Ultrasonic Meters Working with Hydrogen: PMQs !

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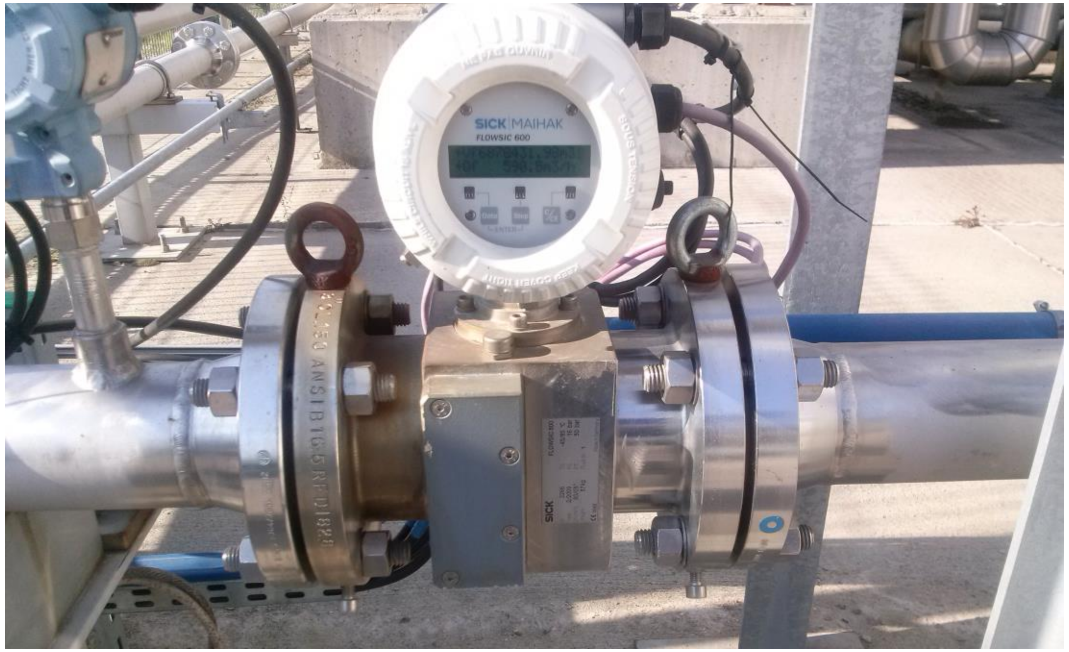
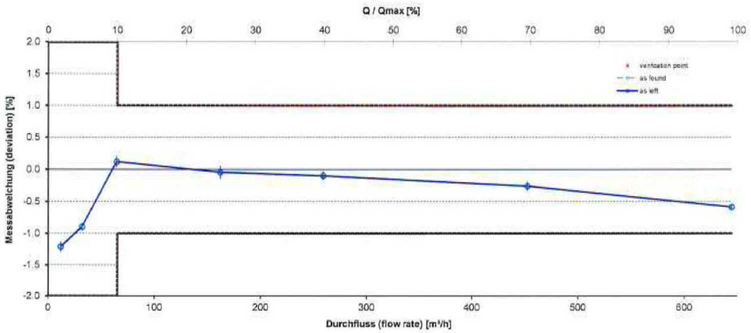
“great leaders ask great questions” – John Maxwell

Topics to be Covered

Can an ultrasonic meter measure Hydrogen, what are the challenges and limitations ?
How do we calibrate, what options do we have ?
What are our references, how are standards developing ?
Can an ultrasonic meter give information around composition ?
Are the benefits of the using BIG data, how can we use AI as projects develop ?

Can an USM measure Hydrogen ?





High Accuracy Measurements

Ultrasonic meters provide precise measurements of gas flow, ensuring reliable data for custody transfer and industrial processes.

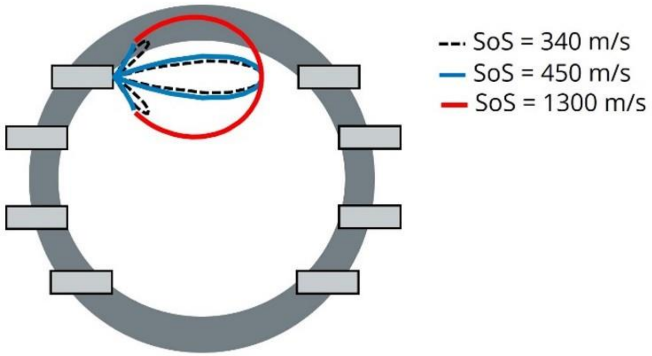
Historically …

Process metering has been carried out on Hydrogen using ultrasonic meters, generally using 2 path meters with a target uncertainty of around 2%-3%

Moving forwards …

Can we measure to a fiscal standard (what will the requirements be) and what are the limitations ?

Can an USM measure Hydrogen ?



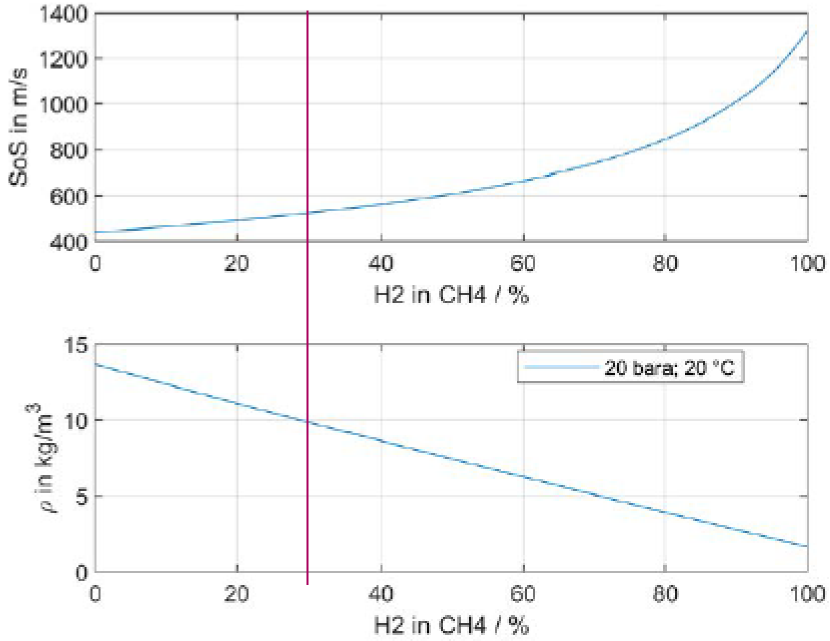
Hydrogen in Natural Gas
Properties

- 8x lighter than natural gas
- 3x higher SOS than natural gas
- 3x lower heating value than natural gas (volume based [kWh/m³])

Natural Gas vs. Hydrogen

	NatGas (typ.)	Methan	100% H_2
density / kg/m³	0,76	0,66	0,089
Viscosity / µPa*s	10.5	11	8,8
Speed of sound / m/s	420	445	1300
Heating value (LHV) / kWh/m³	10,5	10	3
Heating Value (LHV) / kWh/kg	13,2	18,8	33,3

Hydrogen containing gas



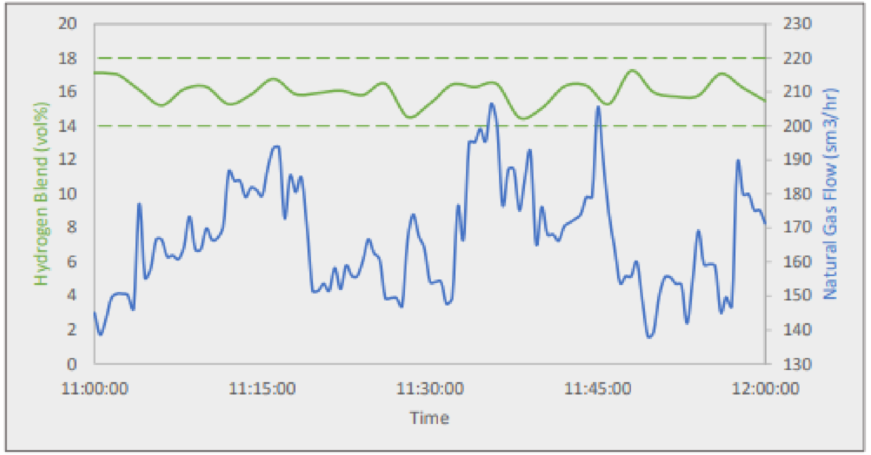
Can an USM measure Hydrogen ?

… lets start with a blended gas application

Project fed gas to 668 houses, a schools and a number of small business's for 10 months from August 2021

- FLOWSIC600-XT pilot project "HyDeploy"
  - FLOWSIC500 USM for 100% natural gas
  - FLOWSIC600-XT USM for blended gas
  - H2 content: around 18%

Figure 17: Natural gas demand profile and blend percentage



Can an USM measure Hydrogen ? … UK proof of concept

National Gas: FutureGrid Testing Guide

1 High Pressure Reservoir

60m length of new 1200mm (48") diameter X65 grade carbon steel pipe and wall thickness 22.4 mm sourced directly from manufacturer in 2020.

2 Ball valve

Two 450mm (18") diameter ball valves and 50mm (2") bypass pipework manufactured in 1992 sourced from Billingham, Stockton on Tees.

3 Filter

A 450mm (18") diameter filter manufactured in 1992 sourced from Billingham, Stockton on Tees.

4 Ultrasonic meter

Two 3" ultrasonic meters which have been newly sourced to be suitable for a twin stream system.

Can an USM measure Hydrogen ? … UK proof of concept

“Comparison of Metering Technologies and Gas Properties in Hydrogen Measurement Systems”

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Can an USM measure Hydrogen ?

Approvals

Ultrasonic meters provide precise measurements of gas flow, meeting fiscal approvals i.e. first meter is now MID approved

Minimum pressure is required

On natural gas we work down to atmospheric pressure, dependent upon line size and flow rates USMs will require a minimum pressure of between 8-16 bar

Maximum velocity

Meters will be able to measure up to 60m/s giving equivalent energy transportation capacity. Work is required on pipeline standards / operating velocities to facilitate this.

How do we calibrate ?

H_2-Loop

High-pressure calibration of gas meters used for hydrogen

State-approved test center

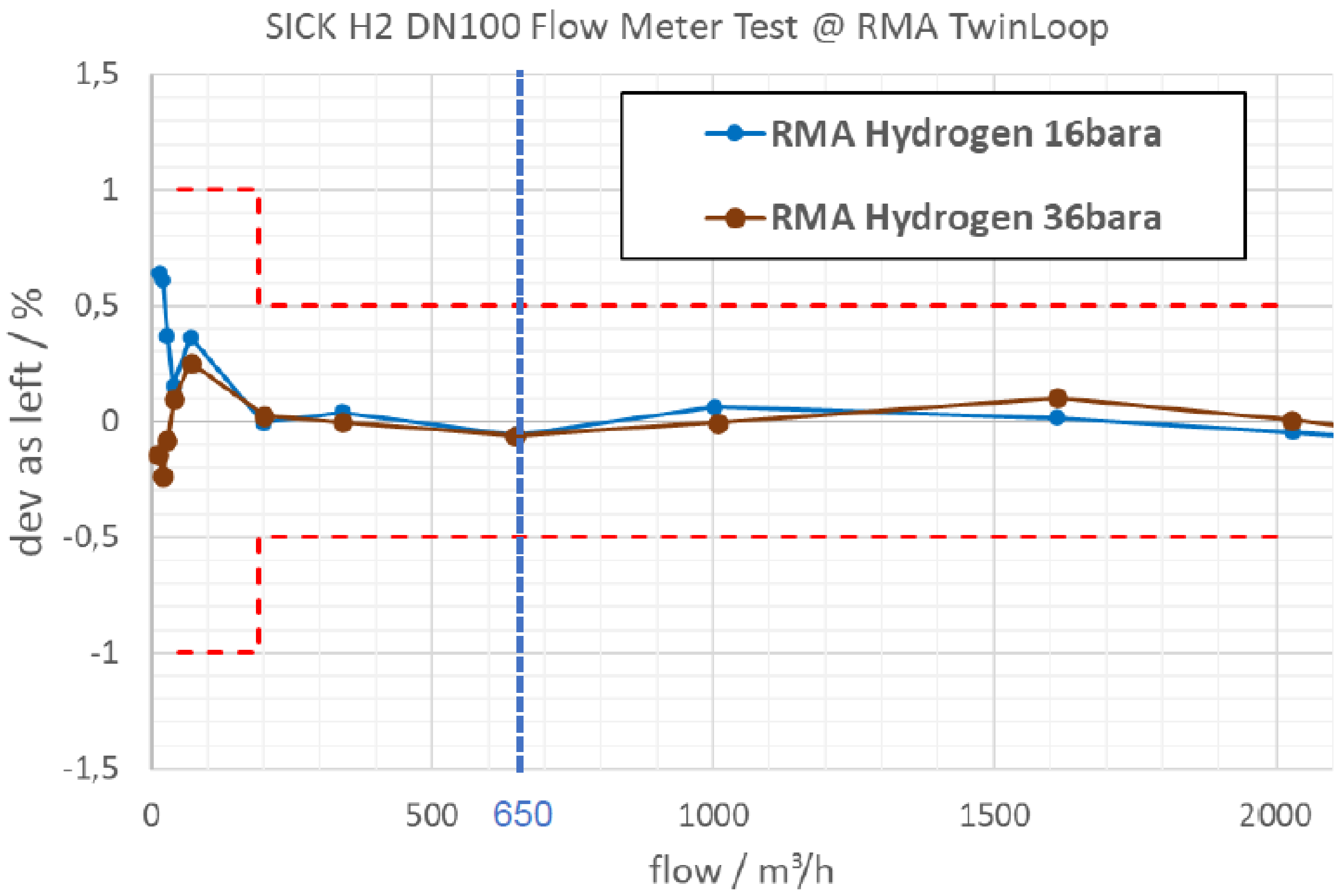
The H_2-Loop is designed as a closed loop system in which hydrogen is transported in a controlled manner. After generating and stabilizing the flow in a high performance blower, which for safety reasons is located in a pressurized cabin, hydrogen is first passes the reference meter (with the standards), then the test samples before returning to the blower.

Technical data of the H_2-Loop

- 2 test tracks à 11 m
- Nominal sizes of calibrated gas meters of DN 50 up to DN 300
- Flow rates of 5 – 6.500 m^3/h*
- Pressure range of 8 bis 51 bar(a)
- Measure uncertainty: 0,2 – 0,3 %
- Continous monitoring of hydrogen purity

*Conformity assessments and custody transfer measurements can be performed in flow ranges from 16 – 6,500 m^3/h.

How do we calibrate ?



How do we calibrate ?

EU Project H2FlowTrace

To establish a robust metrological infrastructure for flow rates up to1300 m3/h at 0.1 MPa or 45 m3/h at 3.3 MPa(g) with a primary focus on pure hydrogen, but also enabling traceability for hydrogen/natural gas blends in small industrial meters, with a measurement uncertainty of 0.20 % or less

To establish a robust metrological infrastructure for flow rates of 200 m3/h to 10 000 m3/h, and pressures of 0.3 MPa(g) to 6.2 MPa(g) for pure hydrogen and hydrogen/natural gas blends in large industrial meters, with a measurement uncertainty of 0.30 % or less.

To design and test traceability transfer skids for pure hydrogen and hydrogen/natural gas blends. In addition, to carry out intercomparisons to determine the equivalence of independent traceability chains based on primary standards, secondary standards using a bootstrapping/upscaling approach, and secondary standards calibrated with alternative fluids to hydrogen.

How do we calibrate ?

GHTDF Planned Capabilities

- Electrolyser testing (bays for up to 250kW and up to 1 MW)
- Equipment leakage testing bay
- Flexible testing bay for integration and energy systems testing
- Additional space for future expansion
- Large scale flow loop
  - Flow rate 1 - 1000 m^3/h
  - Pressure up to 100 bar
  - Temperature 10 to 30 °C

How do we calibrate ?

5 FLOW CALIBRATION WITH DIFFERENT TEST GASES

In March 2024, Dr. Eric Starke, in his article "Testing and Calibration Challenges of Hydrogen Gas Meters," provided a comprehensive analysis of the key factors impacting the calibration of both hydrogen and alternative gases. He concluded that hydrogen ultrasonic flow meters can easily achieve the expected measurement uncertainty after hydrogen calibration. However, current calibration capabilities are quite limited, raising the question of whether calibration with different test gases than Hydrogen is feasible. Initial investigations have shown that this is possible if the calibration is conducted at multiple pressures to cover the Reynolds number range, as illustrated in Figure 7.

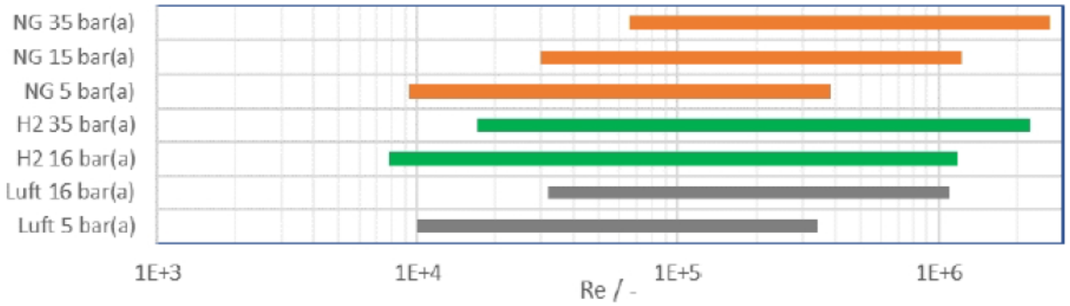
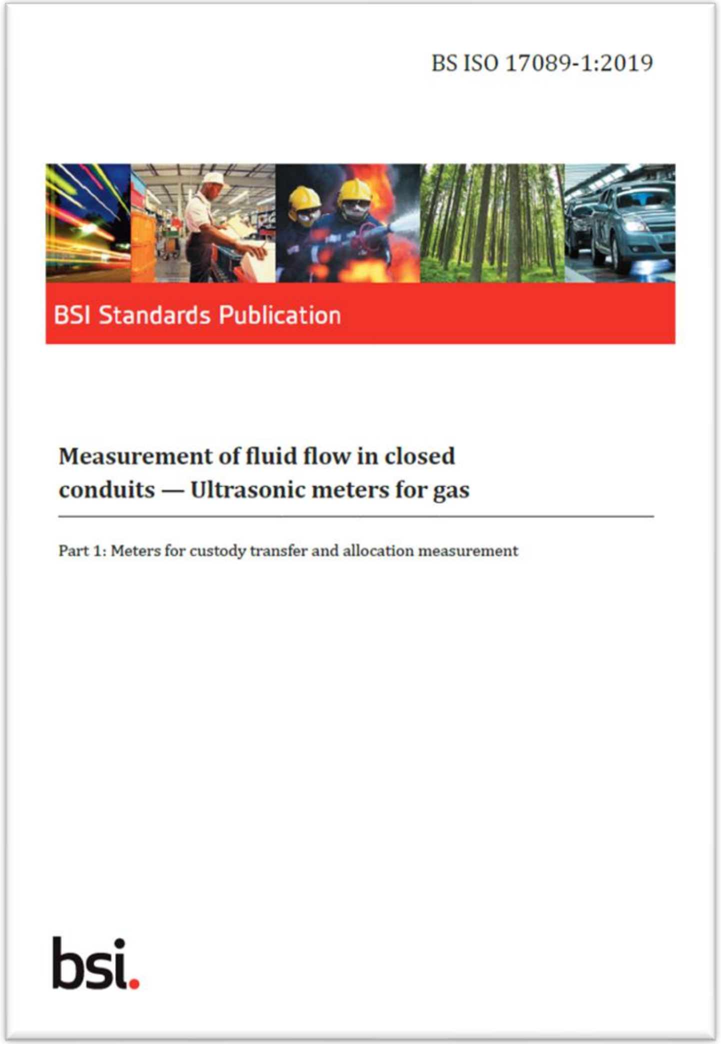


Figure 7. Reynolds number ranges for an exemplary hydrogen USM DN100 for different medium and pressures

Transferability between gasses

- Comprehensive testing was undertaken to assess the transferability of Reynolds numbers from natural gas (NG) to hydrogen (H2).
- The primary outcome indicates that transferability is achievable; however, the associated uncertainty is approximately 0.3–0.5%.
- This degree of uncertainty is suitable for non-fiscal metering purposes, but remains insufficient for fiscal applications at present.
- Principal challenges identified include:
  - Insufficient statistical data
  - Lack of complete confidence in the transferability methodology and laboratory results
- Consequently, the NG to H2 transferability approach was not incorporated into the MID certificate, as the current uncertainty precludes the maintenance of a class 1 meter rating.
- Additional positive findings were observed when assessing AIR to H2 transferability using the National Gas test. The meter demonstrated satisfactory performance following dry calibration on our Air HP test stand, despite the absence of specific NG or H2 calibration.

What are our references … what about standards ?



ISO17089-1

- Currently kicking off re-write
- New version to include Hydrogen (and Carbon dioxide)
- Planned to be published in May 2028

What are our references … what about standards ?

IGE/GM/4

- Scope: The standard provides guidance on the specification, design, installation, and operation of meter installations for low uncertainty flow measurement of:
    - Natural Gas (NG)
    - NG blended with hydrogen
    - Hydrogen (gaseous phase only)
- Pressure Range: It applies to installations operating at inlet pressures exceeding 38 bar and not exceeding 100 bar.
- Meter Types Covered:
    - Orifice meters
    - Turbine meters
    - Ultrasonic meters (USMs)
- Temperature Range: Applicable for gas temperatures between −20°C and 75°C.

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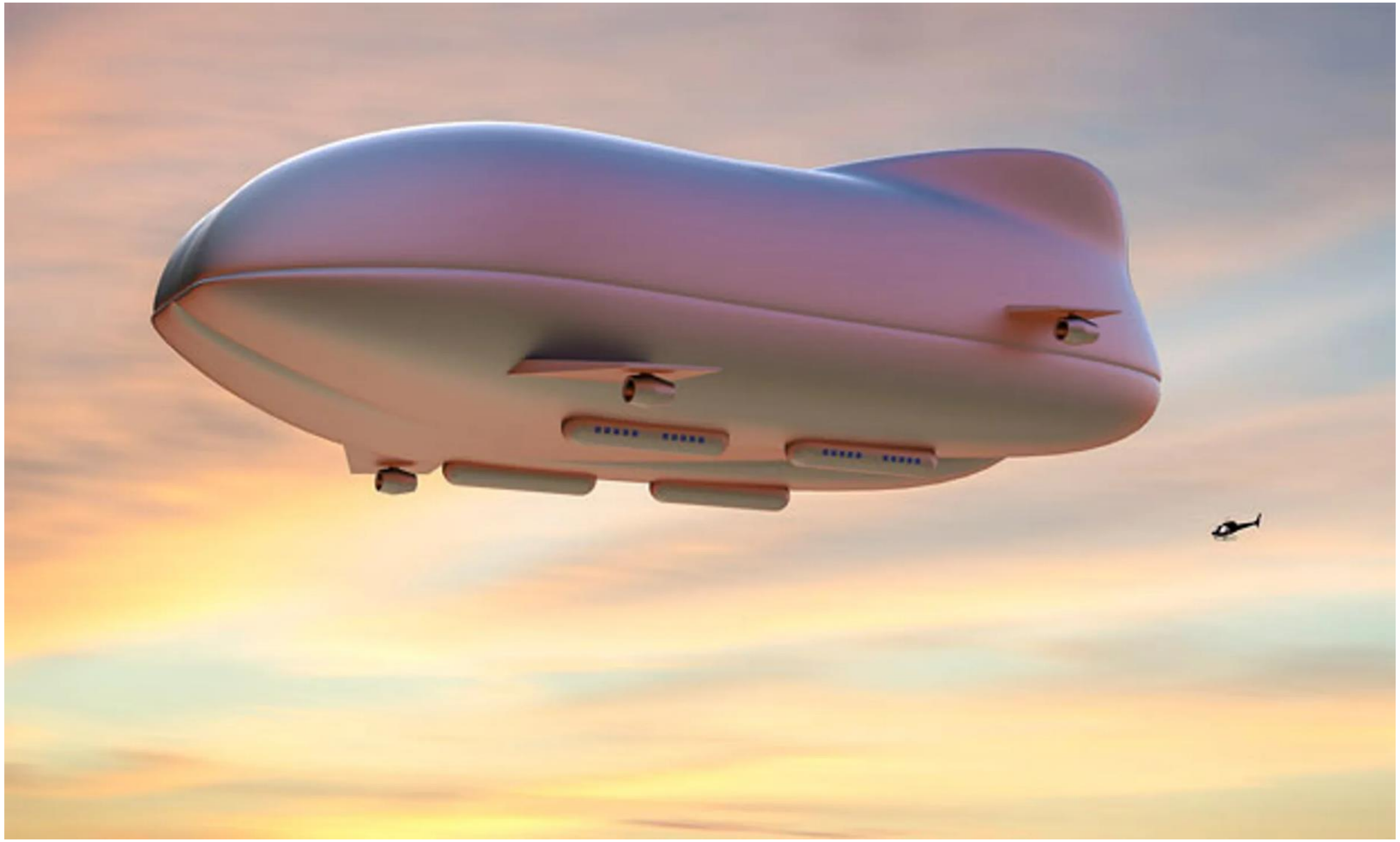
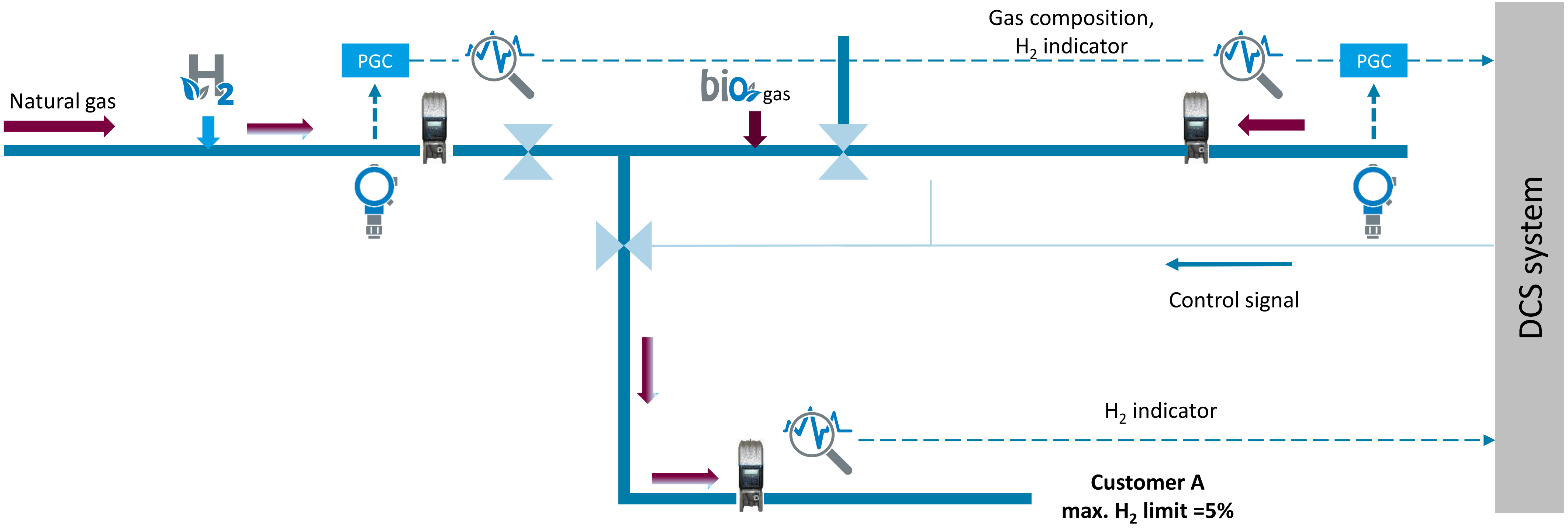
Can a USM give composition information ?



Can a USM give composition information ?

- Application example: Monitoring of hydrogen **limit for customer / network node**



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Can a USM give composition information ?

What is the Gas Quality Indicator (GQI)?

H2 measurement will support safety case
Both an “Enabler” & “Cost Saving”

- $GQI = f(SOS, P_{act}, T_{act}, P_{ref}, T_{ref}, \ldots)$

Meter needs to know

- Base composition (without H2)
- Pressure
- Temperature

Can a USM give composition information ?

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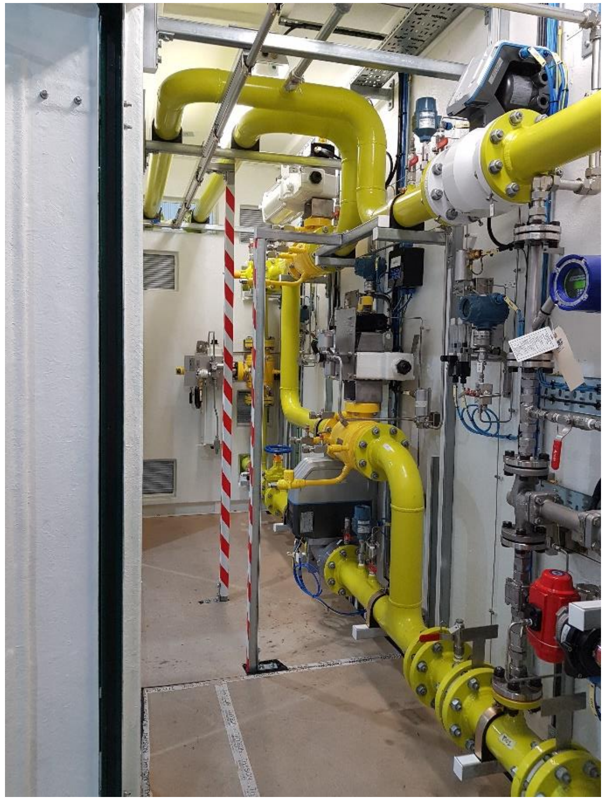
Alternative solutions

- GC with long sample times
- Bespoke, additional, instrumentation

Can a USM give composition information ?



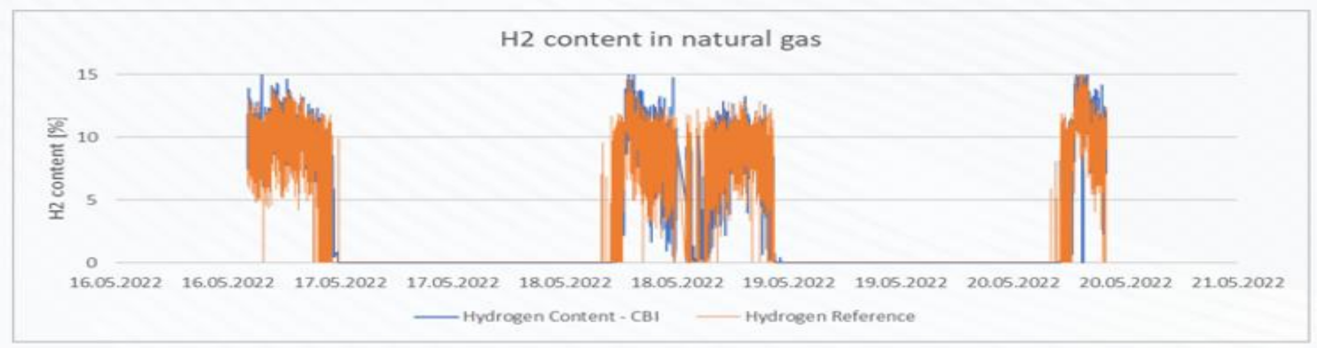
>> Pressure approx. 2 bar
>> Temperature approx. 5degC

>> H2 content of up to 18%

>> Natural Gas for the local distribution network

>> GQI specification on blended gas is better than 2% determination of H2 content

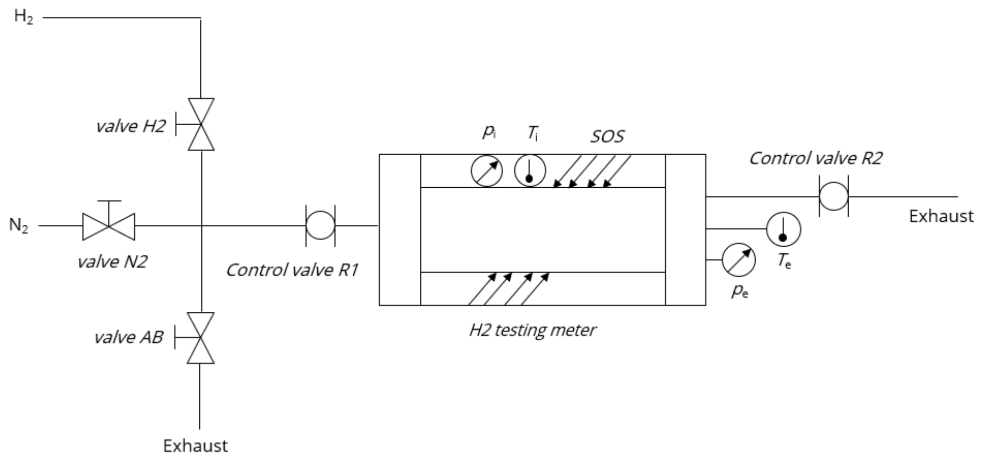
>> Correlation of 0.6% between PGC and GQI



Can a USM give composition information ?

- **Goal:**
- Investigate how precise hydrogen purity determination by SOS measurement (GQI function)

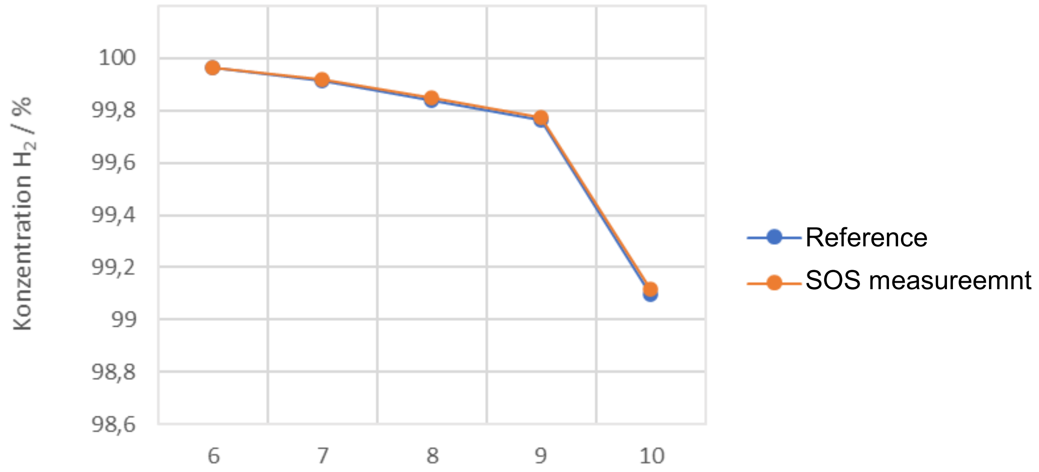
- **Test setup:**
  - H2 cylinder class 6.0 (99,9999% H2),
  - N2 cylinder class 5.0 (99,999% N2),
  - H2 Pilot meter (Dn100, 4 paths)
  - Internal temperature and pressure sensor
  - External temperature and pressure sensors
  - Pipes, valves, accessories



Can a USM give composition information ?

SOS measurement capable to detect **purity classes** of hydrogen

Precise differentiation of the hydrogen content between **99,9 % (CL 3.0) and 99,999 % (CL 5.0)** via SoS is possible



USM is detecting purity of hydrogen with an uncertainty below **0,01 %**

What about BIG data, how does AI fit in ?

- “AI-driven analytics unlock unprecedented precision in hydrogen flow measurement, enabling real-time optimisation and predictive maintenance, which are essential for scaling up clean energy infrastructure with confidence and reliability.”
- “As hydrogen becomes central to global energy transition, leveraging data and AI allows flow measurement systems to adapt to complex variables, reduce operational risks, and ensure transparent monitoring for regulators and stakeholders.”
- “The integration of AI and robust data streams will revolutionise hydrogen flow measurement, yielding insights that maximise efficiency, minimise losses, and empower smarter decision-making in every step of the hydrogen value chain.”

What about BIG data, how does AI fit in ?

"Big data- this really depends on who is operating the network/system. We have an excellent data historian system which we pull all the USM CBM data through to. This allows us to monitor the health of the meters really closely, troubleshoot e.g. VOS calculated vs Measured discrepancies etc both looking at the meter and also the **wider process**. This is definitely something the likes of the UK Gas Networks could benefit from doing and I think there would be big advantages to all operators/system owners to pull all available health data into a central database to allow monitoring. The "Hydrogen revolution" offers a good opportunity to put this in place."

What about BIG data, how does AI fit in ?

- "I see the main role of AI in hydrogen measurement as being "next-level" CBM related i.e. developing, from the outset of a project, the use of digital twins - AI-powered "replicas" of flow systems to simulate and optimize hydrogen transport networks and improve operational efficiency. I am quite excited about the potential of the digital twin idea. I think that in a large network, like the "European hydrogen back-bone", if the meters (and other related instruments) were all connected to a 24/7/365 AI model it could locate leaks, identify mis-measurements, make for more intelligently planned maintenance, and improve safety by keeping people away from places that they don't need to be. A real step change from the networks that we grew up with for oil and gas where it was all isolated instruments and stranded diagnostics."

What about BIG data, how does AI fit in ?

“Big data and AI are increasingly essential, not just in emerging energy fluid flow solutions, but also in traditional fossil-based systems, insights gained from established methods should be seamlessly transferred to emerging solutions. They help demonstrate compliance, reduce operational expenditure, and optimise resource use. This enables teams to focus on genuinely value-adding activities, improving economic recovery, extending operational life, and lowering the carbon footprint across the energy system lifecycle.

Measurement is fundamental, whether for accounting, regulatory compliance, financial reporting, commercial agreements, or environmental monitoring. We measure to maintain control and ensure systems perform as expected. Traditionally, this has meant manual calibration and validation against known standards, but skilled personnel are becoming increasingly scarce and expensive. Offshore access is often challenging, and the logistics around calibration facilities are both costly and complex.

By leveraging data and AI—whether deployed locally in the field or remotely, we can monitor system performance and health in real time, enable remote diagnostics and interventions, and take corrective action proactively. This not only improves reliability and responsiveness but also frees up skilled manpower to focus on higher-value tasks”