



Closure of EU-funded MetCCUS project with great success on developing tools to support industry in carbon capture, utilisation and storage (CCUS)



- 21 partners from 12 European countries have concluded this 3-year project, developing metrology tools and reporting on best practices in CCUS. It was coordinated by the National Metrology Institute of the Netherlands, VSL.
- MetCCUS received funding from the European Union through the European Partnership on Metrology, co-financed by the European Union Horizon Europe Research and Innovation Programme and from the Participating States. MetCCUS budget was €2.1 million over its three-year duration.

MetCCUS (Metrology Support for Carbon Capture, Utilisation and Storage) EU-funded project announces its conclusion after three years of activity. During this time, the 21 project partners have worked together to find solutions to reduce CO₂ emissions and thus meet the European Union's targets of reducing greenhouse gas emissions by 55% by 2030 and achieving carbon neutrality by 2050.

The overall aim of this vanguardist and pioneer project has been to develop new metrology tools for carbon capture, utilisation and storage. In this case, the project has developed several tools in the form of primary standards and methods. Also, MetCCUS has worked on relevant best practices, guidelines and literature reviews that will foster the CCUS industry in Europe.

MetCCUS has achieved this overall goal by assessing this issue from 4 different perspectives. First, the project has raised a metrology infrastructure for monitoring the CO₂ flow, developing calibration facilities for gaseous CO₂ and investigating the state of the art for traceable liquid CO₂ flow measurement. Second, MetCCUS has developed metrological tools to support the measurement and reporting of nitrosamine emissions from CO₂ capture plants and CO₂ leaks, in order to ensure the environmental integrity of CCUS infrastructure. Third, the project studied the chemical composition of CO₂, developing primary reference materials for key impurities in CO₂, used to calibrate monitoring equipment. Last, the consortium has provided understanding of the physical properties of CO₂, producing experimental data and working on simple formulations of equations of state for carbon dioxide mixtures with impurities.

Project Contributions

The contributions made by the project will encourage work in various areas related to CCUS, providing knowledge to the industry and the scientific community. CCS operators and CO₂ emitters will be able to determine the appropriate conditions and materials to operate facilities safely. Then, laboratories, research organisations, and academia will profit from using the new capabilities developed to perform high-quality measurements and support the development of new CCUS technologies. Also, MetCCUS have promoted the results of the project within the standardisation community, providing input into the standardisation process, and supporting the development and revision of standards within CEN/TC 474 CCUS, CEN/TC 264 Air Quality, among others.

Beyond technical advances, MetCCUS will also contribute to the economy, society, and the environment as a whole. On the economic front, CCUS will reduce operating costs by improving flow metering, emissions monitoring, purity analysis, and physical property measurements of CO₂. In addition, new capabilities to monitor for carbon dioxide leaks will

ensure health and safety in the gas industry and protect citizens. MetCCUS findings will support European companies in implementing CCUS technologies, decreasing CO₂ emissions from industrial and energy processes, and accurately measuring carbon dioxide in CCS processes, to comply with ETS and ultimately reduce greenhouse gas emissions.

Highlights and resources:

- Publications: MetCCUS [website](#) and [zenodo](#) repository.
- [Final stakeholder workshop on 'Metrology for enabling CCUS at scale – Challenges and Opportunities'](#)
- Watch recording of webinar: [Metrology Supporting Safe and Efficient CCUS Infrastructure – Lessons from MetCCUS and path ahead with COREu](#)
- Watch recording of webinar: [Metrology Support for Carbon Capture, Utilisation and Storage](#)
- MetCCUS featured in publication: [IEAGHG workshop on comparative technoeconomic assessment of commercially available CO₂ conditioning technologies – IEAGHG](#)

The project is funded by the European Union through the European Partnership on Metrology, co-financed by the European Union Horizon Europe Research and Innovation Programme and from the Participating States. The programme was proposed by EURAMET and follows EMRP and EMPIR funding programmes. In total, MetCCUS has had a budget of €2.1 million over its three-year duration.

Consortium

The consortium was made up of 21 partners from 12 countries, including national metrology institutes, universities, research institutes and industry.

	<u>VSL (NL, leader of the project):</u> VSL is a worldwide leading NMI in both static and dynamic gas mixture preparation and in the development of high-accuracy reference analytical methods for the comparison of the composition of gas mixtures. VSL has abundant experience with the determination of the contents of trace-level impurities in various matrices. VSL has state of the art flow standards and decades of experience in performing SI-traceable calibrations of the gas meters that are used in the gas grid. VSL has a leading position in the field of water flow, low- and high-pressure gas flow, and cryogenic flow calibration through its water, gas flow and LNG flow calibration facilities.
	<u>CMI (CZ):</u> The Czech Metrology Institute has experience in the preparation of static reference gas mixtures by gravimetry. This NMI routinely prepares more than a hundred cylinders per year and these mixtures are used as a reference material for the verification of breath

	analysers and process gas chromatography. Currently, CMI is working on the development of a method for the verification of drug testers. Their laboratory is also equipped with a variety of instruments like GC-MS, TOFMS and GC-PDD. They participated in comparisons in gas mixture analysis, in the framework of DUNAMET. Further, CMI participates in a comparison in the analysis of gas mixtures with low concentration VOC's under the auspices of CCQM.
	DFM (DK): DFM is the Danish National Metrology Institute which has 20+ years of experience in optical spectroscopy. DFM has comprehensive experience in the quantitative optical spectroscopy of molecules, including custom-made fitting procedures. In addition, DFM has in recent years developed new compact field deployable spectrometers for onsite measurements that are relevant to the monitoring community.
	FORCE (DK): FORCE Technology is a Designated Institute and holds the national reference for gas measurement, and is world leading within gas metering, calibration and type-testing. This DI provides knowledge and experience to the flow measurement and traceability community in Denmark. They have facilities to measure high pressure gas flow and facilities to measure flow with air. FORCE is also an active member in several standardisation organisations and has close links to stakeholders.
	INRIM (IT): INRIM has recognised experience in measuring the transport and thermodynamical properties of fluids, especially the speed of sound, viscosity and density. The thermodynamic program of INRIM addresses accurate characterisation of the thermo-physical properties of fluids for energetic applications, measuring transport and thermodynamical properties of pure and blended fluids by means of the experimental speed of sound, viscosity and density measurements. INRIM also focuses on the development of numerical models for the determination of the fluids EoS.
	IPQ (PT): IPQ has an excellent track record in participation and managing international R&D projects. This NMI has considerable knowledge and experience of the preparation of gaseous reference materials using gravimetry, and is a CRM provider according to ISO 17034.
	JV (NO): Justervesenet is the National Metrology Institute, the national regulator for metrology and the notified body for MID and NAWI in Norway. This NMI is responsible for the in-field verification of meters under legal control. JV has relevant experience within gas and hydrogen metrology, and close contact with Norwegian industry within CCUS, as well as experience within uncertainty considerations. JV is a member of several international committees, among others

		EURAMET TC Flow, EMN Energy Gases, and WELMEC WG 11, as well as several EMPIR projects.
 Physikalisch-Technische Bundesanstalt Nationales Metrologieinstitut		<u>PTB (DE):</u> PTB is the German National Metrology Institute with scientific and technical service tasks. PTB is one of the leading institutes in Europe in reaction kinetics and gas spectroscopy. For the latter PTB has experience in the development of spectrometers for different applications including natural environmental monitoring through their metrological experience in the Metrology in Chemistry area on IR-spectrometric gas metrology. PTB covers metrology-based research on reaction kinetics in chemical processes of the atmosphere, energy conversion and material synthesis.
 Research Institutes of Sweden		<u>RISE (SE):</u> is the National Metrology Institute in Sweden with a strong profile directed to the gas industry. RISE participated in numerous EMRP and EMPIR projects related to gas metrology (EMRP JRP ENG01 GAS, EMRP JRP ENG54 Biogas, EMRP JRP ENG60 LNG II, EMPIR JRP 15NRM03 Hydrogen, EMPIR JRP 16ENG01 MetroHyVe, EMPIR JRP 16ENG05 Biomethane). Their laboratory in Gothenburg provides analyses of energy gases (biogas, biomethane, hydrogen).
		<u>VTT (FI):</u> VTT is one of Europe's leading research institutions, which advance the utilisation and commercialisation of research and technology in commerce and society. VTT has vast experience in developing field-deployable gas sensing instruments based on laser spectroscopy and will use their expertise and connections with the industry to advance the work in WP2 for CO ₂ leak detection and quantification from CCUS processes and transport. VTT will exploit its extensive experience in research, development and field studies in the field of reference gas generation and optical spectroscopy for reactive gases in different matrices.
		<u>Air Liquide FuE (DE):</u> Air Liquide FuE is a world leader in gases, technologies and services for industry, health, food and electronics. They are present in 80 countries with approximately 68,000 employees that serve more than 3.5 million customers and patients. Air Liquide FuE benefits from 40 years of unique know-how encompassing the entire hydrogen value chain, from production to transportation and distribution, for industry and energy transition, including other gases like carbon dioxide and biomethane. Air Liquide FuE developed - among others - strong skills in gas quality and analysis, in safety and risk management for production, distribution and end-uses thanks to a wide knowledge of accidental phenomena and associated consequences, and several mitigation methods including detection.

	<u>DNV (NL):</u> DNV is the world's leading classification society and a recognised advisor for the maritime industry, and the technical advisor to the oil and gas industry. They deliver world-renowned testing, certification and advisory services to the energy value chain including renewables and energy management. DNV is also a world-leading provider of digital solutions for managing risk and for improving the safety and asset performance of ships, pipelines, processing plants, offshore structures, electric grids, smart cities and more. With 100,000 customers across the maritime, oil and gas, energy, food and healthcare industries, as well as a range of other sectors, DNV operates in over 100 countries.
 Technical University of Denmark	<u>DTU (DK):</u> The Technical University of Denmark has a broad experience and knowledge of optical and spectroscopic methods and sensor development. DTU has excellent experimental facilities for optical spectroscopy, from far-UV to far-IR, which are suitable for a broad range of gases and applications. Facilities include high-temperature/-pressure and long/short gas cells, high-resolution IR/UV spectrometers and UV/IR light sources. These capabilities will be used for the development of a far-UV/FTIR-based method for measurements of impurities in carbon dioxide and for the investigation of possibilities for online sensor development for the monitoring of phase transitions in carbon dioxide.
 THE EUROPEAN GAS RESEARCH GROUP	<u>GERG (BE):</u> The European Gas Research Group is a non-profit international research association with a membership of European gas companies across the value chain, universities and research centres. The association's priorities include hydrogen, biomethane and methane emissions. Taking advantage of its network of stakeholders from industry, academia and standardization, GERG has an expertise in coordination, knowledge management, and dissemination for R&D projects.
 NOVA UNIVERSITY LISBON	<u>NOVA (PT):</u> NOVA (Nova University Lisbon) hosts Metrovac - Laboratory for Vacuum Technology and Metrology, which is an accredited laboratory in the field of vacuum technology. Metrovac is the only laboratory in Portugal offering the calibration of reference leaks, vacuum gauges down to 10⁻⁶ mbar and testing refrigerant gas leak detectors. NOVA was pioneer in Europe in implementing the EU regulation 842/2006 regarding developing a method to test refrigerant gas leak detectors. NOVA was engaged in several EMPIR projects in the field of vacuum gauge calibrations and in developing a high accuracy ionisation gauge to measure pressures from 10⁻⁴ to 10⁻⁸ mbar.

	<u>RUB (DE):</u> RUB (Ruhr University Bochum) has been involved in the development of thermodynamic property standards for more than 35 years including the measurement of highly accurate data for thermal properties, speeds of sound, development of corresponding experimental equipment, and the development of highly accurate multiparameter equations of state for pure fluids and mixtures. The internationally accepted reference equations of state for the main components of natural gas, water, carbon dioxide, nitrogen and a number of other fluids, as well as internationally accepted reference equations of state for natural gas (GERG-2008 and EOS-LNG) and mixtures for CCS (EOS-CG), were established at RUB.
	<u>SINTEF ER (NO):</u> SINTEF Energy Research is part of the SINTEF Group, one of largest independent research organisations in Europe. SINTEF ER has worked on thermophysical properties at least since the early 90s and has been involved in projects related to CCS technologies since 2001. Among its current CCS projects, SINTEF ER is coordinating the Norwegian CCS Research Centre (NCCS) and the Horizon 2020 project ACCSESS. SINTEF ER has leading roles in coordinating bodies for CCS development in Europe: EERA JP CCS (research), ECCSEL ERIC (research infrastructure, and ZEP (technical advisor to EU). Relevant to MetCCUS, SINTEF ER has broad experience in thermophysical and thermodynamic properties, in the development of highly accurate measurement methods, and in the metrology of CO₂, as well as experience with the design of a CO₂ fiscal metering test facility for industrial use and experimental assessment of the performance of ultrasonic technologies for CO₂ measurement for pipeline and shipping conditions.
	<u>UNITO (IT):</u> UNITO (University of Torino) is one of the oldest universities in Italy with more than 75,000 students. UNITO is active at international level through involvement of its researchers in collaborative projects, in the establishment of joint educational courses, such as bi-national degrees and international PhD programs, through the subscription of formal cooperation agreements (roughly 450) with institutions around the world. Moreover, UNITO is deeply involved in scientific research and manages roughly 500 projects per year, both at the national and international level. The research group involved in this project has decennial experience in the electrochemical and photochemical reduction of CO₂, in electrode functionalisation and quantitative measurements of reduction products.
 Universidad de Valladolid	<u>UVa (ES):</u> UVA (University of Valladolid) is one of the oldest universities in Spain. Its research group TermoCal has 30 years of experience undertaking research in fundamental metrology and the thermophysical properties and phase behaviour of multicomponent

	fluid mixtures. They specialise in very low uncertainty measurements and in the comprehensive interpretation and prediction tools needed to develop advanced molecular and engineering modelling, reliable standards, traceable measurements and validated novel techniques. They have actively participated in EMRP JRP ENG54 Biogas and are currently collaborating within EMPIR JRP 19ENG03 MefHySto, EMPIR JRP 20IND10 Decarb and EMPIR JRP 20IND06 PROMETH2O. UVa will carry out technical work using a vibrating tube densimeter, a high-pressure flow calorimeter, and a vibrating wire viscometer.
	NEL (UK): NEL is the Designated Institute that is responsible for maintaining the UK National Standards for flow and density measurement. NEL has relevant experience for metrology of both hydrogen; with designing a hydrogen flow calibration facility for domestic gas meters which will be utilised in this project, and carbon dioxide; previously building and operating a test facility which operated carbon dioxide and impurities across gas, liquid and supercritical states. NEL is a member of the following standardisation committees: ISO TC 30, OIML TC8 and EURAMET TC Flow.
	NPL (UK): NPL (UK National Physical Laboratory) is world-leading in the field of gas metrology and already provides Primary Reference Materials for natural gas, and for impurities in biomethane (EN 16723-1) and hydrogen (ISO 14687 Grade D). They also provide an accredited (ISO 17025) service for performing hydrogen quality assurance for fuel cell vehicles. NPL has previous experience within the energy gas sector for validating sampling methods and online analysers. NPL also successfully coordinated EMPIR JRP 16ENG01 MetroHyVe.

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