Niamh Rogers, Lucie Dangeon-Vassal and Rémy Maury, Cesame-Exadebit, present an initiative for flow measurement traceability for hydrogen in gas networks.

Verifying the hydrogen flow of the future

To mitigate the most severe consequences of climate change, it is imperative to significantly decrease greenhouse gas emissions. Achieving this goal necessitates a reduction in Europe's dependence on fossil fuels, as well as the rest of the worlds.

Hydrogen presents a viable and sustainable alternative, capable of being transported and distributed across long distances through gas networks while addressing societal, economic, ecological and technological objectives. Seasonal or daily hydrogen storage can be performed underground, or in the existing natural gas networks, enabling it to match energy demands with unforecastable and variable renewable energy sources like solar and wind. Gas Distribution System Operators (DSOs) and Transmission System Operators (TSOs) are central actors, as they will transport hydrogen using repurposed and new pipelines across Europe, with over 57 000 km of hydrogen pipelines by 2040.[6] In fact, the European Network of Network Operators for Hydrogen (ENNOH) has been established in 2025 to support this extensive network.[7]

The European Union is dedicated to establishing Europe as the first climate-neutral continent by 2050. Realising this ambitious objective necessitates a comprehensive overhaul of the European energy system, which is responsible for over 75% of the EU's greenhouse gas emissions.[1] To achieve these targets, many technological innovations are essential and, focusing on hydrogen, an acceleration on the development of a dedicated infrastructure is expected. Pipelines are considered the most effective means of transporting large quantities of hydrogen, particularly across extended distances.[9] Nevertheless, the existing deficiency in infrastructure poses a significant barrier to this progress.

Recent research at the European Gas Research Group outlines that due to hydrogen's lower calorific value, the energy conveyed by pipelines is lower than that of natural gas, from a volumetric standpoint. Therefore, a significant increase in the gas velocity in the pipeline is necessary to compensate for the lower energy value per cubic metre if the operative pressure is maintained around the values typical for existing natural gas networks.[8] Despite large-scale decarbonised hydrogen projects proliferating across the world, there is currently a lack of capability to conduct calibrations for pure hydrogen within gas networks. Such capability is urgently needed to establish the link between hydrogen flowmeters and the SI-units of measurement. Existing natural gas network measurements heavily rely on calibrated flowmeters to ensure the accuracy of their readouts and avoid any biases when trading takes place. Successful supply chain management hinges on precise measurements; therefore, without them, the penetration of the hydrogen market as envisioned by decision makers will not be achievable.

Developing calibration capability for pure hydrogen flow in gas networks

Recently, a project dealing with the capability to calibrate hydrogen flowmeters at high pressures and high flowrates in the typical range of gas networks was developed. The project is called H2FlowTrace. On 1 September 2024, the H2FlowTrace initiative was launched, consisting of 17 partners from 11 different European nations, co-financed by EURAMET, coordinated by Cesame-Exadebit. The consortium unites National Metrology Institutes (NMIs), and Designated Institutes (DIs) specialised in flow measurement, gas metrology, and the assessment of physical properties. This project is further enhanced by the inclusion of research institutes, industrial entities and a university. The multidisciplinary and collective knowledge and expertise in flow measurement within the consortium will be leveraged to tackle the measurement challenges associated with hydrogen flowmetering (as well as those associated with hydrogen-enriched natural gas (HENG), in order to enhance energy management benefits.)

The 36 month project is currently at the seventh month, making good progress. The project will be completed in August 2028.

The consortium aims to rectify the deficiency by facilitating the establishment of a large-scale verified metrological framework through the development of metrological infrastructures across a wide flow spectrum, so that calibrations of pure hydrogen and HENG flowmeters can be performed in which traceability to the SI-units of measurement is established. This development holds the potential to strengthen Europe's prominent role in the hydrogen economy.

H2FlowTrace objectives

H2FlowTrace seeks to address this challenge. The primary goal is to create a system for tracking gas flow of hydrogen within gas networks. The specific aims include:

1. To establish a robust metrological infrastructure (Figure 1): for flowrates up to 1300 m^3/h at 0.1 MPa(g) or 45 m^3/h at 3.3 MPa(g) with a primary focus on pure hydrogen but also enabling traceability for HENG blends in small industrial meters, with a measurement uncertainty of 0.20% or less.
2. To establish a robust metrological infrastructure for flowrates of 200 m^3/h to 10 000 m^3/h, and pressures of 0.3 MPa(g) to 6.2 MPa(g) for pure hydrogen and HENG blends in large industrial meters, with a measurement uncertainty of 0.30% or less.
3. To design and test traceability transfer skids for pure hydrogen and HENG 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.

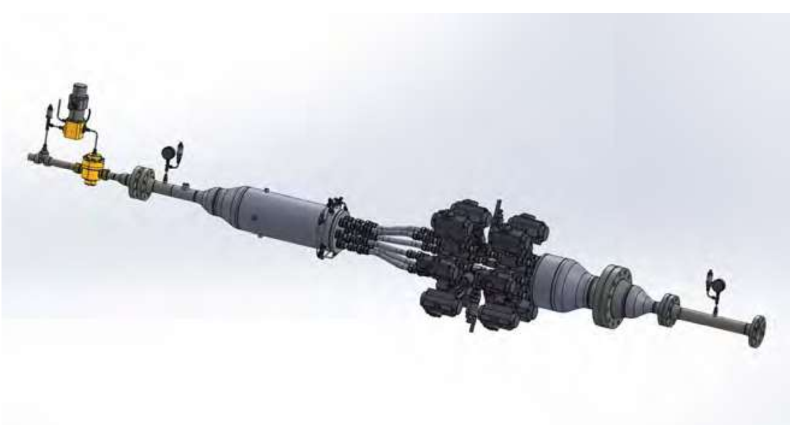

Figure 1. Small-scale transfer skid (SSTS) design.

4. To perform (i) primary calibrations of domestic gas meters (ultrasonic, diaphragm, thermal mass flow) with air and/or methane and with pure hydrogen up to 30 m^3/h at atmospheric pressure, and (ii) primary and secondary calibrations of industrial gas meters (ultrasonic, rotary, turbine) with air and/or natural gas and hydrogen/natural gas blends at flowrates of up to 1000 m^3/h and pressures of up to 6.2 MPa(g). Based on these results as well as existing data, to deliver statistically meaningful datasets for air, natural gas, or other alternative fluid calibration for the transferability to hydrogen gas flow conditions for domestic and industrial flowmeters.
5. To demonstrate the establishment of an integrated European metrology infrastructure and to facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited calibration and testing laboratories, European Metrology Network for Energy Gases), standards developing organisations (ISO/TC 30, OIML TC 8/SC 7, CEN/TC 237) and end users (energy gas transmission, distribution operators, FARECOGAZ, ENTSOG, Hydrogen Europe).

This project further aims to integrate the SI traceability of measurement institutions with the capability of key industrial stakeholders to transport hydrogen at the required flowrates and pressure levels.

Environmental impacts

As previously stated, the European Union aims to establish a carbon-neutral environment by 2050,[1] while also setting specific climate and energy objectives by 2030, with hydrogen potentially playing a crucial role in this endeavour.[4] The EU's initiatives for energy system integration and hydrogen development are instrumental in achieving these goals, supported by frameworks such as the Next Generation EU Recovery Package,[2] the European Green Deal,[3] and the EU Hydrogen Strategy.[4] Nevertheless, the journey will encounter various technical challenges. Hydrogen is pivotal for facilitating the energy transition, offering the capability to carry renewable energy minimising the use of fossil fuels, and serving as both short-term and long-term energy storage to address supply intermittency.

Impacts on gas metrology

The expansion of hydrogen utilisation is significantly reliant on metrology (the science of measurement), necessitating a robust metrological infrastructure for accurate hydrogen flow measurement, which will be addressed through objectives 1, 2, and 3. Objective 4 focuses on generating new insights regarding the compatibility of different meter types with hydrogen. Establishing best practices and ensuring traceability to the SI units of measurement in hydrogen flows will be vital for the efficient operation of decarbonised gas networks. In the long run, this will foster trust in billing, fiscal and custody transfer measurements, and maintain public support for the transition to net-zero carbon dioxide emissions. Ultimately, this will contribute to a positive environmental outcome.

Furthermore, the use of hydrogen as a fuel in the automobile industry could greatly diminish greenhouse gas emissions in the future, further permitting the ability to achieve the EU's objectives. For example, positive effects have been already seen in the past since improved traceability for hydrogen flow measurement significantly bolsters the approval process for hydrogen refuelling stations. This advancement could enable the market of hydrogen-powered vehicles, including public transport buses, trucks, and cars, thereby contributing to a reduction in greenhouse gas emissions and the consumption of fossil fuels. At the border separating two nations, flowmeters are installed to facilitate the sale of energy in transit. However, in the context of hydrogen networks, there is currently no infrastructure that is metrologically linked to the International System of Units (SI) for the calibration of these meters. The H2FlowTrace initiative aims to address this deficiency by developing two mobile skids (SSTS and LSTS) designed to accommodate a broad spectrum of flowrates, thereby meeting the requirements of gas transporters within the networks.

Supporting society and industry in the energy transition

This project aims to develop an integrated service for the measurement of traceable hydrogen (blend) gas flow, which will enhance metrological traceability with SI-units for gas networks. In domestic applications, datasets will facilitate the assessment of transferability of calibrations using alternative to hydrogen fluids in gas flow applications. This is crucial for promoting hydrogen as a viable energy source, as establishing flow measurement traceability is essential for gaining the trust of consumers and gas meter manufacturers in achieving the necessary accuracy standards for measuring hydrogen and/or HENG. Meter manufacturers will benefit from new traceable calibration facilities, allowing them to conduct research and development with pure hydrogen at flowrates and pressures

Figure 2. The project (23IND05 H2FlowTrace) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the participating states.

pertinent to large industrial meters. Consequently, industry end users will be empowered to make informed choices since manufacturers will be able to better assist end-users in their decisions regarding hydrogen flowmeters, backed by the metrology community and validated calibration facilities.

Moreover, the datasets produced through this initiative will allow the consortium to evaluate the reliability and cost-effectiveness of calibrations using alternative fluids (HENG, natural gas, nitrogen, water, etc.) for various types of gas meters, including ultrasonic flow, thermal mass flow, diaphragm, and Coriolis meters. Consequently, this will lead to significant cost reductions for testing and calibration laboratories. Ultimately, this will facilitate a rapid increase in the use of hydrogen and HENG, with minimal modifications required to the existing metrological infrastructure. Furthermore, establishing metrological traceability for hydrogen and HENG gas flow in industrial settings will enable the current test loops within the consortium to gain full confidence in the calibrations they conduct for industrial clients.[5] The comparison of hydrogen and HENG facilities, along with a comprehensive calibration campaign involving at least 40 industrial gas meters, will serve as a fundamental element for creating a metrologically harmonised hydrogen and HENG transmission infrastructure.

Ensuring the accuracy, repeatability, traceability, and cost-effectiveness of flow measurement is essential for fostering the sustainable development of the hydrogen sector in Europe and eventually the world. This focus will contribute to a more robust market for hydrogen technology and service providers, thereby stimulating innovation and creating new job opportunities for citizens across the continent. The long-term effects of this initiative will include facilitating manufacturers in the design and certification of advanced flowmeters, as well as empowering gas network operators to advance their hydrogen infrastructure projects.

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