EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g07**
Version: 1.0

Title: Metrology for hydrogen advanced storage solutions

Abstract

Advanced storage solutions for hydrogen will help to achieve the ambitious new EU energy target of using 32 % of renewable energy by 2030. The newly released Renewable Energy European Directive 2018/2001 paired with metrological reliability in the energy supply chain involving hydrogen storage and a greater control of hydrogen chemical and physical properties by traceable measurements and validated techniques will further support the efforts towards meeting this target.

Keywords

Hydrogen storage, Gas-to-Power, Power-to-Gas, metering, fuel cell, hydrogen-natural gas mixtures, standardisation, metal hydrides

Background to the Metrological Challenges

Advanced storage solutions are related to the most promising hydrogen uses addressing the EU integrated energy and climate policy objectives. Further investigation in Power-to-Hydrogen, Power-to-Gas, Gas-to-Power and hydrogen storage in reversible metal hydride assemblies is needed.

In terms of long-term energy storage, PEM (proton-exchange membrane) water electrolysis technology is the most suitable approach for converting surplus amounts of electricity from renewable energy sources (wind and solar) to hydrogen. However, the intermittent operation of a PEM water electrolysis cell induces frequent start-stop transient periods with inherent, unstable, predefined idle conditions, during periods lacking excess electrical energy in the grid which affect the quality and longevity of the produced hydrogen.

In relation to Power-to-Gas, the harmonisation of national gas regulations for gas grid hydrogen composition is lacking as the accepted hydrogen levels can vary from 0.1 % vol to 10 % vol. If the rates of hydrogen are higher than 10 % vol in the grids then there is a risk of non-compliance for the energy meters used for fiscal billing purposes, as it can lead to reduced accuracy of the meters due to uncomplete specific thermodynamic data for H2NG mixtures.

In Power-to-Power (P2P) systems, the electricity produced by fuel cells (FC) is affected by the kinetics of the chemical reaction involving the hydrogen and oxygen quality resulting in contaminated PEM FC membrane electrode assembly. These halogenated impurities can provoke major performance losses in PEMFCs. As such, a detailed and systematic study of halogen-based compounds on the performance of PEMFC, under automotive load cycling is needed so that FC durability can be improved further.

In hydride tanks, manufacturers use known intermetallic powders as hydrogen absorbents which are recognized as stable and reversible. This controlled technique is difficult to define normalized user procedures ensuring a given volume of hydrogen stored, as absorption/desorption cycles are not repeatable due to the inherent thermomechanical and thermophysical properties varying during the dynamic phases. To improve the volume of hydrogen stored in the hydride tanks and make this storage means competitive, thermodynamic properties of hydrides in function of temperature and rate of absorption have to be highly reliable.

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 development of metrological capacity in the hydrogen supply chain by ensuring traceability of the chemical and physical measurements of hydrogen for advanced storage solutions.

The specific objectives are

1. To assess the quality of hydrogen produced from PEM (proton-exchange membrane) water electrolysis during imposed transient use periods for rapid electricity requests using between 0 % to 100 % of the nominal power of the electrolysers. In particular, to develop and validate an online gas analyser for measuring key impurities (including water vapour and oxygen) in hydrogen produced when PEM electrolysers are pushed to a peak power demand of up to 200 % of input power for a short period of time.
2. To develop a flow calibration standard for hydrogen, and an associated validation model, with a target uncertainty of < 1 %, including the assessment and validation of a gas analyser enabling accurate measurements of hydrogen quality (e.g. in hydrogen enriched-natural gas mixtures) for injection volumes ratios of up to 20 %. In addition, to improve the reference equations of state used for modelling hydrogen injection up to 20 % vol. for energy metering by providing traceable density measurements with a target uncertainty of between 0.03 % to 0.5 % in order to comply with ISO standards.
3. To investigate sustainability and reliability of fuel cells (FC), impacted whose performance is affected by impurities in hydrogen and air, by conducting loss of performance tests on segmented fuel cells. This should include the development of gas reference materials to study the contamination effects and decomposition mechanisms of key halogenated compounds inside operating fuel cells and also the validation of an air quality optical sensor for monitoring FC performance and durability.
4. To provide a validated method for measuring and calculating heat conductivity of hydrogen absorbed in an intermetallic material as a function of temperature, pressure, hydrogen absorption capacity and rate, considering dynamic heat flux impact. In addition, to develop a calibrated flow method with a target uncertainty of < 1 %, to improve the mass measurements of hydrogen stored.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by: the measurement supply chain (water electrolyser manufacturers, metal hydride tanks manufacturers), standards developing organisations (CEN/TC 234, ISO/TC 197, CEN/CLC/JTC 6 and CEN/CLC SFEM WG Energy Storage), end users (hydrogen industry, energy sector, gas suppliers for distribution and transport; EMN on Energy Gases) and energy research communities (IEA, MARCOGAZ, ERIG and research centres for PEM fuel cells).

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 project goes beyond this. *(Author to include here any specific past projects to be referenced)*

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 across all selected projects in this TP.

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 energy storage 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.