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TECH FORUM

LNG Quality

Presentations

Opening speech

Alexander Schwanzer

MARCOGAZ President

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Technical Association of the European Gas Industry

MARCOGAZ Tech Forum on LNG Quality

Alexander Schwanzer, President Marcogaz

Tuesday, 20 May 2025

LNG in EU energy policy

EU energy policy

- decarbonisation
- competitiveness
- **security of supply**
- **sustainability**

Its objectives

- functioning of the energy market
- **secure energy supply** within the EU
- energy efficiency and savings
- development of renewable energies
- **interconnection of energy networks**

Energy Union

- **Diversify Europe's sources of energy, ensuring energy security**
  - solidarity and **cooperation between EU countries**
- Ensure the functioning of a fully integrated internal energy market, **enabling the free flow of energy**
  - **through the EU** through **adequate infrastructure** and **without technical** or regulatory **barriers**
- Improve energy efficiency, **reduce dependence on energy imports,** cut emissions, drive jobs and growth
- Decarbonise the economy, a low-carbon economy in line with the Paris Agreement
- Promote research in low-carbon and clean energy technologies, prioritise research and innovation to drive the energy transition, improve competitiveness

LNG in EU energy policy

- **Achievements**
  - **General policy framework**
    - Energy Union Strategy
  - **REPower-EUPlan**
    - **Diversification of energy imports**
      - **EU Energy Platform**
        - **Pooling** and structuring increased **demand**
        - **Optimized** and transparent use of **gas import, storage, and transport infrastructure**
        - **Actions** at the **international level**
          - focus on establishing long-term cooperation frameworks with trusted partners e.g. the procurement of gas, LNG and hydrogen
    - **Smart investments**
      - additional investments of €210 billion are needed under REPowerEU by 2027
      - Projects to expand **storage and offtake capacity** should be adequately supported
      - Importing sufficient quantities of LNG and pipeline gas from other suppliers will require an estimated €10 billion in investments by 2030
  - **Legal provisions on this can be found e.g.:**
    - decarbonised gas and hydrogen markets (Directive 2009/73/EC)
    - voluntary demand aggregation of gas (Regulation (EU) 2022/2576; EU Energy Platform)

LNG in EU energy policy

- **The EU's gas demand approx. 330 bcm per year**
  - Natural gas: **a quarter** of the EU's overall energy consumption
  - **26% used in the power generation** sector (including in combined heat and power plants)
  - **23% in industry**
  - residential and services sectors, mainly for heating buildings

- **Following the Russian invasion**
  - EU energy imports has fallen from 41% in 2021 to about 18% in 2024
  - **Replaced** mainly
    - **LNG** from the US
    - **pipeline gas imports** from Norway, North-Africa and Azerbaijan

- **Global LNG supply**
  - To rise **slightly in 2025**
  - Increases in production and liquefaction capacities
  - **Ease the pressure** on global gas markets and **lead to lower prices** on the European markets
  - The **largest LNG global exporters** in 2024: US, Australia and Qatar

- **Several EU countries**
  - **Increasing** their **LNG import capacity**
  - **Accelerating investments** in LNG terminals
  - The **EU's LNG import** capacity **grew** by 70 bcm in 2023-2024
  - **Additional 60 bcm** is expected between 2025-2030

- **MARCOGAZ Database**
  - **No public database** on the quality/composition of liquefied natural gas (LNG)
  - **MARCOGAZ WG 5**: survey among its members in 2023 to collect current data on LNG quality
  - **Facilitate** decision-making for EU natural gas market players in the current **natural gas supply situation in Europe**

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Thank you!

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Liquefied Natural Gas (LNG) Quality database

Jose A. Lana

R&D project coordinator and gas quality expert at Enagás & Chair of Gas Quality & Metering at MARCOGAZ

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MARCOGAZ

LNG Quality database

José A. Lana, Chair G5 Gas Quallity & Metering

Tech Forum, 20th May 2025

Introduction

Why MARCOGAZ did collect liquified natural gas (LNG) quality information?

- Most cited source in different publication, GIIGNL , is from a 2012 report
- Many liquefaction terminals (or expansions of old ones) and new countries have started operation in last decade, so the previous information is no longer complete
- Natural gas supply scenario changed dramatically in 2022, due to the war in Ukraine
- New sources of natural gas have appeared in Europe, mostly LNG

Due to this reasons, MARCOGAZ former WG Gas Quality agreed in 2023 to launch a survey amongst its members to collect recent quality data of LNG, in order to help decision to natural gas market actors in the present natural gas supply scenario in Europe

Scope of work

- Collect LNG composition data from MARCOGAZ members managing LNG terminals
  - Data from each individual cargo downloaded
    - *Only information of cargos coming from liquefaction terminals*, not reloading operation between LNG regasification terminals, i.e, between European countries

- The information will be used to calculate the main gas quality parameters from the different origins
  - Average gas composition and standard deviation
    - Maximum and minimum of each component
  - Gross calorific value, Wobbe index, relative density, density and Methane number
    - Average of all the cargos
    - Range: maximum and minimum value

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Scope of work, some considerations

- It is known that the composition of LNG slightly changes during ship transportation
  - So, the information collected will not be exactly the quality of the LNG as it was at its country of origin, after the liquefaction train, but *the LNG quality that arrives to Europe, after the journey*

- In any case, *the information collected from MARCOGAZ member LNG terminals will show approximately the maximum range of composition, and properties, that can be expected from a specific LNG origin at the arrival in Europe*

- The information collected and presented is of LNG arriving to LNG terminals, not the natural gas injected into National transmission networks
  - Any natural gas injected into the network at the exit of a LNG regasification terminal shall be inside the range defined by the applicable National natural gas quality regulation/specification

- No information about the amount of LNG (either volume or energy) downloaded by cargo has been collected, as this is considered commercial sensitive information

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Information collected

- 7 members of MARCOGAZ supplied information to the database
  - Some members argued confidentiality clauses which its included in the contract signed between the LNG terminal operator and the LNG shipper company for not giving information

- The information covers years 2022 and 2023

- Information of *760 individual cargos* from 5 Europea countries was collected and used in the analysis
  - Some additional information was provided by other members, but the format/structure/data did not allow to process

- Information included *LNG from 16 exporting countries*

- *Although not optimal, the amount of information received is considered sound for representing the current LNG quality received in Europe*

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Analysis of data

The analysis of the data was as follows

- *Mean average composition*, and maximum and minimum composition of each component of LNG, collected per origin.
  - Standard deviation of the average is included.
- *Main properties*: Wobbe index, Gross Calorific Value, density, relative density and Methane number
  - Average, maximum and minimum value per origin.
- From some origins only few data are available but for many supply origins to Europe, the number of cargos collected gives to the information a *quite sound statistic value*

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Composition

The information provided for composition was compiled in tables:

- *Country of origin and number of cargos* collected
- *Average value of each LNG component*, mol/mol
- *Maximum value of each LNG component*, mol/mol
- *Minimum value of each LNG component*, mol/mol
- *Standard deviation value of each LNG component*, mol/mol

Some remarks

- Carbon dioxide is not considered because is not a component present on LNG in a measurable amount
  - CO2 is eliminated from natural gas in the treatment before liquefaction
- Neo-pentane is not considered because its presence is almost negligible in LNG
  - Most of gas chromatograph cannot detect it
- Oxygen is not a normal component of LNG
  - Although in recent years the presence of O2 has been reported in some cargo manifestos arriving to Europe, the amount is very small and is not normally analyzed/detected by the gas chromatograph installed in LNG terminals

Composition (example)

Country (nº cargos)		Nitrogen	Methane	Ethane	Propane	Iso-Butane	N-Butane	Iso-Pentane	N-Pentane	Hexane+
Qatar (47)	Avg	**0.00281**	**0.93018**	**0.06342**	**0.00260**	**0.00040**	**0.00059**	**0.00000**	**0.00000**	**0.00000**
	Max	0.00481	0.93497	0.08125	0.02078	0.00388	0.00586	0.00002	0.00003	0.00001
	Min	0.00000	0.90818	0.05813	0.00014	0.00000	0.00000	0.00000	0.00000	0.00000
	StD	0.00102	0.00746	0.00315	0.00597	0.00113	0.00171	0.00000	0.00001	0.00000
Russia (80)	Avg	**0.00183**	**0.95840**	**0.03084**	**0.00532**	**0.00204**	**0.00150**	**0.00005**	**0.00001**	**0.00001**
	Max	0.00320	0.96827	0.05102	0.01822	0.00270	0.00261	0.00026	0.00019	0.00006
	Min	0.00012	0.92538	0.02564	0.00064	0.00021	0.00008	0.00000	0.00000	0.00000
	StD	0.00040	0.00502	0.00286	0.00195	0.00043	0.00041	0.00003	0.00002	0.00001
Trinidad & Tobago (17)	Avg	**0.00017**	**0.98479**	**0.01174**	**0.00258**	**0.00033**	**0.00032**	**0.00004**	**0.00002**	**0.00001**
	Max	0.00160	0.98741	0.01792	0.00318	0.00077	0.00103	0.00009	0.00005	0.00003
	Min	0.00000	0.97819	0.00948	0.00140	0.00016	0.00020	0.00000	0.00000	0.00000
	StD	0.00038	0.00250	0.00232	0.00036	0.00012	0.00021	0.00002	0.00001	0.00001
USA (299)	Avg	**0.00108**	**0.96495**	**0.03156**	**0.00178**	**0.00025**	**0.00028**	**0.00004**	**0.00002**	**0.00004**
	Max	0.00812	0.97942	0.06395	0.00513	0.00202	0.00210	0.00012	0.00010	0.00040
	Min	0.00002	0.93218	0.01469	0.00056	0.00004	0.00002	0.00000	0.00000	0.00000
	StD	0.00114	0.00916	0.00916	0.00071	0.00018	0.00031	0.00004	0.00002	0.00005

Gas properties

The information provided in the report, tables and graphs, for gas properties was:

- *Country of origin and number of cargos* collected
- *Maximum, minimum and average Gross Calorific Value (GCV),* in ISO 15/15 condition (*)
- *Maximum, minimum and average Wobbe index value (WI),* in ISO 15/15 condition (*)
- *Maximum, minimum and average relative density value (dr),* in ISO 15/15 condition (*)
- *Maximum, minimum and average density value (d),* in ISO 15/15 condition (*)
- *Maximum, minimum and average Methane number value (MN) (+)*

(*) ISO 6976:2016, Natural gas - Calculation of calorific values, density, relative density and Wobbe indices from composition.

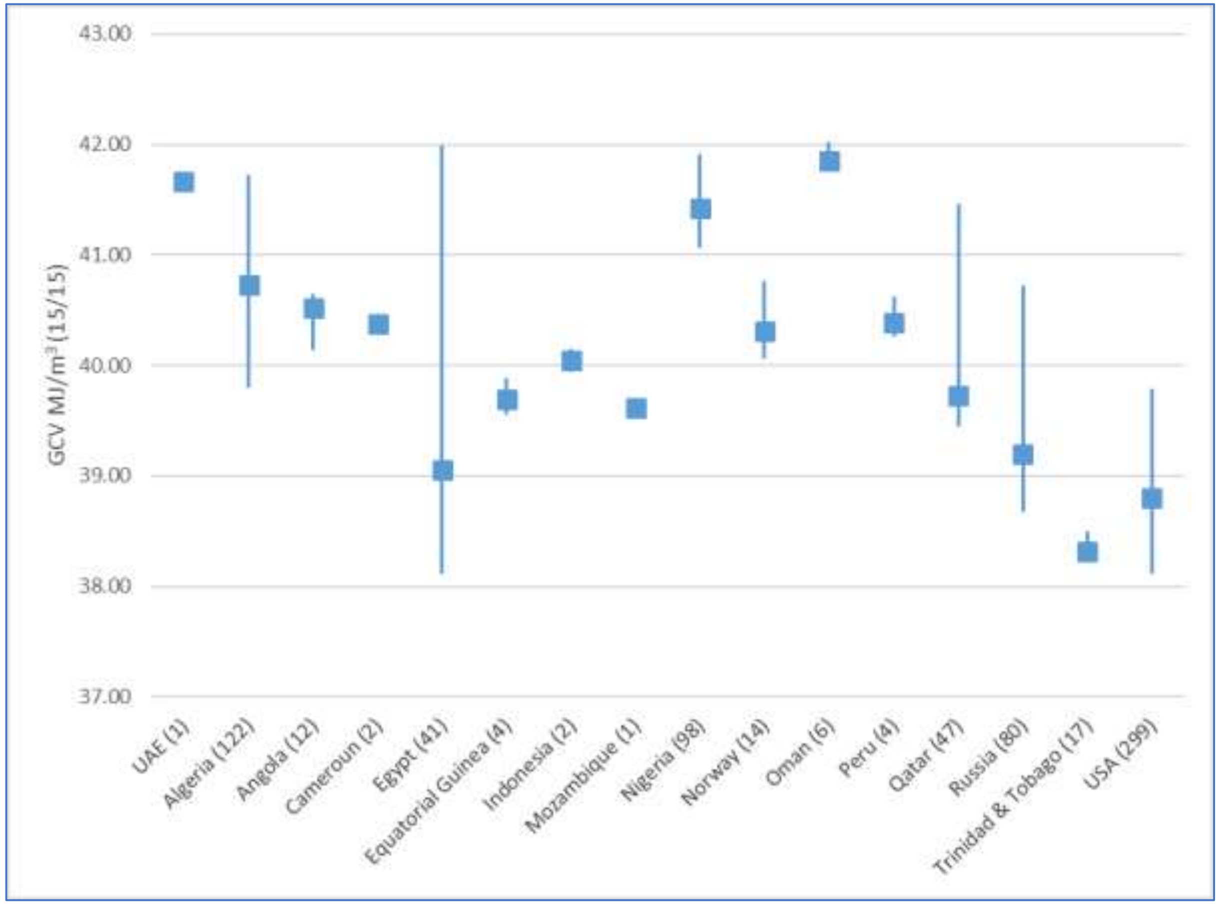
(+) EN 16726:2015+A1:2016: Gas infrastructure - Quality of gas - Group H.

Gas properties

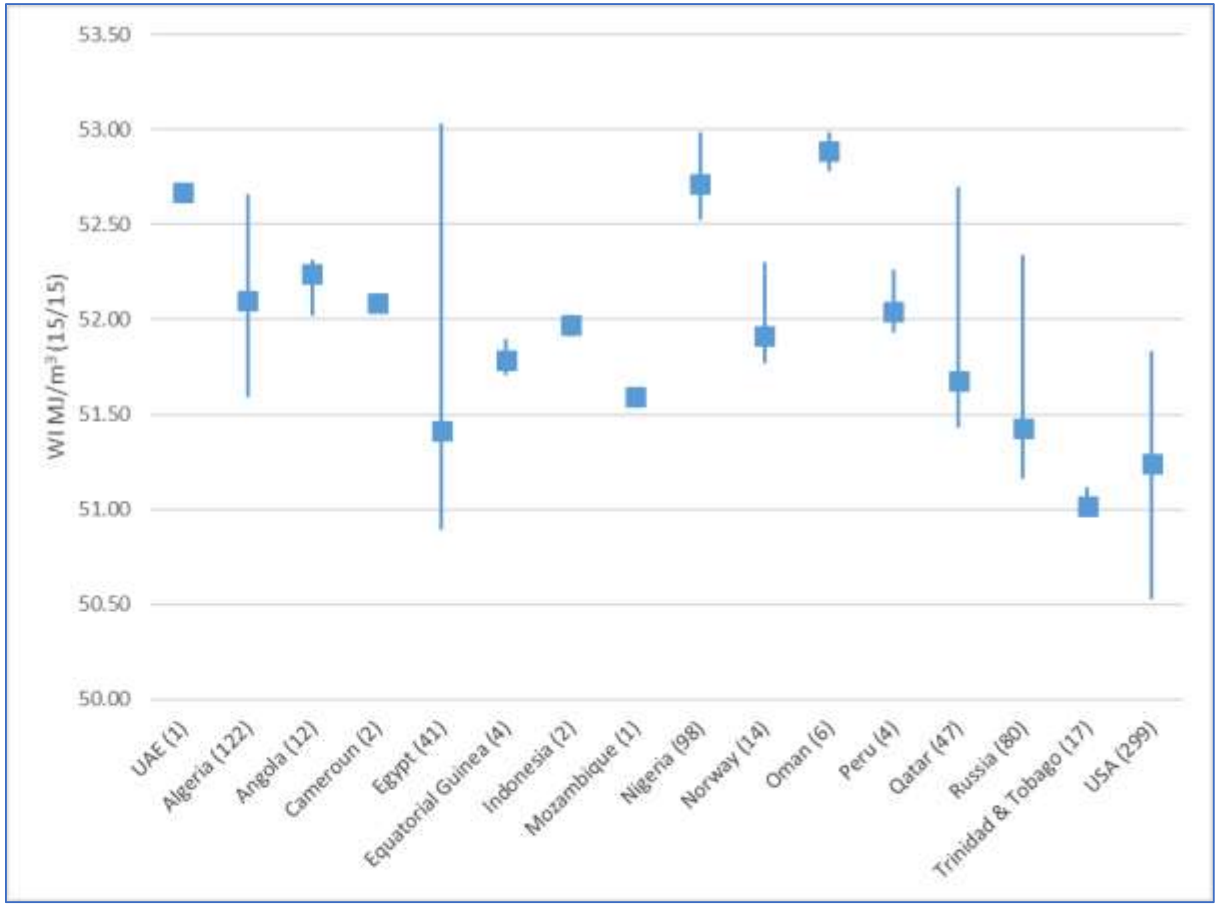
Country (nº cargo)	GCV, MJ/m³ (15/15)			WI, MJ/m³ (15/15)			Relative Density (15/15)		
	Max	Min	*Avg*	Max	Min	*Avg*	Max	Min	*Avg*
UAE (1)	-	-	*41.67*	-	-	*52.67*	-	-	*0.63*
Algeria (122)	41.73	39.79	*40.73*	52.66	51.59	*52.10*	0.63	0.59	*0.61*
Angola (12)	40.65	40.14	*40.52*	52.31	52.02	*52.24*	0.60	0.60	*0.60*
Cameroun (2)	40.43	40.31	*40.37*	52.13	52.03	*52.08*	0.60	0.60	*0.60*
Egypt (41)	41.99	38.12	*39.05*	53.03	50.89	*51.42*	0.63	0.56	*0.58*
Equatorial Guinea (4)	39.88	39.56	*39.69*	51.89	51.71	*51.79*	0.59	0.59	*0.59*
Indonesia (2)	40.14	39.94	*40.04*	52.03	51.91	*51.97*	0.60	0.59	*0.59*
Mozambique (1)	-	-	*39.61*	-	-	*51.59*	-	-	*0.59*
Nigeria (98)	41.91	41.07	*41.42*	52.99	52.52	*52.72*	0.63	0.61	*0.62*
Norway (14)	40.77	40.06	*40.31*	52.30	51.77	*51.91*	0.61	0.60	*0.60*
Oman (6)	42.02	41.77	*41.85*	52.99	52.78	*52.89*	0.63	0.62	*0.63*

Gas properties

Gross Calorific Value

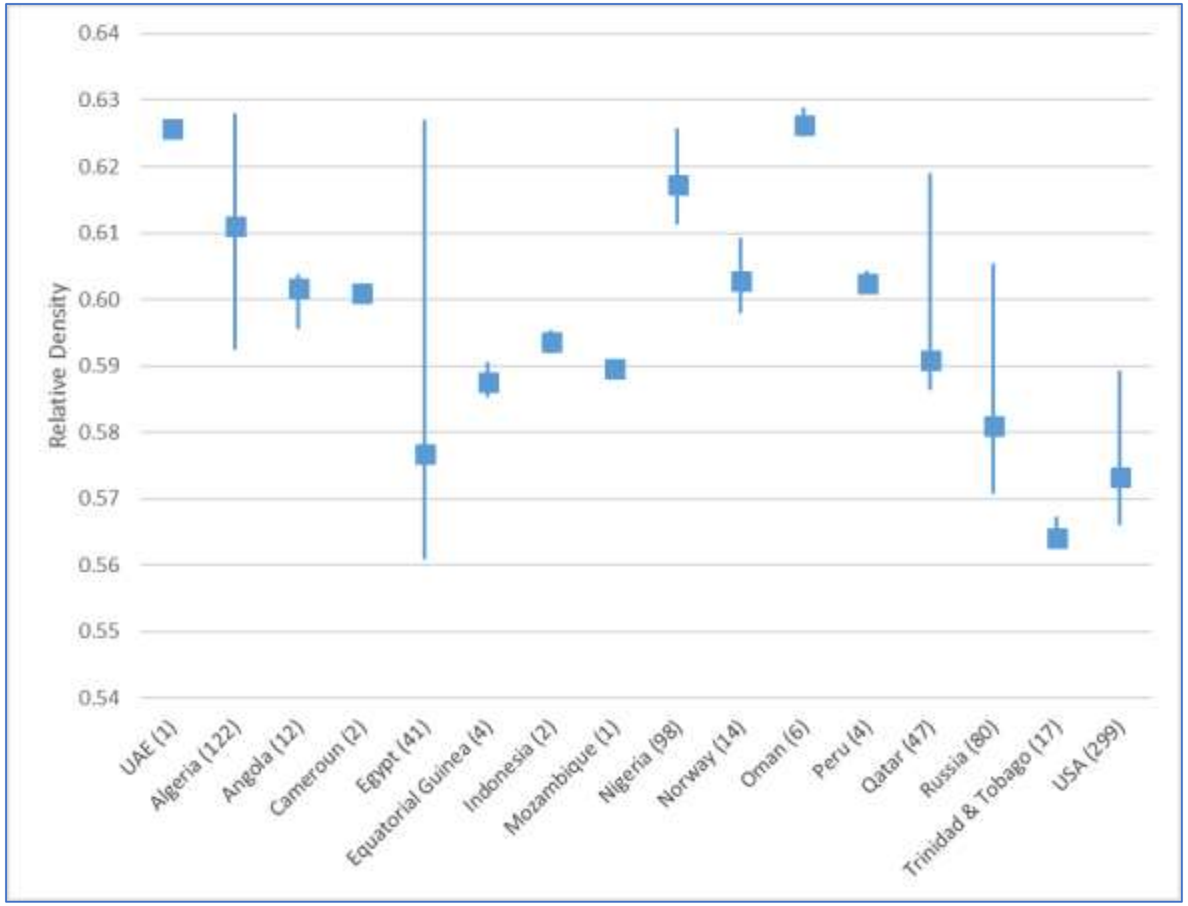


Wobbe index

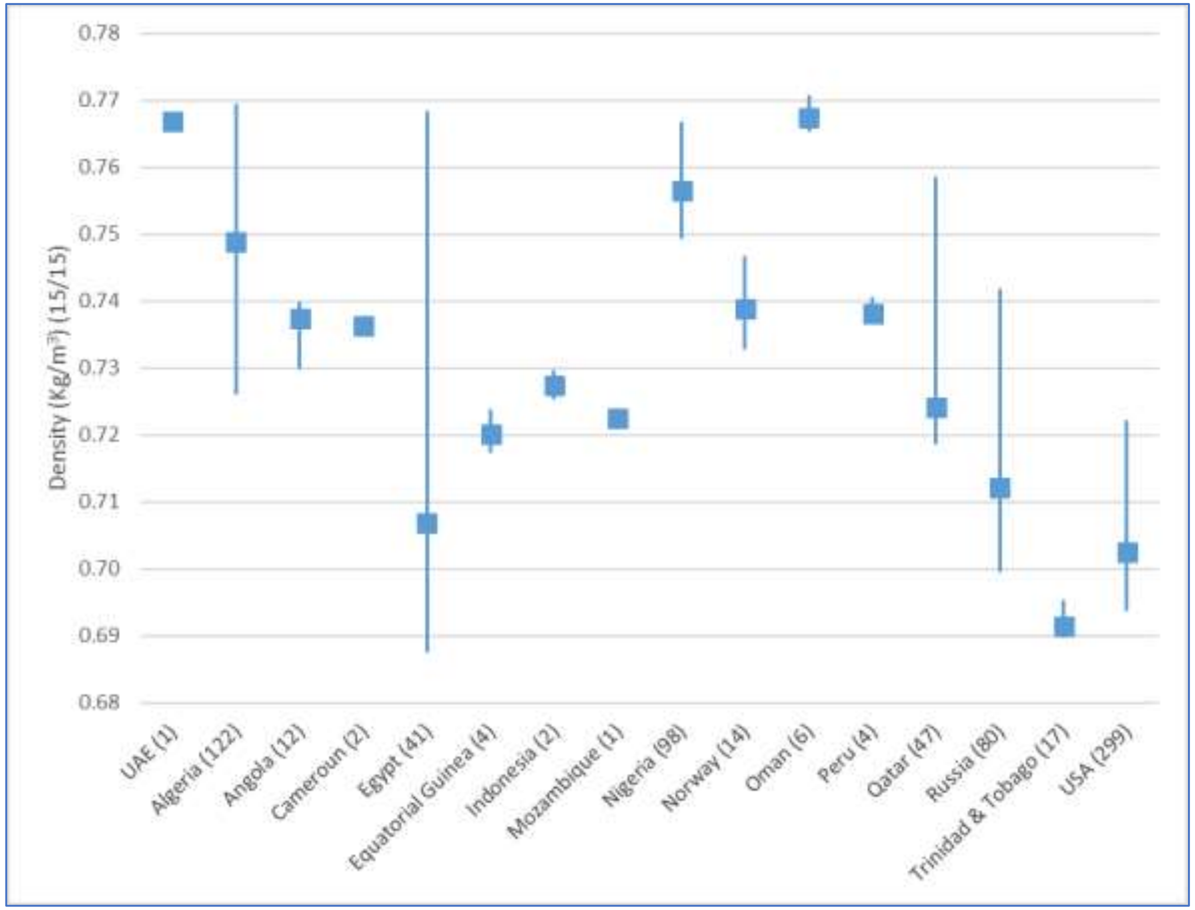


Gas properties

Relative density



Density



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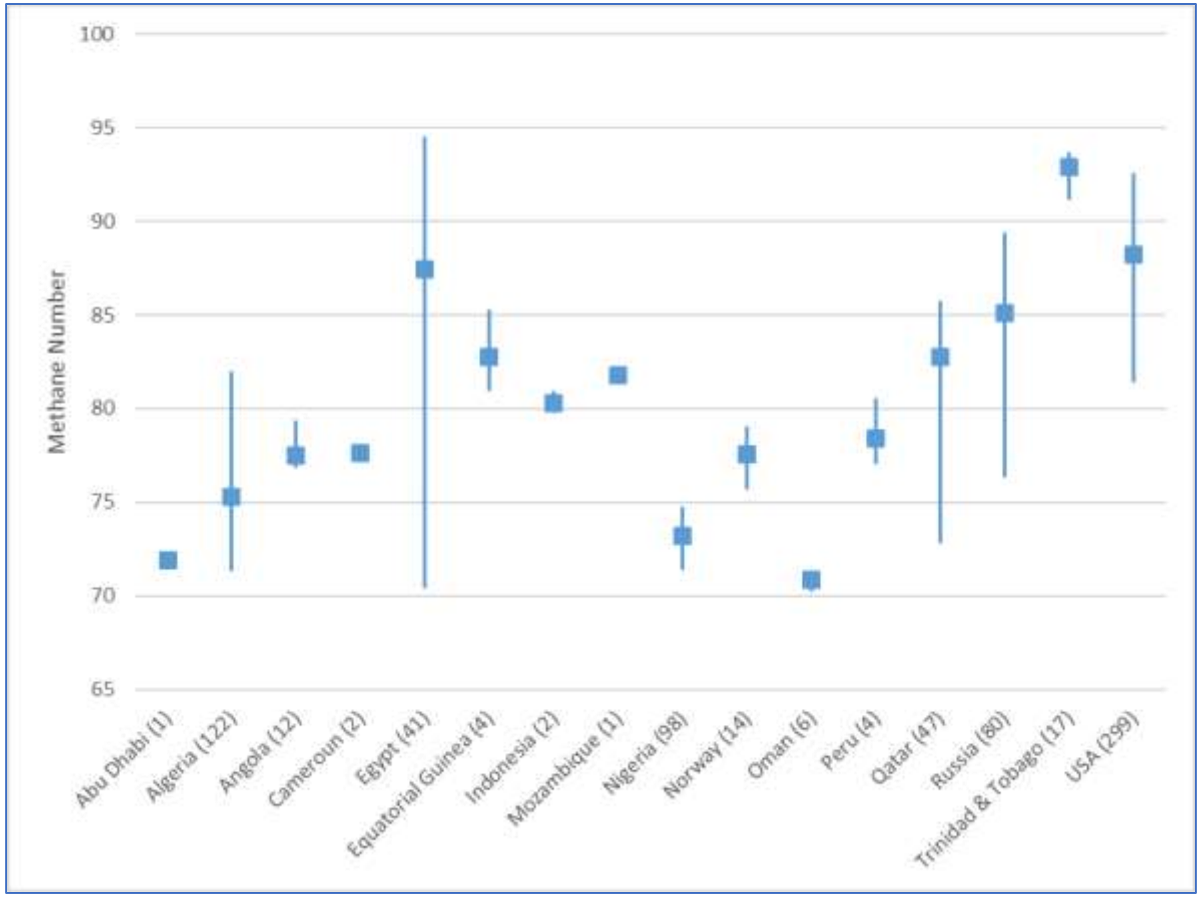
Gas properties

Methane number



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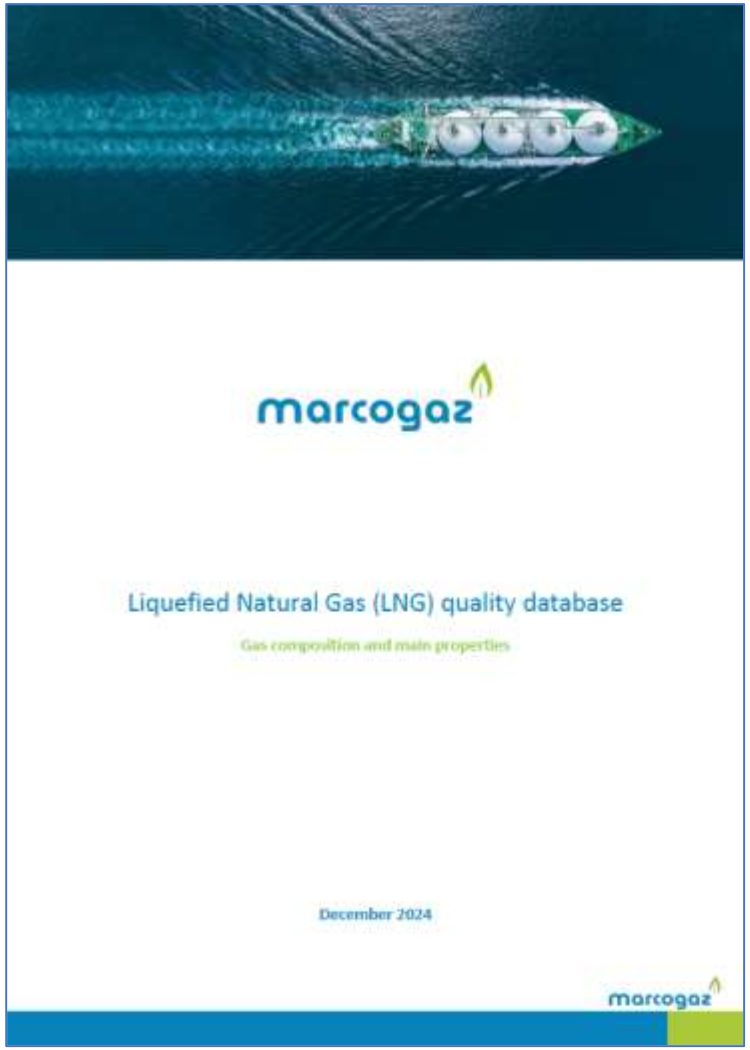
Conclusions



- MARCOGAZ Group 5 Gas Quality & Metering has carried out an *exercise of collecting LNG composition information*
- Information for *760 cargos arriving to 5 EU countries and from 16 exporting countries* have been included in the database
- *Main properties of LNG has been calculated* and presented in the report
  - The composition information provided allows to calculate any other property
- The *process has been described and published* in a report available on MARCOGAZ website

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Thank you!

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The role of LNG quality when designing industrial gas appliances

Jörg Leicher

Research Engineer / Group Manager Simulation at the Gas and Heating Institute Essen (GWI)

20 May, 2025

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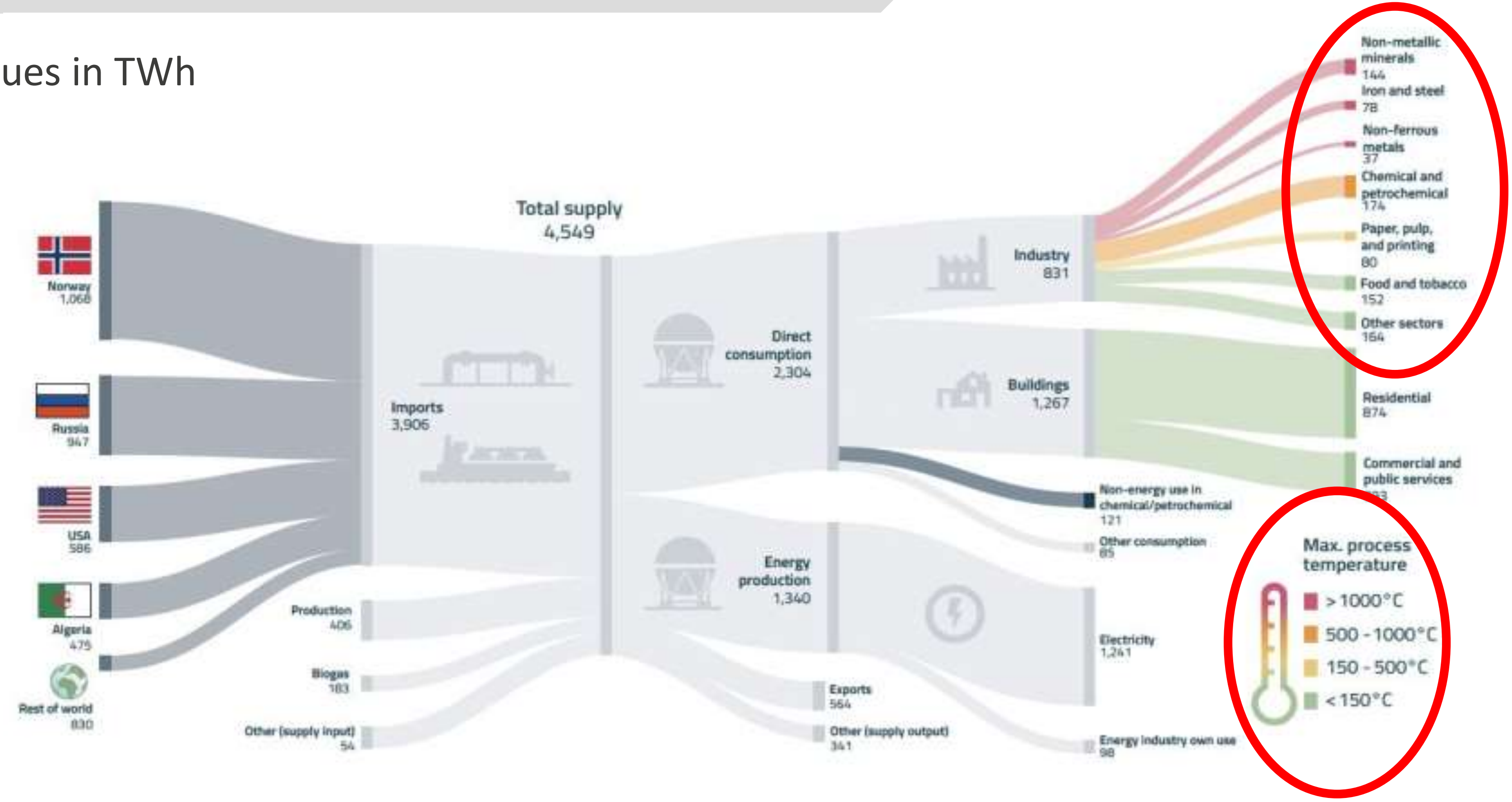
The role of LNG quality when designing industrial gas appliances

MARCOGAZ Tech Forum on LNG Quality

Jörg Leicher, May 20, 2025

Natural gas in Europe: flows and utilization (2022)

Values in TWh



Source: EUROSTAT (data); FCA (visualization)

Breaking it down to the basics: gas combustion and natural gas / LNG quality

- Almost every gas combustion process can be characterized by two process parameters:

  - **Firing rate**: $\boldsymbol{P} = \dot{V}_{n,fuel} \cdot H_{i,vol}$ [W]

  - **Air excess ratio**: $\boldsymbol{\lambda} = \frac{\dot{V}_{n,air,actual}}{\dot{V}_{n,air,min}} = \frac{\dot{V}_{n,air,actual}}{Air_{min} \cdot \dot{V}_{n,fuel}}$ [-]

- Gas-fired combustion processes are **always designed** and **adjusted** with **a specified fuel gas** in mind to fulfill their purpose safely, efficiently and with low emissions.

- **Adjustment** means that the volume flows of fuel and oxidizer (usually air) are set in such a way that the device fulfills its purpose with optimum performance.
  Equipment is **always** adjusted when the device is first commissioned and put into service, or after maintenance/repairs.

gwi

Breaking it down to the basics: gas combustion and natural gas / LNG quality

End users care far more about **relative changes of local gas quality** than national specifications like upper and lower WI or GCV limits!

The challenge is almost always the **change** of the fuel quality, in comparison to the fuel that the system was **originally designed and adjusted** for.

The larger this difference is, the stronger the consequences of the gas quality change can be.
Consequences can be loss of efficiency, higher pollutant emissions (NO_X), reduced product quality or even safety issues.

Why industrial equipment can be more sensitive than residential appliances to gas quality changes

- Residential natural gas-fired appliances are operated with **high air excess ratios** ($\lambda \approx 1.2 - 1.4$) and (supposedly) adjusted **by the manufacturer** to a defined gas quality (usually G20, i.e. pure methane).

- Industrial combustion processes have to be operated with **low air excess ratios** ($\lambda \approx 0.95 - 1.15$) and **are always adjusted to the local gas** at the time of commissioning. Often, the **quality** of the local gas at the time is **unknown**.

- **Low air excess** makes a combustion process **more sensitive** to gas quality changes, especially when the gas shifts towards higher calorific value or WI (**CO formation**!).

- At the same time, **low λ values are required** for high **efficiency** and low **NO_X emissions**, especially in high-temperature applications. The O_2 concentration in the flue gas may be relevant for **product quality** as well.

Wobbe Index: meaning and limitations

- The **Wobbe Index** (WI) was introduced as an easy way to assess the impact of a **fuel gas change** on the **heat release** in a simple **uncontrolled** combustion system:
  Two fuel gases with the **same Wobbe Index** will release the **same amount of heat** over time if they are burned at the **same nozzle** with the **same nozzle pressure**.
  Thus, the two gases are **interchangeable** for this system **in terms of heat release**, there is no need to physically change the equipment to use both gases.

- This is valid for **residential or commercial appliances**, but also for many larger applications.

- **But:** the WI **only** considers **heat release**, not any other important aspects of combustion (safety, emissions, efficiency, temperatures, stability, …).
  Also, its meaningfulness is severely reduced if **chemically very different** fuel gases are compared (=> H_2).

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The limits of the Wobbe Index: hydrogen

	Unit	100 % CH_4	94 % CH_4 / 6 % CO_2	92 % CH_4 / 8 % N_2	100 % H_2
WI	MJ/m^3	50.64	45.28	45.27	45.78
NCV	MJ/m^3	34.06	32.02	31.34	10.24
GCV	MJ/m^3	37.80	35.53	34.78	12.10
d	-	0.5571	0.6157	0.5901	0.0698
Air_{min}	m^3/m^3	9.524	8.952	8.762	2.381
T_{ad} (λ = 1)	°C	1,982	1,971	1,974	2,096
s_L (λ = 1)	cm/s	38.57	36.79	37.52	209
MN*	-	100	105	99	0

*: MWM method

@ 15 °C / 15 °C, 1.01325 bar

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MN*	-	**100**	**105**	**99**	**0**

@ 15 °C / 15 °C, 1.01325 bar

*: MWM method

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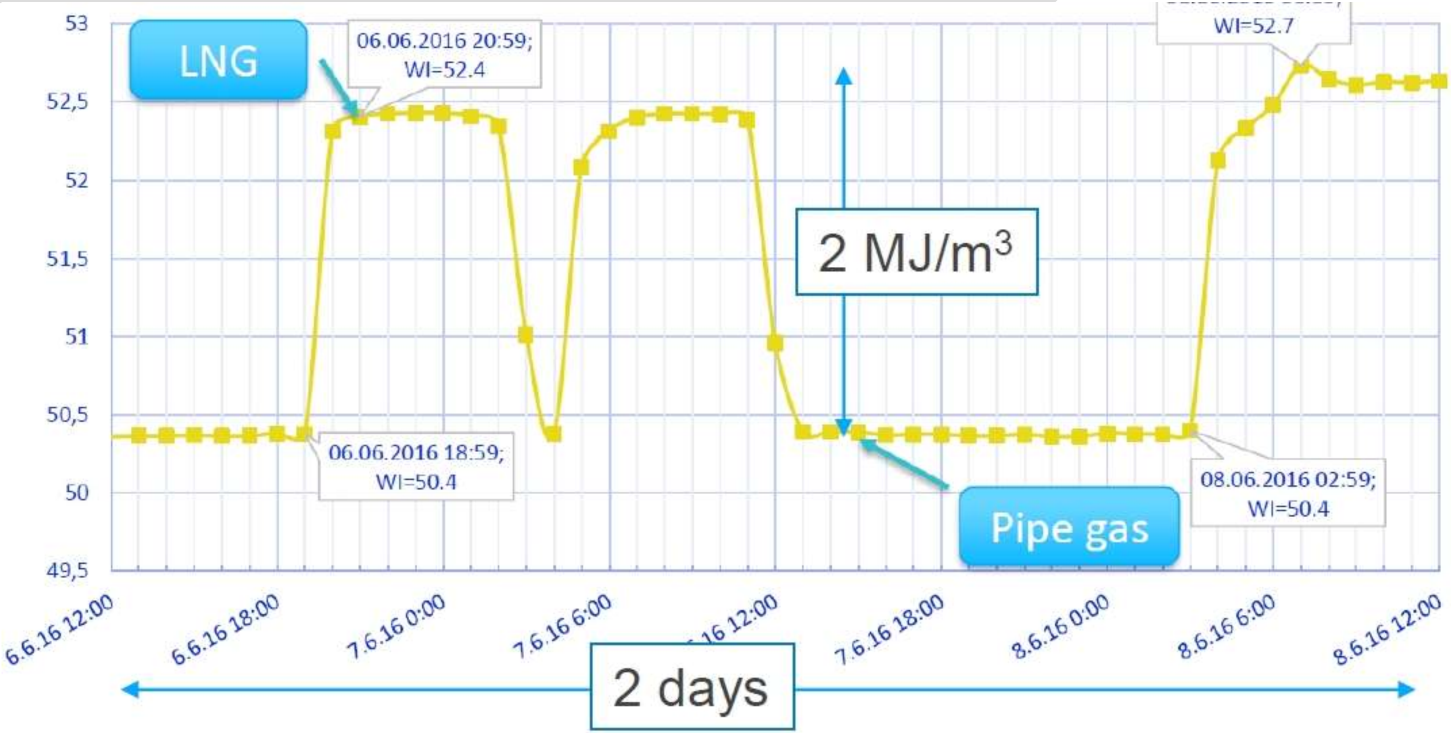
Example: local gas quality fluctuations in France (2016)



Note:

The revision of EN 16726 will likely prescribe a WI range of **46.44 – 53.0 MJ/m³** for the entry range.

That's a spread of -8.5%/+4.5%, based on methane (WI = 50.64 MJ/m³)!

Source: Ourliac, M., „Deal with gas quality variations and melt glass with syngas from gasification", IFRF/GWI TOTeM 44 "Gaseous Fuels in Industry and Power Generation: Challenges and Opportunities", Essen, Germany, 2017

Example: effects of a local gas quality change

- Pipe gas: WI_{Pipe} = 50.4 MJ/m³
  LNG: WI_{LNG} = 52.7 MJ/m³

- The furnace is adjusted to **λ = 1.05** with pipe gas.
  What happens if the local gas quality **switches to LNG**?
  Assumption: **no combustion control**!

$$\frac{\lambda_{LNG}}{\lambda_{pipe}} \approx \frac{W_{pipe}}{W_{LNG}} \Rightarrow \lambda_{LNG} = 1.00$$

- Likely consequences:
  - increase in CO formation (=> safety)
  - increased flame length
  - potential impact on product quality due to reduced O_2 content in the flue gas

Image: WS Wärmeprozesstechnik GmbH

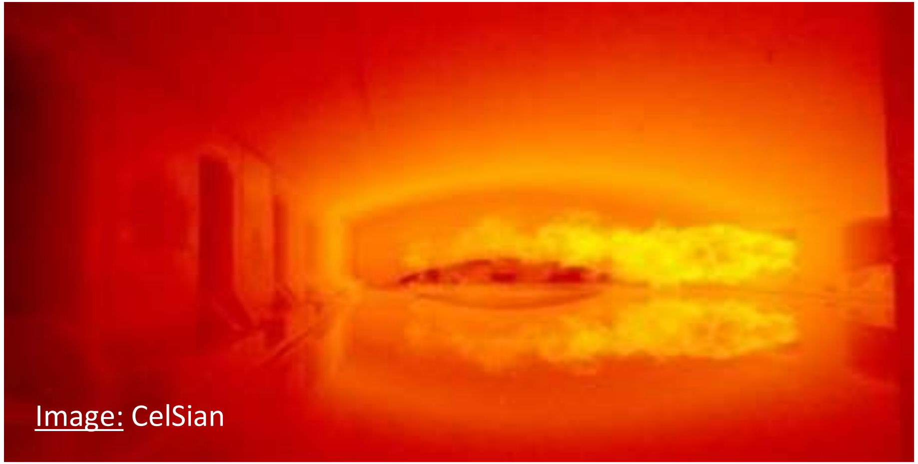


Image: CelSian

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$$\frac{\lambda_{pipe}}{\lambda_{LNG}} \approx \frac{W_{LNG}}{W_{pipe}} \Rightarrow \lambda_{pipe} = 1.1$$

- Likely consequences:
  – increase in NO_X formation
  – reduced flame length and efficiency
  – potential impact on product quality due to increased O_2 content in the flue gas


Image: WS Wärmeprozesstechnik GmbH

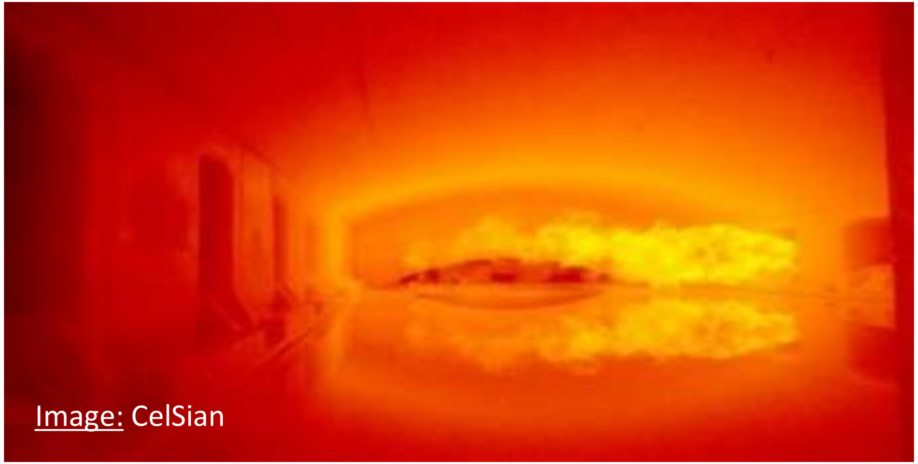


Image: CelSian

EN 676: Forced-draught burners for gaseous fuels (snippet)

Annex R
(informative)

Impact of the variations of the gas quality in EU gas grids to gas burners

Burners according to this document are not intended to be connected to gas grids where the quality of the distributed gas is likely to vary to a large extent over the lifetime without corrections of the burner-set-up.

Burners in Europe were adjusted, taking into account the local Wobbe index at the time of intervention, and optimized during operation in accordance. If higher, short-term oscillating gas quality fluctuations should occur in the future; the following burner plant qualities can no longer be warranted:

— Burner plant safety:

 — In regard to higher CO emission;

 — in regard to flame stability (explosion);

 — overload /lifetime of heat exchanger;

— Burner plant reliability and availability;

— Guarantee of legal and required emission limits;

— Burner plant efficiency with the total efficiency of the heat exchanger.

The following recommendations and statements are valid for gas burners according to EN 676:

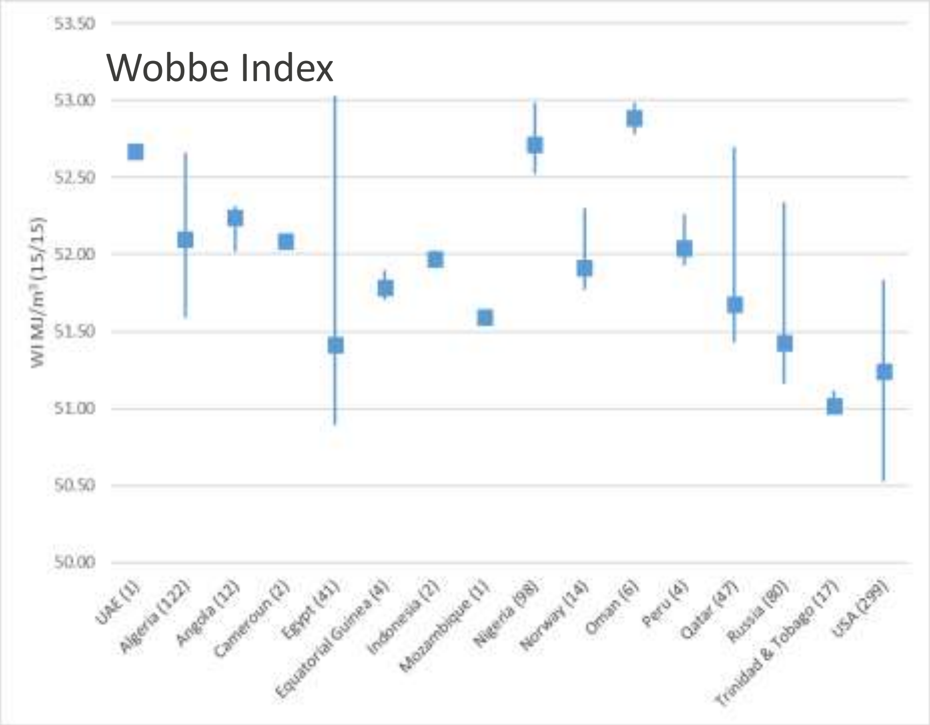
1. The Wobbe index of the gas supplied on site should be known during commissioning/setting of the burner.

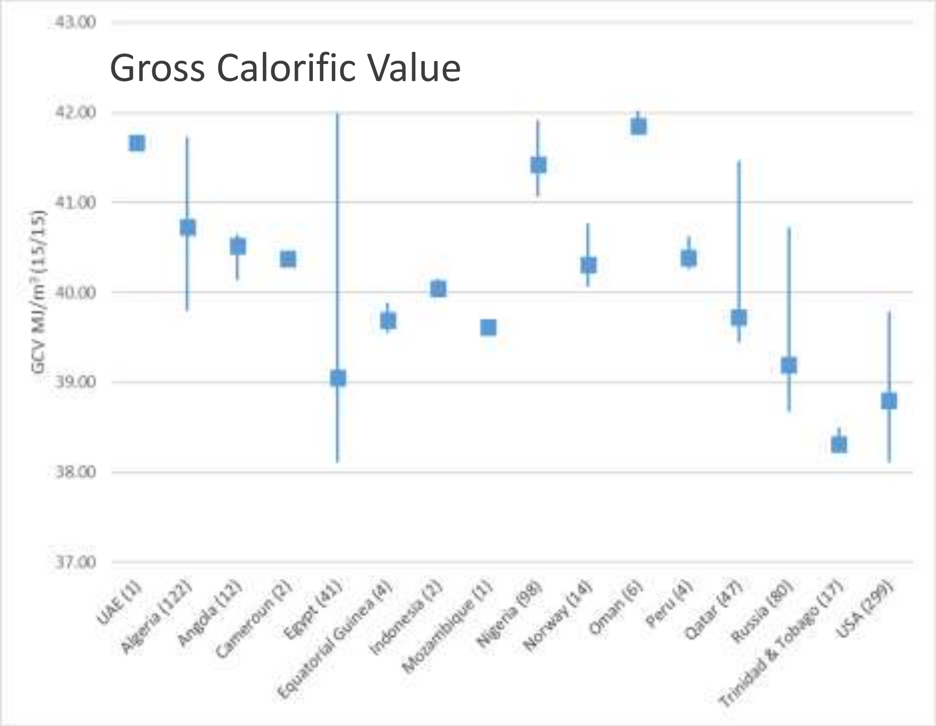
2. The Wobbe-Index fluctuation range may differ at maximum up to ± 2 % without using additional measures for combustion optimization, if the gas quality is known during commissioning.

...

Image: Dreizler GmbH

Overview of LNG qualities (MARCOGAZ LNG database)





Note that renewable gases (biomethane, SNG, NG/H_2 blends) tend towards lower WI /GCV!

The power of (appropriate) combustion control: Impact on an industrial burner system

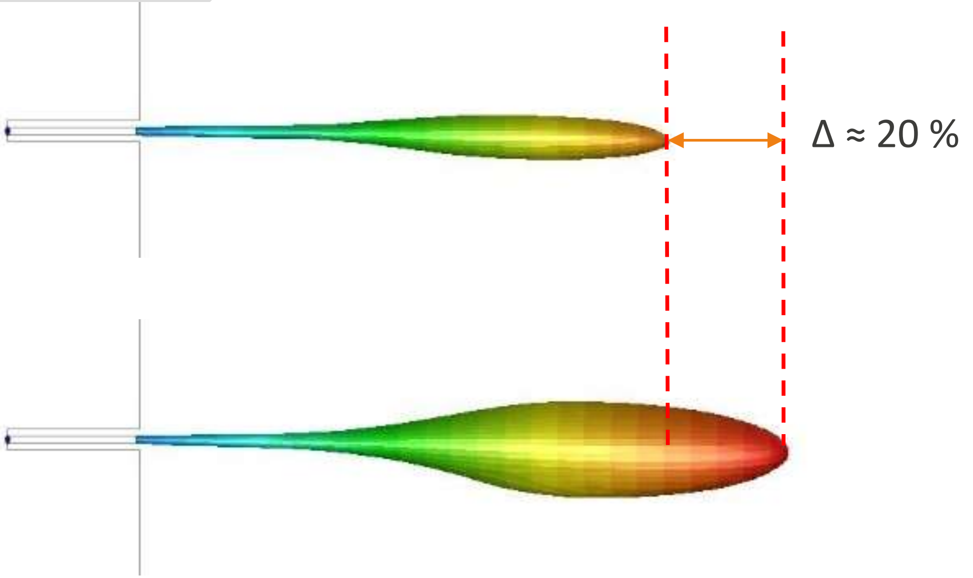
Reference case:

Russian H-Gas
(P = 200 kW, λ = 1.1)

Δ W_S = 0.4 %
Δ H_i = 4 %

Existing setup:

North Sea H-Gas
Volume flows constant
(P = **208 kW**, λ = **1.056**)
↑ 4 % ↓ 4 %



The power of (appropriate) combustion control: Impact on an industrial burner system

Reference case:

Russian H-Gas
(P = 200 kW, λ = 1.1)

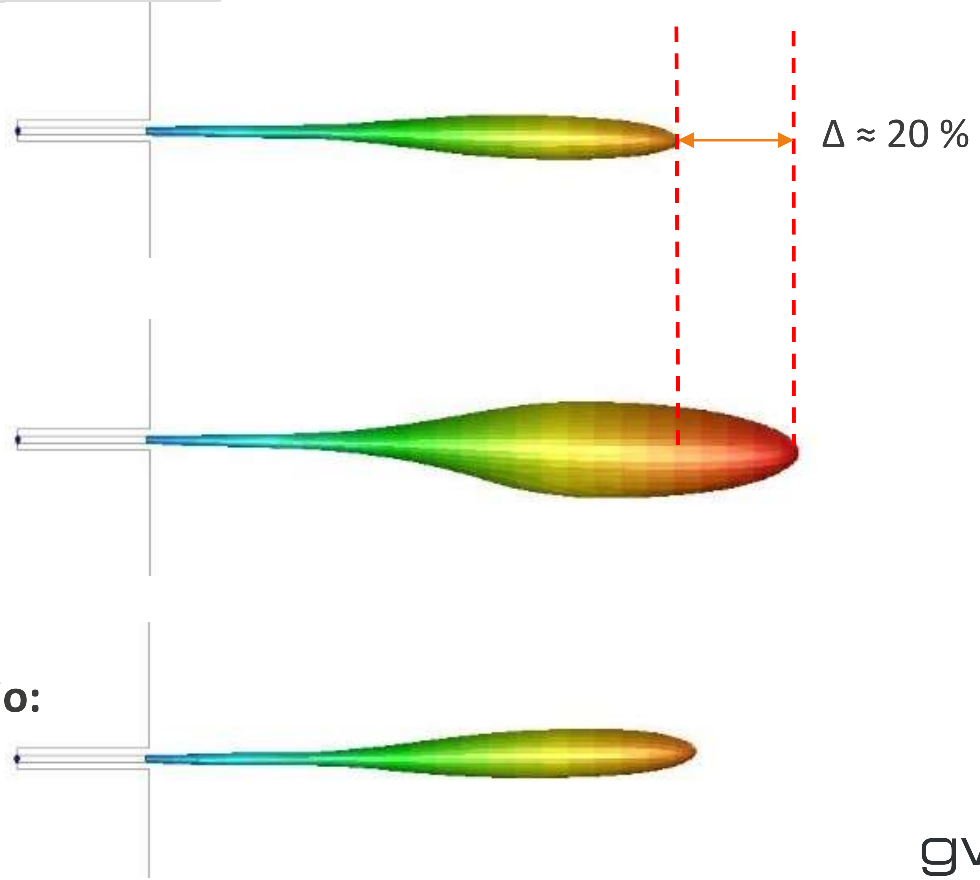
Δ W_S = 0.4 %
Δ H_i = 4 %

Existing setup:

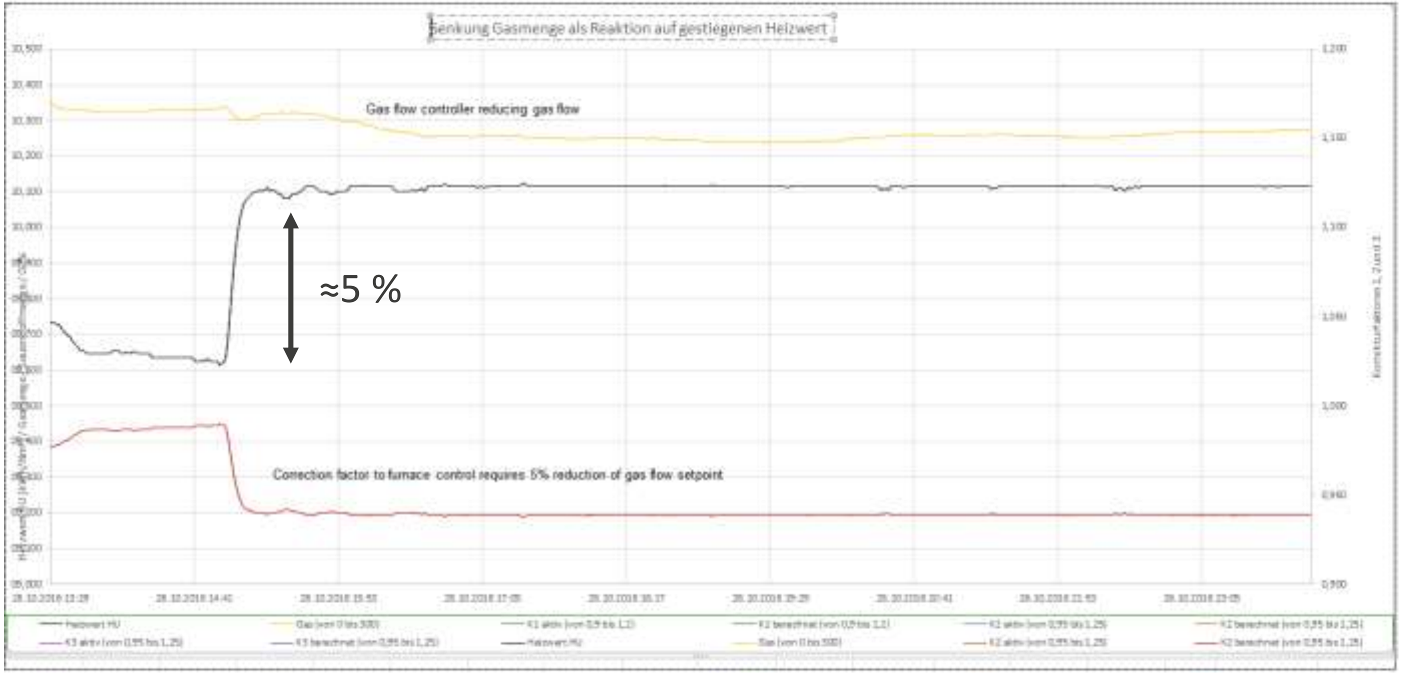
North Sea H-Gas
Volume flows constant
(P = **208 kW**, λ = **1.056**)
↑ 4 % ↓ 4 %

Control of firing rate and air excess ratio:

North Sea H-Gas
(P = **200 kW**, λ = **1.1**)
Air and fuel volume flows set separately



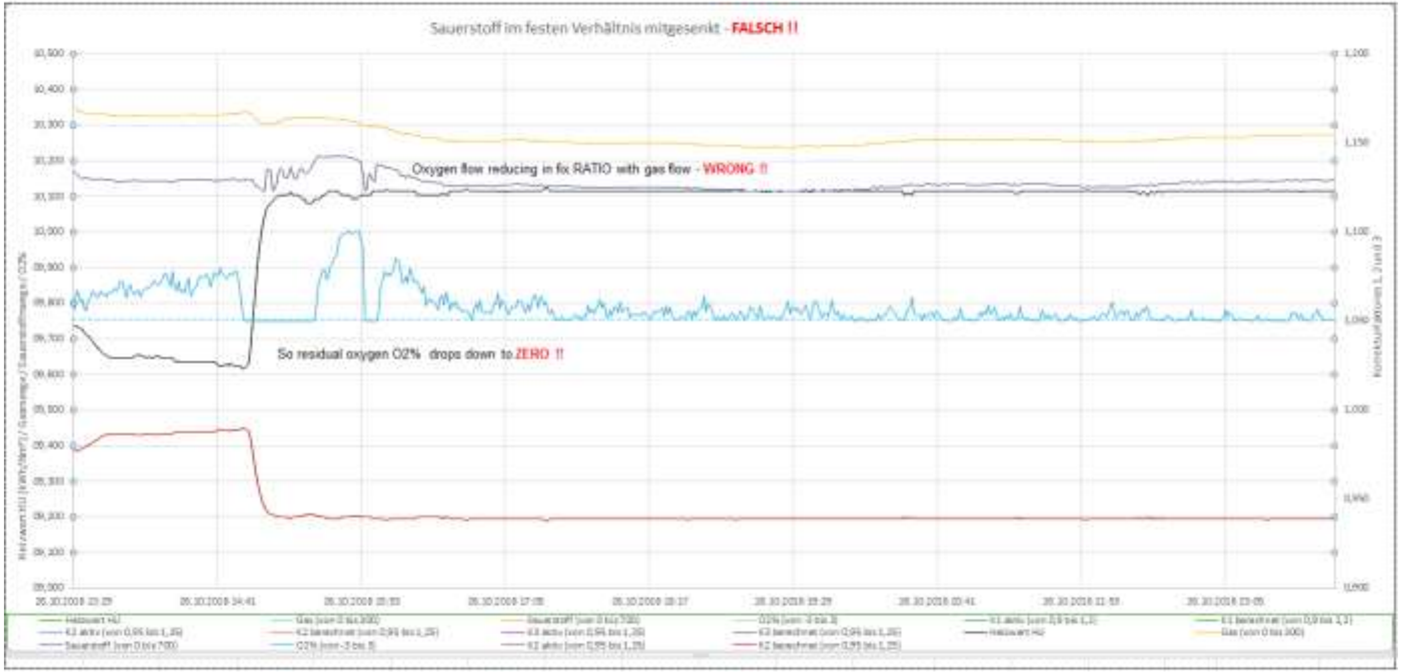
How not to control a furnace in times of varying gas qualities…



GQ measurement detects increased **NCV** => V_{gas} reduced

Source: P. Hemmann, Regelungstechnische Lösungen zur vorausschauenden Kompensation schwankender Gasqualität Workshop "Erdgasbeschaffenheitsschwankungen in der Prozessindustrie - Hintergründe, Auswirkungen, Lösungsansätze“, Düsseldorf, Germany, 2018

How ~~not~~ to control a furnace in times of varying gas qualities…



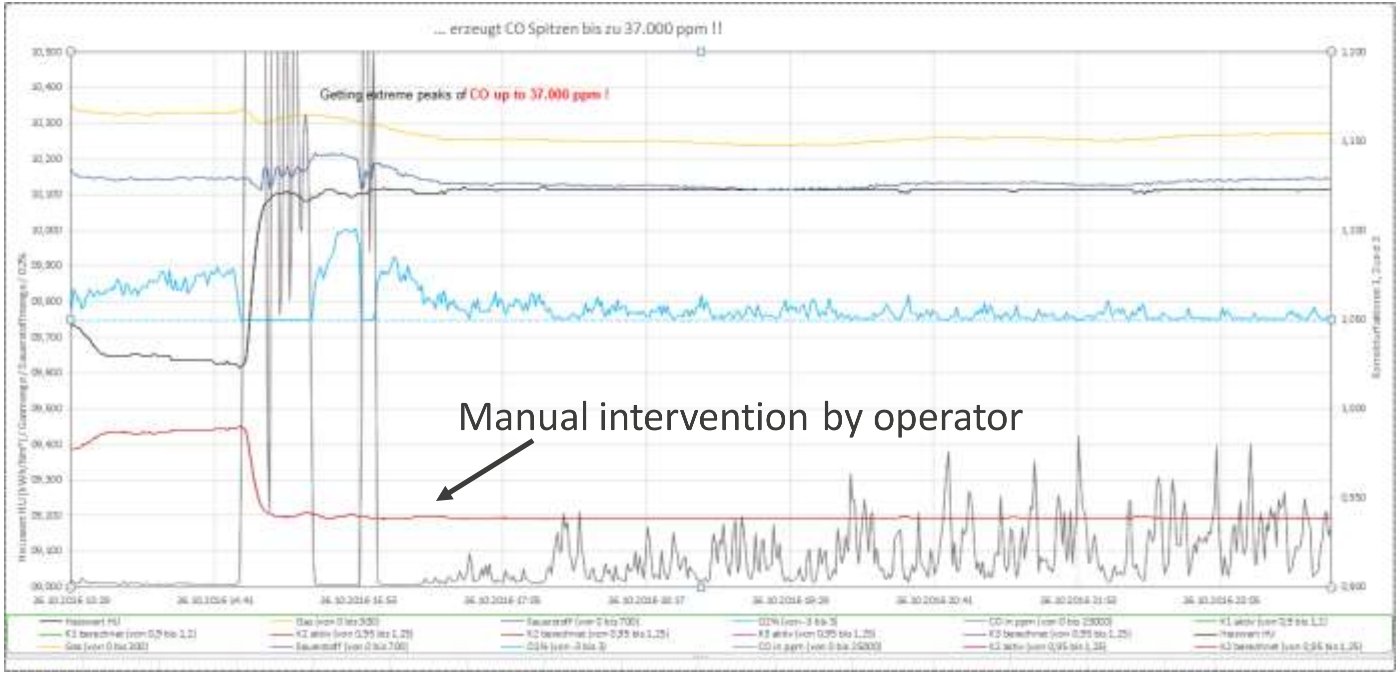
GQ measurement detects increased **NCV**
=> V_{gas} reduced

Fixed ratio of V_{O2}/V_{gas} set in furnace control

O_2 in flue gas drops to 0
(=> $\lambda < 1$)

Source: P. Hemmann, Regelungstechnische Lösungen zur vorausschauenden Kompensation schwankender Gasqualität
Workshop "Erdgasbeschaffenheitsschwankungen in der Prozessindustrie - Hintergründe, Auswirkungen, Lösungsansätze“, Düsseldorf, Germany, 2018

How not to control a furnace in times of varying gas qualities…



GQ measurement detects increased **NCV** => V_{gas} reduced

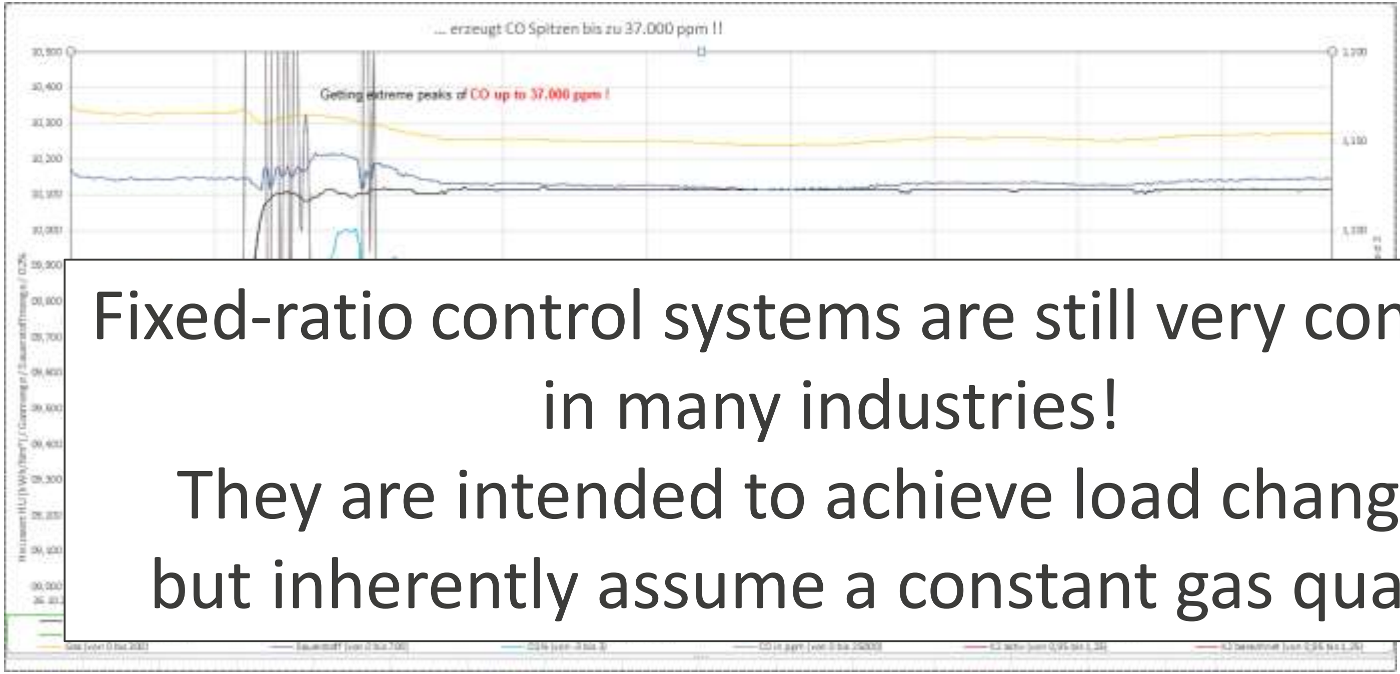
Fixed ratio of V_{O2}/V_{gas} set in furnace control

O_2 in flue gas drops to 0 (=> $\lambda < 1$)

Extreme CO formation!
Bad idea!

Source: P. Hemmann, Regelungstechnische Lösungen zur vorausschauenden Kompensation schwankender Gasqualität Workshop "Erdgasbeschaffenheitsschwankungen in der Prozessindustrie - Hintergründe, Auswirkungen, Lösungsansätze“, Düsseldorf, Germany, 2018

How <u>not</u> to control a furnace in times of varying gas qualities…



Fixed-ratio control systems are still very common in many industries!
They are intended to achieve load changes, but inherently assume a constant gas quality.

GQ measurement detects increased **NCV** => V_{gas} reduced

Fixed ratio of V_{O2}/V_{gas}

nace control

gas drops to 0

CO formation!

Source: P. Hemmann, Regelungstechnische Lösungen zur vorausschauenden Kompensation schwankender Gasqualität Workshop "Erdgasbeschaffenheitsschwankungen in der Prozessindustrie - Hintergründe, Auswirkungen, Lösungsansätze“, Düsseldorf, Germany, 2018

Conclusions

- Natural gas/LNG use in industry (and power generation) is **diverse** and **heterogeneous**. Industrial gas-fired equipment is operated under very different and often more demanding conditions and constraints, compared to residential appliances.

- For end users (and OEM), the **relative changes in local gas quality** matter, not national or supra-national specifications in absolute terms (min/max WI, GCV, …).
  Acceptable gas quality variations for actual equipment are usually **much smaller** than what national gas quality regulations allow into the grids!

- The **Wobbe Index** as a gas quality criterion is **far less relevant for industrial end-use** than for the residential sector. **Calorific values** or Methane Numbers are often more important.

- **Appropriate** combustion control is **one** powerful tool to mitigate the effects of gas quality changes. There are others (fuel conditioning, grid-level measures, …).

Thank you for your attention

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Q&A Session and closing remarks

Frédéric Vulovic

Head of Expertise and Engineering Department at NaTran & Vice-Chair of Gas Quality & Metering at MARCOGAZ

Q&A Session and closing remarks are available in the full video of the webinar, published on the Communications Hub/Videos section of our website