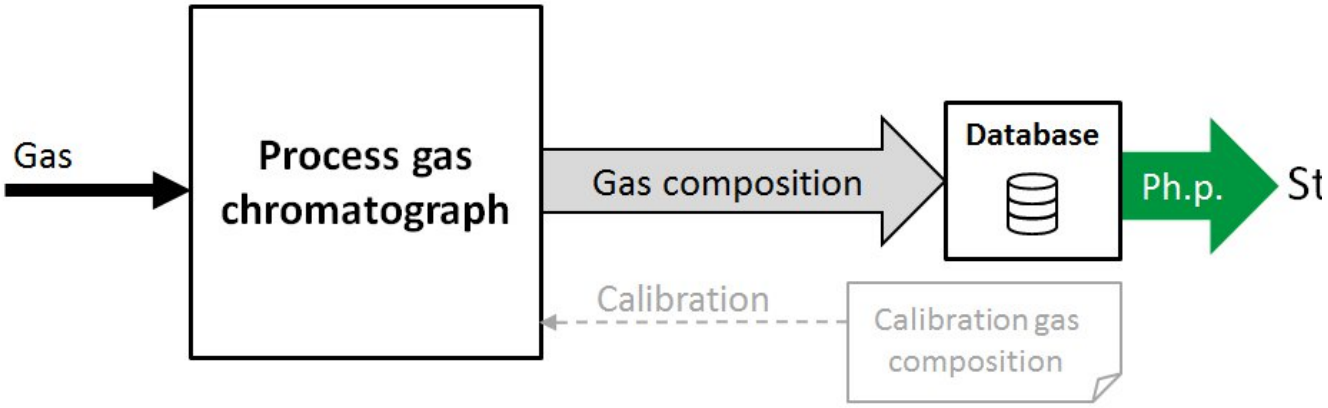
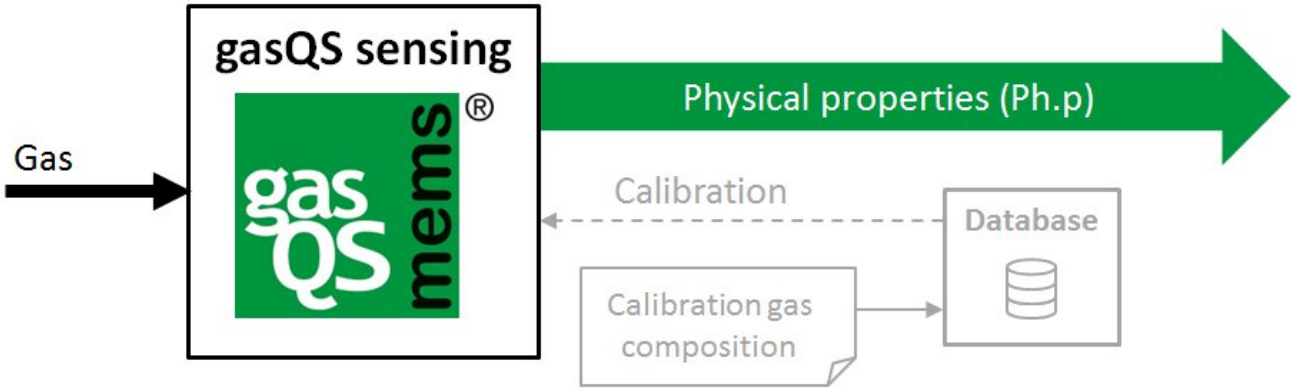
Innovative Messtechnik in der zukünftigen Gasinfrastruktur

How to measure gas qualities?

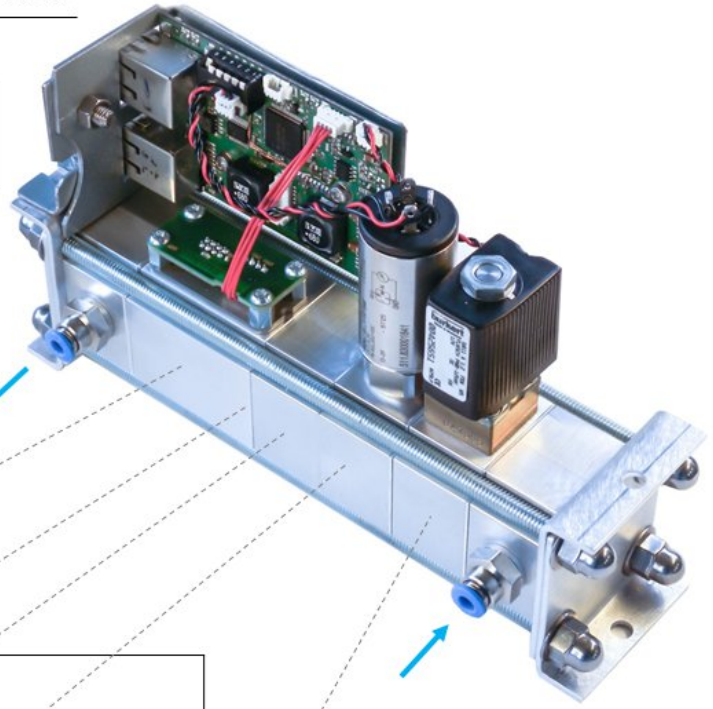




New «direct» approach

mems AG

gasQS Gas Quality Sensor: Principle



Power, data

Electronics

p-Sensor

Gas out

CMOS-Sensor

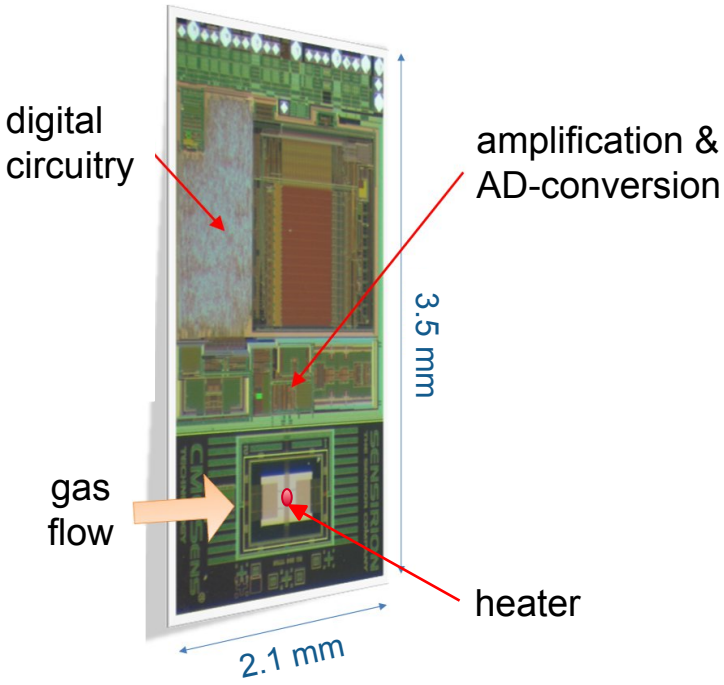
Critical Nozzle

Gas reservoir

Valve

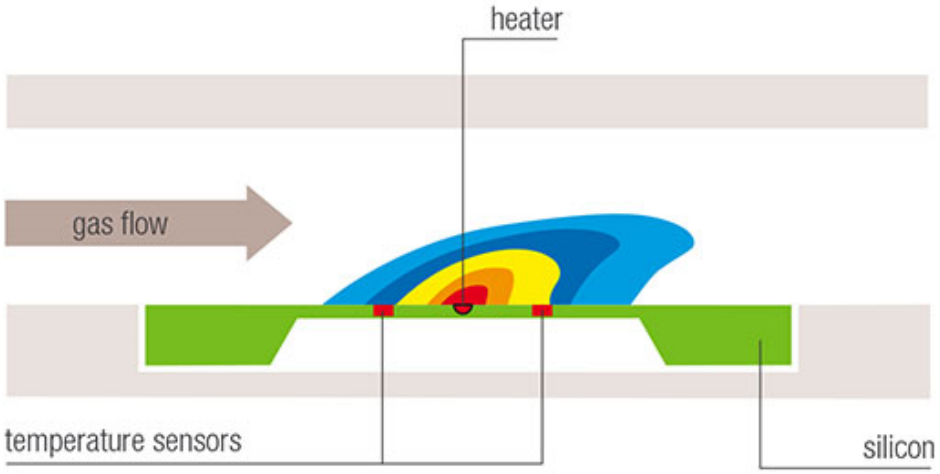
Gas in

Micro-thermal Sensing



CMOS Chip Technology

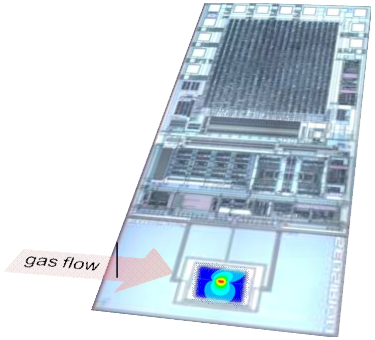
- Fully integrated hot-wire anemometer
- Standard industrial production process
- Low cost technology



Source: https://www.sensirion.com/de/ueber-uns/technologie/cmosensr-technologie-fuer-gasfluss/

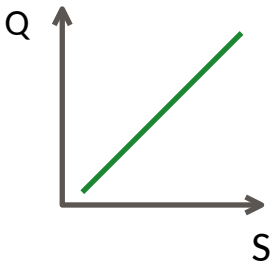
gasQS Modeling

Measurement → Calculation based on physics → Correlation



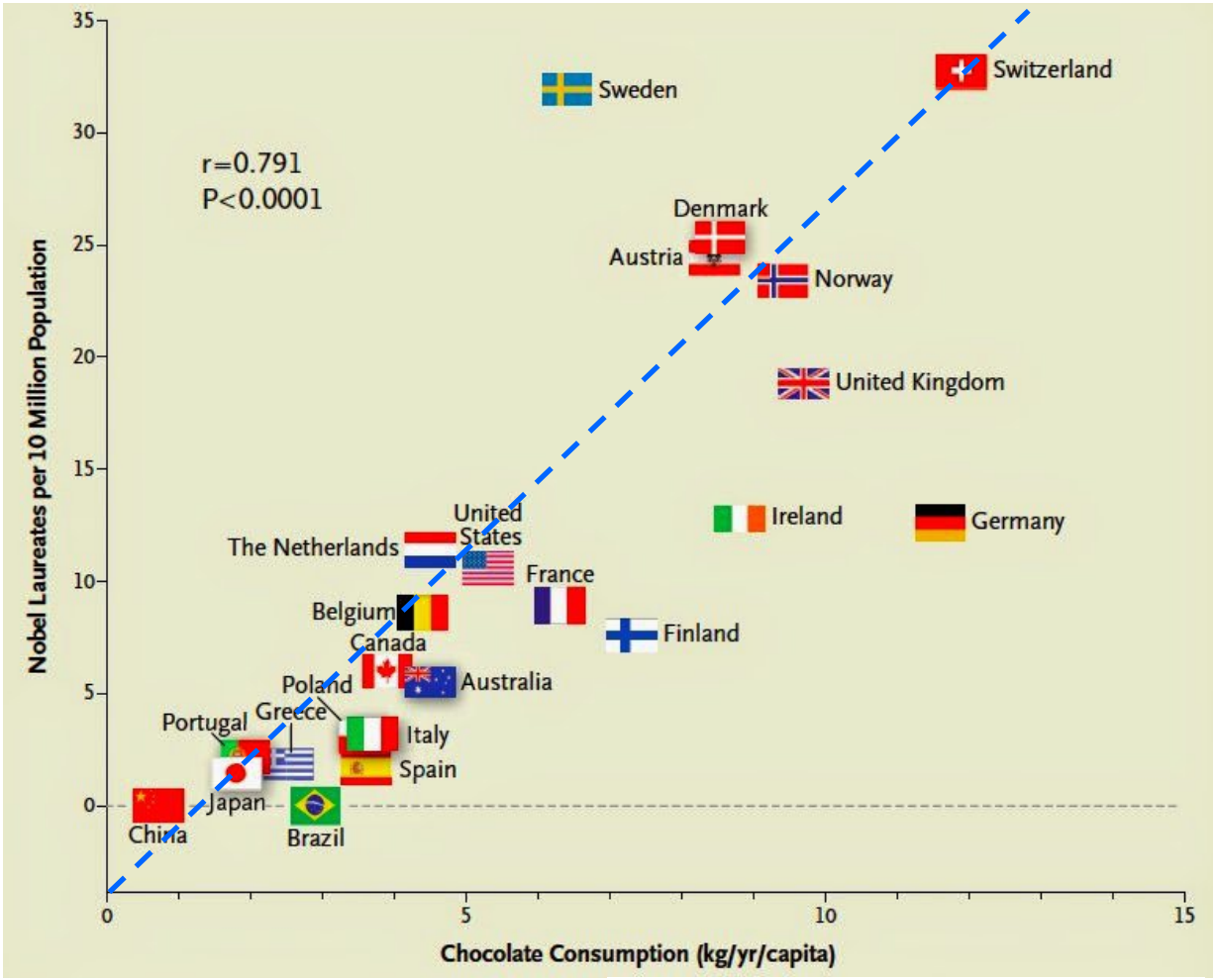
Model calculation of thermal properties of natural gas:

$$c_p\rho\left(\frac{\partial}{\partial t}+\vec{v}\cdot\vec{\nabla}\right)T=\vec{\nabla}(\lambda\cdot\vec{\nabla}T)-c_p\rho(\vec{\nabla}\cdot\vec{v})T+H$$



Correlation Example

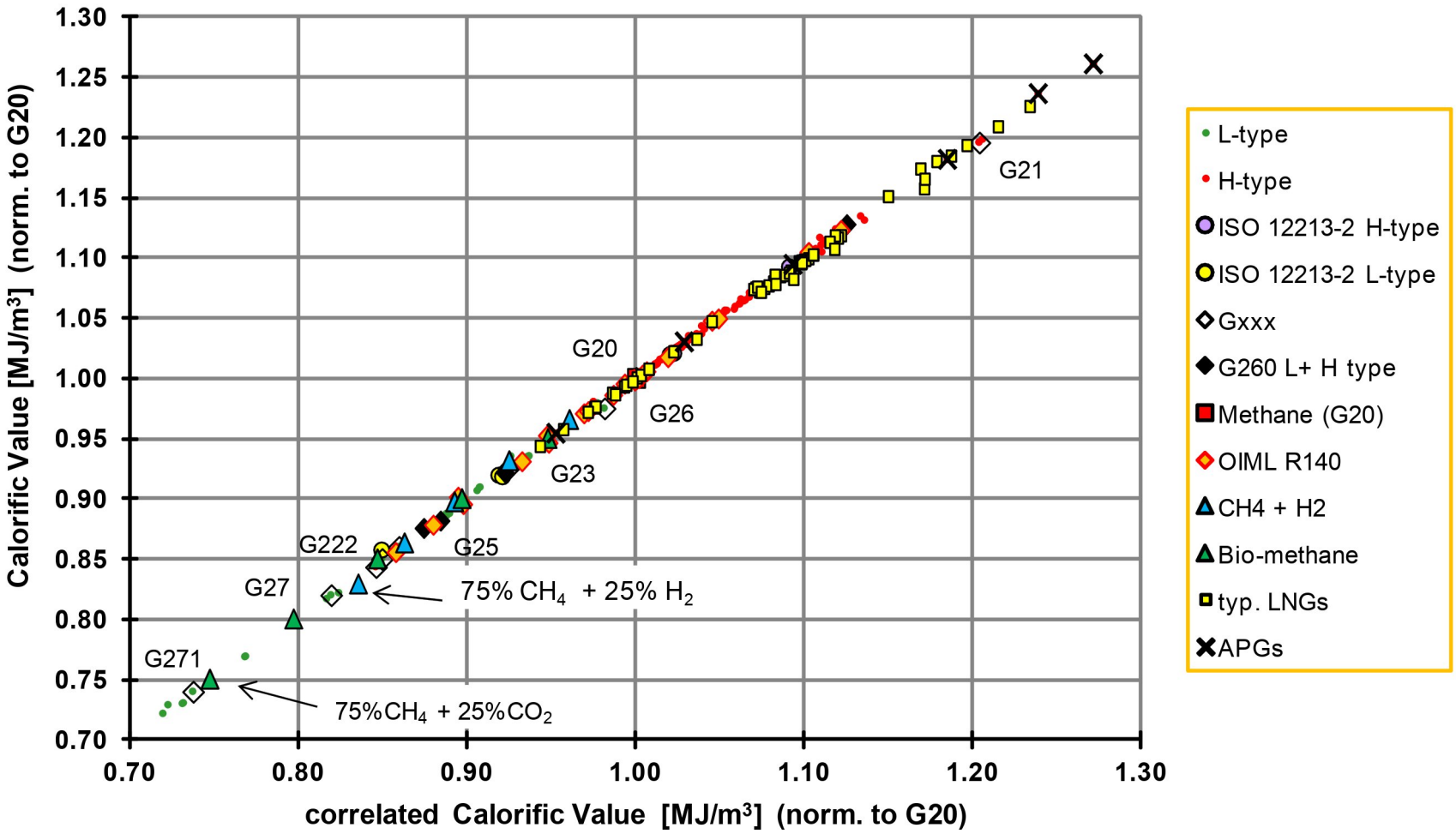
Correlated value $Q=f_{corr}(S)$



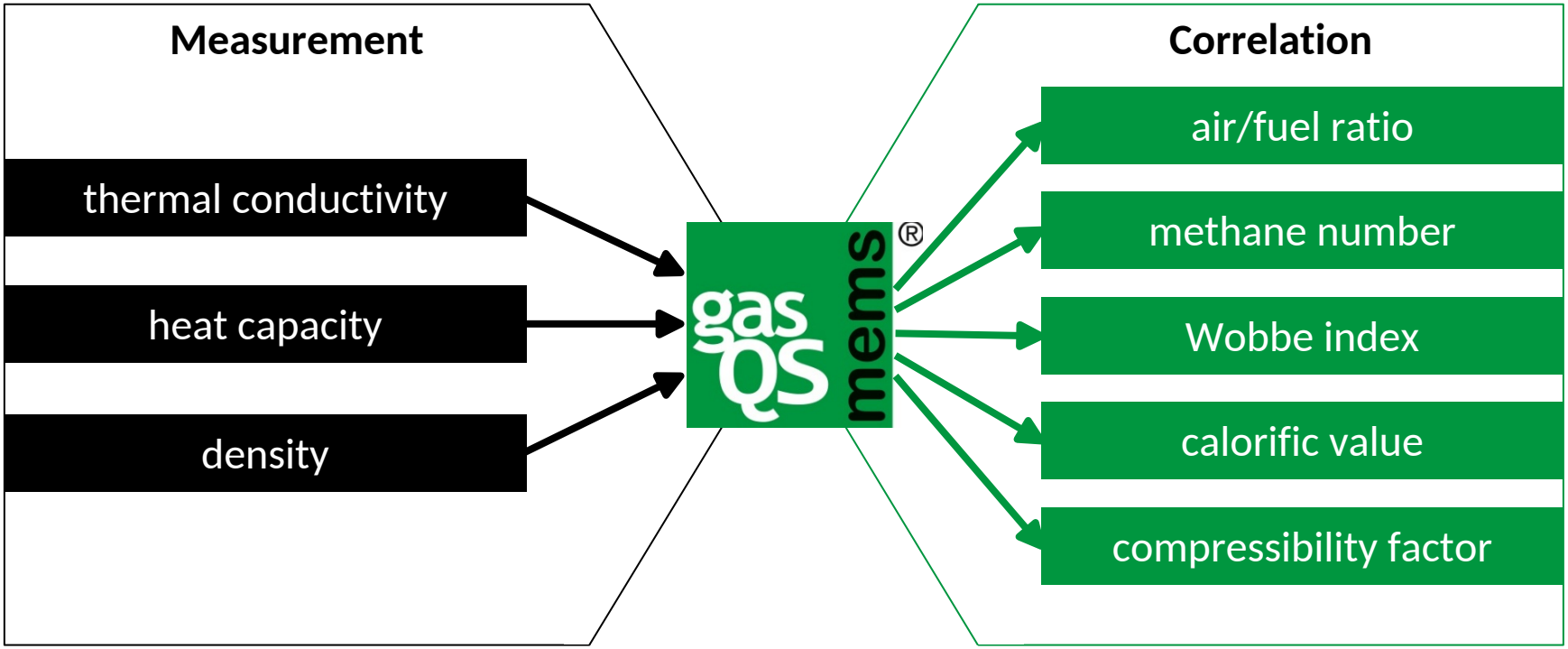
Input values for Correlation S=f(I)

correlation: yes
causality: no

Calorific Value (HHV)



Gas Quality Factors



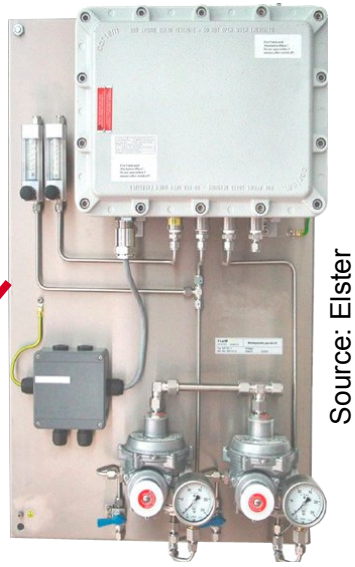
Correlative Measurement Products

EMC500

Source: RMG Honeywell

Correlative Measurement Principle		
Input 1	**Input 2**	**Input 3**
dielectric const.	c_{sound}	CO_2 content
c_{sound} (p_1)	c_{sound} (p_2)	CO_2 content
□ (T_1)	□ (T_2)	c_{sound}
□	c_p	□
□	IR absorption (□)	IR absorption (□)
gasQS		
□	CMOS sensor	Sonic nozzle

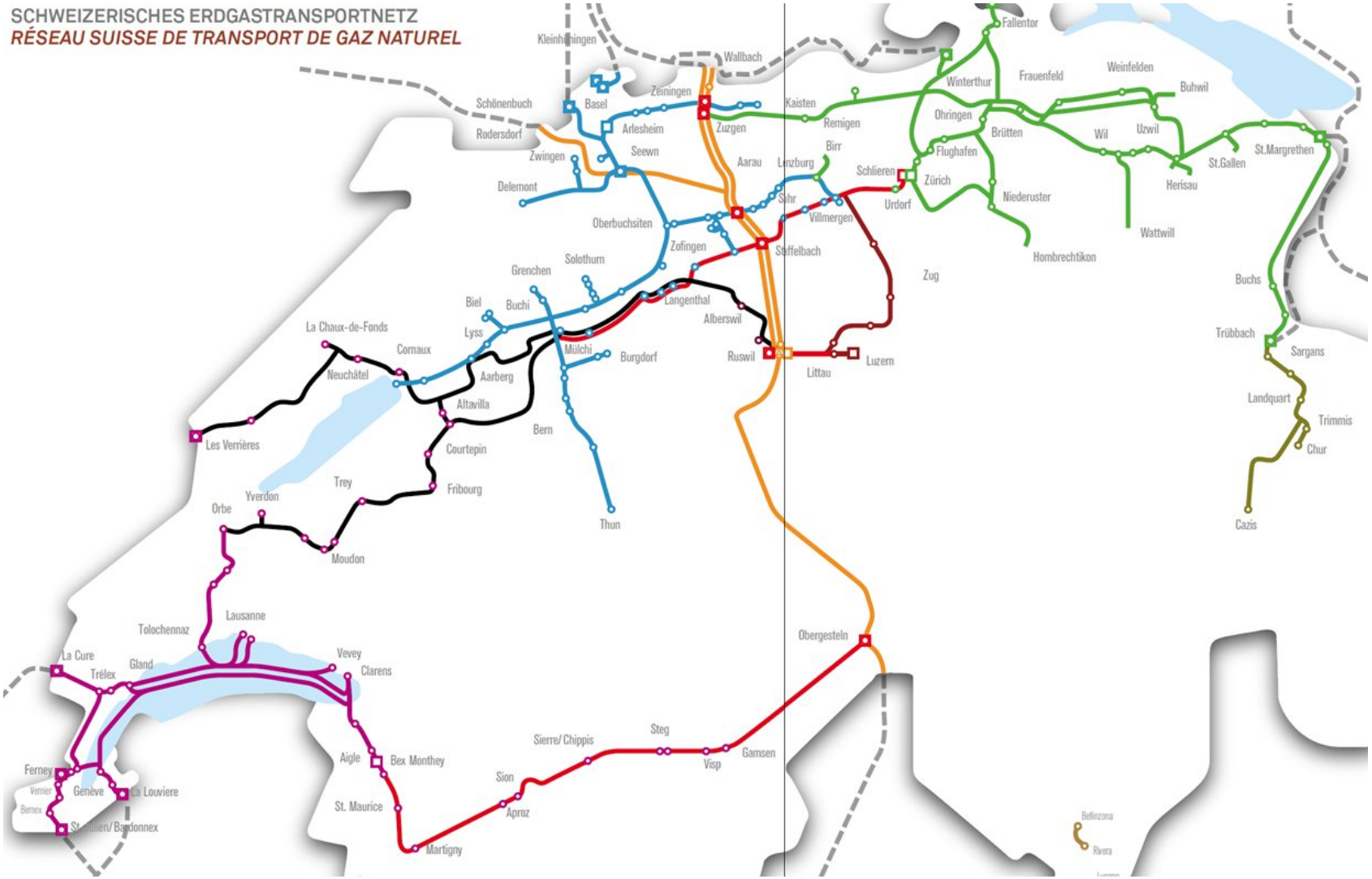
Gas Lab Q1



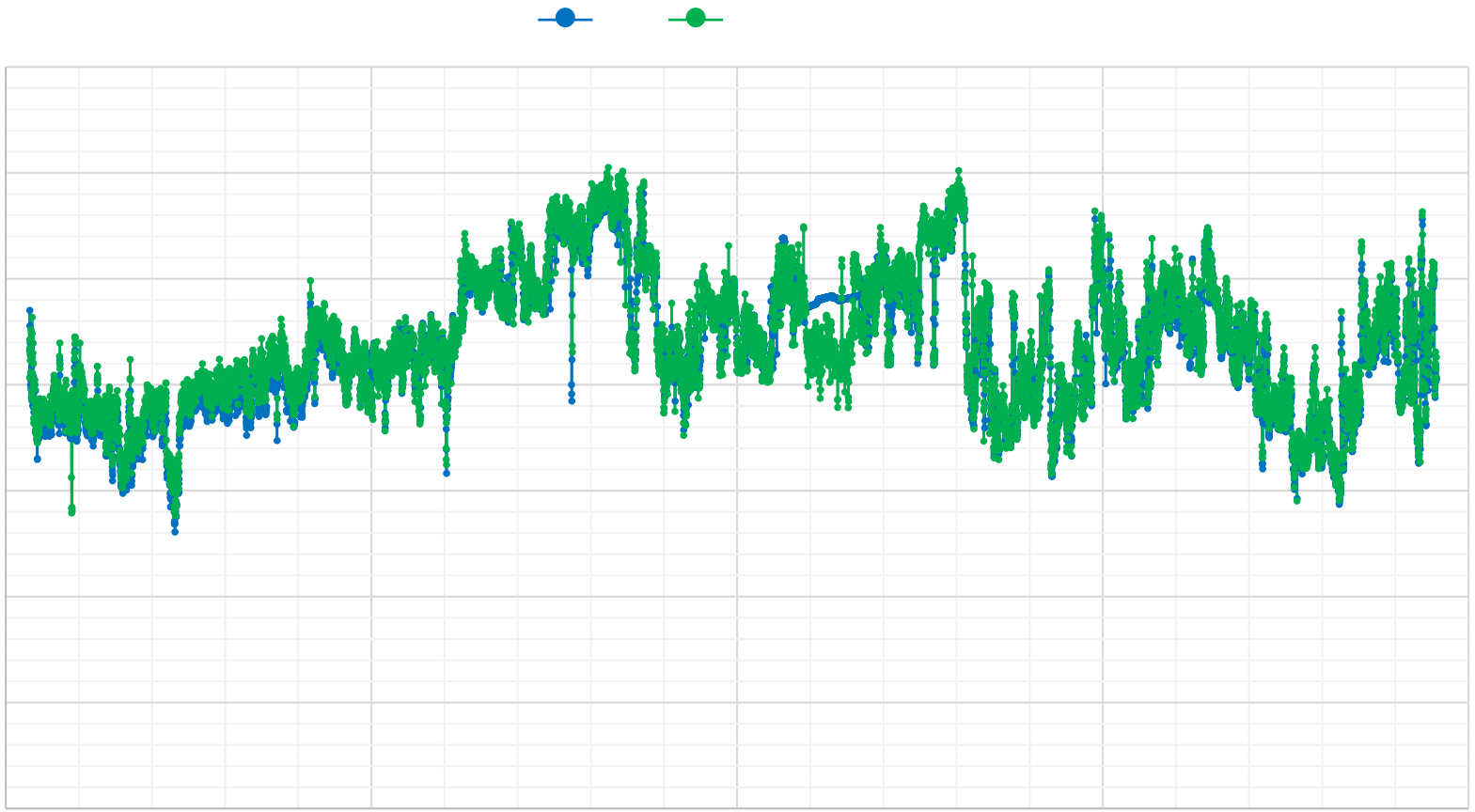
Source: Elster

mems AG

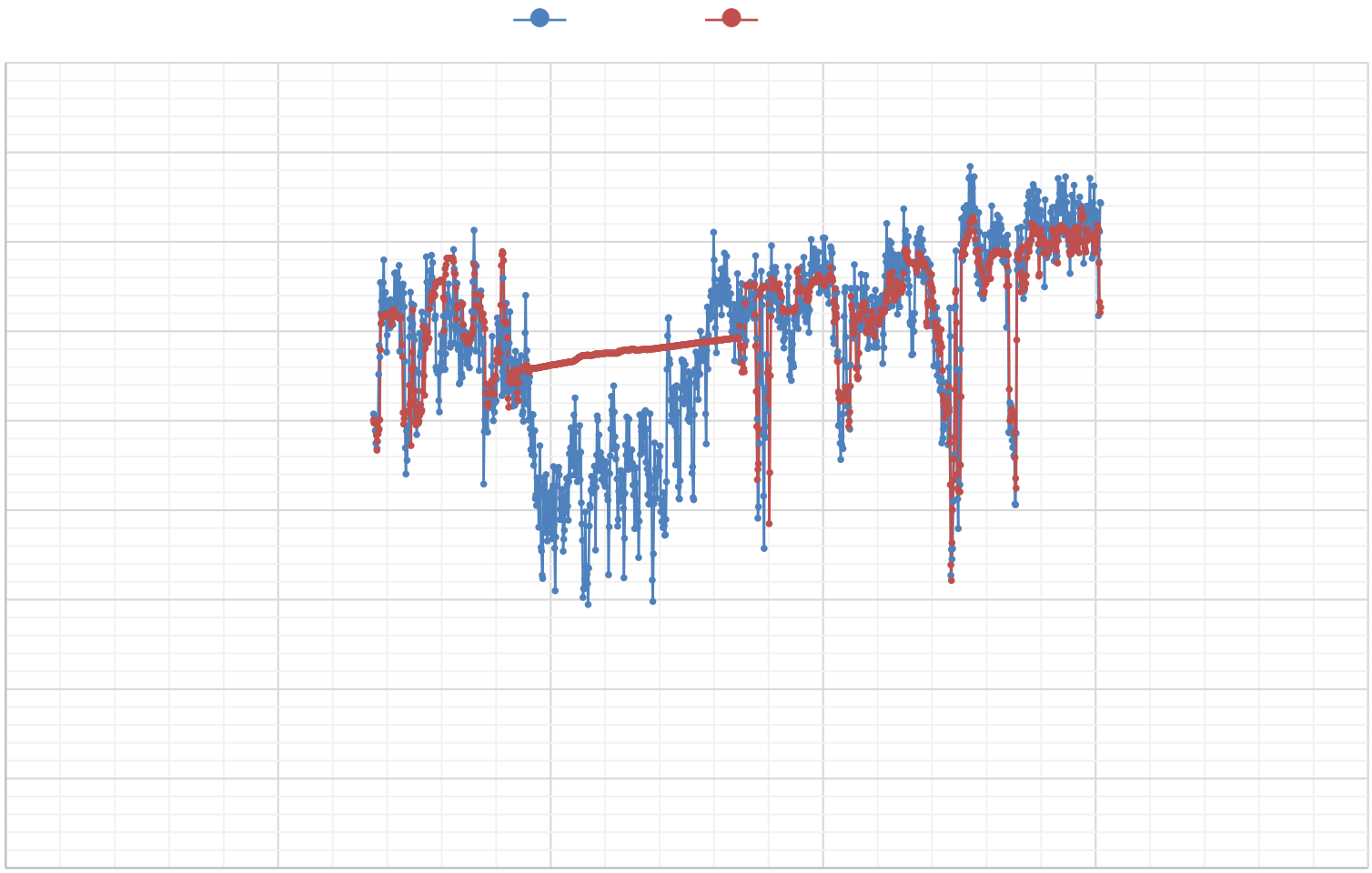
High Pressure Gas Networks Simulators



Verification of Gas Network Simulators II

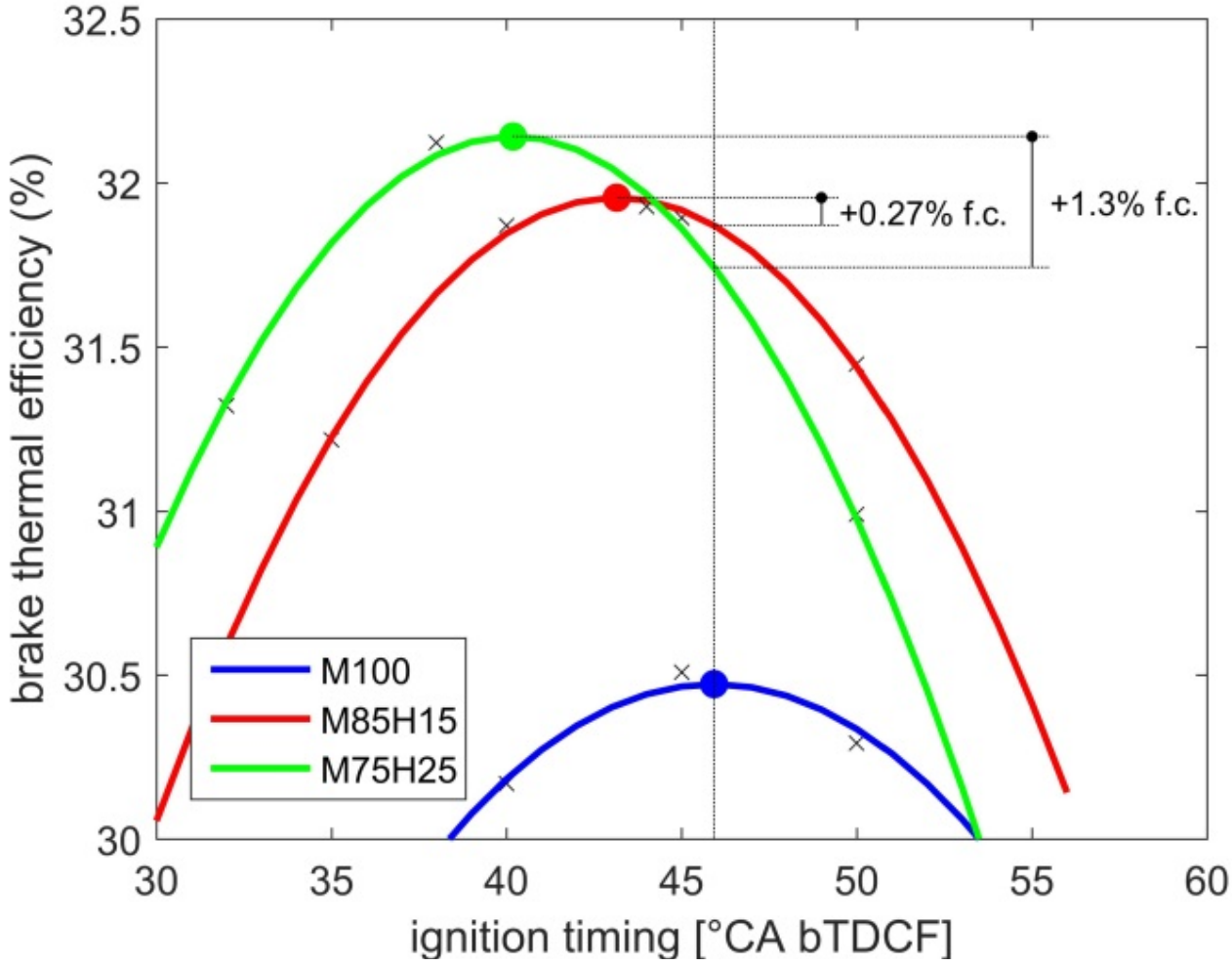


Verification of Gas Network Simulators III



Gas engine efficiency

Source: Measurement 91 (2016) 661–679



f.c. = fuel consumption

Gas Power Plant in Kiel (Northern Germany)

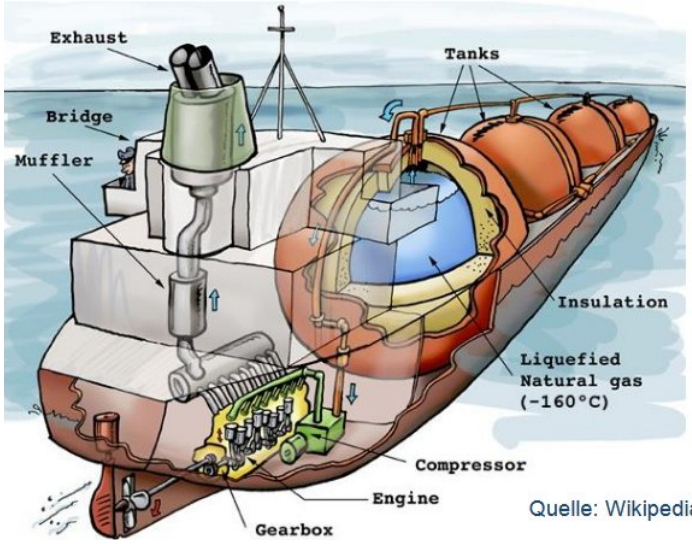
400 MW Power: efficiency optimization by gasQS flonic

gasQS flonic to Measure Methane Number

Gas consumption: 42'000 m^3/h - efficiency + 0.1 % = + 400 €/d

gasQS flonic successfully in operation

Hotspot: Gas quality of «LNG boil-off gas»



Quelle: Wikipedia

Molar Composition (%)	Light LNG	Medium LNG	Heavy LNG
Methane (CH_4)	98.60	92.30	85.87
Ethane (C_2H_6)	1.18	5.00	8.40
Propane (C_3H_8)	0.10	1.50	3.00
Butane (C_4H_{10})	0.02	0.60	1.20
Pentane (C_5H_{12})	–	0.10	0.23
Nitrogen (N_2)	0.10	0.50	1.30
Density (kg/m^3) (−162 °C/ 1.3 bar)	427.58	451.58	474.87
LHV (kJ/kg)	49,935	49,557	48,984

Ignacio Arias Fernández, Review of propulsion systems on LNG carriers, 2016

Methane has a boiling point of −161 °C
Nitrogen has a boiling point of −196 °C

- Gas Quality of LNG boil-off gas changes over time!

LNG & CNG filling station Bubendorf

Gasqualität Glas (GQG): Stakeholders / General

- Ardagh Glass GmbH
- ABB Automation GmbH
- Karl Dungs GmbH & Co. KG
- Deutscher Verein des Gas- und Wasserfaches e.V.
- Honeywell (Elster Group GmbH)
- GMB Glasmanufaktur Brandenburg
- HEINZ-GLAS GmbH & Co. KGaA
- Hobré Instruments B.V.
- LAMTEC Meß- und Regeltechnik für Feuerungen GmbH & Co. KG
- Mems AG
- Noelle + von Campe GmbH & Co. KG
- Orbital Gas Systems Limited
- Praxair Deutschland GmbH
- Ritzenhoff AG
- Siemens AG
- UNION Instruments GmbH
- Verallia Deutschland AG

GasQualitaetGlas

Project Duration:
01.07.2015 – 30.06.2018

Conducting Research Institute:

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

Tested Gas Quality Sensors:

- 3 Calorimetric Devices
- 2 Gas Chromatographs
- 4 Correlative Devices

Gasqualität Glas: Results for G222 (23%H2 / CH4)

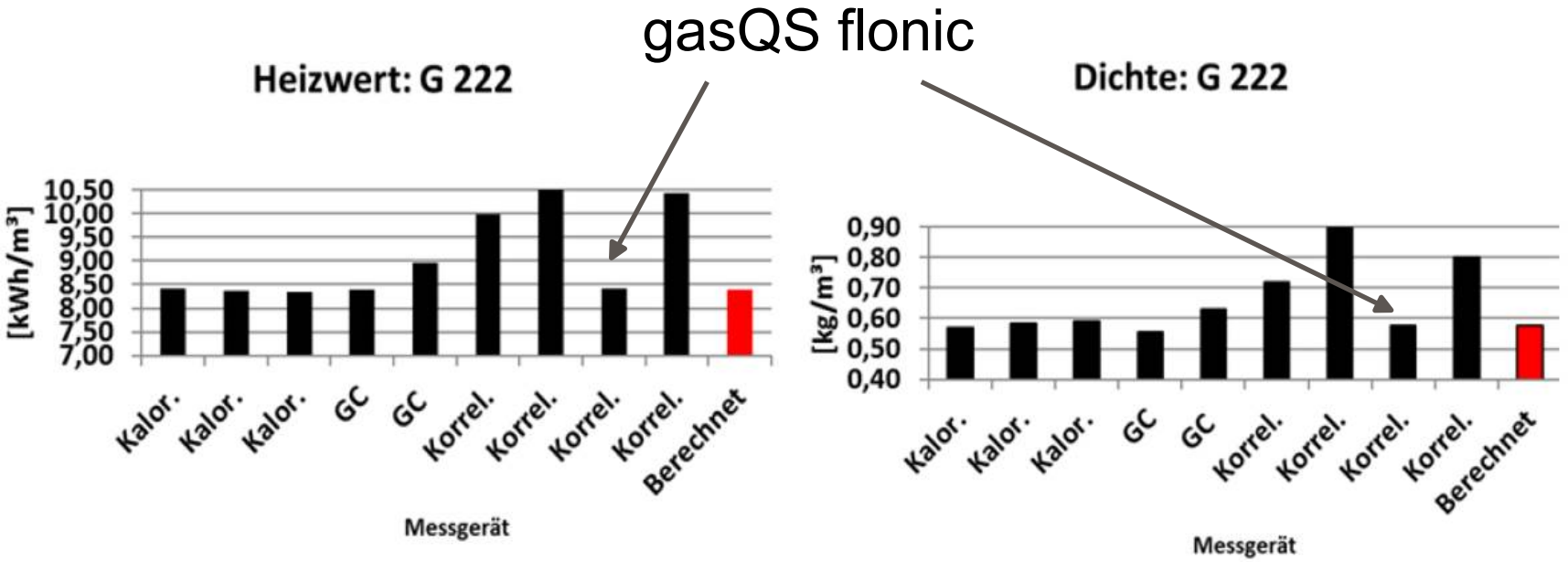
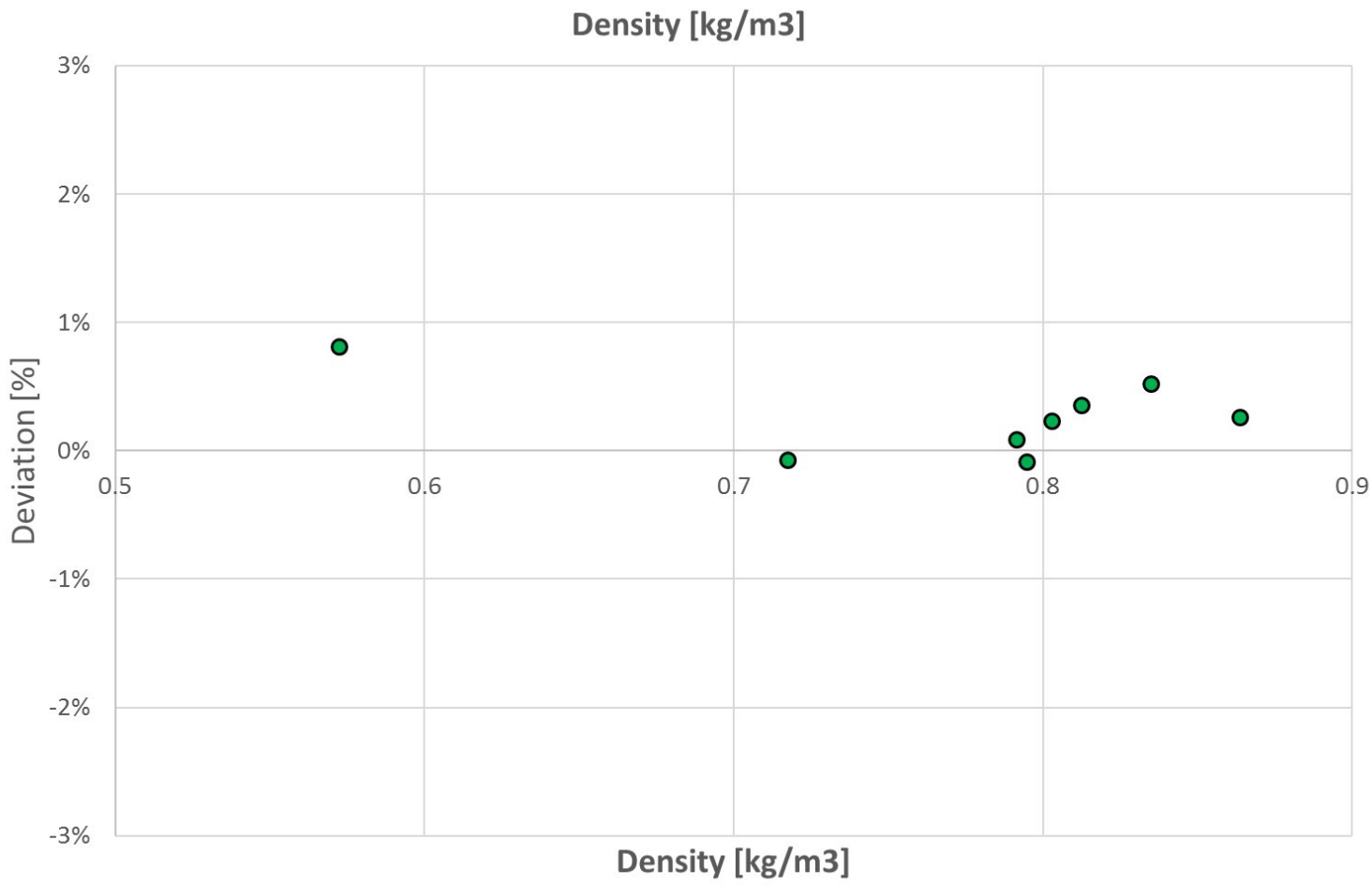


Abbildung 3.11: Messergebnisse für das Prüfgas G 222, Parameter Heizwert (links) und Normdichte (rechts), alle Angaben im deutschen Bezugssystem 25 °C / 0 °C (Quelle: GWI)

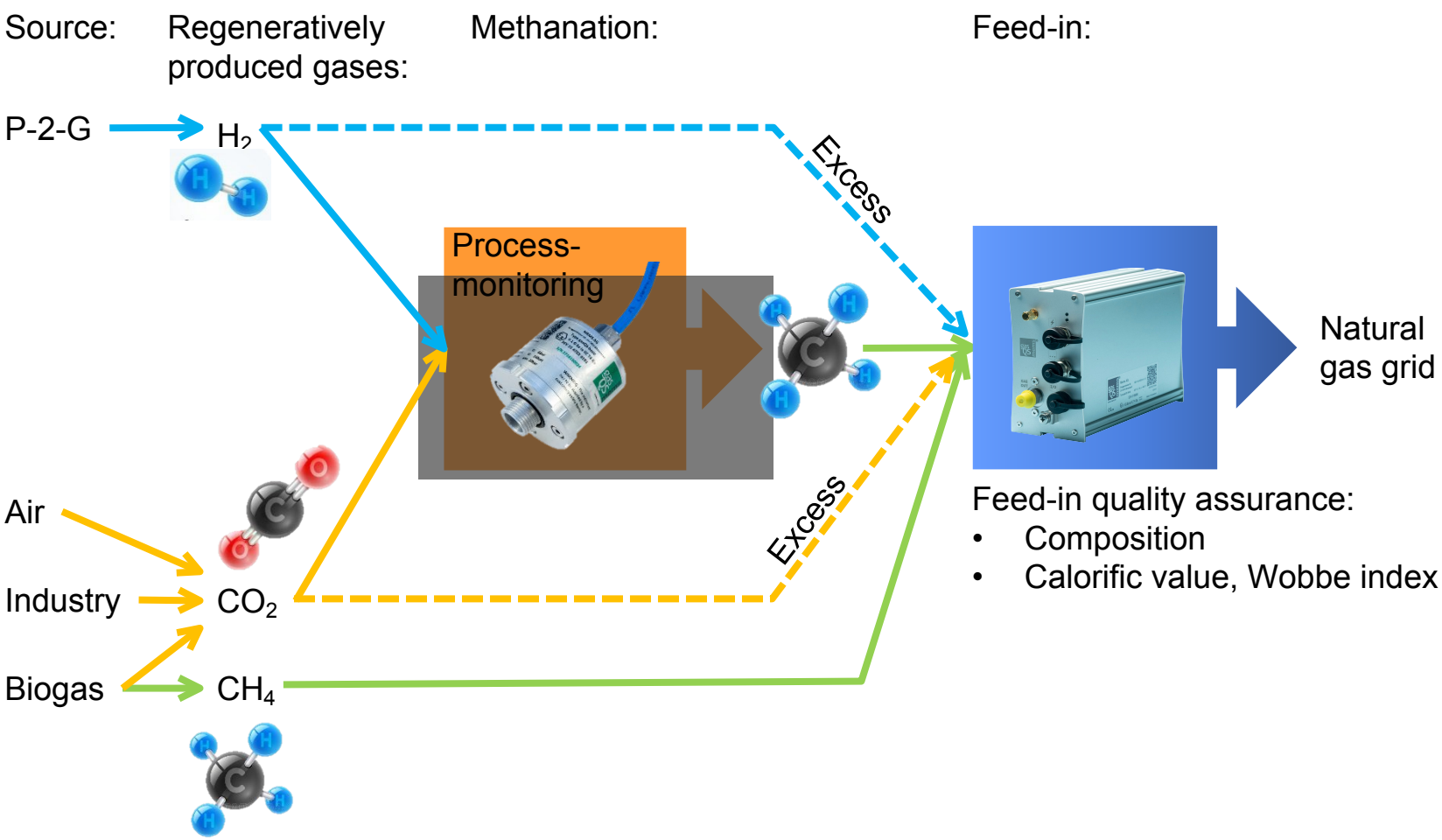
gasQS flonic: very good accuracy for natural gases with H2

Gasqualität Glas: Results for all 8 tested gases II



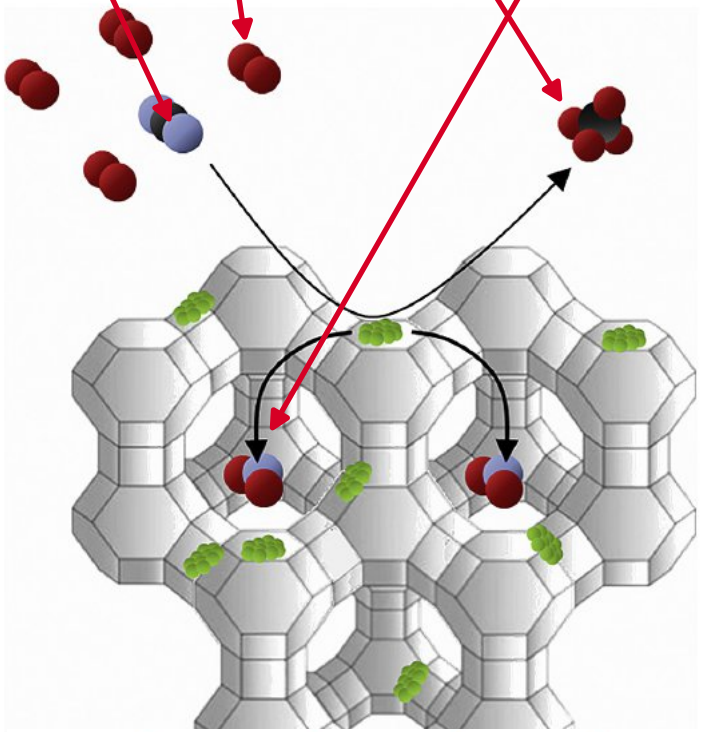
gasQS flonic: Better than 1% accuracy for all gases tested

Gas Quality Controlled P2G Process



Sorption enhanced methanization

$$CO_2 + 4H_2 \rightleftharpoons CH_4 + 2H_2O$$



R. Delmelle [a,*], R.B. Duarte [a], T. Franken [a], D. Burnat [a], L. Holzer [b], A. Borgschulte [c], A. Heel [a]

[a] Institute of Materials and Process Engineering (IMPE), ZHAW – Zürcher Hochschule für Angewandte Wissenschaften, Winterthur, Switzerland

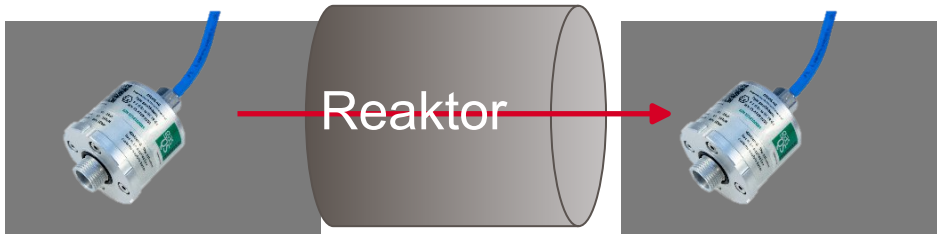
«Sorption enhanced methanization»:

- H_2O verbleibt im Zeolith
- 100% Umwandlungseffizienz, bis Zeolith gesättigt
- bei Sättigung: CO_2 und H_2 brechen durch
- H_2O wird in der Regenerationphase ausgegast

Prozesssteuerung
Produktions-/Regenerationsphase mittels gasQS:

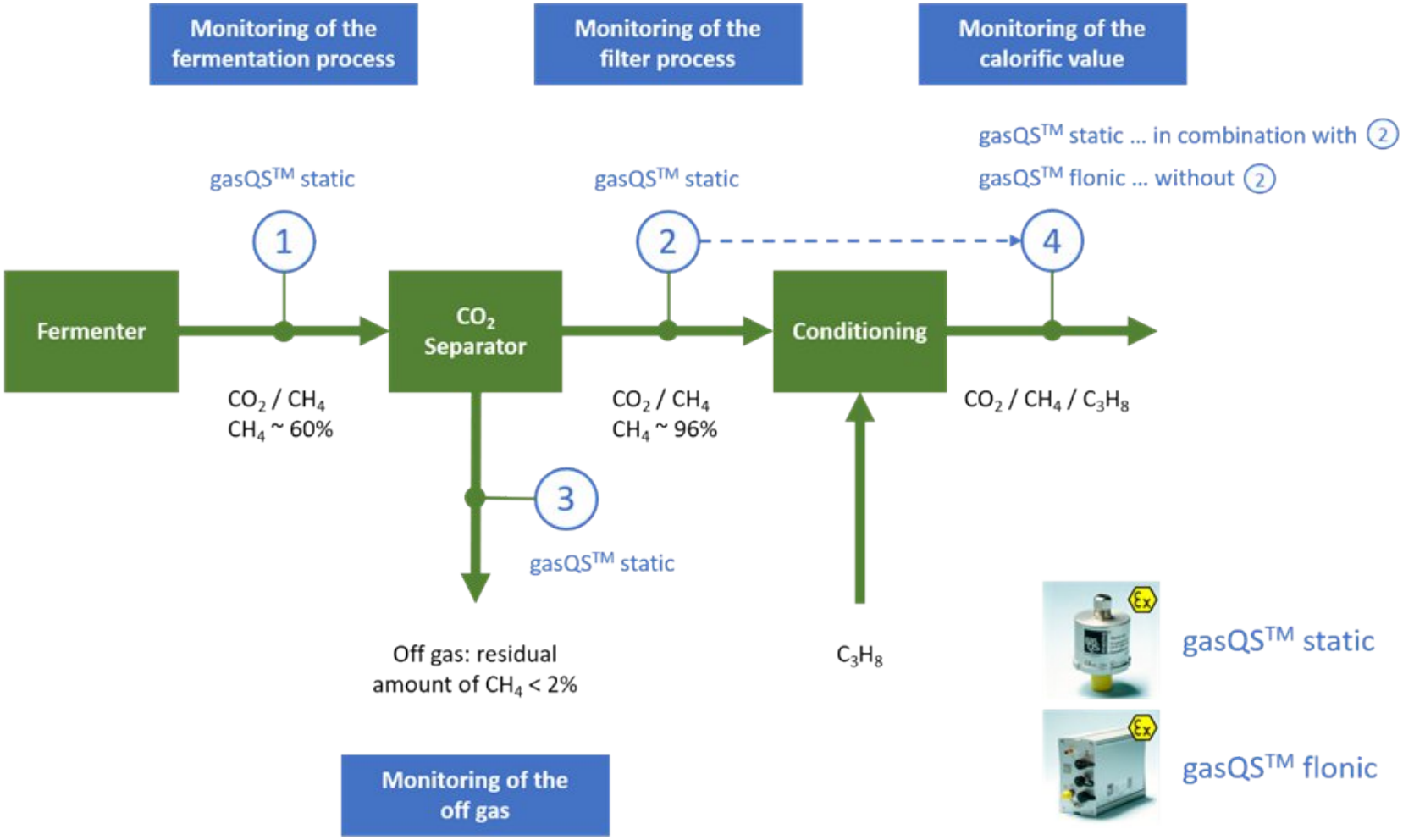
Regelung Stöchiometrie:
CO_2 und $4H_2$ am Eingang

Detektion Sättigung:
CO_2 und $4H_2$ am Ausgang



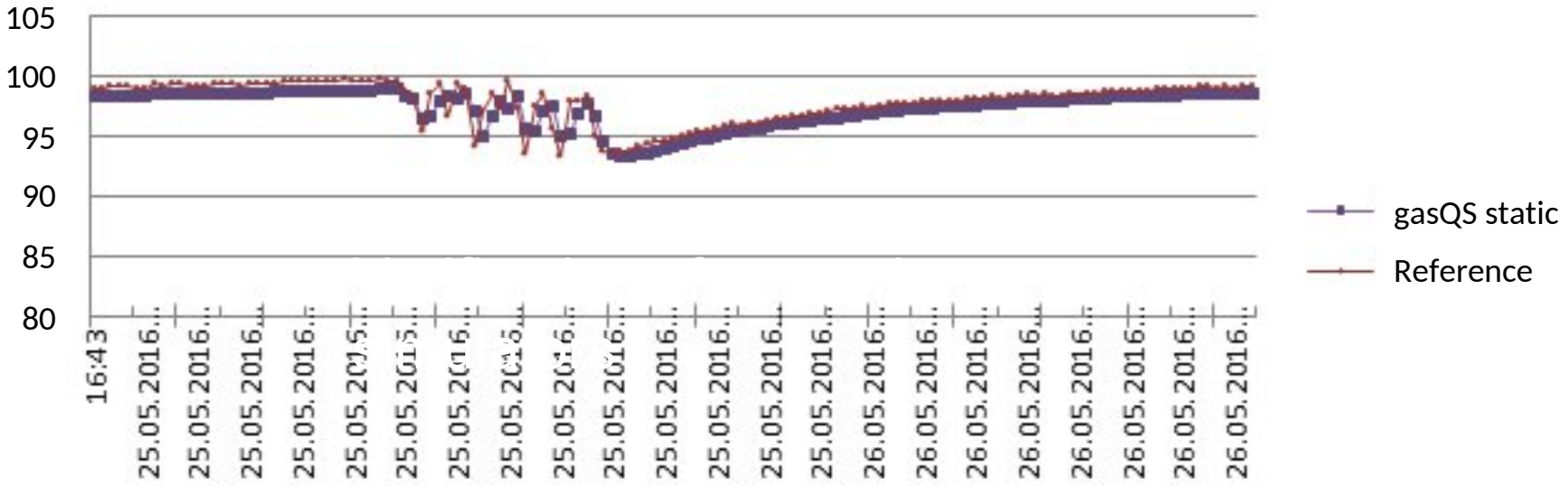
Finanzierung:
FOGA & Forschungsfond Aargau

Gas Quality controlled Biogas Plants



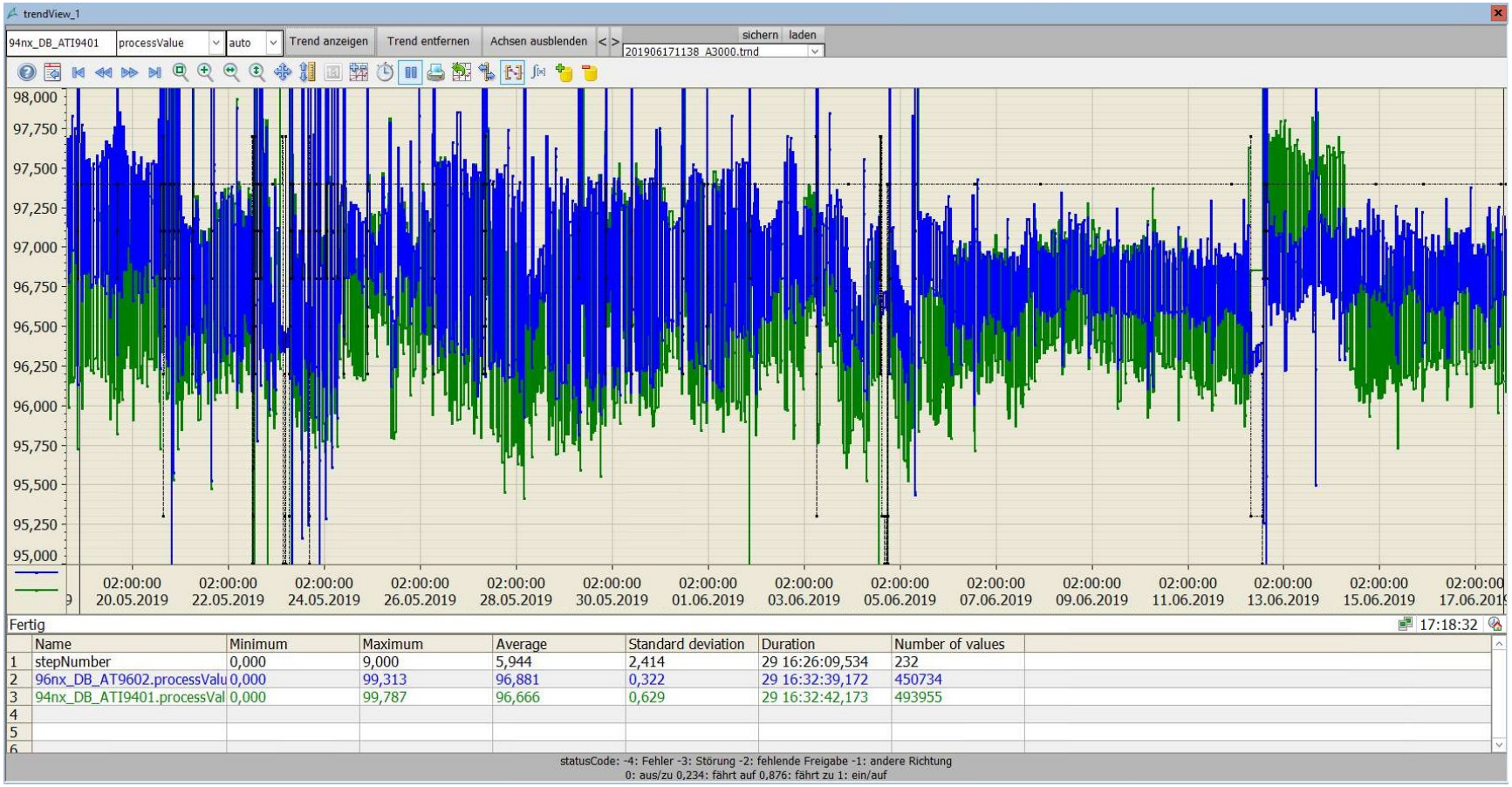
gasQS static - Biogas Plant „Blue Bonsai“

Process Gas % Methane



„The gasQS static is excellently suited to measure the CH4 concentration in the process gas of a biogas plant. It is compact, easy to install and has been reliable so far (almost for three years by now).“

Bachenbülach comparison gasQS vs. ExTox



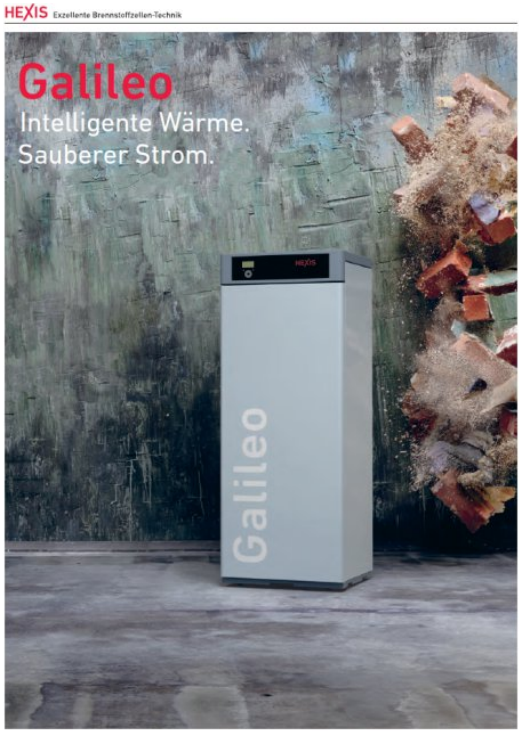
	Name	Minimum	Maximum	Average	Standard deviation	Duration	Number of values
1	stepNumber	0,000	9,000	5,944	2,414	29 16:26:09,534	232
2	96nx_DB_AT9602.processValu	0,000	99,313	96,881	0,322	29 16:32:39,172	450734
3	94nx_DB_ATI9401.processVal	0,000	99,787	96,666	0,629	29 16:32:42,173	493955
4							
5							
6							

CH_4-values in Bio Gas Plant Bachenbülach (ATI9401 = ExTox, AT9602 = gasQS static)

Average Value ExTox: 96.67%

Average Value gasQS static: 96.88%

SOFC Fuel Cells (Viessmann) – gasQS Inside

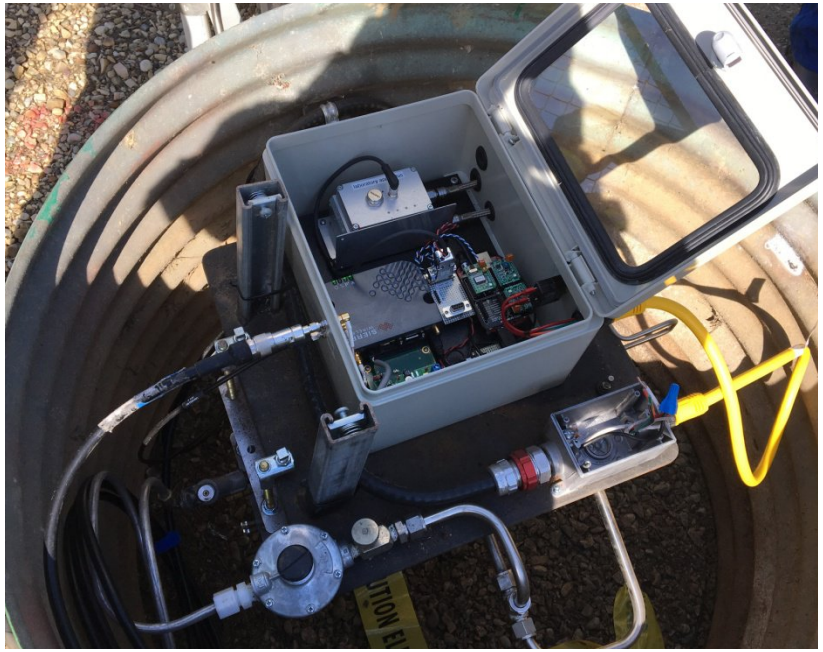


Source: Hexis

Gas reformation of natural gas for fuel cells

- air number determination for different gas qualities
- air/gas ratio control
- improved efficiency, life-time extension

Field Test by a Gas Utility in North America



Feedback from the customer (Mai 24th 2017):

"The results are very promising and exceed our expectation where the highest reported error was 0.52% from the lab results"

Date	Lab reported HV	MEMS reported HV	% difference
April 28-May 1	38.80	38.81	-0.04%
May 1-2	38.58	38.61	-0.08%
May 2-3	38.39	38.25	0.35%
May 3-4	Sample failed	37.98	-
May 5-8	38.17	38.14	0.07%
May 8-9	38.32	38.12	0.52%
May 9-10	38.03	37.93	0.26%

Summary gasQS

- For all types of combustible gases
- For natural gases with high hydrogen content
- Control of P2G and biogas plants
- Control of gas-driven “devices”
- Verification of gas network simulators
- Measurement of gas properties relevant for combustion
- Periodically and automatically verifiable
- Sufficiently accurate and stable over the long term
- Technology implemented worldwide
- Technology with several granted patents
- ATEX certified, energy certification in the pipeline

Matter engineering for metering systems

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