

Title: Metrology for carbon capture and storage

Abstract

In order to mitigate climate change due to emissions of greenhouse gases (GHGs), the European Community (EC) encourages the development of carbon capture and storage (CCS) technologies within its emission trading (ETS) scheme. It is believed that Carbon Capture and Storage (CCS) can be of great help to reduce the overall CO₂ emissions.

Research studies have highlighted a vast amount of CCS measurement challenges, including flow measurement, sampling, chemistry, fugitive emissions and geological monitoring. There is an urgent need for focused and collaborative research to address these wide ranging issues in order to support this fast developing technology.

The proposed JRP should seek to improve the measurement of CO₂ streams, to enable detection and quantification of leaks from capture, transportation and geological storage sites. In addition current pilot studies have used CO₂ gas, however larger CCS facilities will require supercritical CO₂ which is denser and thus more efficient to store and transport. There are currently insufficient measurement techniques for accurate and traceable measurement of supercritical/dense CO₂ and the project should seek to address this requirement.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on “Grand Challenges” related to Environment on page 24.

“Research into innovative new systems and technologies that mitigate environmental impacts. These require:

- Internationally-recognised standards to underpin measurements of the flow and concentration of species regulated under the Kyoto protocol and EU’s emission trading schemes.”

“Minimising future negative environmental impacts depends on the implementation of policies that encourage the sustainable use of energy and resources. The EMRP will develop new measurement capabilities for:

- The validation of the long-term efficiency of carbon sequestration technologies.”

Keywords

Climate change, global warming, environment, carbon capture and storage, carbon sequestration, carbon dioxide, supercritical CO₂, CO₂ emissions, greenhouse gas, EU emissions trading scheme, emission allowances trading, carbon content, monitoring, verification, regulatory measurement, process measurement, traceability, novel technology, standardisation, gas standards, gas measurement, absorption coefficient, flow metering.

Background to the Metrological Challenges

Climate change is one of the most severe challenges for mankind today. The EC is fighting against this change by reducing its greenhouse gas (GHG) emissions substantially within the next years, i.e. up to 30 % until 2020. In addition an emission-trading scheme (ETS) based on monitoring, reporting and verification and of annual activity specific GHG emissions is being implemented. This involves detailed methodologies and data to determine emissions including requirements that are calculation-based, and measurement-based including traceability and uncertainty. The Emission trading

allowance (ETA) includes the determination of avoided emissions due to carbon capture and storage (CCS).

CCS has the potential to provide short to medium term mitigation for the continued use of fossil fuel in primary power production. It is estimated that CCS can contribute to the necessary reduction of GHG emissions by 15 % until 2030. However if CO₂ leaks, the ETA must be surrendered to compensate for the fact that the stored emissions were credited under ETS. However there are no validated methods to directly monitor emissions of CO₂ to the atmosphere from injection, transport or storage activities, which has led several bodies to express concerns:

- The EC stated *"The environmental integrity of CCS is the Commission's overriding concern. This is partly a matter of ensuring that the CO₂ captured and stored remains isolated from the atmosphere in the long term; and partly about ensuring that the capture, transport and storage elements do not present other health or ecosystem risks."*
- The Intergovernmental Panel on Climate Change (IPCC) states the need for CCS to be 99 % efficient over 100 years to be viable as a climate change mitigation mechanism.

The EC has decided to build up 10 to 12 large-scale reference installations for CCS until 2015 to explore the technical and economical feasibility of this technology. 7 Mt CO₂ shall be stored underground until 2020 and 160 Mt until 2050. This creates an urgent requirement for the direct measurement of CO₂ losses to the atmosphere, to verify that the injected CO₂ is behaving as expected. A suitable measuring technology is necessary to confirm the requirements on the storage facility, i.e. leakage must be smaller than 1 % in 100 years.

The principle of the trading of the captured CO₂ streams will require monitoring of the CO₂ composition and mass flow rate. The majority of CO₂ streams will be in the supercritical phase at high pressures (170 – 400 bar), and this has specific issues related to flow metering. There are currently available flowmeters (differential pressure meters, volumetric meters and the Coriolis mass flow meter) that can be used to measure CO₂, however, their application to supercritical CO₂ is not trivial, due to low temperatures, large density fluctuations, zero surface tension, near zero viscosity (which may cause sealing difficulties in process plants) and the corrosive effects of CO₂ forming an acid in the presence of water vapour. Furthermore supercritical CO₂ is a strong solvent giving possible toxic contamination problems for people following a leak, and it is a known asphyxiant, which may be difficult to detect at low temperatures, because instruments do not operate well at very low temperatures.

Scientific and Technological 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 JRP protocol.

The proposed JRP should aim to develop a measurement infrastructure to support development and implementation of carbon capture and storage which will enable the development and uptake of this key climate change mitigation mechanism. Measurement capability will be developed to provide support for the development of technologies for carbon capture and storage, to improve the measurement of CO₂ streams and to detect and quantify leaks from capture, transportation and geological storage sites.

The aim of your JRP should be to provide validated and reliable measurements/methods with traceability wherever it is practicable to do so for:

1. Develop improved methods to directly measure mass emission rate of CO₂ in emissions streams from carbon dioxide capture facilities with uncertainty <1.5 % (determination of concentration of CO₂ and volume flow rate).

Background: significantly better mass emission rate measurement will be required to validate and monitor capture efficiency of operational plant, to demonstrate this performance as viable climate change mitigation measure and for trading purposes. Uncertainties will need to be 1.5 % or better.

2. Develop field proven measuring instruments and open-path wide area screening of fugitive losses of CO₂ from CCS-facilities, capable of measuring minute changes (PPB level) in CO₂ concentration in the presence of high atmospheric CO₂ background, over long distances and

large volumes, and capable of measuring locally excess fossil carbon in CO₂. This is necessary to measure and locate leakage, assess the safety for public health of CCS facilities and be able to give an answer to public concerns.

3. Develop improved metering of flow and (on-line) composition for high pressure and supercritical/dense CO₂ flows. The majority of CO₂ streams will be in the supercritical phase, and this has specific issues related to flow metering, and also issues related to equipment integrity, due for example to the corrosive effects of CO₂ forming and acid in the presence of water vapour. There will also be risks associated with the transport of CO₂ in supercritical phase.

Proposers shall give priority to work that meets documented stakeholder needs and may include measures to facilitate the development of European standards and Directives.

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

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

In your JRP submission please detail the impact that your proposed JRP will have on the following Directives (see references for full details):

- Directive 2009/31/EC “geological storage of carbon dioxide”
- Directive 2009/29/EC “to improve and extend the greenhouse gas emission allowance trading scheme of the Community”
- Directive 2004/22/EC “measuring instruments”
- Directive 2003/87/EC “ establishing a scheme for greenhouse gas emission allowance trading within the Community”

You should also detail other Impacts of your proposed JRP as detailed in the document “Guidance for writing a JRP”

You should detail how your JRP results are going to:

- feed into the development of urgent standards through appropriate standards bodies
- transfer knowledge to the Climate change and weather forecasting sectors.
- Interface with the Intergovernmental Panel on Climate Change (IPCC)

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of 3 years duration.

Additional information

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

Directives:

- [1] Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF>
- [2] Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF>
- [3] Directive 2004/22/EC of the European Parliament and of the Council of 31 March 2004 on measuring instruments, Annex MI002 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:135:0001:0080:EN:PDF>
- [4] Directive 2003/87/EC EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:275:0032:0032:EN:PDF>

EC decisions

- [5] DRAFT: Commission Decision of xx/xx/2009 amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for greenhouse gas emissions from the capture, transport and geological storage of carbon dioxide
- [6] Commission Decision 2009/339/EC of 16 April 2009 amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for emissions and tonne-kilometre data from aviation activities <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:103:0010:0029:EN:PDF>
- [7] Commission Decision 2009/73/EC of 17 December 2008 amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for emissions of nitrous oxide <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:024:0018:0029:EN:PDF>
- [8] Commission Decision 2007/589/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:en:PDF>
- [9] COM(2006) 843 final Communication from the Commission to the Council and the European Parliament. Sustainable power generation from fossil fuels: aiming for near-zero emissions from coal after 2020 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0843:FIN:EN:PDF>
- [10] Brussels European council 8/9 March 2007 Presidency Conclusions. P10-14, p19,-23 <http://register.consilium.europa.eu/pdf/en/07/st07/st07224-re01.en07.pdf>

Other References

- [11] EC page: What is Carbon Capture and Geological Storage (CCS)? http://ec.europa.eu/environment/climat/ccs/what_en.htm
- [12] IPCC Special Report on Carbon dioxide Capture and Storage <http://www1.ipcc.ch/ipccreports/srccs.htm>
- [13] General hazards of carbon dioxide <http://www.hse.gov.uk/carboncapture/carbondioxide.htm>

- [14] Summary Environmental Impact Assessment: Underground storage of CO₂ in Barendrecht, Shell CO₂ Storage B.V., The Hague. Report No.: EP200809225671 http://www-static.shell.com/static/nld/downloads/co2/engelstalige_mer_summary.pdf
- [15] ISO 12039:2001 Stationary source emissions -- Determination of carbon monoxide, carbon dioxide and oxygen -- Performance characteristics and calibration of automated measuring systems http://www.iso.org/iso/catalogue_detail.htm?csnumber=20797
- [16] ISO 10780:1994 Stationary source emissions -- Measurement of velocity and volume flowrate of gas streams in ducts http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=18855
- [17] ISO 3966:2008 Measurement of fluid flow in closed conduits -- Velocity area method using Pitot static tubes http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=50626
- [18] Questions and Answers on the proposal for a directive on the geological storage of carbon dioxide <http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/36&format=HTML&aged=0&language=EN&guiLanguage=en>
- [19] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Reference Manual (Volume 3) <http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.html>
- [20] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Reporting Instructions (Volume 1). Annex 1 "Managing Uncertainties", p. A1.4 <http://www.ipcc-nggip.iges.or.jp/public/gl/invs4.html>
- [21] IPCC Special Report on Carbon Dioxide Capture and Storage. Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L.A. Meyer (eds.). Cambridge: Cambridge University Press, 2005 http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm
- [22] OIML Recommendation R 140 (2007), "Measuring systems for gaseous fuel", p. 20
- [23] L. S. Rothman et al., The HITRAN 2008 molecular spectroscopic database, Journal of Quantitative Spectroscopy & Radiative Transfer 110 (2009) 533–572
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- [25] EU action against climate change. Leading global action to 2020 and beyond. 2009 Edition. Luxembourg: Office for Official Publications of the European Communities, http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KH7809725