European Partnership on Metrology
Call 2024 –Digital Transformation, Green Deal, Normative and Research Potential

Selected Research Topic number: **SRT-v05**
Version: 1.0

Title: Metrology support for carbon capture utilisation and storage 2

Abstract

Carbon Capture Utilisation and Storage (CCUS) represents an array of technologies to capture carbon dioxide (CO_2) from industrial emissions and geologically store it or further use it to obtain fuels, chemicals or materials. CCUS contributes to significant decrease of CO_2 emissions in industrial processes. Metrology plays a crucial role in measuring the carbon footprint. Traceable flow metering, process monitoring, composition measurements and physical properties of CO_2 are essential in order to track the amount of carbon captured, utilised, and stored, provide an accountable record of reduced CO_2 emissions and ensure safe and efficient CCUS operation. Submitted proposals should aim to further develop the metrological measurement infrastructure needed to implement CCUS.

Keywords

CO_2, carbon capture, storage, utilisation, flow metering, composition, purity, decarbonisation, monitoring, physical properties

Background to the Metrological Challenges

The European Union (EU) is committed to reaching zero CO_2 emissions by 2050. To reach this challenging goal one of the solutions in the European Green Deal is the reduction of greenhouse gas (GHG) emissions through carbon capture, utilisation and storage. Currently, CCUS provides a key solution to decrease industrial CO_2 emissions. However, there are many challenges to overcome, such as setting up an infrastructure for transport, utilisation and storage of CO_2, developing new and improved utilisation pathways, setting up a regulatory framework, with standards, regulations and specifications, and setting up the metrological sound measurement infrastructure.

In order to facilitate technological development of CCUS, accurate measurements are needed. Currently, in the EMPIR project 20IND10 Decarb and Partnership project 21GRD06 MetCCUS, primary calibration facilities are being developed for CO_2 gas flow and a study is being conducted to determine the current state of the art in traceable liquid CO_2 flow measurements and primary standard requirements. However, primary calibration facilities need to be developed for flow metering of these fluids to calibrate flow meters. Accurate measurements of each CO_2 phase are important for the CCUS industry to monitor flow in delivery systems for leak monitoring. Furthermore, the effect of the CO_2 quality on flow metering is not explored so far and industrial CO_2 streams are never pure. Therefore, the influence of varying CO_2 compositions needs to be studied to ensure safe and efficient use of CCUS.

To ensure the environmental integrity of CCUS processes, monitoring is key. In the project 21GRD06 MetCCUS, methods are being developed to determine the emission from CCUS processes and infrastructure. There is a need to continue this work and to introduce methods to determine how dispersion and flow in stack influence CO_2 emission measurements as well as methods to determine liquid drop out of impurities. Physics-based models are needed to enhance metering and monitoring equipment to investigate where to measure and to determine which flow meters provide reliable results. In addition, it is important to develop real time monitoring methods and technologies (e.g., analysers and sensors) for different stages of the CCUS process (e.g., raw gas, CO_2 leak detection and emission quantification, and purified CO_2 for transport, storage and utilisation). Furthermore, the impact of reactive impurities (e.g., amines, NOx, SOx and H_2O) in CCUS processes needs to be determined to facilitate the development and improvement of CCUS.

The composition of the CO_2 stream must be verified prior to transport, utilisation or storage. Therefore, storage locations and industries utilising CO_2 set requirements for the impurities and their levels allowed in CO_2. In the EMPIR projects 20IND10 Decarb and 21GRD06 MetCCUS, primary reference standards, sampling and analysis methods are being developed for key impurities in CO_2 at relevant amount fractions. As the CCUS industry have picked up the pace over the past few years, new understanding of risks associated with impurities is gained. Thus, specifications became much more stringent within a short period of time. Therefore, novel primary reference standards need to be developed for unexplored impurities, such as SO_3, mercury (Hg) and particles. Static and dynamic reference standards with impurities in CO_2 need to be improved with lower amount fractions to comply with the stringent specifications. New primary reference standards are crucial for the validation of methods and technologies developed for the real time monitoring of CCUS processes.

In the EMPIR project 21GRD06 MetCCUS, novel experimental measurements are being set up to determine the physical properties of CO_2 in a mixture with amine-based capture solvents and water in the liquid phase, existing equations of state (EoS) relevant to CCUS and flow metering are validated, and calibration methods for humidity in CO_2 are being developed. However, experimental measurement methods are also needed to determine the physical properties (e.g., density, speed of sound, viscosity and heat capacity) of varying CO_2 compositions before and after capture and in the supercritical phase. For this, an improvement of EoS is also required. In addition, traceable measurements are needed to determine the properties of humid CO_2, in particular the water vapour enhancement factor in a wide range of CO_2 pressures (up to 6 MPa) and compositions (from sub-ppm to 2000 ppm of water) to support the development and validation of models and EoS of CO_2 after capture. A thorough understanding of the CO_2 behaviour and the effects of impurities on the behaviour will ensure efficient and safe usage of CCUS and reliable fiscal metering.

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 proposal shall focus on the development of metrological sound measurement infrastructure to support the CCUS industry.

The specific objectives are:

1. To advance CO_2 flow measurements by developing novel capabilities and methods for the calibration and validation of flow metering equipment to measure CO_2 gas flow, CO_2 liquid flow and CO_2 supercritical flow. This includes primary standards and transfer standards for the calibration of these CO_2 flows with target uncertainties < 0.3 % across a wide flow range (3 m^3/h - 100 m^3/h and 0.1 MPa - 20 MPa), and measurement capabilities to determine the influence of varying CO_2 compositions.
2. To improve the monitoring of CCUS processes by developing methods and technologies for the real time monitoring of the CO_2 composition in different stage of the CCUS process, CO_2 leak detection and emission quantification, determining the impact of CO_2 capture on regulated emissions and the impact of reactive impurities upstream of the capture process, developing models to enhance metering, and developing standard test methods for corrosion rate measurement of containment materials.
3. To support the determination of the composition and purity of CO_2 in CCUS processes by developing and validating static and dynamic gas standards with impurities in CO_2 at relevant amount fractions (e.g., NOx, SOx, Hg and particles), developing sampling methods for process conditions with compatible materials, and developing methods for the validation of methods and technologies developed in objective 2.
4. To determine the physical properties of CO_2 in different stages of the CCUS process. This includes developing measurement methods and techniques to determine, validate and monitor the physical properties (e.g., density, speed of sound, viscosity and heat capacity) of CO_2 in the liquid phase and supercritical phase with varying composition, improve the formulation and uncertainty of equations of state (EoS), and developing methods for determining the properties of humid CO_2.
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 (CEN/TC 474, ISO/TC 265), and end users (CCUS industry).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. Proposers shall give priority to work that meets documented needs, in particular those supporting the European Green Deal. 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. In particular, proposers should outline the achievements of the EMPIR project 20IND10 Decarb and Partnership project 21GRD06 MetCCUS and how their proposal will build on those.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.8 M€ and has defined an upper limit of 3.5 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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 proposal's 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,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the industrial 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 the Metrology Partnership 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.

Timescale

The project should be of up to 3 years duration.