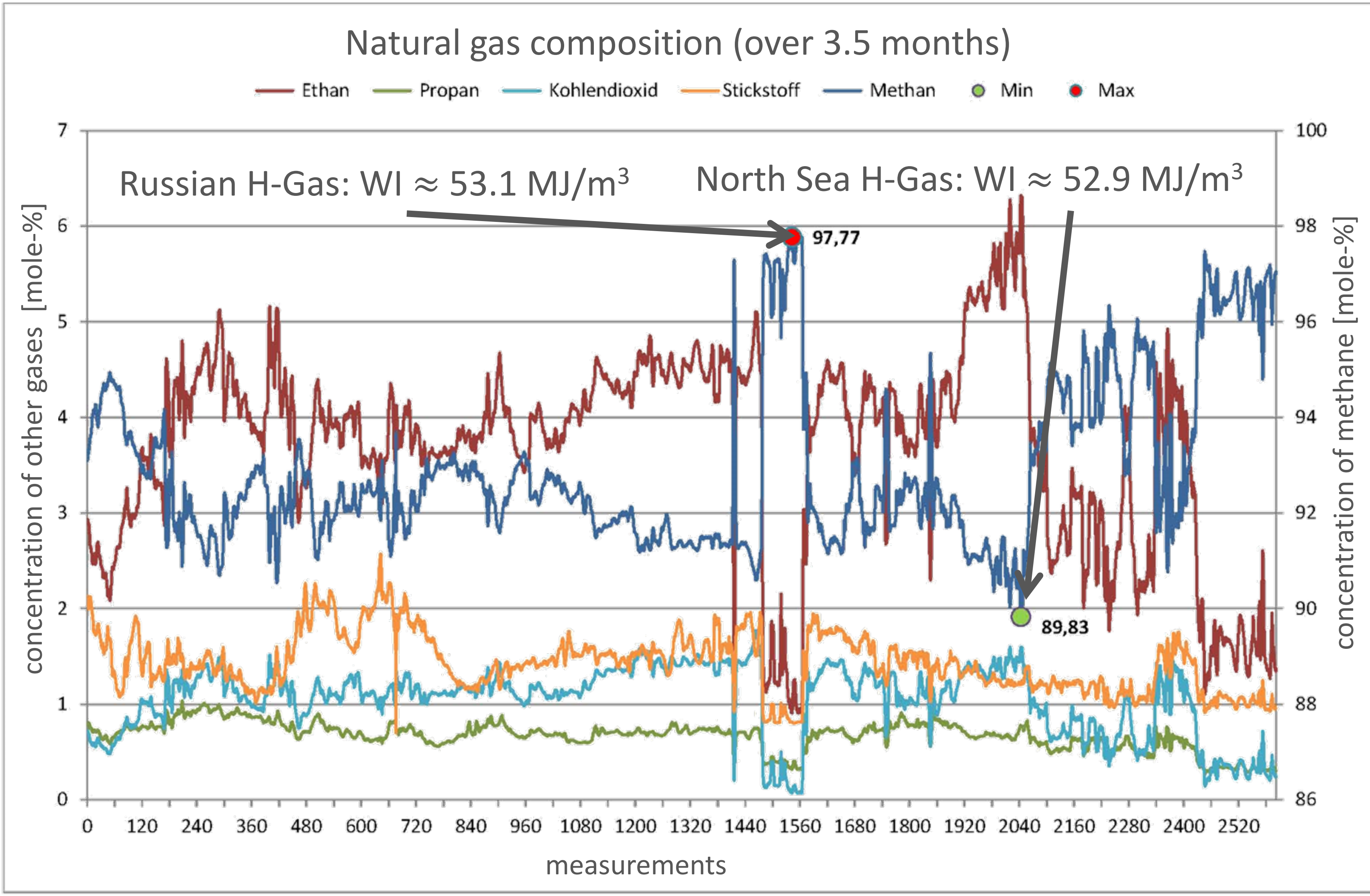
Changing Markets

- The international markets for natural gas are changing for a variety of reasons:
  - Decline of L-Gas from European sources
  - Increasing importance of imports (Russia, Middle East, LNG)
  - New gases: biogas, LNG, possibly H_2 from power-to-gas applications in the near future
  - „Unbundling", short term supply contracts
  - Harmonization of European gas quality standards (prEN 16726)

- These changes bring a number of benefits to both private and industrial gas consumers, but they also mean that end users will face greater fluctuations in gas quality at any given location within the supply grid.

- For many industrial users, this is a new situation, for which they are often ill-prepared. Some are not even aware of the changing situation.

Gas Composition Measurement near Leipzig/Halle, 2011



DVGW Research Project „Gasbeschaffenheit Industrie“

- The potential impacts of changing gas qualities on industrial combustion processes in Germany were investigated in a DVGW-funded research project.

- Both experiments with semi-industrial burner test rigs and CFD analysis were used to examine a number of industrial applications.

- Various scenarios and control strategies were simulated.

- The impacts of gas quality changes on various gas-fired manufacturing processes were assessed.

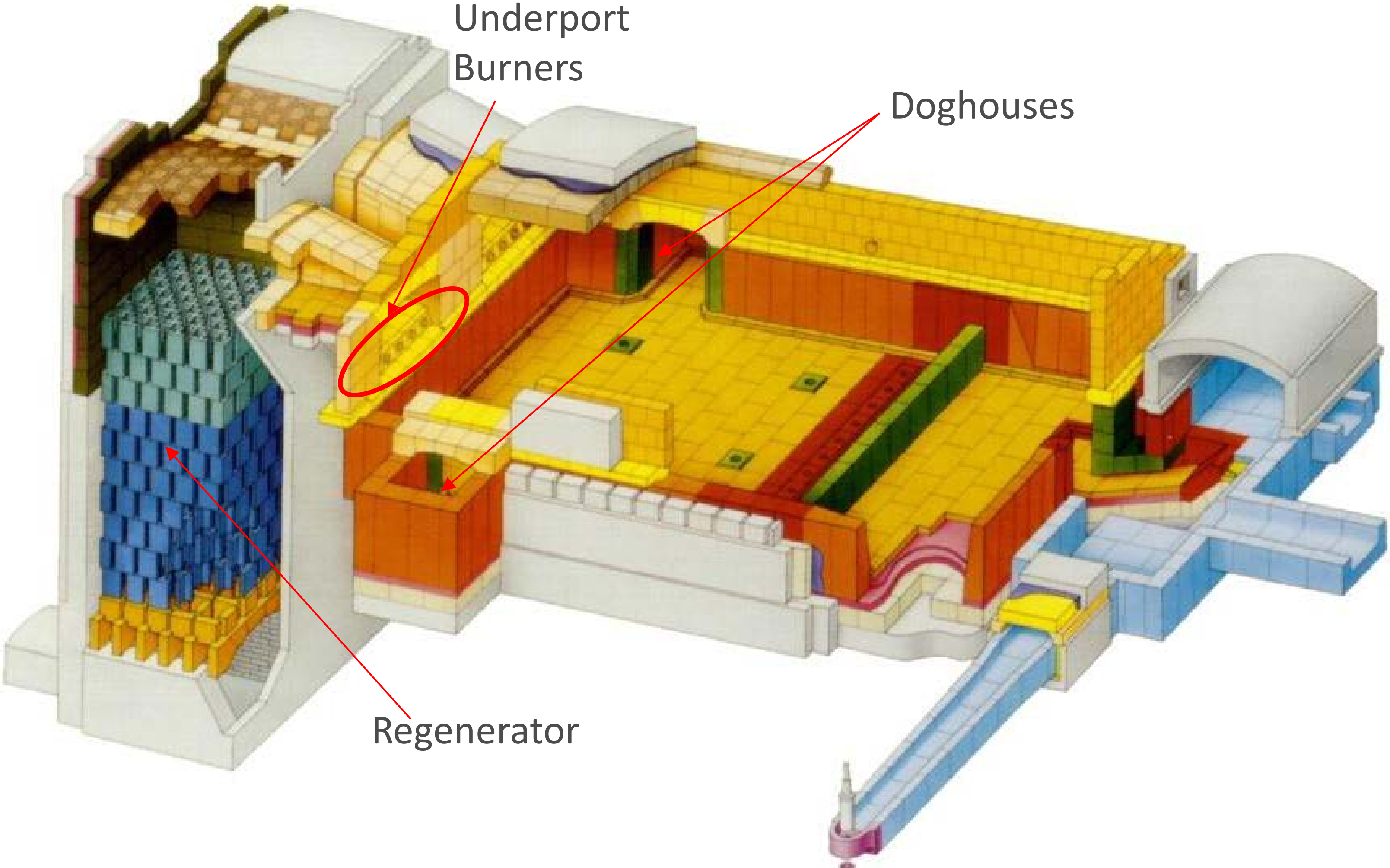
DBI GUT Gas- und Umwelttechnik GmbH

DVGW

gwi Gas- und Wärme-Institut Essen e.V.

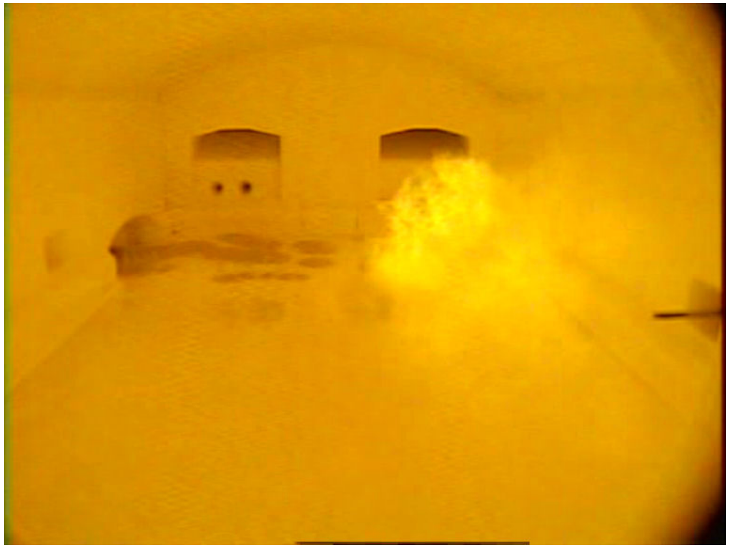
CFD Case Study: Glass Melting Furnace

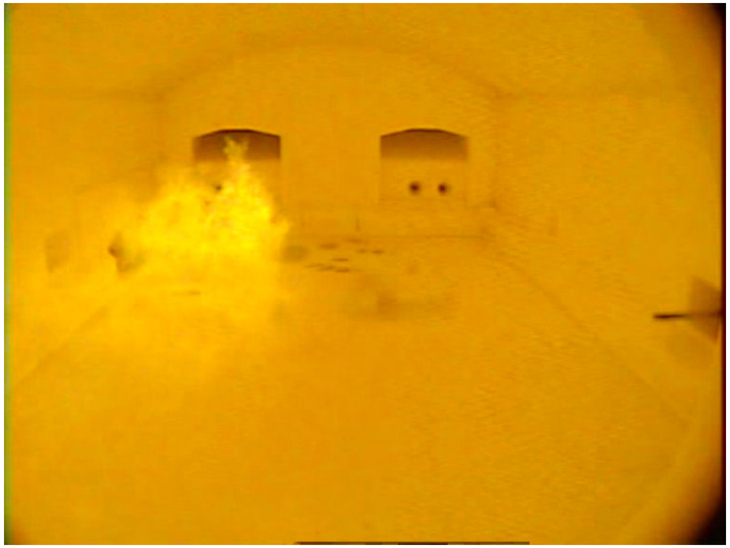
Regenerative Glass Melting Furnace

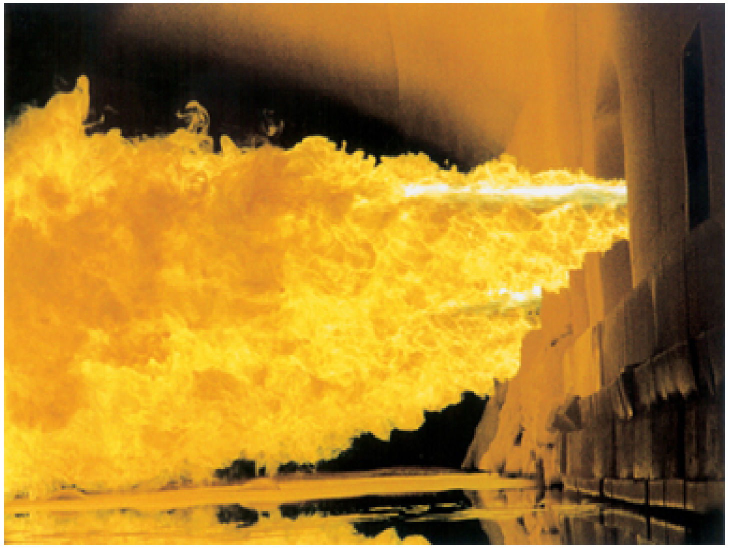


Source: C. P. Ross; G. L. Tincher; M. Rasmussen: Glass melting technology: a technical and economic assessment, GMIC, 2004

Impressions from the Interior of the Furnace





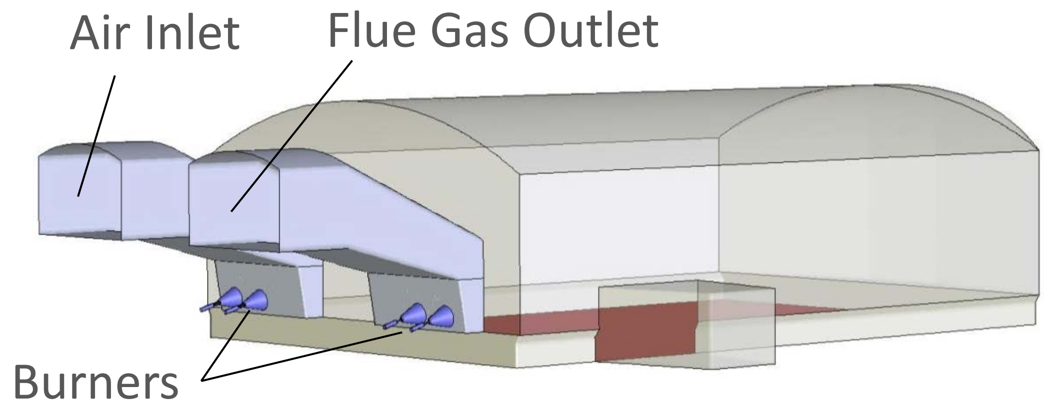


Source: HVG

CFD Setup and Boundary Conditions

Operating Parameters (Reference Case):

- Load Burner 1: 2000 kW
- Load Burner 2: 2000 kW
- Air Ratio: 1.05
- Gas Temperature: 20 °C
- Air Temperature: 1300 °C
- Glas Melt Surface Temperature: Profile

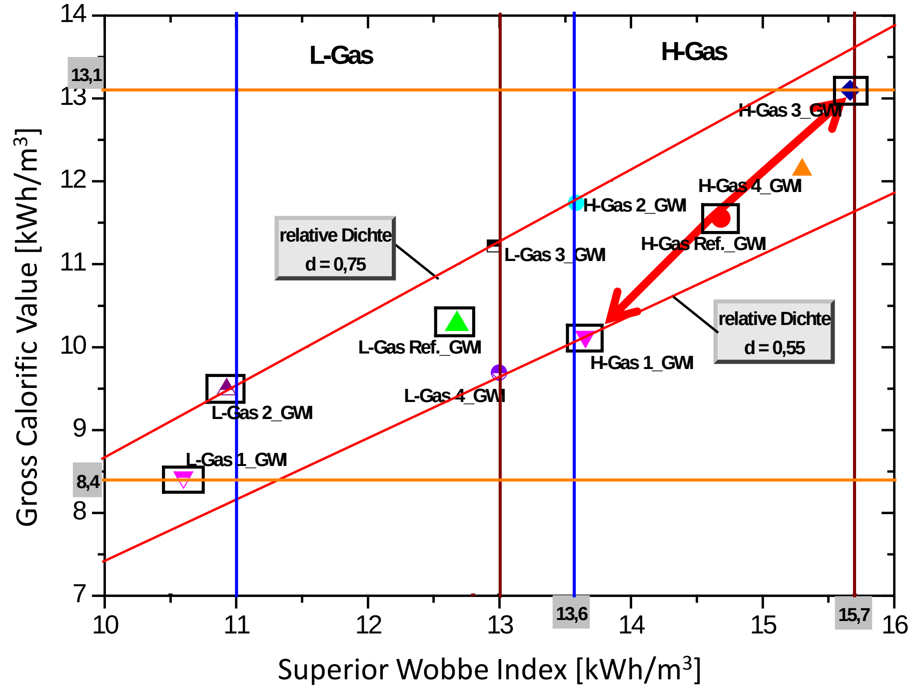


Approach:

- Test gases at the extremes of German gas quality code DVGW G260 were defined
- Process was adjusted for reference gas and then supplied with another test gas
- Steady CFD simulations were used to examine the impact of a gas quality change
- Various furnace control strategies were investigated

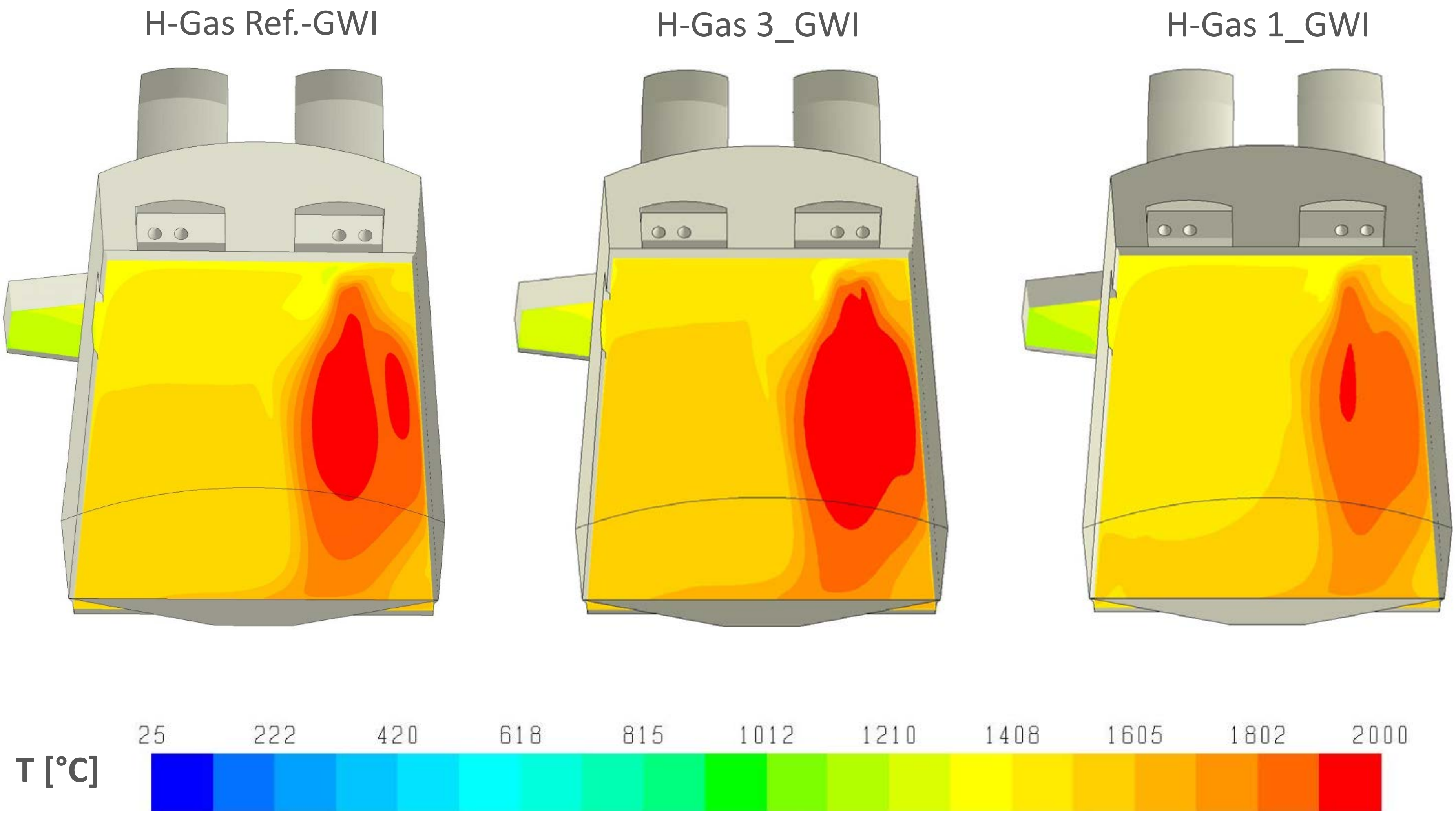
Scenario I

- Fuel gas composition changes from H-Gas Ref._GWI to H-Gas 1_GWI or H-Gas 3_GWI... an oxygen sensor detects the change.
- Volume flow of air is adapted for constant λ.
- But: volume flow of fuel remains constant !



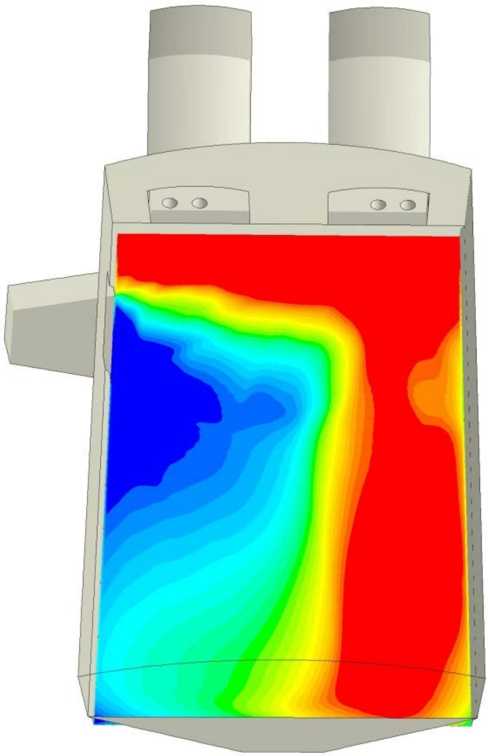
Gas Type	$H_{i.n}$ [kWh/m³]	Q_{Burner} [kW]	$\rho_{n.Gas}$ [kg/m³]	$V_{n.Gas}$ [m³/h]	Air_{min} [m^3_{Air}/m^3_{Fuel}]	λ [-]	$V_{n.Air}$ [m³/h]
H-Gas Ref._GWI	10.436	4000	0.8004	383.3	9.99	1.05	4021
H-Gas 3_GWI	11.884	4554	0.9043	383.3	11.27	1.05	4536
H-Gas 1_GWI	9.114	3494	0.7110	383.3	8.65	1.05	3482

Scenario I: Temperatures above the Glass Melt



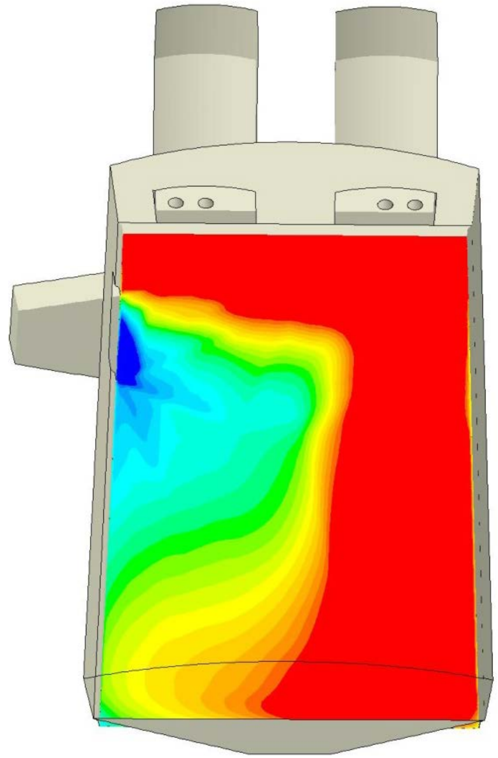
Scenario I: Total Heat Fluxes into the Glass Melt

H-Gas Ref._GWI



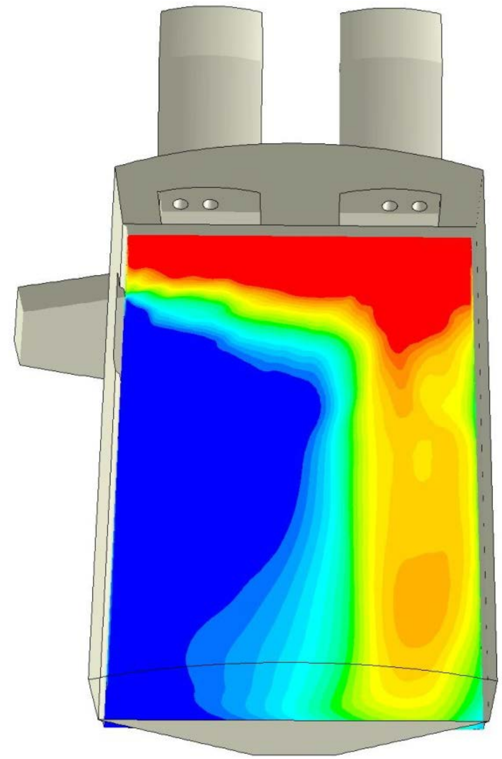
Q= 1096 kW

H-Gas 3_GWI



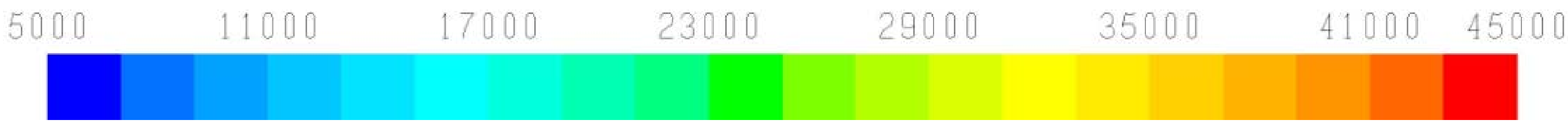
Q= 1455 kW
Δ=32.6 %

H-Gas 1_GWI



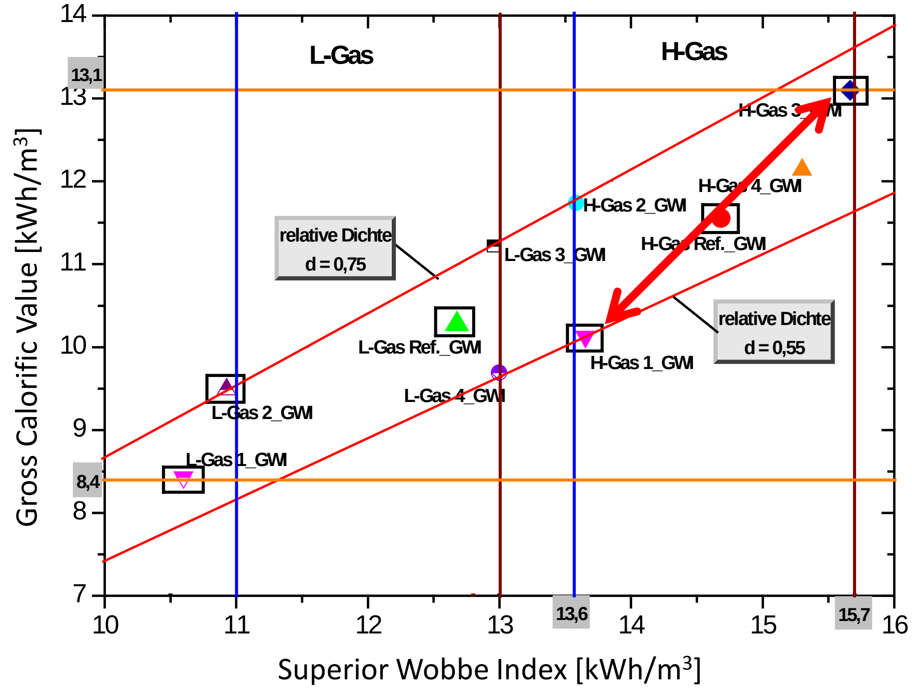
Q= 741 kW
Δ=-32.4 %

q [W/m²]



Scenario II

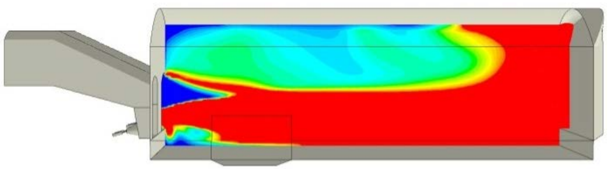
- Fuel gas composition changes from H-Gas Ref._GWI to H-Gas 1_GWI or H-Gas 3_GWI… and no one notices !
- Volume flows of **both** fuel and oxidizer remain constant.
- Definitely a worst case scenario !



Gas Type	$H_{i,n}$ [kWh/m³]	Q_{Burner} [kW]	$\rho_{n,Gas}$ [kg/m³]	$V_{n,Gas}$ [m³/h]	Air_{min} [m^3_{Air}/m^3_{Fuel}]	λ [-]	$V_{n,Air}$ [m³/h]
H-Gas Ref._GWI	10.436	4000	0.8004	383.3	9.99	1.05	4021
H-Gas 3_GWI	11.884	4554	0.9043	383.3	11.27	0.93	4021
H-Gas 1_GWI	9.114	3494	0.7110	383.3	8.65	1.21	4021

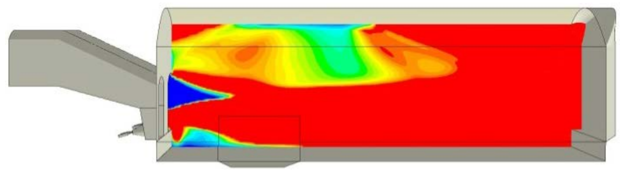
Scenario II: Impact of Fuel Gas Changes

H-Gas Ref._GWI



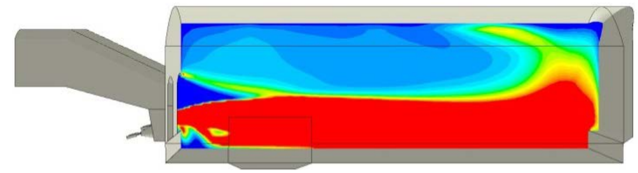
Total Load	kW	4000
Air Ratio	-	1.05
CO_2	Mole-%	11.38
N_2	Mole-%	87.39
O_2	Mole-%	1.23
H_2	Mole-%	0.00
CO	ppm	11
NO_x @ 3 % O_2	ppm	3460

H-Gas 3_GWI



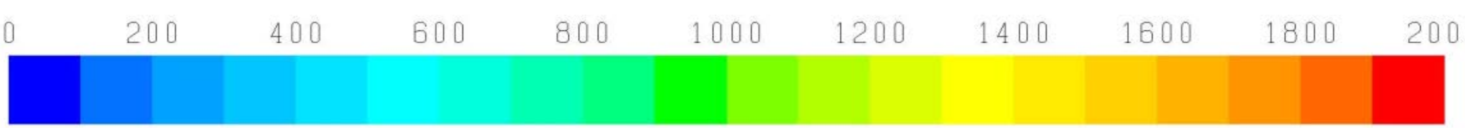
Total Load	kW	4554
Air Ratio	-	0.93
CO_2	Mole-%	11.11
N_2	Mole-%	85.86
O_2	Mole-%	0.00
H_2	Mole-%	1.18
CO	ppm	18526
NO_x @ 3 % O_2	ppm	1670

H-Gas 1_GWI



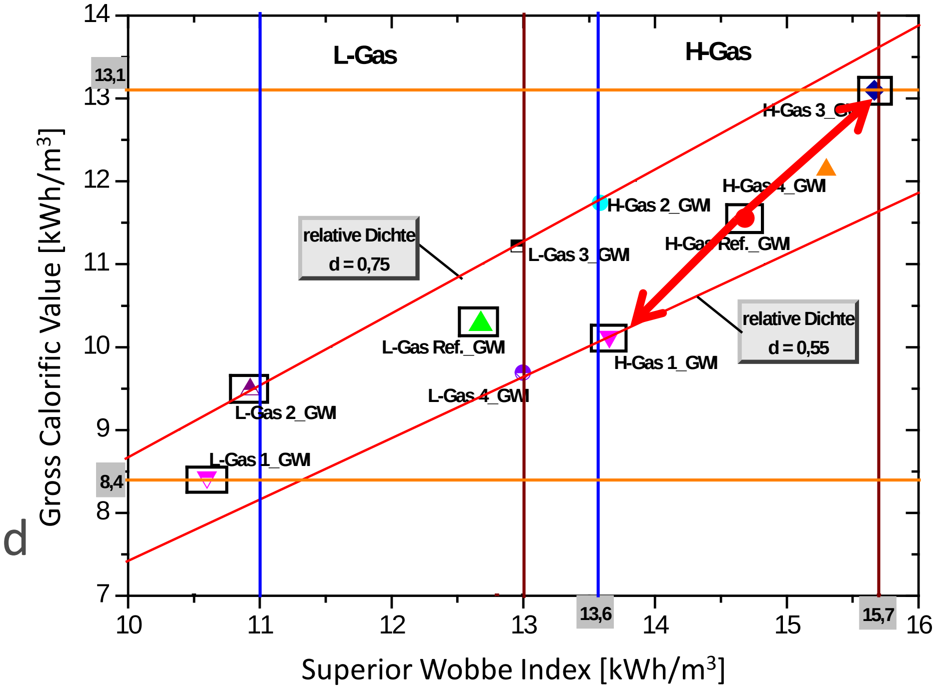
Total Load	kW	3494
Air Ratio	-	1.21
CO_2	Mole-%	9.50
N_2	Mole-%	86.34
O_2	Mole-%	4.16
H_2	Mole-%	0.00
CO	ppm	3
NO_x @ 3 % O_2	ppm	2850

CO_{dry} [ppm]



Scenario III

- Fuel gas composition changes from H-Gas Ref._GWI to H-Gas 1_GWI or H-Gas 3_GWI… fuel composition is constantly monitored (PGC).
- Volume flows of air and fuel are adapted for constant λ and burner load.
- Technologically, the most sophisticated solution… but expensive!



Gas Type	$H_{i,n}$ [kWh/m³]	Q_{Burner} [kW]	$\rho_{n,Gas}$ [kg/m³]	$V_{n,Gas}$ [m³/h]	Air_{min} [m^3_{Air}/m^3_{Fuel}]	λ [-]	$V_{n,Air}$ [m³/h]
H-Gas Ref._GWI	10.436	4000	0.8004	383.3	9.99	1.05	4021
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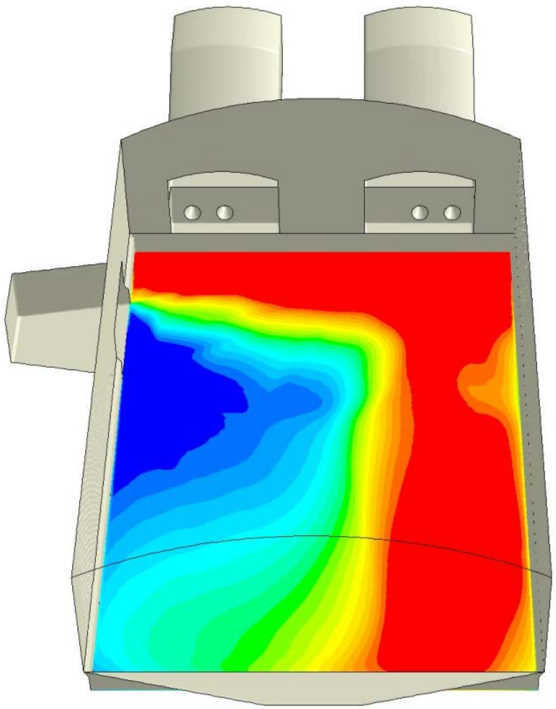
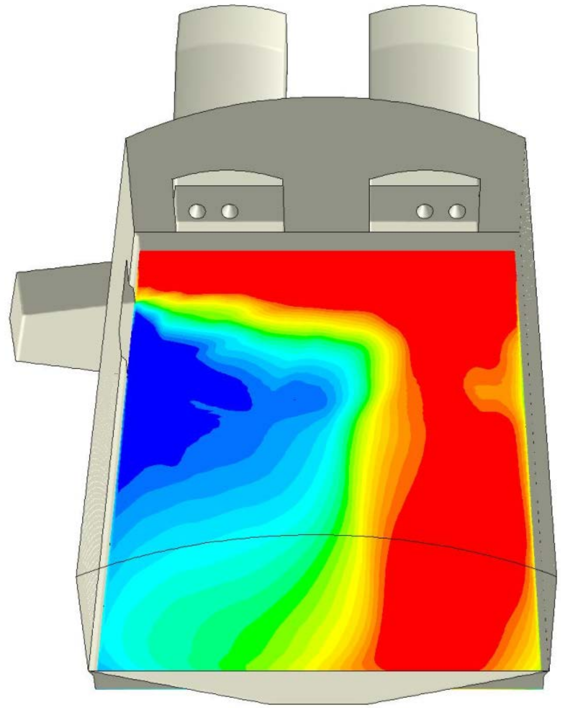
Scenario III: Total Heat Fluxes into the Glass Melt

H-Gas Ref._GWI



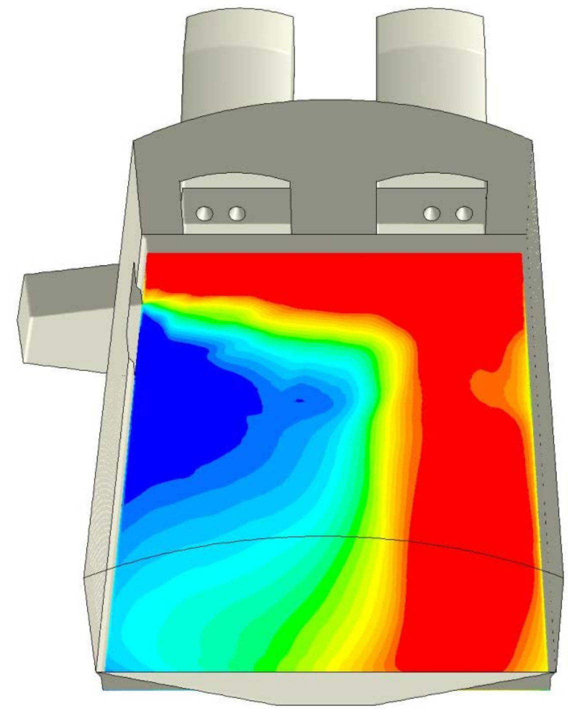
Q= 1096 kW

H-Gas 3_GWI



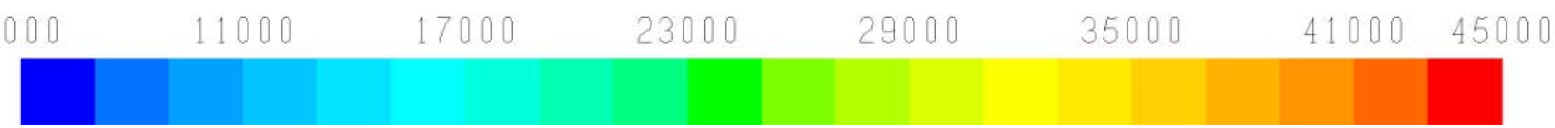
Q= 1102 kW
Δ=0.6 %

H-Gas 1_GWI



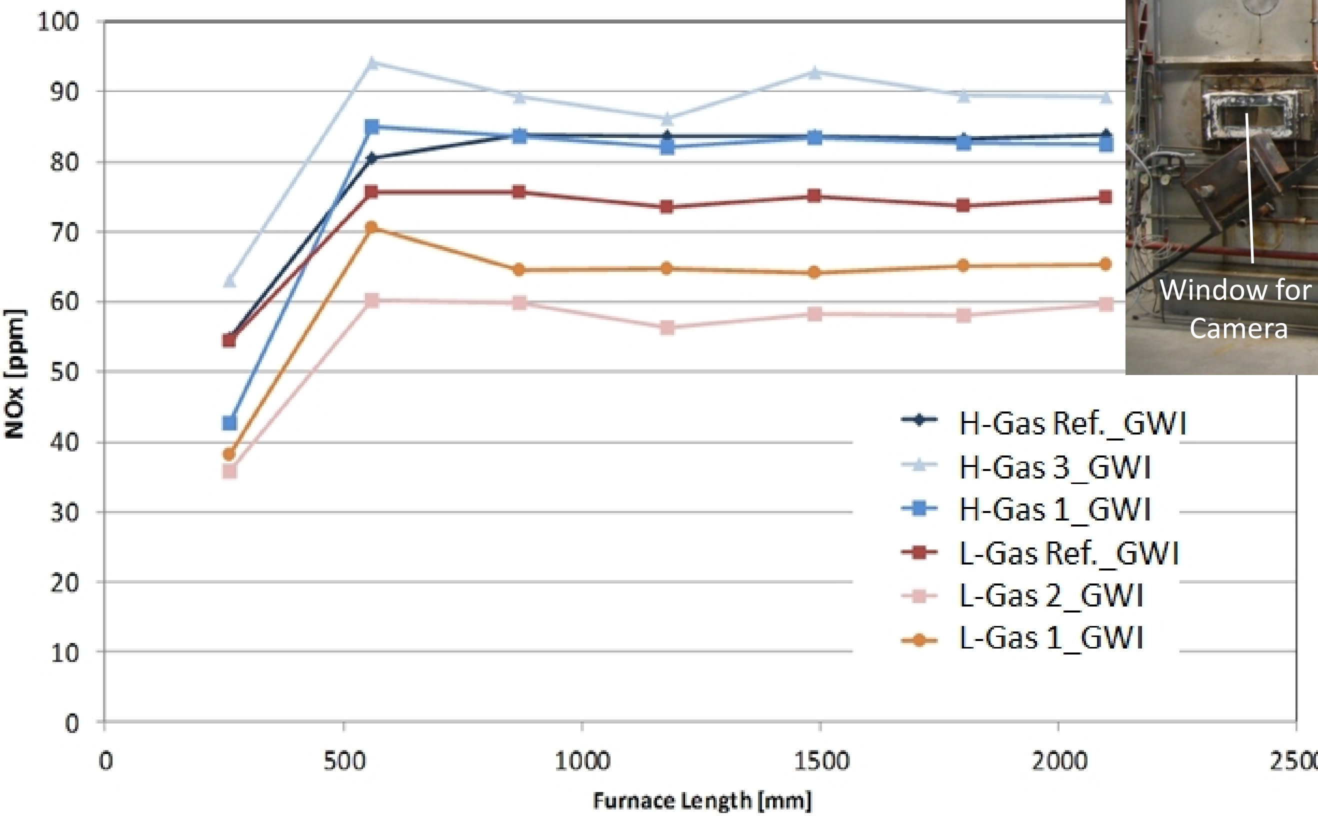
Q= 1076 kW
Δ= -1.8 %

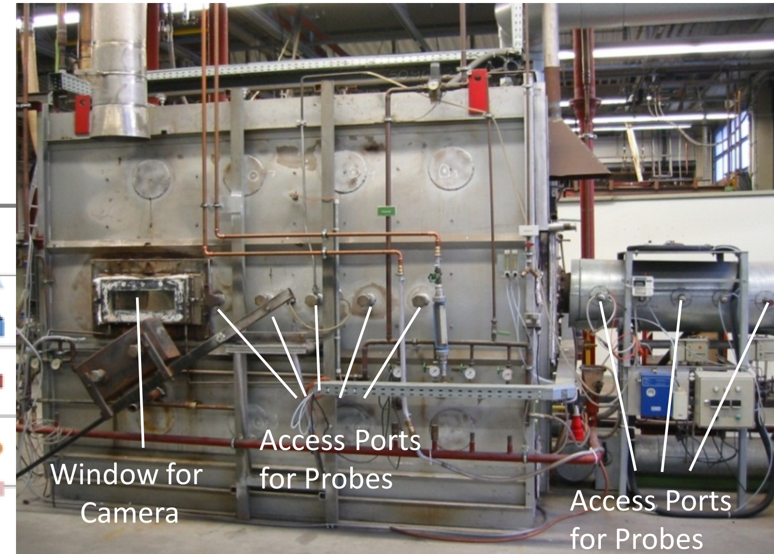
q [W/m²]



Test Rig Measurements

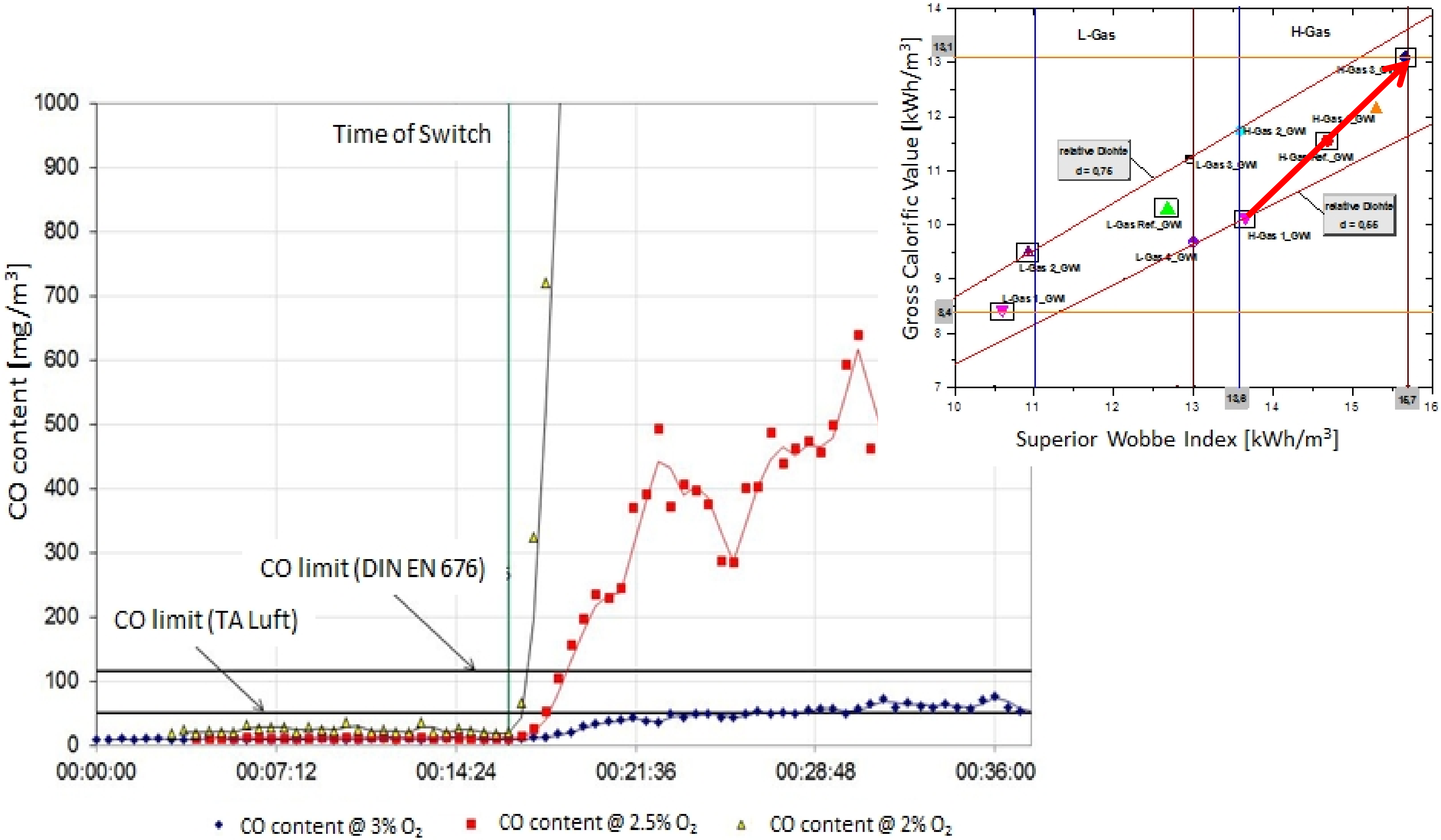
GWI Test Rig Measurements: NO_X along Central Axis





GWI Burner Test Rig: all measurements performed at $P = 200$ kW, $\lambda = 1.15$, $T_{air} = 200$ °C

DBI Test Rig Measurements: Effect of Gas Switch on CO



Sensitivity Assessment (DVGW-Study)

Industry	Process	Efficiency	Safety (Emissions and Thermal Overload)	Product Quality
When switching from lower to higher Wobbe Index (maximum possible range according to DVGW G 260)				
Heat	boilers	yellow	red	green
Heat	luminous radiant heaters	yellow	red	green
Heat	direct and indirect drying	yellow	yellow	yellow
Metallurgy	pre-heating (metals)	yellow	red	yellow
Metallurgy	thermochem. heat treatment	yellow	yellow	green
Metallurgy	zinc coating	yellow	green	red
Metallurgy	melting (non-ferrous metals)	red	red	red
Ceramics	calcination	yellow	yellow	yellow
Ceramics	brick & tiles manufacturing	yellow	red	red
Ceramics	porcelain firing	yellow	red	red
Glass	glass melting (float)	red	red	red
Glass	glass melting (container), feeder	red	red	red
Glass	glass finishing treatment	red	red	red
Other	chemical engineering, plastics	red	red	red

- green: no intervention required
- yellow: intervention possibly required
- red: intervention required

Conclusions

- The issue of fluctuating qualities of natural gas in the grids will play a bigger role for industrial gas consumers in the years to come. It is yet unclear how local gas quality changes will affect many industrial applications as they are typically not designed for such fluctuations.

- DVGW funded a research project to investigate and assess the susceptibility of various industrial gas-fired applications to gas quality changes. Some results were presented.

- There is no single way to prepare a thermal processing plant to fluctuating gas qualities. Every process is different and requires its own tailor-made solution.

- Advanced measurement and furnace control technologies can help mitigate the impact of fluctuating gas qualities. These may be significant investments especially for small and medium-sized enterprises.

DBI, EBI and GWI gratefully acknowledge the support by DVGW and our industrial partners in the supervisory committee.

The final report of the project (in German) is available at the GWI website:
www.gwi-essen.de

Gas- und Wärme-
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Thank you for your attention !

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