Publishable Summary for 24GRD11 MetroHyVe3
Metrology for hydrogen vehicles 3

Overview

The number of hydrogen refuelling stations (HRS) in the European Union (EU) will increase significantly over the coming years, as stipulated in the EU Regulation 2023/1804 on the deployment of alternative fuels infrastructure. The hydrogen refuelling infrastructure is maturing rapidly: achieving higher flow rates for fast heavy-duty refuelling, tapping into new hydrogen sources to guarantee sufficient supply, and reducing downtime to cope with the increasing demand. To support these developments, this project aims to develop metrology infrastructure and provide new measurement standards, methods, and best practices for measurement of both hydrogen quality and quantity.

Need

In line with EU Regulation 2023/1804, the overall need of this project is to improve hydrogen mass balance verification at HRS as this drives the deployment of hydrogen fuel across Europe and net zero hydrogen vehicles. As the hydrogen refuelling infrastructure matures, new metrological challenges have arisen, relating to the need for improved hydrogen quantity and quality measurements.

For quantity measurements, there is a strong need for traceability for hydrogen flow rates up to 18 kg/min, which existing standards cannot deliver. Furthermore, the calibration process needs to be sped up through the use of master meters, and the potential for using surrogate fluid calibrations of hydrogen flow meters needs to be understood. This will simplify the type-approval process and enable more cost-effective traceability chains to be put in place. (objective 1)

To reduce HRS downtime, integrated metrology services need to be developed, which will combine hydrogen quantity measurements with sampling for hydrogen quality determination. (objective 2)

Safety and quality at HRS are essential and this needs accurate online monitoring. Metrological guidance needs to be developed for the validation and implementation of the hydrogen sensors that are used for quality and safety purposes. Methods and standards also need to be developed to calibrate these sensors at the HRS, in order to reduce downtime. New low-cost sensors need be developed to enable cost-effective quality control. (objective 3)

Finally, the evolution of the hydrogen supply chain may lead to new contaminants in hydrogen, which need to be identified. Moreover, the impact of the new contaminants needs to be assessed to determine regulatory requirements and the need for standardisation. (objective 4)

Objectives

The overall aim of the project is to develop metrology infrastructure to support the measurement of hydrogen quantity and quality at hydrogen refuelling stations (HRS).

The specific objectives of the project are:

1. To extend existing flow measurement traceability to the very high flow hydrogen refuelling of heavy-duty vehicles (up to 18 kg/min) and to demonstrate its applicability to larger vehicles (e.g., ships, trains, planes). To compare calibrations of the most frequently used HRS flow meters (e.g., Coriolis), using surrogate fluids (water, kerosene, nitrogen, and air), and hydrogen (when the HRS flow meter is

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under operational conditions). In addition, to determine the measurement uncertainty, at the HRS dispenser, of the flow meter calibrated by surrogate fluids.

2. To develop mobile integrated HRS verification units, that incorporate traceable flow standards and validated sampling systems for determining hydrogen quality (major/common impurities and gas composition) and dispenser accuracy during a single site visit. These units will be used to achieve the light-duty and heavy-duty HRS measurement performance requirements of OIML R139 (or equivalent) and the hydrogen fuel quality requirements of EN 17124. The expected benefits of using these units, at light duty and heavy-duty hydrogen refuelling stations (operating at up to 18 kg/min and 87.5 MPa), will be estimated.
3. To develop traceable and deployable methods and procedures in the laboratory for transfer to, and use at, HRS sites for the validation of the sensors and analytical instruments used for process control, the online monitoring of hydrogen quality, and for hydrogen leak detection. On-site HRS sensors and analyser calibration/performance verification procedures must include the use of primary standards (OGS or transportable standards such as N_2 and O_2 or H_2O standards), or traceability transfer by another method. Quality control and influence parameters, specific to the location of the measurand, will be included.
4. To extend knowledge on hydrogen quality by determining the probability of impurity/contaminant presence in the novel and emerging hydrogen supply chain for production (e.g., alkaline electrolysers, H_2 carriers etc.), storage (e.g., gas grids, underground or chemical storage) and from their generation in new HRS components. The presence of impurities/contaminants generated at these hydrogen supply chain sources will be evaluated using a representative number of real-world samples (> 45 samples) and calibration methods. The analysis will consider various chemical compounds from inside and outside of the EN 17124 and ISO 14687 specifications (e.g., ammonia, microbiological compounds, toluene, ions).
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers, notified bodies), standards developing organisations (OIML, ISO, CEN), and end users (e.g., HRS operators, hydrogen vehicle manufacturers).

Progress beyond the state of the art and results

Traceable secondary standards for hydrogen flow up to 18 kg/min at 70 MPa

Three potential routes to traceability, for master meter facilities, will be investigated i.e., master meters systems based on Coriolis meters calibrated with hydrogen, the same systems calibrated with alternative fluids to hydrogen and finally master meter systems based on critical flow Venturi nozzles. Master meters will be used as secondary standards for validating hydrogen flow up to 18 kg/min at 70 MPa. This project will deliver 5 new master meter skids, and validate a sixth, covering both LDV and HDV applications and three different traceability routes (Coriolis meters calibrated with hydrogen, Coriolis meters calibrated with alternative fluids and master meter systems based on critical flow Venturi nozzles). The application of master meters aims to significantly reduce the downtime of HRS, as in contrast to the gravimetric (primary) methods, no time is needed to vent hydrogen tanks. An investigation of the uncertainties associated with surrogate fluid calibrations will be performed, which could enable a traceability route and provide evidence to support a more cost-effective type approval process for HRS.

Integrated metrology for hydrogen quantity and quality

This project will develop two systems (integrated test units) which combine hydrogen flow measurement with sampling, leading to integrated HRS metrology, which will significantly reduce downtime at HRS. A thorough review of the requirements for both parts of these systems will lead to a design in which the two measurement systems can be combined, without negative effects on the accuracy. These integrated systems will then be built, tested and validated in a field test, resulting in new integrated metrology services for HRS. The systems also aim to be suitable for the testing of the HRS according to EN 17127, thus combining three test campaigns into a single site visit that will take less than 50 % of the current sampling and verification time.

Online quality control

This project will study different types of sensors for use in the monitoring of hydrogen leaks and in the monitoring of the most common fuel quality contaminants (water, oxygen, nitrogen) that are found in hydrogen fuel. The sensors will be validated in laboratory conditions and then tested at a HRS under real conditions. The onsite standards, which will be used for the calibration of these sensors, will be developed using artefacts (primary gas standards) and optical gas standards (calibration based on traceable spectral data). New sensor technologies will be tested for the new types of contaminants that occur in the supply chain. The aim is to provide HRS operators with a list of new, reliable sensors, which have been tested, and this will deliver a calibration infrastructure that will be adapted to HRS requirements. Guidance on the testing and validation of the sensors will be provided. This project will progress beyond the state of the art by developing traceable and deployable methods and procedures to test the different types of sensors and analytical instruments that are used for process control, for detecting hydrogen leaks and the most common quality contaminants (water, oxygen, nitrogen) in hydrogen fuel.

Reliable datasets on new contaminants

This project will review the hydrogen supply chain in order to identify the emerging supply chain elements and to identify if any information is missing in relation hydrogen fuel quality. More than 15 new hydrogen production methods, hydrogen carriers (including NH_3, CH_3OH, and liquid organic hydrogen carrier), storage technologies (including underground storage, type IV cylinders) and HRS components will be theoretically studied to determine the probability of contaminants being present. To validate the findings, the consortium will sample more than 24 different sites and realise more than 45 analyses using state of the art analysis, targeting compounds of interest which will increase the rate and relevance of findings. The participants will provide an overview of the potential new contaminants that the industry could face and will provide first results on the impact of a few of them on hydrogen fuel cells. The results will support better quality control of HRS, evolution of the international standard and the identification of new measurement challenges. This project will progress beyond the state of the art by targeting more than 15 new hydrogen production methods including, hydrogen carriers (including NH_3, CH_3OH and LOHC), storage technologies (including underground storage, type IV cylinders) and HRS components for the probability of contaminant presence (chemical compounds from outside of the EN 17124 and ISO 14687 specifications) and this will be correlated with measurements on real-life samples with sampling intervals and frequency reflecting the complexity and size of the energy infrastructure, using calibrated analysers (e.g., in-line or via a sampling container).

Outcomes and impact

Key dissemination and communication activities

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Outcomes for industrial and other user communities

This project will provide five new calibration facilities which will be directly relevant to the HRS industry, and it will enable the reliable verification of flow measurement at HRS according to OIML R139 or equivalent. This will ensure fair billing. Two integrated test units will be developed, which will enable hydrogen flow verification and sampling for fuel quality to be completed in a single site visit, thus reducing the downtime of the HRS.

This project will deliver good practice guides to ensure safety during verification at HRS and in hydrogen sensor implementation. The HRS industry will be able to integrate reliable sensors into their operations to ensure hydrogen safety and fuel quality. New calibration standards and reference materials will be developed to test these sensors under HRS conditions. These improvements will lead to fewer HRSs delivering non-compliant fuel, thus reducing maintenance costs and increasing HRS availability.

The provision of a large open access dataset of hydrogen quality measurements from various sources, will allow the industry to prepare for the future supply chain, by investing in new measurement technologies, purification solutions and cost-efficient hydrogen imports.

Outcomes for the metrology and scientific communities

Six flow laboratories will be able to claim new Calibration and Measurement Capabilities (CMCs) for their master meter skids, enabling new services to be provided for the verification of HRS flow measurement. The demonstration of surrogate fluid calibration for hydrogen will provide new opportunities to improve accuracy and uncertainty at HRS conditions to 0.6 %. The “integrated test units” will enable Cesame and VSL to offer hydrogen flow verification and the sampling of hydrogen quality as a combined service.

The good practice guides on quality sensors will enhance the reliability and traceability of sensor validation, creating a virtuous circle led by the metrology community. Instrument manufacturers will be provided with the methodology and infrastructure that they need to support the validation of their online sensors for hydrogen quality control.

The National Metrology Institutes and Designated Institutes (NMIs and DIs) will develop new calibration services for new sensors. Accredited commercial laboratories will be able to develop and deploy cost-efficient secondary standards. New calibration routes will be developed to deliver traceability to gas quality measurements. This will allow commercial gas analysis laboratories, sensor manufacturers and HRS operators to perform reliable and traceable hydrogen quality measurements.

Outcomes for relevant standards

The outcomes of this project will be shared in EURAMET Technical Committees and relevant committees of the International Bureau of Weights and Measures (BIPM).

This project will support the revision of OIML R 139 by providing OIML/TC 8/SC 7 with technical evidence and guidelines on calibration, the achievable uncertainty, and flow metering for high flow (up to 18 kg/min) at HRS.

The good practice guide on sensor validation will provide important input to ISO TC 158/JWG 7 for the revision of ISO 21087 and the addition of online analysis in the scope of the standard. Currently the standard excludes online analysis due to the lack of fit-for-purpose guidance on onsite analyser evaluation criteria.

The provision of technical evidence on the probability of contaminants occurring in 15 parts of the hydrogen supply chain will support ISO TC 197/WG 28 and CEN TC268/WG 5 in the revision of ISO 19880-8 and EN 17124 respectively. New evidence and potential examples will be provided for inclusion.

The results of the new contaminants study and the impact of the new contaminants will support ISO TC197 WG27 and CEN TC268 WG 5 in the revision of ISO 14687 and EN 17124 respectively.

Longer-term economic, social and environmental impacts

The expected results will contribute to reduced downtime for HRS, accurate billing, better hydrogen quality control, and resulting from this: lower hydrogen price. The knowledge that hydrogen quality control and accurate billing can be attained at reasonable cost, will aid final investment decisions on the construction of new HRS. In the longer-term, this project will contribute, in this way, to the goal of attaining 1000 HRS in Europe and along the 'Trans-European Transport Network’ (TEN-T) as prescribed by the Alternative Fuels Infrastructure Regulation (AFIR).

As the quality control, safety, fair billing of hydrogen fuel, and HRS availability will be properly arranged, as is the case for traditional fuel, hydrogen will be able to decarbonise transport where battery use is unsuitable (heavy-duty long-distance transport, taxi fleets). With more HRS available, an increase in the trustworthiness of hydrogen vehicles will be experienced, making hydrogen vehicles increasingly popular, especially for heavy duty vehicles where short refuelling times and low vehicle weights are important. Through societal acceptance, and growth in number, greenhouse gas emissions will reduce, thus supporting better health and a cleaner environment.

Moreover, by studying green hydrogen production technology or related pathways, this project will support the development of the net zero hydrogen supply chain. This will speed up the transition by providing reliable datasets to other green hydrogen users (avoiding late discovery of quality challenges) and it will support hard to decarbonise sectors (e.g., heavy industry, industrial heating).

List of publications

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Project start date and duration:	1 August 2025, 36 months	
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Internal Beneficiaries: 1. NPL, United Kingdom 2. BAM, Germany 3. Cesame, France 4. FORCE, Denmark 5. INRIM, Italy 6. JV, Norway 7. NEL, United Kingdom 8. PTB, Germany 9. RISE, Sweden 10. VSL, Netherlands	External Beneficiaries: 11. BHAM, United Kingdom 12. DLR, Germany 13. DTU, Denmark 14. ENGIE, France 15. ERIG, Europe 16. FBK, Italy 17. HOBRE, Netherlands 18. POLITO, Italy 19. TNO, Netherlands 20. ZBT, Germany	Unfunded Beneficiaries: 21. Emerson M, Netherlands
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