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Accurate Quantity and Quality of Hydrogen Fuel Delivered at Hydrogen Refueling Stations (HRS) across Europe

Collaborating NMIs across Europe have developed new calibration standards and reference material services to improve hydrogen fuel calibration and HRS verifications

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The Challenge

Hydrogen is becoming an important low-emission alternative to petrol and diesel, especially for heavy-duty vehicles. With 186 public refueling stations already in operation, the hydrogen network is growing quickly. But wider adoption depends on trust. Drivers, fleet operators, and regulators need confidence that hydrogen stations deliver the correct amount of fuel and that the fuel meets the required quality standards. Before this work, achieving that confidence was harder because the measurement infrastructure was incomplete. There were no suitable calibration standards for checking hydrogen flow rates at refueling stations, making accurate billing more difficult, and no agreed reference materials for benchmarking laboratories that test hydrogen quality. Although regulations existed, proving compliance was often slow and expensive. Removing these barriers was essential to support wider uptake of hydrogen as a transport fuel.

The Solution

A consortium of European NMIs, energy companies, research organizations, and an automotive company collaborated to overcome the measurement challenges. They developed a mobile secondary standard and method to accurately verify hydrogen flow rates at the HRS site, and reference materials to benchmark analytical laboratories performing hydrogen fuel testing.

Building on the EMPIR project MetroHyVe,¹ the consortium developed a metrologically traceable framework for testing dispensing meters at HRS, including primary and secondary standards for type approval and initial verification of flow meters at the HRS. Thanks to the project's success, CESAME-EXADEBIT (French designated institute for flow) ensured that type approval and initial verification of HRS were completed in half the time, using metrologically traceable, accurate standards, enabling customers to be charged correctly when refueling heavy-duty vehicles.

The partners laid the groundwork for new reference materials for hydrogen fuel quality testing. To do this, they carefully prepared reference gas mixtures and studied their stability over time across more than 10 different cylinder types. This showed how reference materials can be produced with the accuracy and shelf life needed for laboratories to check their

¹ EMPIR Project 16ENG01 MetroHyVe, "Metrology for Hydrogen Vehicles" https://www.euramet.org/research-innovation/search-research-projects/details?tx_eurametctcp_project%5Bproject%5D=1461&cHash=8e0faebc728f251485e738327bffdcee

hydrogen test results against a trusted benchmark. Before this work, no full interlaboratory comparison had covered all regulated hydrogen fuel contaminants, so the performance of commercial testing laboratories was not well understood, and studies had already highlighted differences between laboratory results. By enabling these comparisons, the project helped improve the reliability and consistency of hydrogen fuel quality testing.

A Quantifiable Impact

CESAME-EXADEBIT integrated these standards into a calibration service capable of providing flow-rate measurements for both light- and heavy-duty hydrogen refueling stations. Their services were available to the entire European hydrogen industry, leading to many services being delivered to the HRS industry (> 30 HRS verified). It enabled the industry to meet the applicable regulation's accuracy requirements and allowed HRS to be verified twice as fast as before. For example, TEAL Mobility, an energy consortium comprising TotalEnergies and Air Liquide, which operates a network of HRS in Europe, used the new calibration standard and services to certify its HRS as regulation-compliant in a timely and cost-effective way, lowering barriers to further expanding its network. The work performed bolsters consumer confidence in accurate billing at HRS and contributes to the acceptance of hydrogen as a viable alternative for all types of vehicles. This secondary standard, developed by CESAME-EXADEBIT, was a pioneer, and follow-on replication is planned by EU metrology institutes and calibration laboratories as part of the European Partnership for Metrology project 24GRD11 MetroHyVe 3 or business development.

Fuel quality testing at hydrogen refueling stations is expensive—typically around €6 000 per station each year—so it is important that the results are reliable. This matters because even small amounts of contamination in hydrogen can affect vehicle performance, causing reduced range, unexpected stoppages, or wider disruption to transport services. Building on the MetroHyVe 2 project, HyQuality Europe (grant number: 101101447) enabled NPL to organize three interlaboratory comparisons covering all regulated hydrogen contaminants. These comparisons benchmarked more than 20 testing laboratories and improved performance: the rate of satisfactory results increased from 58 % for 4 compounds to 73 % for 13 compounds. From a metrology perspective, this strengthens confidence that hydrogen fuel quality measurements are consistent, comparable, and traceable across laboratories—supporting the wider international measurement system championed by organizations such as the BIPM. In practice, this provides hydrogen station operators with more reliable test results and helps build public confidence in hydrogen as a safe and reliable transport fuel.

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A complete list of participants is provided on the EMPIR Project 19ENG04 MetroHyVe 2 page.^{2,3}

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² EMPIR Project 16ENG01 MetroHyVe, “Metrology for Hydrogen Vehicles” https://www.euramet.org/research-innovation/search-research-projects/details?tx_eurametctcp_project%5Bproject%5D=1461&cHash=8e0faebc728f251485e738327bffdcee

³ EMPIR Project 19ENG04 MetroHyVe 2, “Metrology for hydrogen vehicles 2” https://www.euramet.org/research-innovation/search-research-projects/details?tx_eurametctcp_project%5Bproject%5D=1699&cHash=b908625805e427652112638c417b827c