EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g06**
Version: 1.0

Title: Metrology and new techniques for Hydrogen-Enriched Natural Gas

Abstract

The use of Hydrogen-Enriched Natural Gas (H2NG), where hydrogen - produced with surplus energy from photovoltaics and wind turbines - is mixed with natural gas, then stored and distributed in the existing natural gas grids, is widely regarded as having a significant potential to decarbonise the gas market. Initial studies have shown that natural gas facilities can tolerate hydrogen but technical knowledge is lacking in the handling of H2NG on par with other natural gas qualities.

In order to support the safe use and fair trade of H2NG in European gas grids, further investigation is required to establish confidence and traceability for measured chemical and physical parameters of hydrogen mixed with natural gas, together with guidelines on limits for admixtures.

Keywords

Hydrogen, natural gas, NG, power to gas, P2G, H2NG, HCNG, alternative fuels

Background to the Metrological Challenges

Admixtures of hydrogen are produced by electrolysis with surplus electrical energy from photovoltaics or wind turbines and added to natural gas ("Power To Gas"), to form H2NG. Employing H2NG and using the existing gas grids for distribution, has the potential to form a key part of Europe's decarbonisation strategy for a CO_2-free energy supply, and leads to two major advantages: the former electrical energy can be i) transported to the customer through the existing gas grid without building additional power lines and ii) stored in the pipelines and the existing gas storage facilities and used to even out supply when sunlight and wind sources are low. Prototype production sites have already been built in several European countries, and although initial safety and material compatibility challenges have been resolved [1] and investigations of the influence of hydrogen on the established natural gas measurement facilities in national gas grids are available [2], a more comprehensive determination of the composition and physical properties of H2NG is required to provide reliable, safe, precise and accepted techniques and measurement methods for its use, thus removing technical and psychological barriers in the EU and supporting standardisation.

The European natural gas infrastructure is well established with numerous International and European standards governing its use. However, these standards do not fully cover the emerging use of hydrogen admixtures, particularly in the case of physicochemical data, burning behaviour and measurement techniques. For example, the gas quality measurement standards (ISO 6974-series and ISO 6975) are limited to natural gases with less than 0.5% hydrogen; in order to be applicable to H2NG these need to be extended to 20% admixtures. An update to ISO6976, covering the measurement of natural gas properties including the calculation of calorific values, is mainly based on old measurements [3], [4], requiring verification of the hydrogen calorific value and validation of the uncertainty evaluation.

In addition to a review of the above standards, the practical implications of adding hydrogen to the natural gas supply must be considered. For example, type assessments and the in-service control of gas meters are typically carried out with air or natural gas (EN 437). The measurements are influenced by properties like density, viscosity, thermal conductivity and speed of sound. Enrichment of natural gas with hydrogen alters these properties. The behaviour and applicability of the meters with new components are therefore unknown. In addition, as hydrogen results in a higher burning velocity compared with natural gas, the emissions, efficiency and heat output characteristics of the burner will change, affecting its reliability and lifetime potential. Further, for billing purposes, equations of state are used to convert volumes of gas at metering conditions to volumes at reference conditions. The current equations of state employed for this purpose, described in ISO

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

12213-2 and ISO 12213-3, limit hydrogen to 10 %, whilst at least 20 % is required for H2NG. Further investigations are therefore necessary to establish the safe use and fair billing for H2NG.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of chemical and physical parameters of hydrogen mixed with natural gas, in order to support the safe use and fair trade of H2NG in European gas grids.

The specific objectives are

1. To provide a suite of validated online instrument technologies for the measurement of physical parameters and components of H2NG, to support an update to the gas quality measurement standards (ISO 6974-series and ISO 6975). The technologies to include gas chromatographs, calorimeters, Wobbe index determining devices and other optical techniques used in natural gas grids.
2. To verify the calorific values and uncertainties of the main components of H2NG mixtures using gas chromatography and gas calorimetry according to the methods detailed in ISO 6976.
3. To assess the applicability of current household metering equipment for use with H2NG, and to provide defined error limits and traceable investigations of combustion behaviour (e.g. burning velocity), supporting the development of automatic adjustment of household burners for safe use of H2NG.
4. To validate the applicability to H2NG of the equations of state presented in ISO 12213-2, ISO 12213-3 and ISO 20765-2, by using metrologically characterised primary reference gas mixtures to measure gas density and other thermodynamic properties.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrument manufacturers), standards developing organisations (ISO, CEN/CENELEC) and end users (energy sector, power distribution companies, power generation sector). In particular to provide physicochemical data for admixtures to natural gas in grids to contribute to guidelines on correct energy measurements, safe burning and fair billing in these sectors.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,

- Transfer knowledge to the power generation and supply sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”.

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] NATURALHY - Preparing for the hydrogen economy by using the existing natural gas system as a catalyst. Final publishable activity report, 25.03.2010.

[2] Einfluss von Wasserstoff auf die Energiemessung und Abrechnung, Abschlussbericht, DVGW-Forschungsprojekt G 3-02-12, 04.04.2014

[3] F. D. Rossini, “The heat of formation of water”, Bureau of Standards Journal of Research 6 (1931) “The heats of combustion of methane and carbon monoxide”, Bureau of Standards Journal of Research 6 (1931) 37-49. “Calorimetric determination of the heats of combustion of ethane, propane, normal butane, and normal pentane”, Bureau of Standards Journal of Research 12 (1934) 735-750

[4] D. A. Pittam, G. Pilcher, “Measurements of heats of combustion by flame calorimetry. Part 8. Methane, Ethane, Propane, n-Butane and 2-Methylpropane”, J. Chem. Soc. Faraday Trans. I 68 (1972) 2224-2229