Publishable Summary for 18NRM06 NEWGASMET
Flow metering of renewable gases
(biogas, biomethane, hydrogen, syngas and mixtures with natural gas)

Overview

The European Green Deal encourages the development of renewable energy sources and gases (biogas, biomethane or hydrogen) produced for this purpose. As their characteristics differ from the well-known natural gas, the industry needs to understand their impact on flowmeters and demonstrate their compliance with the Measuring Instruments Directive 2014/32/EU. To support this need, the NEWGASMET project partners published an overview of existing data and wrote recommendations on the design of gas meters. Durability tests were performed with biogas and hydrogen, while accuracy tests with hydrogen. Calibration benches have been adapted and European inter-comparison tests have been performed with hydrogen and methane.

Need

The European policy to increase renewable energy sources has a significant impact on the characteristics of energy gases throughout Europe and therefore on the European gas infrastructure:

- Power generation from wind and solar sources leads to the development of so-called “power to gas (P2G)” solutions; these plants will compensate for fluctuating electricity supplies by converting electricity into hydrogen to be injected in large quantities into the gas network.
- Biogas produced by the anaerobic digestion of organic waste needs to be directly measured in cogeneration facilities or before injection into the gas network after purification to biomethane.

The gas network is connected within Europe but the gas supply is dependent on the coordination of national operators for transport and distribution (TSO and DSO); this industry first needs were to draw an overview of existing disseminated scientific results related to metrology and different national renewable energy policies (objective 1). So far, gas meters have been tested, calibrated and certified for natural gas applications according to Measuring Instruments Directive and to CEN standards. Consequently, the evolution of the gas energy mix was expected to impact the accuracy of measuring instruments that are used to bill transactions according to commercial contracts. Although, experts were expecting a significant influence on the design of gas meters and on the tests performed, this impact was not fully evaluated (objective 2). This new context was also resulting in the absence of accredited laboratories to provide metrological calibrations of the meters that are used with renewable gases (objective 3). This project aimed to address the need for a common European approach to evaluate the conformity of commercially available meters to EN standards and to MID directive, and to provide recommendations to adapt their designs and the associated standards documents (objective 4).

Objectives

The overall objective of the project was to increase knowledge about the accuracy and durability of commercially available gas meters after exposure to renewable gases. This has led to the improvement of existing meter designs and flow calibration standards.

The specific objectives of the project were:

1. To assess the typical uses of renewable gas for which the effects on accuracy, costs and lifetime were not sufficiently known. Furthermore, to define an acceptable range of gas compositions, suitable to support the new “renewable” framework and to list the missing tests which needed to be performed during calibration to cover the use of renewable gases with existing gas meters.
2. To develop traceable methods for the type testing and verification of flow meters that are used to measure renewable gas flows in compliance with the requirements of the 2014/32/EU Measuring

Instruments Directive and to determine the uncertainty budget. Uncertainties of 1/5 Maximum Permissible Error (MPE) had to be achieved for type testing and 1/3 MPE for field verification. In addition, this project studied and evaluated the integrity of the meters' internal components, the durability of the materials, the insulation of electronic components and other possible technical issues (dependent on the composition of the evaluated gas).

3. To validate the calibration methods and uncertainty budgets developed for two flow calibration standards via an appropriate inter-laboratory comparison and to carry out type testing procedures for domestic and commercial gas meters with hydrogen.
4. To contribute to the standards revision work in technical committees CEN/TC 237 and OIML TC8/SC7 to ensure that outputs from the project would be aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into standards at the earliest opportunity.

Progress beyond the state of the art

Certification of the legal metrology meters uses harmonised CEN/TC 237 standards and the OIML R137:2012 recommendation are already used for the certification of the legal metrology meter, but they are intended for use with conventional natural gas. The use of renewable gases was not taken into account and no international studies about their impact were spread and known by the industrial and laboratory community.

The NEWGASMET project, first gathered available knowledge on the performance of existing gas meters with renewable gases. Based on experts' expectations the study focused on accuracy and durability aspects and provided an overview of the gas compositions that can be produced, transported and metered in Europe. This bibliographic conclusion highlighted the knowledge gaps faced by the scientific community and industry and defined the important areas which have to be studied.

The normative standards used to demonstrate conformity to the MID have been challenged against the wider scope of metering renewable gases. Moreover tests were defined and even performed within the scope of this project to propose evolutions of current gas meter normative standards.

NEWGASMET collected the available knowledge on the calibration principles that can be used for accuracy testing with renewable gases and proposed solutions which provide sufficiently low uncertainties (1/5 MPE for type testing).

Based on the operating ranges of currently available test facilities for hydrogen and methane, an inter-comparison test campaign on domestic gas meters demonstrated the equivalence of the existing flow calibration standards, as well as checking the applicability of new test procedures.

Results

Bibliography study about impact of renewable gases, overview of European context and gap analysis to assess gas meters conformity (objective 1)

In 2020, NEWGASMET project published deliverables related to a literature review. This study was first one to gather available knowledge on the performance of existing gas meters and to demonstrate whether they could be used with renewable gases. This study collected data from laboratories and industry actors with a survey that has been sent to project partners and 57 other interested parties throughout Europe, including gas manufacturers, calibration laboratories (NMIs) and Transmission/Distribution System Operators (TSO and DSO).

The conclusions of this study were as follows:

1. Very few scientific data are available on the flow metering of renewable gases, especially about hydrogen metering, and this confirmed the real expectations of the NEWGASMET project,
2. Biomethane is considered throughout Europe as equivalent to natural gas and no impact is expected on the flowmeters' performance with this type of gas,
3. Hydrogen tightness of gas meters is a very specific challenge for the whole gas infrastructure and especially for gas flowmeters,
4. State of the art is that the impact of blending 10 % hydrogen with natural gas is not expected to affect metrology performance,

5. Use of biogas (or even syngas) addresses the issue of contamination and composition variability related to the durability and accuracy of the instruments.

The literature study also defined an overview of the European gas network in relation to gas composition ranges as well as metering technologies used in the field. It was based on both published economic forecasts and answers to the survey. Depending on the type of gas, compositions are related to the blending rate for biomethane or hydrogen, or for the rate of contamination for biogas and syngas.

Recommendations for the adaptation of gas meters design, of traceable methods for type testing and for calibration (first part of objective 2)

An expert group has been created to study the theoretical impact of renewable gases on the standards that are used to demonstrate the conformity of gas meters to the European Measuring Instruments Directive 2014/32/UE (MID). This group is in close contact with the CEN/TC237 committee and they studied the impact on the technical standard that is used for the usual certification and testing processes of rotary, turbine, diaphragm, thermal mass flow, and ultrasonic gas meters. Suggestions for possible modification of the gas meter standards, in order to make them suitable for demonstrating compliance with the MID when using renewable gases, were communicated to the CEN/TC237 WG convenors for the different gas meter standards (EN12480, EN12261, EN1359, EN14236 and prEN17526 European standards) and to OIML TC8/SC7 concerning use of OIML R137 recommendation. NEWGASMET experts also regularly participated in TC237/WG5 meetings to provide data and advice to CEN experts.

Evaluation of meter integrity after durability tests with renewable gas (second part of objective 2)

Durability tests were performed where three major steps were defined in a specific test protocol; (1) customary calibration by a European National Metrology Institute with air, (2) exposure to renewable gas, and (3) air calibration and investigation of gas meters by Energy Dispersive X-ray Analysis Scanning Electron Microscopy (EDX-SEM) after exposure. The meter types studied were domestic diaphragm, ultrasonic, and a thermal mass flow gas meters that market-leading suppliers have donated.

The prior air calibrations were completed, after which the gas meters were installed in a biogas plant in flowing conditions and in two test benches with static hydrogen exposure. For reference, gas meters were also exposed to natural gas in flowing conditions. The exposure lasted for twelve months. Some meters have been removed after a shorter duration. The effect on meter performance has been determined by comparing air calibrations after exposure with the initial air calibrations.

The conclusions of this study were as follows:

1. All tested diaphragm gas meters were within tolerance, as defined in CEN/TC 237 standards, after durability tests with natural gas.
2. All tested accuracy class 1.5 diaphragm gas meters were within tolerance of twice initial MPE after they were subjected to durability testing with hydrogen.
3. Most of tested diaphragm gas meters were within tolerance of twice initial MPE after they were subjected to durability testing with biogas. Different issues were nevertheless observed attributed to blockages in the gas meters internals.
4. Regarding durability tests with static hydrogen the observed drift globally did not exceed 2%. A wider spread is observed for thermal mass gas meters with respect to diaphragm gas meters.

These results have been completed with EDX analysis of the inner parts of the meters which provided data about the effects of biogas or hydrogen on materials used in gas meters. While for natural gas and hydrogen little effects were observed, for biogas corrosion of gas meters internals and salt deposition was identified.

As an add-on activity to the project, durability tests on the pressure transducers used in in volume conversion devices were performed with hydrogen in static conditions. Prior and recalibration of the pressure transducers did not indicate an important shift at the pressure point Pmax. Some inconclusive results occurred at Pmin. Furthermore, a study has been undertaken on the hydrogen tightness of gas meters. This was performed with a specific test bench designed for that purpose which showed that pressure loss could be observed, depending on the meter type, however at a rate below the criterium of tightness. The project published the gas tightness results in a newsletter and in a specific report which is available as open-access document on the project website.

As a conclusion NEWGASMET gave recommendations to adapt test benches to renewable gases such as using in some cases a calibration test gas closest to operational conditions. Regarding durability tests NEWGASMET is a first interesting step. For fully understanding durability, further experience covering the lifetime of the gas meter is needed, e.g. by periodically verifying gas meters installed in the field where renewable gases are used.

Validation of calibration methods for two flow calibration standards and type testing for meters with hydrogen (objective 3)

A result of the ongoing literature study, taking into account the most important journals and conferences, more than 60 publications were identified which provided information about flow standards that are usable for testing and calibrating gas meters with renewable gases. Classification of their content was summarised with respect to influences and restrictions; this study has been used to create a generic uncertainty budget and benchmarking of available flow standard techniques.

After checking the CMCs of the involved partners, 5 different flow rates and 4 test gases were defined which have been then investigated in the inter-comparison procedure. This study concluded in using a laminar flow element, a critical nozzle and a rotary meter as the transfer package. Project partners designed and realised transfer package, and then they sent it to five different laboratories (4 NMIs and 1 manufacturer). This inter-comparison process concluded to good results between measures from different laboratories.

NEWGASMET has also designed and realised test benches for the calibration and testing of gas meters as part of the conformity assessment with renewable gases. Modifications of the high pressure natural gas test bench was performed as well as an investigation of meters with a larger flow rate range (from 5 to 160 m^3/h) at up to 16 bar working pressure with natural gas mixed with up to 16 % hydrogen. The conclusions of these tests haven't identified significant impact on meter accuracy due to the use of gas mixtures, for the tested conditions.

In the same approach, test benches have been built for calibration with hydrogen and air. They were used to perform calibrations with hydrogen on different meters technologies, which are used for domestic purposes. The comparison of flow rate calibration as part of the accuracy tests shows, that the concerned laboratories come to comparable results for diaphragm meters.

These activities allowed the gas meter testing as necessary during type testing in the final stage of the project in order to compare the results, in particular, for hydrogen.

Impact

The project has built a wide stakeholder committee to spread this knowledge to research organisations and industrial users. NEWGASMET's objectives and conclusions from the bibliography study were presented at different national and international meetings such as CEN, Working Group Measuring Instruments (WGMI European Commission), Energy Gases EMN and Welmec. Then a strong relationship was built with the TC237 standardisation group in order to present the analysis of different standards and their necessary evolutions to include use of renewable gases.

Impact on industrial and other user communities

The results from the bibliographic study are considered as useful for the industrial and standardisation communities. The consortium created a relevant dissemination network comprising active actors in the gas sector and authorities with a stakeholders committee and discussion with TC237 technical committee in CEN organization. In addition, a training session was organised with over 50 interested parties from Europe and even US.

To promote new knowledge about the flow metering of renewable gases, and to broadly share the data generated during the project with scientific and industrial end-users, different partners participated in conferences organised by standardisation bodies and industry associations like CIM 2021 in Lyon, the Italian Gas Forum or ENLIT Europe 2021.

Meetings with the stakeholders have been held in continuation of the project meetings to spread progress and to ensure that the project is in line with the expectations from the industry. Furthermore the stakeholders' meeting has been used as an opportunity to present the conclusions of the French DSO's project about the injection of hydrogen into the gas network in 2020.

Impact on the metrology and scientific communities

In relation to the development of traceable methods for renewable gases, a setup was developed by a National Metrology Institute to assess leaky gas meters; this development could become an exploitable result for use in the technical standards that are used to prove the hydrogen tightness of gas meters. This particular issue is crucial as existing gas meters can be tight with natural gas, but not with hydrogen.

The partners have also developed durability test setups for hydrogen and biogas. Using their expertise, these setups will be used for further durability test services, which would be of interest to gas meter manufacturers, DSOs and TSOs.

Impact on relevant standards

Contacts have been made with regulation authorities at national and European levels. The CEN/TC237 secretary was chief stakeholder and the other committee members have included gas manufacturers and TSO/DSO. The results from the literature study and the outcome from the study of the EN-standards and OIML recommendations were presented at the CEN/TC 237 plenary meetings in 2021.

Furthermore the chief stakeholder was regularly invited to the project meetings to give recommendations and to take part in the stakeholder committee meeting.

Several partners were also involved in regular standardisation working groups such as Welmec (Measuring Instrument Directive harmonisation) or WGMI (European Commission Working Group for MID) to create harmonization between different standardisation groups in Europe.

Longer-term economic, social and environmental impacts

The EU strategy plan aims to reduce greenhouse gas emissions by 40 % by 2030 compared to the 1990 level, and to increase the renewable share of total energy consumption to at least 27 %. This major change aims to decarbonise energy production and to avoid energy imports from countries outside Europe. These renewable energies are produced using natural processes that are constantly replenished such as electricity produced by solar, wind or biomass resources. A new process called P2G or P2X aims to transport this potential power to end-users using the existing European gas network by converting electricity into hydrogen, or Synthetic Natural Gas (SNG) when hydrogen is combined with carbon dioxide. Another way to develop energy bio-sources is to install biogas/biomethane facilities that are supplied by agricultural by-products or by bio-waste which can be burned or injected into the gas network.

By investigating the effect on gas meters and delivering solutions to industry and to standards bodies, this project improved the confidence of consumers and suppliers in the billing of renewable gases. This will help to develop renewable resources in Europe in order to reduce fossil fuel consumption according to the European Union Directive for Renewable Energy.

List of publications

There are no peer-reviewed publications.

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

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NewGasMet

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Project start date and duration:	June 2019, 40 months	
Coordinator: Christophe Brun, LNE Tel: (00 33) 1 40 43 40 91 E-mail: christophe.brun@lne.fr Project website address: https://newgasmet.eu/		
Chief Stakeholder Organisation: CEN/TC237 “Gas Meters”	Chief Stakeholder Contact: Jim Sibley	
Internal Funded Partners: 1. LNE, France 2. Cesame, France 3. CMI, Czech Republic 4. FORCE, Denmark 5. NEL, United Kingdom 6. PTB, Germany 7. VSL, Netherlands	External Funded Partners: 8. Enagas, Spain 9. FHA, Spain 10. GRTgaz, France 11. ISSI, Italy	Unfunded Partners: 12. HONEYWELL, Germany 13. ITRON, Germany 14. METERSIT, Italy 15. SICK, Germany
RMG: -		