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Department for Science, Innovation & Technology

Accurate Billing for Hydrogen Energy Supply

11/05/2023 – All-Energy Conference

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TÜV SÜD at a Glance

150+
YEARS OF
QUALITY, SAFETY
& SUSTAINABILITY

1,000
LOCATIONS
WORLDWIDE

€2.4
BILLION
IN ANNUAL
REVENUE

24,000
EMPLOYEES

43%
OF REVENUE
OUTSIDE GERMANY

574,000
CERTIFICATES

100%
INDEPENDENT &
IMPARTIAL

1-STOP
SOLUTIONS
PROVIDER

The UK’s National Measurement System

Each year, the UK Government’s Department for Science, Innovation and Technology (DSIT) invests £65 million in the National Measurement System (NMS), to:

- Maintain the UK’s measurement traceability chain – to enable open and fair markets – domestically and internationally
- Develop documentary standards
- Enable industry through transfer of knowledge and best practice
- Fund metrology research to address sector wide challenges (especially where there is market failure) for the public good

<u>**NEL is the Designated Institute for Flow and Density Metrology**</u>
with responsibility for providing the UK’s physical flow and density measurement physical standards

The net zero challenge: UK Perspective

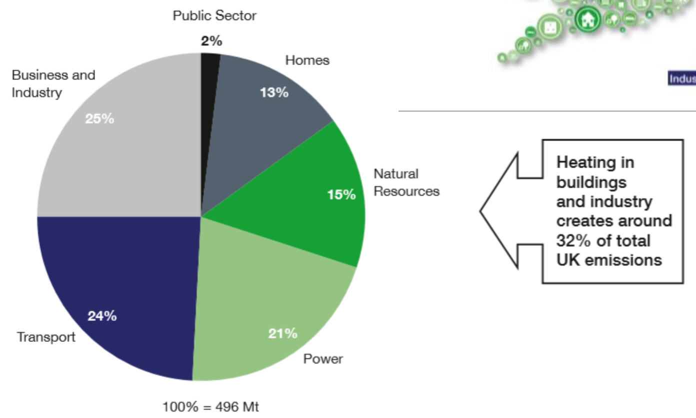
In the UK, heating and transport are responsible for 56% of total emissions.

There is tremendous potential for reducing emissions through the decarbonisation of both heat and transport.

The UK Government Clean Growth Strategy recognises:

- The role of electrification (electricity from solar, wind etc, battery electric vehicles, heat pumps)
- The role of biomass and bioenergy
- The role of carbon capture, utilisation and storage
- The role of hydrogen

Figure 2: UK emissions by sector, 2015[27]



Source: BEIS

The role of hydrogen in the transition to net zero

- Mobility
  - Use of hydrogen fuel cell vehicles
  - Better range and refuelling times compared to battery electric vehicles
  - Better suited for larger, heavier vehicles and those on a high duty cycle
- Hydrogen storage
  - Generating hydrogen from renewables at times of excess supply provides energy buffer
  - Removes impact of conversion inefficiency
  - Suitable for long term (intra-seasonal) storage
- Heat
  - Conversion from natural gas to hydrogen
  - Either pure hydrogen or blends up to 20%
  - Minimises need for upgrading electrical grid
  - Uses existing gas network infrastructure, expertise
  - Line packing to deal with ‘morning energy ramp’
- Direct Flame Applications in Industry
  - Simply cannot be replaced by electricity
- Energy Transport
  - Via the National Transmission System or tanker

Metrology for Hydrogen Vehicles

EMPIR joint research project, 2017 – 2020

- Flow Metering (OIML R139)
- Hydrogen Quality Assurance (ISO 14687-2)
- Hydrogen Quality Control (ISO 19880-8)
- Sampling (ISO 19880-1)

Continued in MetroHyVe 2, 2020 – 2023

- Research extended to larger vehicles
- Fuel cell impurity testing

https://www.sintef.no/projectweb/metrohyve-2/downloads/

The situation for existing vehicle refuelling

The existing regulatory requirement for ‘liquid fuels’ (petrol, diesel, etc) is that errors ‘at the nozzle’ must be -0.5% to +1.0% (at the minimum measured quantity, MMQ of 5 L) **[Class 0.5 fuel dispensers under OIML R 117]**

If a UK consumer disputes the dispensed volume, Trading Standards will investigate
- The equipment and skills to test fuel dispensers is well established
- Volumetric collection with standard measures, traceable to SI

In 2018, the UK exchequer received:
- £28 bn in fuel duty – 0.5% of which is £140 m
- >£1.5bn in VAT on fuel

The situation for hydrogen vehicle refuelling

- The accuracy requirements for hydrogen refuelling station (HRS) dispensers are set out in the international recommendation OIML R139
- Challenging to achieve due to operating conditions at hydrogen refuelling stations, which are specified in the worldwide accepted standard SAE J2601
- OIML R139 does not say which testing equipment should be used, but flow standards have been developed by measurement institutes

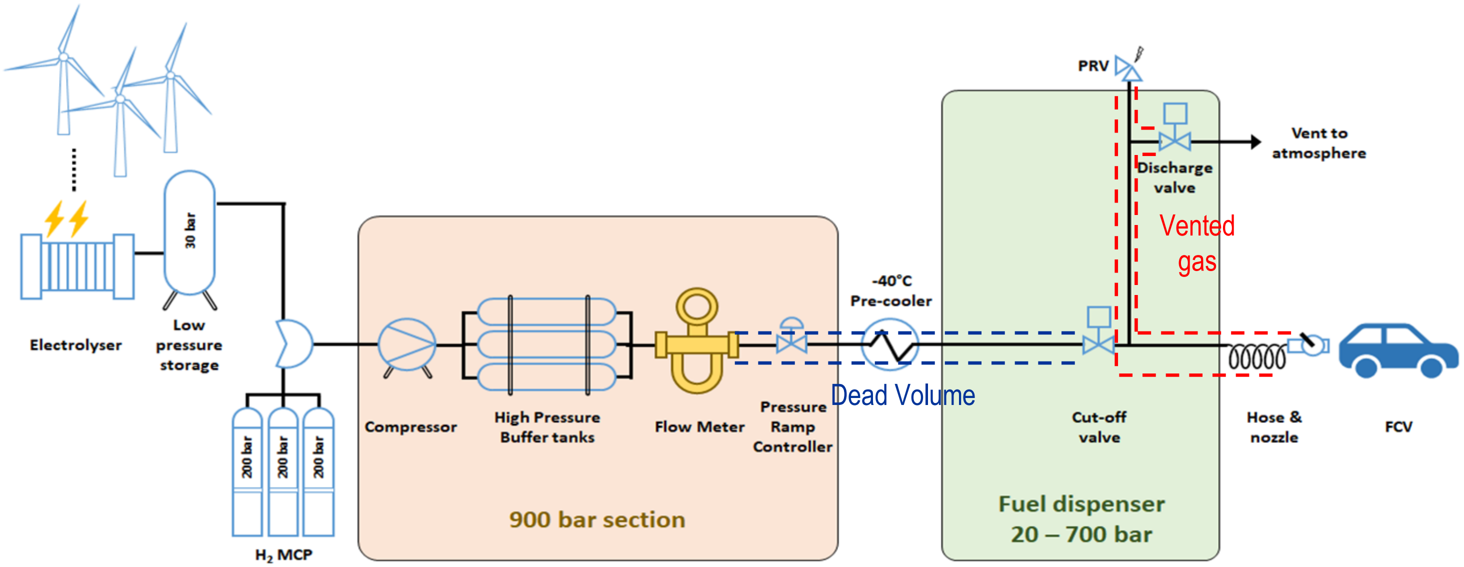
Table 1 - MPE values

Accuracy class		MPE for the meter [in % of the measured quantity value]	MPE for the complete measuring system [in % of the measured quantity value]	
			at type evaluation, initial or subsequent verification	in-service inspection under rated operating conditions
For general application	1.5	1	1.5	2
For hydrogen only	2	1.5	2	3
	4	2	4	5

The situation for hydrogen vehicle refuelling

Considering the typical HRS, the main sources of measurement error/uncertainty are:

1. Accuracy of the flow meter
2. Gas vented at end of refuelling
3. Density changes in "dead volumes"

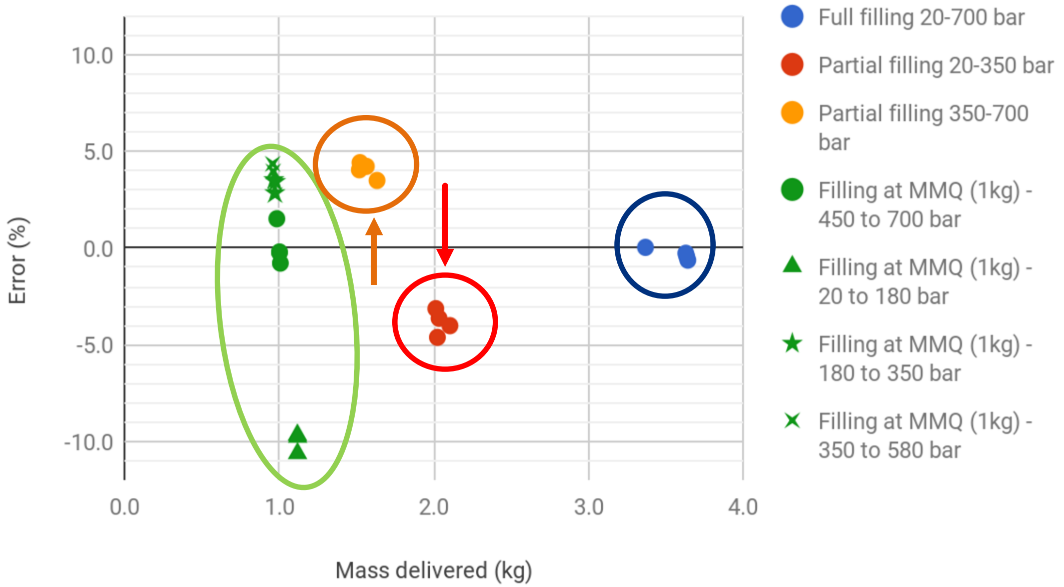


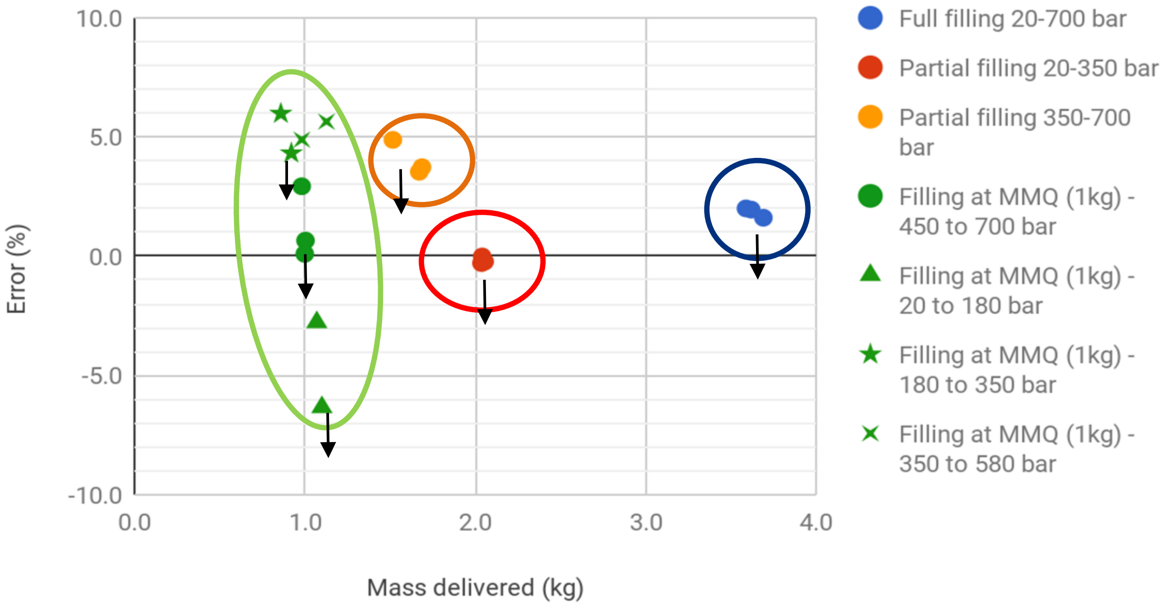
The various influences on the flow meter accuracy (incl. flow rate, temperature, pressure, density) were studied in detail in MetroHyVe. The other two influences can be calculated from PVT data.

The situation for hydrogen vehicle refuelling

Some results from field testing during MetroHyVe…

Flow meter upstream of the heat exchanger





Ref: "Hydrogen refuelling station calibration with a traceable gravimetric standard", R. Maury et al., Flow Measurement and Instrumentation, Special issue: 18th International Flow Measurement Conference – FLOMEKO 2019

The role of measurement in achieving net zero emissions?

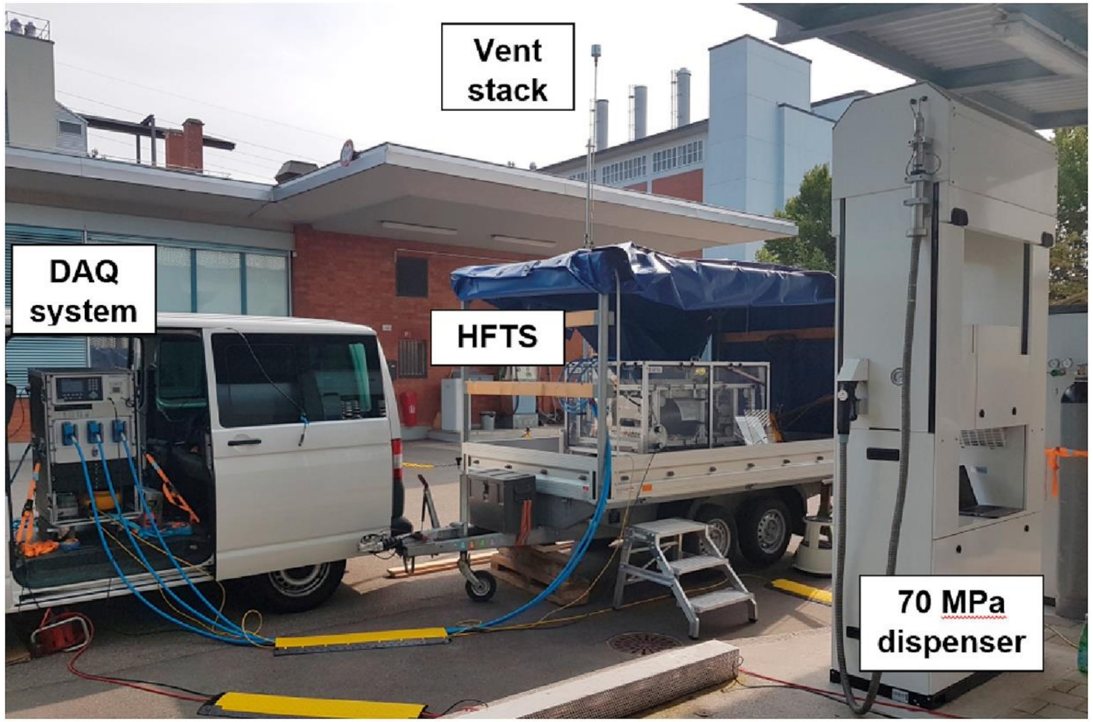
- To assess the magnitude of these sources of error, several field test standards (FTSs) have been developed

- NIST and NREL
- Air Liquide
- METAS
- VSL
- Justervesenet
- CESAME
- BEV
- TÜV SÜD NEL

MetroHyVe &
MetroHyVe 2

- The FTSs are based on a collection vessel with an accompanying scale

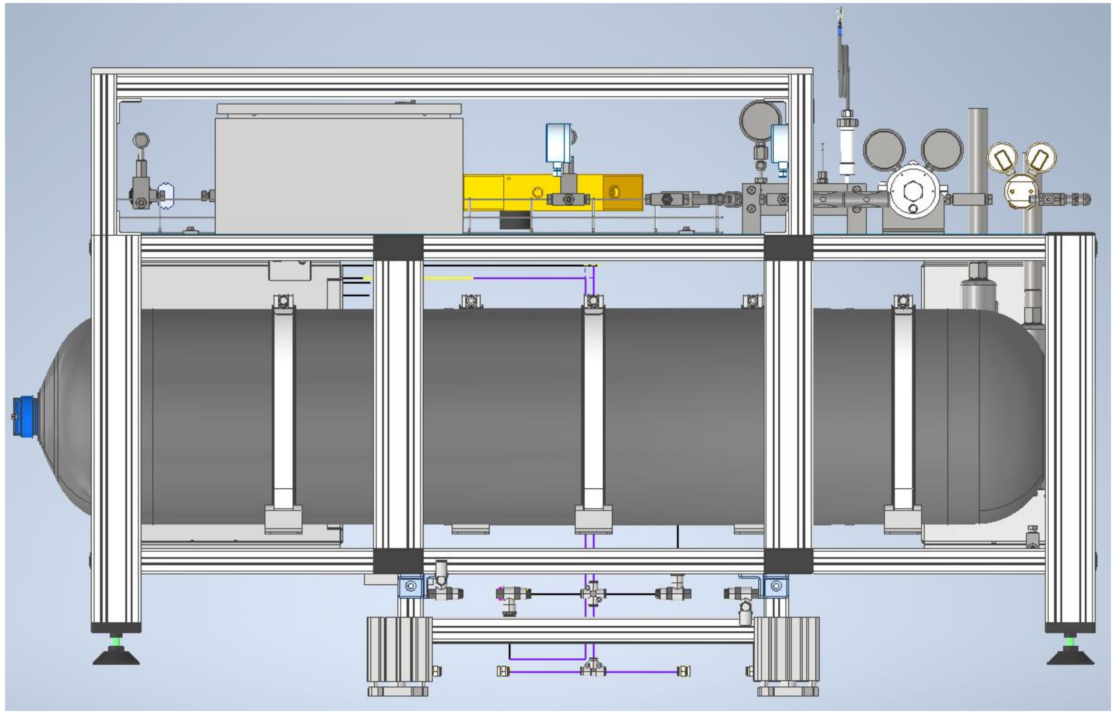
- When in use, the FTS takes place of the vehicle tank in a hydrogen refuelling station and can be used to assess the sources of flow measurement errors

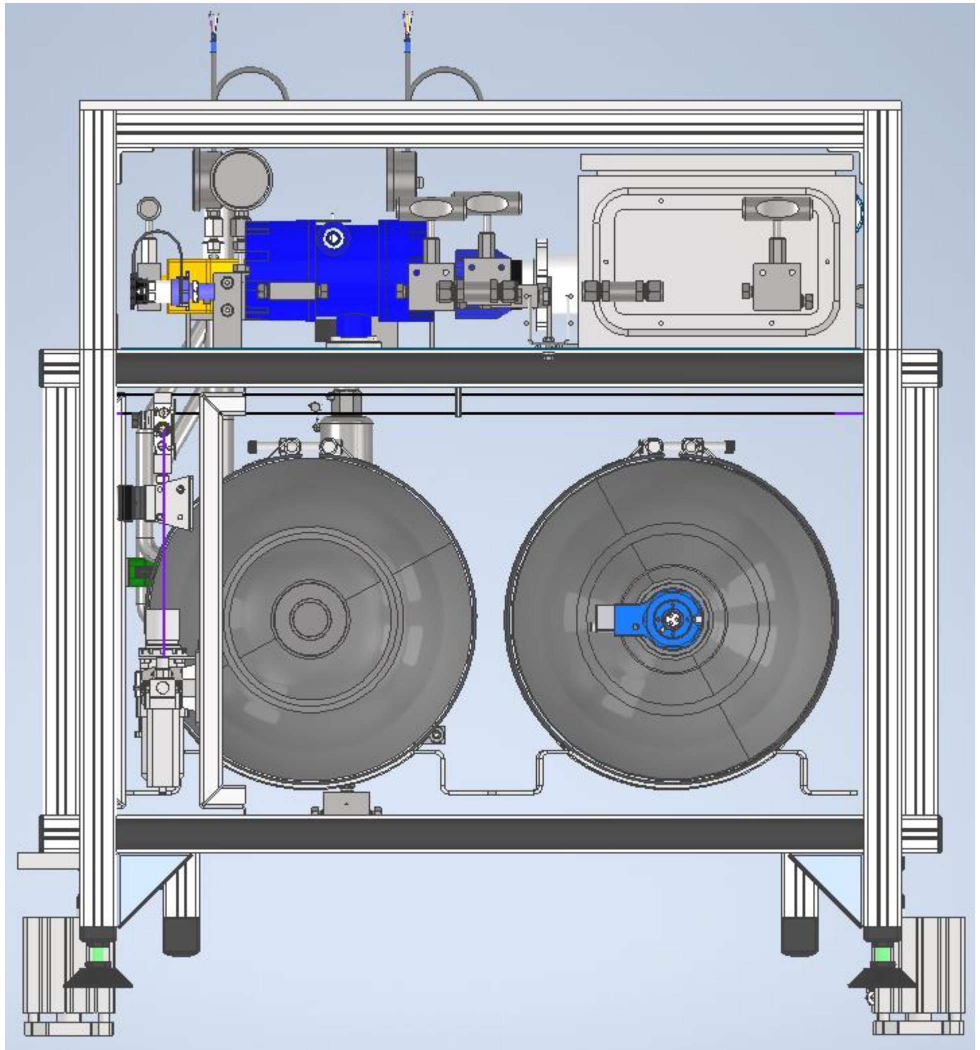


Ref: "Design of gravimetric primary standards for field-testing of hydrogen refuelling stations", M. de Huu et al., Flow Measurement and Instrumentation, Volume 73, June 2020,

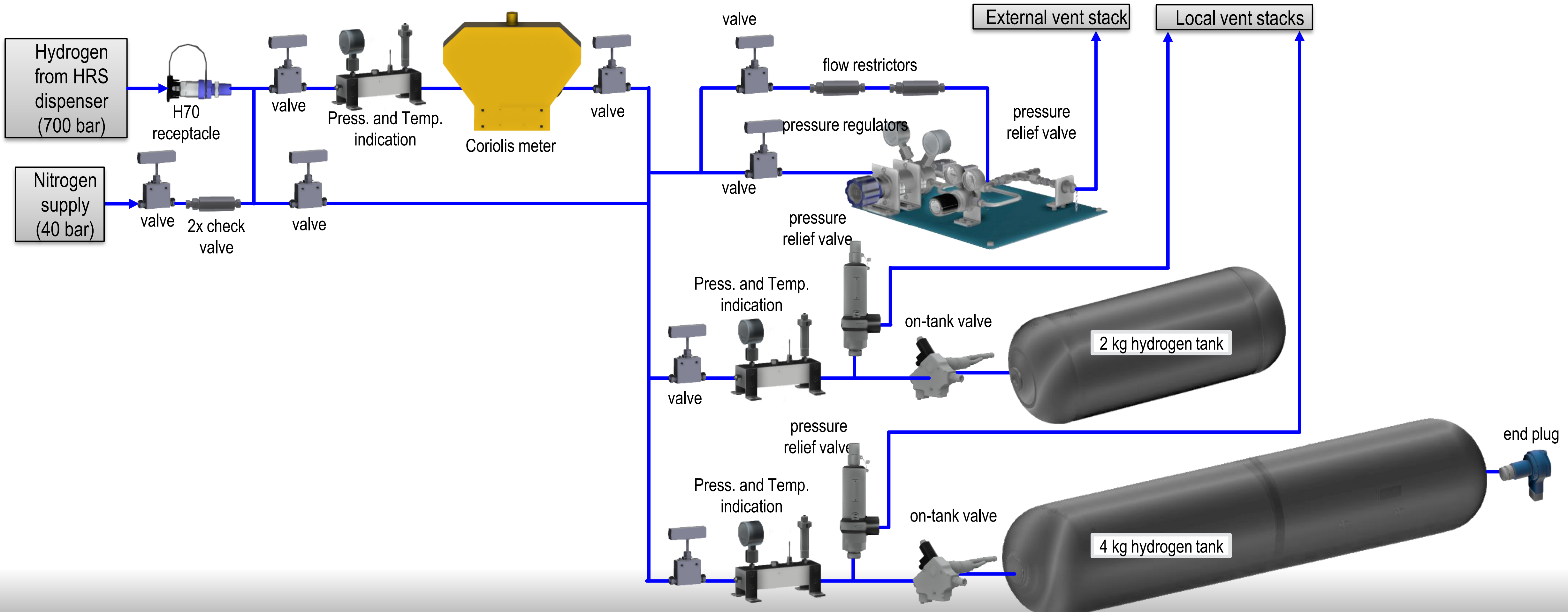
NEL Mobile Primary Standard for HRS testing

- Build completed, now in the commissioning stage
  - Gravimetric system, 0.3% (k = 2) target uncertainty at 1 kg MMQ §
  - Dual tank (103 L and 51 L), total 6 kg H_2 capacity at 700 bar





Key components of the primary standard



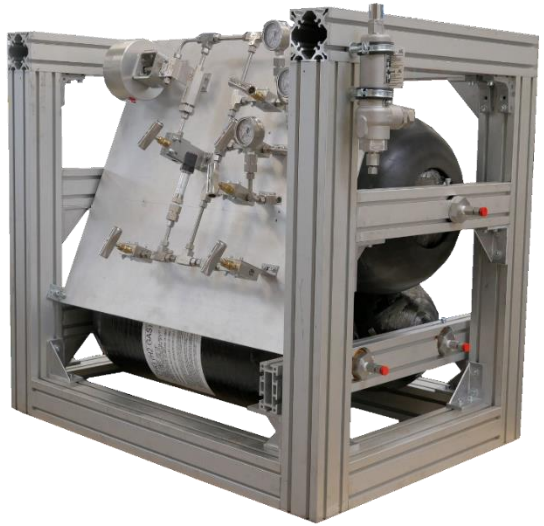
NEL Mobile Primary Standard for HRS testing

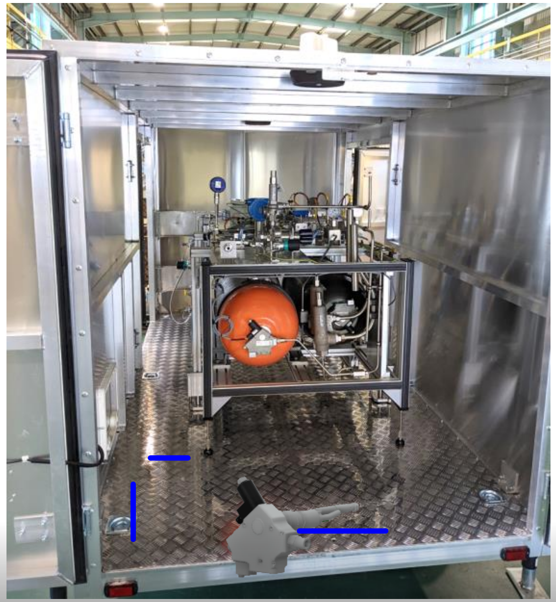
Progress to date

- Construction, commissioning, certification of flow standard
- Metrology checks with nitrogen

Upcoming

- MetroHyVe 2 intercomparison with hydrogen (Sep 2023)
- Validation of UK HRS (2024)





Hydrogen Domestic Gas Metering

- Many UK demonstration projects are considering use of hydrogen in gas networks
  - H21, HyDeploy, Hy4Heat etc.

- The projects primarily focus on safety, technical feasibility, public acceptance etc.

- Increasingly the metrology aspects are considered, including the gas meter accuracy
  - With pure hydrogen
  - With hydrogen – natural gas blends

Hydrogen Domestic Gas Metering

- Three meter types currently used:
  - Diaphragm: Increased errors from internal leakage?
  - Ultrasonic: Increased errors from signal attenuation, timing resolution?
  - Thermal Mass: Differences in heat capacity, specification of heating element and sensors?

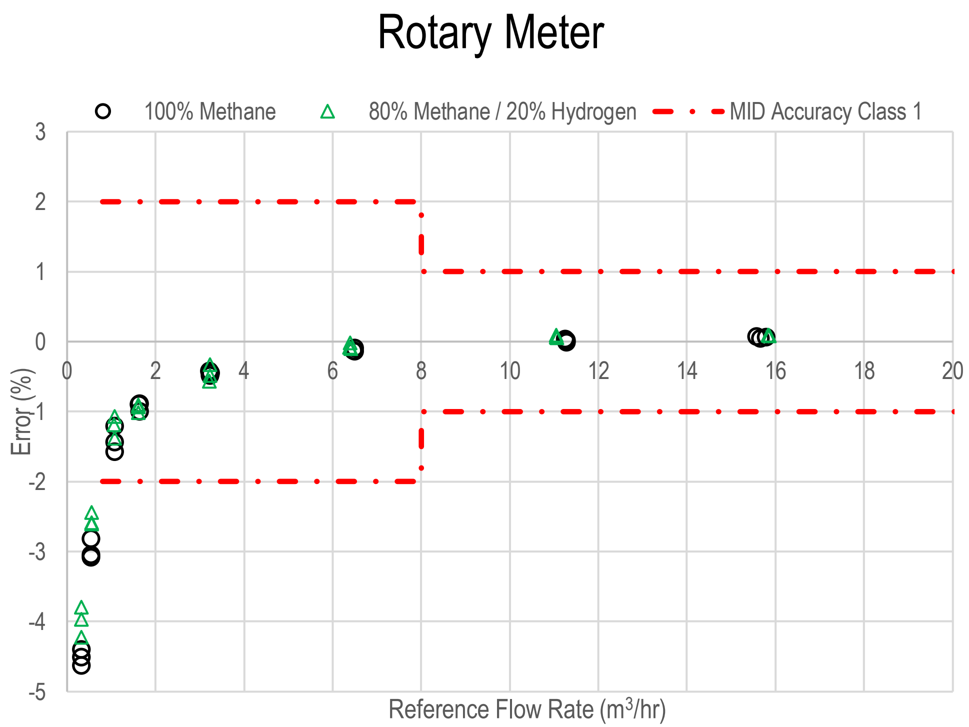
- New test data is required to answer these questions:
  - Meter calibration with air/nitrogen, followed by hydrogen
  - No existing hydrogen calibration facilities are available
  - Choice and traceability of reference flow device?

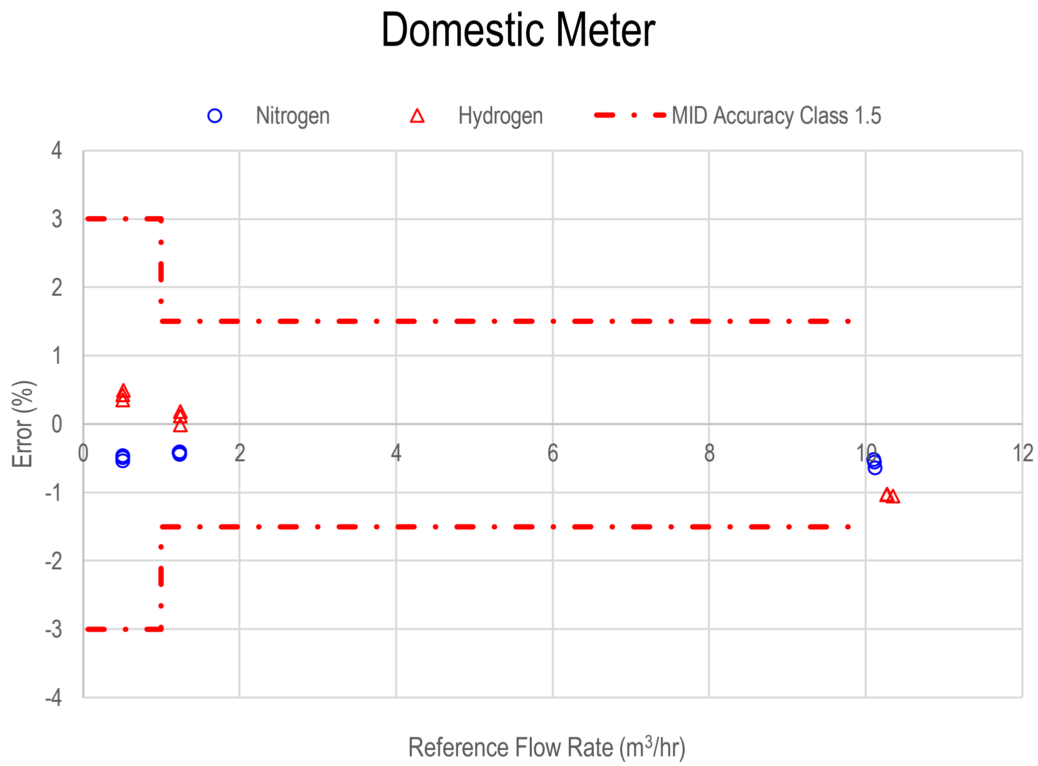
Hydrogen Domestic Gas Meter Facility

- The facility opened in March 2021
- Flow rates up to 50 m^3/h, 20 – 1500 mbar(g)
- H_2, CH_4, N_2, or mixtures of any two in any ratio
- Measurement uncertainties
  - N_2 : 0.2% (k = 2)
  - H_2 : 0.3% (k = 2)
- Uncertainties will be further reduced, currently building a new hydrogen primary standard

- First job was a test programme to support the UK HyDeploy project
  - 26 flow meters tested with 100% CH_4 and 80% CH_4 - 20% H_2 mixtures
- Now being used for meter manufacturer R&D, and EMPIR research projects NewGasMet MetHyInfra
- domestic and small industrial meters tested with 100% H_2

Hydrogen Domestic Gas Metering – Some Results





HyDeploy

20% H_2, 80% CH_4

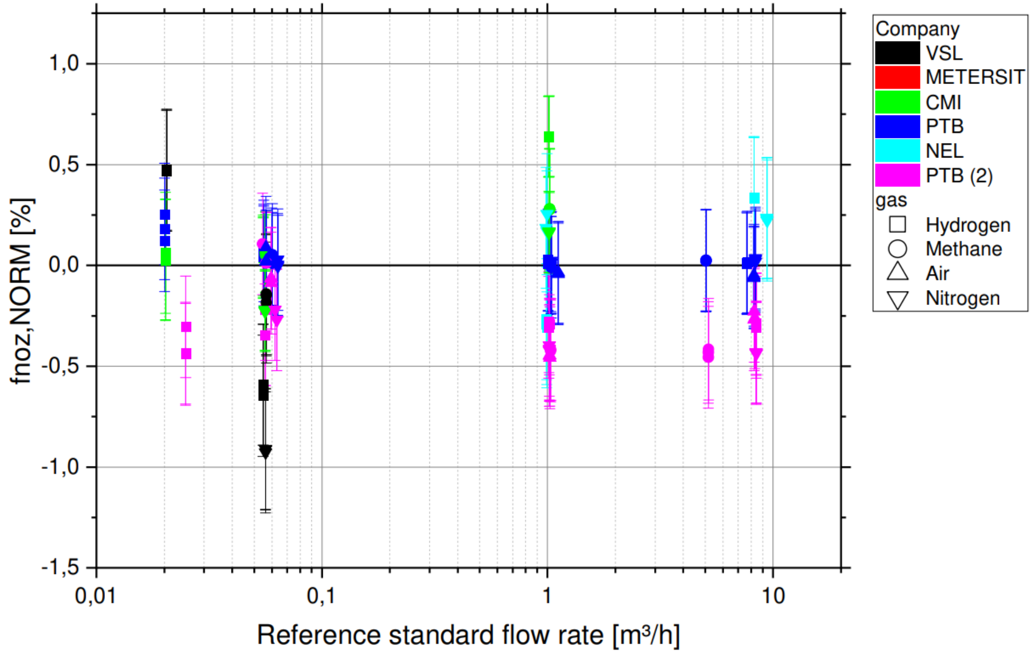
NewGasMet

100% H_2

Hydrogen Domestic Gas Metering

Progress to date

- Successful intercomparison testing, supports our claimed measurement uncertainty
- Completed test programmes for gas network operators, meter manufacturers, research projects
- First MID certification for hydrogen domestic gas meter, using data from NEL & PTB test facilities



Upcoming

- Continue to support manufacturer R&D on flow meters and other equipment
- Support ongoing revisions to standards
- Test a wider sample of meters in research projects
- Determine statistically if hydrogen is always needed for accuracy testing, or when safer, cheaper tests can be performed

SIT spa

PRESS RELEASE

The first MID-certified, 100% hydrogen meter in the world is Italian, and is produced by SIT

The "MID - Measuring Instruments Directive" certification issued by the Dutch NMi certifies the accuracy and reliability of the Domusnext® 2.0 MMU6 H_2

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