TECHNICAL REPORT

ISO/TR 27915

First edition
2017-08

Carbon dioxide capture, transportation and geological storage — Quantification and verification

Capture du dioxyde de carbone, transport et stockage géologique — Quantification et vérification

Reference number
ISO/TR 27915:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword ..... **v**
Introduction ..... **vi**
1 Scope **1**
1.1 General 1
1.2 Limitations 1
1.3 Stakeholders' requirements 1
1.4 Review of the references 1
1.5 Nomenclature 2
2 Normative references **2**
3 Terms and definitions **3**
4 Principles **8**
4.1 General 8
4.2 Principles relating to the accuracy of measurement 8
4.2.1 Overview 8
4.2.2 Relevance 8
4.2.3 Completeness 8
4.2.4 Consistency and comparability 8
4.2.5 Accuracy 8
4.2.6 Transparency 8
4.2.7 Conservativeness 8
4.3 Principles relating to the fungibility of emission reductions 9
4.3.1 Real 9
4.3.2 Additionality 9
4.3.3 Quantifiable 9
4.3.4 Permanence 9
4.3.5 Environmental effectiveness 9
4.3.6 Enforceable 9
4.3.7 Economic efficiency 9
4.4 Principles relating to equity and relationship with stakeholders 9
4.4.1 Equity 9
4.4.2 Transparency 10
4.4.3 Political acceptability 10
4.4.4 Consistency with IPCC Guidelines 10
5 Defining the CCS system and boundaries **10**
5.1 General 10
5.2 Spatial boundaries 11
5.2.1 Overview 11
5.2.2 CCS Project 11
5.2.3 Capture system boundaries 11
5.2.4 Transportation system boundaries 12
5.2.5 Storage system boundaries 13
5.2.6 Geological storage complex 13
5.2.7 Wells 13
5.2.8 Surface equipment 14
5.2.9 Life cycle assessment (LCA) boundaries 15
5.2.10 Reference to baseline scenario 15
5.3 Temporal boundaries 16
5.4 Use of boundaries for Quantification 17
5.4.1 Importance of Quantification and verification 17
5.4.2 Leakage and risk consideration 17
6 Quantification methodologies **18**
6.1 General 18

6.2 Key elements of GHG accounting approaches for CCS ... 18
6.2.1 Overview ... 18
6.2.2 Program purpose and type ... 18
6.2.3 Scope ... 19
6.2.4 Emission quantification methods ... 21
6.3 Sources and emissions identified in CCS systems ... 21
6.3.1 Overview ... 21
6.3.2 Capture system ... 22
6.3.3 Transportation system ... 22
6.3.4 Storage system ... 22
6.3.5 Other emissions ... 23
6.4 Case studies ... 23
6.4.1 General ... 23
6.4.2 Case study 1: UNFCCC National inventories — Inventory accounting ... 24
6.4.3 Case study 2: ISO 14064-2 and CDM — Baseline emission reduction credit accounting ... 28
6.4.4 Case study 3: EU ETS — Cap and trade accounting ... 30
6.4.5 Case study 4: Alberta CCS protocol — Baseline emission reduction credit accounting ... 33
6.4.6 Case Study 5: Alberta EOR protocol — Baseline emission reduction credit accounting ... 35
6.4.7 Case study 6: US GHG reporting — Inventory accounting ... 36
6.4.8 Case study 7: LCA ... 39
6.5 Discussion — Key commonalities, differences and noteworthy issues ... 39
6.5.1 Key differences ... 41
6.5.2 Issues for further consideration ... 42

7 Measurement and monitoring ... 43
7.1 General ... 43
7.2 Purpose ... 43
7.3 Review of monitoring for ccs ... 43
7.4 Measurement and monitoring in CCS systems ... 45
7.4.1 General ... 45
7.4.2 CCS projects ... 45
7.4.3 Capture system ... 48
7.4.4 Transportation system ... 48
7.4.5 Storage system ... 48
7.4.6 Impurities ... 49
7.4.7 LCA approaches ... 50

8 Environmental impacts of CCS other than GHG capture/emission ... 50
8.1 Objectives ... 50
8.2 Definition of EIA and LCA ... 50
8.3 LCA methodological framework ... 51
8.4 Key features of LCA for CCS ... 54

9 Data management, reporting and verification ... 54
9.1 General ... 54
9.2 Data management ... 55
9.3 Reporting ... 56
9.4 Verification ... 57
9.4.1 Background ... 57
9.4.2 Verification planning ... 58
9.4.3 Assessment of the GHG data, information and controls ... 58
9.4.4 Conclusion and reporting of the verification process ... 59
9.4.5 Verification records ... 59
9.4.6 Competency of verification teams ... 59

10 Conclusions ... 60

Bibliography ... 62

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 265, *Carbon dioxide capture, transportation, and geological storage*.

Introduction

This document is intended to serve as a reference document for future development of any technical standards that could be approved by TC 265 for the quantification and verification (Q&V) of greenhouse gas (GHG) emissions and emission reductions from CCS projects. This document is a review of current practices and requirements, for the Q&V of carbon dioxide captured, transported and geologically stored; as well as for direct and indirect GHGs that can arise from integrated CCS project activities associated with injection of carbon dioxide into geological formations for the purposes of isolation from the atmosphere (and ocean) over the long term. While carbon dioxide (CO_2) is the primary target of the capture process, other GHGs (such as methane, CH_4) may be entrained in the capture stream, and emissions can include GHG's other than CO_2. This document includes limited discussion of other environmental impacts.

This document integrates the various aspects of Q&V adopted by other ISO/TC 265 Working Groups (WGs) into a comprehensive project framework.

The UNFCCC Paris Agreement (adopted on 12 December 2015) lays the foundation for countries to work cooperatively to limit the increase in global average temperature to between 1,5 °C and 2 °C above pre-industrial levels, by reducing emissions of greenhouse gases (GHGs) into the atmosphere and by increasing removals of GHGs from the atmosphere. Many of the climate models considered by the IPCC in their most recent assessment report (IPCC, 2014) suggest that keeping average global temperature rises to less than 2 °C will require large scale deployment of carbon dioxide capture, transportation and geological storage technologies (CCS) in order to reduce anthropogenic emissions from the electrical sector and from industries where there are no viable alternatives. The IPCC (2014) also suggest that CCS with bio-energy (BECCS) will be required to remove carbon dioxide from the atmosphere to meet medium term emission objectives. In the longer term (i.e. 70 to 100 years), it may be necessary, and viable, to further reduce harmful concentrations of CO_2 in the atmosphere by capturing CO_2 directly from the atmosphere for injection into geological formations (DACCS).

While many countries have existing domestic GHG emission reporting requirements, the Paris Agreement emphasizes "robust accounting" for all countries (UNFCCC, 2015, Article 6, paragraph 2), covering both anthropogenic emissions of greenhouse gases by sources and removals of greenhouse gases by sinks (Article 4, paragraph 2). The key principles for accounting and reporting identified in the Paris Agreement are transparency (to ensure that actions are shared and equitable, and that outcomes are real), accuracy, completeness, comparability and consistency, and the avoidance of double accounting (UNFCCC, 2015, Article 4, paragraph 13). Environmental integrity (i.e. no harm to ecosystems or biodiversity) is a fundamental principle for all activities, as are issues relating to the socioeconomic impacts of a project.

ISO/TC 265 was established to develop technical standards for the design, construction, operation, environmental planning and management, risk management, quantification, monitoring and verification, and related activities in the field of CCS. Six working groups (WGs) have been established. They all report through to the Technical Committee (TC) and are charged with focusing on particular aspects of the CCS technology chain.

WG1 – Capture

WG2 – Transport

WG3 – Storage

WG4 – Quantification and Verification

WG5 – Cross-cutting Issues

WG6 – CO_2 storage through Enhanced Oil Recovery (EOR)

This document established under WG4 is intended to provide a credible foundation for future standard approaches for the quantification and verification (Q&V) of GHGs associated with CCS projects (for geological storage or for EOR). Future standards developed in this area will improve understanding

and confidence in CCS related GHG mitigation by regulatory authorities, investors and civil society, as well as enhance validation processes underpinning project compliance obligations.

The development of this document complements the development of other CCS and non-CCS, but relevant, ISO standards and TRs, including in particular the whole ISO/TC 265 catalogue. Documents are referenced from the EU, UNFCCC, IPCC, and various government bodies. As CCS Q&V is an ever-evolving area of examination, this document has been based on the best available information at the time of its release.

The principal GHG considered within this document is carbon dioxide (CO_2), other GHG's (as listed in Chapter 5), are included in the Q&V of CCS projects, but are not usually significant. To some extent, GHG and CO_2 are used somewhat interchangeably and the reader is invited to consider the context of the terms. Most of the GHG captured through the CCS system will be a relatively pure stream of CO_2, perhaps mixed with other gases such as N_2, but in an Enhanced Oil Recovery (EOR) system the recycled CO_2 could also include methane (CH_4). Emissions from fossil-fired industrial activity could also contain some N_2O.

This document aims to provide a transparent and non-prescriptive body of information relating to Q&V processes for CCS projects.

Carbon dioxide capture, transportation and geological storage — Quantification and verification

1 Scope

1.1 General

This document presents a review of publicly available literature identifying materially relevant issues and options relating to "good practices" for quantifying and verifying GHG emissions and reductions at the project level. Its scope covers all components of the CCS chain (e.g. capture, transport, storage) and includes a lifecycle assessment approach to estimating project level emissions and emission reductions from project assessment, construction and operations, through to completion and post-closure activities. This document considers the following at the project level:

— a variety of Q&V related boundaries applicable to all components of a CCS project;

— the composition of the CO_2 stream, including its purity, and requirements for measuring and verifying the physical and chemical state of the CO_2 stream in CCS projects;

— identification and quantification of GHG emissions and reductions across integrated CCS components;

— monitoring objectives, methodologies, and sampling strategies, including locations, periods, and frequencies;

— GHG data collection and reporting;

— verifying GHG expectations with agreed verification criteria;

— life cycle assessment (LCA) of CCS projects.

1.2 Limitations

Q&V approaches to measuring and verifying GHG emissions, reductions and removals for CCS projects continue to evolve. This document identifies the gaps and limitations in current levels of knowledge, of empirical methodologies and application of good practices for CCS Q&V.

This is a Technical Report and so does not seek to recommend technical standards for any specific Q&V method. This document cites existing ISO standards and other good-practice protocols that have been developed to quantify and verify GHGs from integrated CCS projects.

1.3 Stakeholders' requirements

This document aims to inform all stakeholders who influence, or are directly or indirectly involved in the reporting of emissions and emission reductions, or removals, for CCS projects. Stakeholders may include, for example, CCS project developers and operators, policy makers, regulators and other government oversight bodies, verifying entities, the financial community, equipment manufacturers, owners of other resources (e.g. water, coal, oil and gas), and members of the general public.

1.4 Review of the references

This document makes reference to a variety of sub-national, national and international laws applicable to CCS projects; current Q&V practices to measure GHG emissions and reductions, or removals, by CCS projects; existing ISO standards that are directly and/or indirectly relevant to CCS projects; identified stakeholder requirements; and the anticipated outcomes of other ISO/TC 265 WGs.

The discussion of Q&V is applicable to both onshore and offshore environments. At this stage, the offshore experience is from two Norwegian projects, Sleipner and Snohvit, while the onshore experience draws on an expanding range of storage, and CO_2 EOR projects, in North America and China; and from a cumulative body of research, pilot and demonstration projects, in Algeria, Australia, Canada, Europe, Japan and the USA.

References are cited throughout this document, including relevant standards and protocols. These references are listed in alphabetic order in the Bibliography.

1.5 Nomenclature

BECCS	Bio-energy with CCS
CCS	Carbon Capture and Storage (or Carbon dioxide Capture, transportation and geological Storage)
CDM	Clean Development Mechanism
CEMS	Continuous Emission Monitoring System
CMS	Continuous Measurement System
CO_2-e	Carbon dioxide equivalent
DACCS	Direct air carbon dioxide capture and (geological) storage
EIA	Environmental Impact Assessment
EOR	Enhanced Oil Recovery
EU ETS	European Union Emissions Trading Scheme
GHG	Greenhouse Gas
IEA GHG	International Energy Agency Greenhouse Gas R&D Programme
IPCC	Intergovernmental Panel on Climate Change
IPCC SR	IPCC Special Report on CCS (2005)
LCA	Life Cycle Assessment
MRR	Monitoring, Reporting Regulation (ref. EU)
Mt	1 million (metric) tonnes
Q&V	Quantification and Verification
tonne	1,000 kg
tCO_2-e	tonne CO_2 equivalent
TR	Technical Report
UNFCCC	United Nations Framework Convention on Climate Change

2 Normative references

There are no normative references in this document.