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NEWSLETTER

Metrology Support for Carbon Capture Utilisation and Storage

The MetCCUS project has concluded, with remarkable achievements after 3 years. It was the 1st project fully dedicated to developing metrological sound measurement standards and methods to support the CCUS industry.

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Overview of MetCCUS final results

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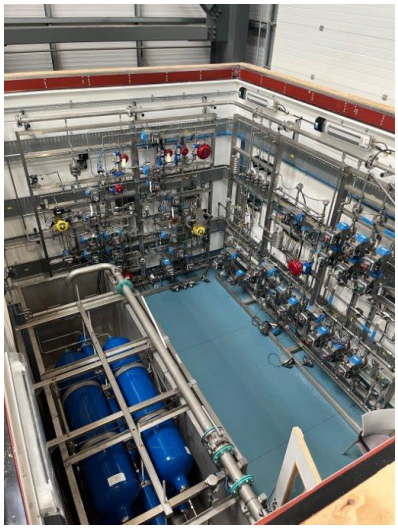
Project Highlights

After 3 years of research, MetCCUS achieved valuable results that will serve as a backbone for the CCUS industry in Europe, supported by the metrology infrastructure it developed.

Challenges remain, and further research is essential to ensure the safe scale-up of CCUS, enabling it to serve as an efficient and reliable decarbonisation route.



Flow Metering

Participants upgraded and repurposed their existing primary facilities for intermediate scale flow, as well as large scale flow (up to 400 m^3/h and 30 bar). An upscaling methodology and strategy was developed to provide a traceability chain.

As a result, calibration facilities for gaseous CO_2 have been developed, for different types of meters at different sizes.

An investigation of the transferability of the calibration was conducted to decide whether a surrogate fluid could be used when calibrating meters used for CO_2.
Participants theoretically investigated the effect of impurities.

Key results include a report on the development, intercomparison, operating ranges and traceability of new facilities (intermediate and large scale), enabling the calibration of flow meters with an uncertainty below 1.5%, a good practice guide for CCS fiscal metering and a report on the state of the art of traceable liquid CO_2 flow measurement and liquid CO_2 primary standard requirements.

In summary, primary facilities have been developed for both intermediate and large-scale gas flow (traceability to primary facilities was also established). The facility for liquid flow h theoretically been described.

Figure 1. MuT mounted on VSL's GOPP, accompanied by hydrogen gas cylinders.

Figures – Primary facilities at INRIM, NEL, VSL and FORCE

Emissions Monitoring

Emissions of CO_2 and pollutants, including amines/nitrosamines, to the atmosphere from carbon capture processes, were investigated. Activities included a study on the conditions in flue gas post-combustion flue gas, assessment of the properties of nitrosamines (paper on nitrosamine measurement, new work item proposal to CEN/TC 264), and the assessment of monitoring methods, including the definition of concentration matrix. Delivering a good practice guide for the monitoring of nitrosamines from amine capture plants.

With regard to CCUS equipment and infrastructure, MetCCUS reviewed the requirements for leak detection (report on detection of CO_2 leaks, upgrade of a calibration facility for reference leaks), developed the capability to simulate CO_2 emissions at component and site scales (modified Controlled Release Facility to generate CO_2 releases and have used this to assess a CO_2 instrument), developed an adapted high-flow approach to enable the quantification of CO_2 leaks, among others.

In order to assess potential approaches for the detection and quantification of emissions of CO_2 into the environment from geological storage, the MetCCUS team first studied the requirements for the ambient detection of leaks from geologically stored CO_2 and investigated zero-background tracer suitability for geologically stored CO_2. Acoustic detection of subsea leaks was also studied, with a review of existing methods/data and a report on performance requirements for sensors.

The summary output will be a report on the options for the measurement and reporting of emissions to air from different stages of the CCUS process and the performance and capabilities of techniques to monitor emissions into the environment through carbon capture processes, infrastructure (leaks), or geological storage.

Figure – Hi-Flow sampler used for leak quantification

Chemical Metrology

Over a period of 3 years, MetCCUS generated substantial findings regarding Primary Reference Materials (PRMs) for impurities in CO_2, starting with a literature survey on commercially available cylinders for the preparation of PRMs for CCUS, and the identification of key impurities within CCUS with the corresponding amount fractions (see Newsletter 1). PRMs for impurities in CO_2 with CCUS-relevant amount fractions were prepared in multiple facilities across Europe. These were then monitored for up to 2 years, confirming stability within uncertainty limits for most of them. Multi-component gas mixtures were also prepared; challenges remain to further reduce some uncertainties and improve stability monitoring.

Regarding material compatibility of CO_2 sampling, several reports were produced, starting with a literature review, some experiments to test the sampling of impurities, against materials, for key impurities and materials, as well as a good practice guide for the sampling of CO_2 for CCUS.

A review of existing analytical methods, instruments and sensors used for on-line CO_2 purity assessment was conducted. VSL hosted a comparison study to evaluate the performance of commercial instruments used for rapid impurity measurements in CO_2. These instruments were assessed using calibration gas mixtures with varying amounts of water and oxygen in a CO_2 matrix. Key performance parameters, including response time, range, linearity, bias, and uncertainty were evaluated. An on-site demonstration of some instruments took place in a CO_2 capture installation in the Netherlands. Offline analytical methods for CO_2 quality were also studied and a publication on the quality of biogenic CO_2 stream from biogas plants, led by RISE, in Sweden, is available in the journal of CO_2 utilisation.

Physical Properties

In addition to the protocol for the preparation of binary mixture of amine and CO_2 produced at the beginning of the project, MetCCUS participants are finalising a manuscript on the experimental measurements of the thermophysical properties of CO_2 mixtures that were carried out in the Project. Among the most important thermophysical properties, the density, speed of sound, viscosity and specific heat capacity were chosen to be measured. For density and speed of sound measurements the pressure range was expanded up to 70 MPa and 60 MPa, respectively, instead of 12 MPa. The results have been useful to improve the dedicated EOS-CG formulation.

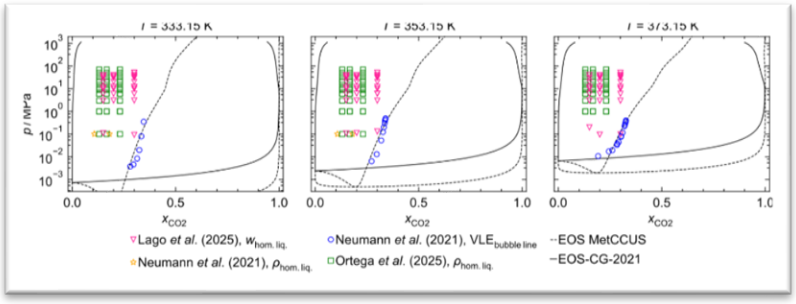


Figure – p,x diagrams for the system CO_2+monoethanolamine calculated with the EOS-CG-2021 and the new equation of state (MetCCUS) at selected isotherms.

Furthermore, in order to support industries' activities in CO_2 transport and capture, two open source simplified novel equations (in liquid and gas phase) were implemented specifically to be included in chemical processing design software.

With the aim to provide procedures, measurements and the specific instrumentation needed to build up confidence in the safe and efficient operation of pipelines transporting CO_2 mixtures, two innovative spectroscopy-based methods for the online monitoring of eventual phase transitions in the CO_2 through the measurements in-site were developed and tested both in laboratory and in-site at ExtrateX (Nancy, France).

Focusing on the corrosion testing of CO_2 pipeline materials within the broader scope of this project, a new facility for corrosion testing of pipeline steel in impurity-containing dense phase CO_2 environment was developed. Methods for controlling and measuring the concentration of impurities (H_2O and O_2) in dense phase CO_2 during corrosion testing were successfully optimised and validated. A robust corrosion test procedure was established for reliable corrosion rate measurements in a simplified binary system (CO_2 - H_2O). The methodology and findings have been disseminated through a journal paper. This result contributed to the development of an international best practice guide: AMPP Guide 21577 - Laboratory Corrosion Testing for CO_2 Transport and Injection, supporting standardisation efforts in corrosion testing of CO_2 infrastructure.

Figure – New facility for corrosion testing of pipeline steel in impurity-containing dense phase CO_2 environment.

Creating Impact

In order to create impact for the MetCCUS project, all participants contributed with dissemination efforts, particularly the new measurement, metering, monitoring and analysis capabilities, as well as the experience gained during the 3 years. This was accomplished by presenting project findings in multiple events across and beyond Europe. MetCCUS was disseminated via oral presentations and poster exhibitions, at least in the following countries: Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, Netherlands, Portugal, Spain, Japan, the United States and the United Kingdom. Furthermore, multiple other online dissemination activities took place.

Standardisation was a key aspect, as MetCCUS findings were presented to several technical committees of the International Organisation for Standardisation (ISO), the European Committee for Standardisation (CEN), among others. This ensures that MetCCUS results contribute to updating and developing standards that support the CCUS industry in areas such as CO_2 stream quality, emissions, and other topics covered in MetCCUS.

MetCCUS kept close connection with stakeholders (Advisory Board composed of over 30 external organisations), other European projects (COREu project), the European Metrology Network (EMN) for Energy Gases, and other key collaborators. We thank you all for your engagement!

If you missed some events, you can revisit:

- Recording of webinar "Metrology Supporting Safe and Efficient CCUS Infrastructure – Lessons from MetCCUS and path ahead with COREu"
- Recording: CCUS Process & Metrological challenges from Industry perspective
- News and Publications on MetCCUS website
- MetCCUS Zenodo repository

Figure – MetCCUS final consortium meeting at NPL, September 2025 (Teddington, UK)

Project Partners

Air Liquide
ČESKÝ METROLOGICKÝ INSTITUT
DNV
DTU Technical University of Denmark
DFM Danish National Metrology Institute
INRiM Istituto Nazionale di Ricerca Metrologica
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