Publishable Summary for 21GRD05 Met4H2
Metrology for the hydrogen supply chain

Overview

The urgent need to mitigate climate change and to limit greenhouse gas emissions is driving actions to reduce the use of fossil fuels. However, meeting current and future energy needs necessitates the increased use of alternative energy sources such as, hydrogen from renewable sources. To achieve this goal, the metrological infrastructure for hydrogen needs to address all parts of the supply chains. This project will provide novel and improved standards for the safe application of hydrogen flow measurement, hydrogen quality assessment and custody transfer. Together with outcomes from previous projects, an infrastructure will be established that provides measurement data that are fit for demonstrating compliance with regulations and contracts. This infrastructure will facilitate ramping up the use of hydrogen and society to adapt to using hydrogen instead of fossil fuels.

Need

The report from the Intergovernmental Panel for Climate Change of 2021 underlined once more the urgent need to reduce greenhouse gas emissions to mitigate climate change. The European Commission developed the European Green Deal to decarbonise energy use, shifting from fossil fuels to renewable fuels. One of the pillars is a phased approach to the introduction of hydrogen to replace fossil fuels in electrical power generation, transport, industry and the built environment. In addition, recent geopolitical developments on the edges of Europe have further highlighted the need for diverse, reliable and resilient, non-fossil fuel-based energy supplies in Europe. To apply hydrogen safely within the existing gas grid network and other infrastructure, traceable measurements for leak testing, material compatibility, sensors for monitoring processes and odorization are required to demonstrate compliance with legislation. Traceable flow measurement and hydrogen quality assessment are necessary for custody transfer and fair trade. Demonstrating compliance with hydrogen quality specifications, such as ISO 14687, and legal metrology requirements, such as International Organization of Legal Metrology (OIML) R140 and OIML R137, for metrological type approval and for assessing the performance of measuring systems, is therefore essential. Hydrogen sampling methods for applications below 20 MPa, such as gas grids, need to be developed and validated, to ensure metrological traceability and reliability of data obtained using those methods.

Metrological traceability and accuracy already developed need to be deployed to onsite measurement systems, so that robust and comparable results are obtained that support their use beyond monitoring processes. Finally, there is a need to improve and expand documentary standards for totalisation of quantity and energy used for custody transfer, such as OIML R140, ISO 15112 and EN 1776, to make them fit for purpose for use with hydrogen-enriched natural gas and hydrogen and to cover the totalisation of impurity content.

Objectives

The overall objective of the project is to further develop and integrate the metrology necessary to support the entire supply chain of hydrogen, from production to storage and end use. The project will disseminate metrological traceability to the field, so that measurement results become fit-for-purpose with respect to health, safety, environmental, and fiscal purposes.

The specific objectives of the project are:

1. To develop calibration and measurement methods to support reliable, traceable, and accurate measurements of hydrogen in production processes and end-user applications, in view of safety, process efficiency and environmental issues, such as for purity, leak detection, odorization, and

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materials performance, ensuring that online measurement instruments and sensors are operating within their specifications (e.g., to ISO 14687, OIML R139, and OIML R140).

2. To develop measurement standards to enable calibration and validation of flow metering equipment under actual conditions (pressure, temperature), used to accurately quantify flow rates of hydrogen (including blended hydrogen) through the hydrogen supply chain, and to facilitate compliance with respect to, e.g., OIML R137, OIML R140, and the Measurement Instruments Directive.
3. To develop and improve measurement standards and methods to enable traceable validation and performance evaluation of gas quality measurement methods for hydrogen, to thus improve on the current lack of equivalence for impurities, e.g., oxygen, hydrogen sulphide, moisture content, and for reactive components such as hydrogen chloride and chlorine. To develop and improve analysers for critical impurities for online monitoring of changes in gas quality, through the supply chain and processing equipment, to ensure the gas quality meets the required specifications (ISO 14687).
4. To develop novel methods for the evaluation of measurement uncertainty along the supply chain as a whole, namely with regard to the measurement of total quantity, and energy and impurity content of hydrogen and hydrogen blends.
5. To facilitate, in cooperation with the European Metrology Network Energy Gases, the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrumentation manufacturers for hydrogen), standards developing organisations (ISO, OIML) and end users (e.g., industry, consumers, power generation and transport).

Progress beyond the state of the art and results

The project will deliver novel standards and methods for leak flow measurement, material compatibility testing, and odorization of hydrogen-enriched natural gas (HENG) and hydrogen. These standards and methods build on previous projects, such as 20IND10 Decarb regarding leaks, and ENG01 GAS and ENG54 Biogas regarding odorization standards, which focused on other energy gases. To support calibration, validation and verification of sensors, rigs and methods will be developed, so that sensors can generate traceable results with a defined uncertainty. This work builds on the work in, e.g., 16ENG01 MetroHyVe and 19ENG04 MetroHyVe 2.

This project will collate and analyse the results from previous projects regarding flow metering (e.g., 16ENG01 MetroHyVe, 18NRM06 NEWGASMET, 19ENG03 MefHySto, 19ENG04 MetroHyVe 2, 20IND10 Decarb, 20IND11 MetHyInfra, and 20IND13 SAFEST) to combine these and improve their accessibility and therefore their uptake. Primary standards for flow metering developed in, e.g., 18NRM06 NEWGASMET will be improved and assessed for equivalence in support of calibration and measurement capabilities (CMCs) of European NMIs. For small-scale gas meters, novel calibration facilities will be developed for use with HENG and hydrogen. With these facilities, open access data will be generated showing how an impurity content of 2 % affects meter performance. Finally, for gas meters for flow rates above 0.2 kg/min, metrological traceability chains will be designed and matched with ongoing developments of calibration facilities to understand better the need for calibrations for these gas meters.

The framework for hydrogen quality assessment developed in, e.g., 16ENG01 MetroHyVe and 19ENG04 MetroHyVe 2 will be expanded to cover chlorine, one of the impurities listed in ISO 14687 for which accurate measurement standards and methods are lacking. Furthermore, sampling methods will be developed and validated for applications below 20 MPa, e.g., for electrolysers and gas grids, supplementing those from 16ENG01 MetroHyVe and 19ENG04 MetroHyVe 2 for hydrogen refuelling stations. The capabilities for analysing trace levels of sulphur will be improved and expanded, focussing on equivalence between facilities in measuring the total sulphur amount fraction around the specification of 4 nmol/mol. Improved spectroscopic methods will be developed for ammonia in hydrogen. Stability studies for moisture and hydrogen chloride in static standards will be performed to generate data for the provision of gas standards with defined stability. Measurement standards for water dew/frost point will be developed or adapted to work with HENG and hydrogen up to 6 MPa, a pressure relevant for transmission grids. Developments in, e.g., ENG01 GAS, ENG54 Biogas and 20IND06 PROMETH2O will be taken up to achieve this outcome. Finally, the metrological traceability chains to onsite measurements will be demonstrated and validated.

The models for calculating the total quantity and energy from, e.g., OIML R140 and EN 1776 will be improved to address correlations in the results used to calculate these totals, dynamic effects in gas grids due to varying flow rate and gas composition in order to avoid underrating the measurement uncertainty. A model for the

calibration for the totalisation of impurity content (purity exposure) will be developed to facilitate calculation of this parameter, which is critical for appliances that are sensitive to the presence of a particular impurity.

Outcomes and impact

Outcomes for industrial and other user communities
This project will support the industry involved in the hydrogen supply chain from hydrogen production to transport and end use.

Novel measurement standards for hydrogen leak rate measurement will enable industry to have reliable devices to monitor the integrity of gas grids, thereby ensuring safety when feeding hydrogen into these grids. The methods and standards for material compatibility assessment will enable universities, research institutes and industry to assess materials for their suitability to be used with hydrogen, ensuring that potential hazardous situations are recognised at an early stage. The odorization standards will enable gas grid operators, for example, to confirm that the odorant level in HENG and hydrogen meets the specifications, thereby ensuring the safe distribution of these gases to the built environment. They also enable research institutes and other bodies to assess the olfactometric properties of these odorants with hydrogen-containing energy gases.

The rigs developed for the calibration and evaluation of sensors for hydrogen quality will enable users and producers of these sensors to have them assessed, so that these sensors have a known performance, and the results obtained are metrologically traceable. This traceability in turn enables users of the sensors to apply them beyond the monitoring of processes, thereby avoiding the need to measure again for, e.g., assessment of compliance with specifications.

The validated primary standards for flow metering of hydrogen-containing energy gases will enable custody transfer for these gases, in combination with the methods for sampling and hydrogen quality assessment, and the improved methods for totalisation and the associated measurement uncertainty evaluation.

The hydrogen quality measurements performed at two industrial sites, electrolyser plant and gas pipeline, will demonstrate to the industry how metrological traceability and accuracy can be delivered in real-life situations. These demonstrations and the good practice guidelines derived from them, will create a close link with the hydrogen production and transport sector as well as with the measurement system manufacturers and therefore, ensure a swift take up of project outcome.

Outcomes for the metrology and scientific communities
In order to facilitate the take up of hydrogen in Europe and worldwide, a well-established measurement infrastructure is a must. This project focuses on developing, optimising and comparing traceable measurement standards and methods, so that this infrastructure is created.

The novel flow measurement standards will enable NMIs, DIs and calibration laboratories to provide measurement services for the hydrogen supply chain and industry to have their instruments calibrated. These in turn enable research into the development of gas meters for HENG and hydrogen. The sampling methods, standards and methods for hydrogen quality assessment will enable services to be provided by the gas industry in the form of secondary and working gas standards and measurements and will provide research groups with the necessary tools to ensure their measurement results are metrologically traceable, so that conclusions from their work can directly be taken up by others.

The improved methods for hydrogen quality assessment will enable metrological traceability to be disseminated to laboratories, which in turn can seek accreditation based on ISO/IEC 17025 for their services related to ISO 14687, including sampling. Research groups will benefit from these capabilities in that they can assess improvements in processes along the supply chain with the necessary standards for calibration of their equipment.

Legal metrology organisations and their national bodies benefit from the work related to especially OIML R137 and OIML R140, as well as the calibration and measurement services enabling assessment of the performance of measurement equipment supporting conformity assessment and type approval.

Outcomes for relevant standards
The project will provide enhanced guidance for calculating the total quantity, energy and impurity exposure of supplied or received gas and good practices in taking into account the dynamics of the gas grid and gas properties in the uncertainty evaluation to OIML R140 and ISO 15112. The work on flow measurements will provide evidence as to whether OIML R140 can also be applied to metering and custody transfer of hydrogen and HENG. Material compatibility testing is covered in standards such as ISO 15105 and ISO 2782; this project

contributes approaches for increasing the sensitivity of the measurement and set-up adjustments allowing for extension of the parameter range in terms of the boundary conditions. The results in WP3 will demonstrate that the scope of ISO 21087 can extended to supply chains other than just PEM fuel cells. The materials compatibility overview for calibration gas mixtures in ISO 16664 can be updated based on the stability study data for static gas standards with, e.g., hydrogen chloride and moisture.

Longer-term economic, social and environmental impacts
As natural gas is the primary fuel source for heating in Europe, the market is approximately 550 billion cubic metres per year. The introduction of hydrogen in this part of the gas supply relieves the pressure on the electrical grids. This project will provide the tools to adapt the measurement infrastructure to distributing HENG in the first instance, and hydrogen at a later stage. Using HENG comes with relatively small changes for end users, and thus is a very economical measure to decarbonise the gas supply in the short term. It is also far less disruptive than requesting end-users to switch from gas to electricity for these purposes.

The outcomes support the safe application of hydrogen in gas transmission and distribution systems, as well as charging end-users and industry for their gas use in accordance with current requirements. Thereby it facilitates the transition from fossil fuels to net-zero carbon dioxide emission renewable fuels. Feeding in hydrogen enables end-users and industry to gradually adapt to this future, with as little disruption as necessary. In the coming years, feeding in green hydrogen in the natural gas grids leads to a reduction of carbon dioxide emissions, thereby contributing to meeting intermittent goals of the European

List of publications
n/a

This list is also available here: https://www.euramet.org/repository/research-publications-repository-link/

Project start date and duration:		01 October 2022, 36 months
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Internal Beneficiaries: 1. VSL, Netherlands 2. BAM, Germany 3. BEV-PTP, Austria 4. CEM, Spain 5. Cesame, France 6. CMI, Czechia 7. CNAM, France 8. DFM, Denmark 9. FORCE, Denmark 10. INRIM, Italy 11. JV, Norway 12. LNE, France 13. PTB, Germany 14. RISE, Sweden 15. VTT, Finland	External Beneficiaries: 16. DTU, Denmark 17. ENVIPARK, Italy 18. GERG, Belgium 19. Nippon Gases, Italy 20. NORCE, Norway 21. POLITO, Italy 22. UL, Slovenia 23. ZAE Bayern, Germany	Unfunded Beneficiaries: 24. SICK, Germany
Associated Partners: 25. METAS, Switzerland, 26. NEL, United Kingdom, 27. NPL, United Kingdom		