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Duration: 36 months

Organisation name of lead contractor for this deliverable:

CO₂GeoNet – OGS
Istituto nazionale di Oceanografia e di Geofisica Sperimentale

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Dissemination Level * : Public

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1. Introduction

Dissemination of knowledge is considered one of the key actions:

- to stimulate knowledge transfer and to educate stakeholders in the field of geological storage of CO₂;
- to raise general awareness of CCS as a climate change mitigation measure;
- to facilitate the implementation of European Industrial Initiatives on CCS, mentioned in the SET Plan;
- to support implementing the EU Directive on CO₂ geological storage in the EU Member States;
- to reduce the arising gap between the ‘forerunners’ countries (with demo and/or pilot projects and extensive R&D activities) and the ‘followers’ ones (where not much is going on in terms of CCS).

At the same time, the dissemination has a large number of targeted audiences, as: CCS policy makers and regulators at both European and national levels; industrial stakeholders with various involvement in the storage part of CCS; broader research community working in various disciplines related to CCS; students and young scientists (both from participating organisations and outside); environmental NGOs; media and journalists; and general public.

To reach all these objectives, while involving the large number of potential audiences, a comprehensive knowledge dissemination plan has been envisaged, with a main role for the central project website.

Its home page, developed at the beginning of the project (see **Figure 1**), has been improved throughout the time, to give access to a larger number of information and documents, in the **Knowledge Repository**.



Figure 1 – Home page of the CGS Europe website, at the beginning of the project.

2. Documents available in the Knowledge Repository

2.1 Main page of the knowledge repository

This section presents the table of contents of the knowledge repository.



Figure 2 – Table of contents of the knowledge repository

From this main page, the EU and National project reports (see **Figure 3**), the Scientific publications (see **Figure 5**), the CO₂ Storage glossary (see **Figure 7**) and the Key reports (see **Figure 8**) are accessible from the list on the left menu.

2.2 EU and National project reports

All the completed and still running projects dealing with CO₂ geological storage, supported by the European Commission under Framework Programme 5, 6 and 7, are included in this section, which is organised to keep also information of national projects.

The screenshot shows the CGS Europe Knowledge Repository website. The header includes the CGS Europe logo, a language selector set to English, and a Login button. The main navigation bar contains links for HOME, CGS EUROPE, PARTNERS, KNOWLEDGE REPOSITORY, NEWS & EVENTS, LINKS, CONTACT US, and CGS EUROPE PUBLICATIONS. The page title is "Pan-European coordination action on CO₂ Geological Storage". The breadcrumb trail indicates the user is in "CGS Europe > KNOWLEDGE REPOSITORY > EU & National project reports". The main heading is "European and National project reports". A left-hand menu lists various projects with expandable arrows, including EU Geocapacity, CASTOR, CO2SINK, ENCAP, InCA-CO2, CO2NET, CO2STORE, NASCENT, RECOPOL, WEYBURN, SACS2, CO2GeoNet, GRASP, SiteChar, CO2CARE, ECO2, QICS, RISC, MUSTANG, ULTIMATECO2, and PANACEA. Below the menu are links for Key Reports, Scientific publications, and CO2 Storage Glossary. The main content area displays details for several projects:

- EU Geocapacity**: Assessing European Capacity for Geological Storage of Carbon Dioxide. The main objective of the project is to Assess the European Capacity for Geological Storage of Carbon Dioxide ... [\[read more\]](#)
- RECOPOL Project**: Reduction of CO₂ emission by means of CO₂ storage in coal seams in the silesian coal basin of Poland. The RECOPOL project is an EC-funded research and demonstration project to inv ... [\[read more\]](#)
- WEYBURN Project**: The weyburn co₂ monitoring and storage project WEYBURN aims to enhance the knowledge and understanding of the underground sequestration of CO₂, especially where associated with e ... [\[read more\]](#)
- SACS2**: Saline Aquifer CO₂ Storage Phase 2. SACS2 aims to monitor and verify the distribution of the CO₂ bubble at the Sleipner Field. Methods were tested for prediction of the CO₂ behaviour thousan ... [\[read more\]](#)
- CO2GeoNet**: The European Network of Excellence on the Geological Storage of CO₂. CO2GeoNet (13 institutes) contains a critical mass of research activity in the area of underground carbon diox ... [\[read more\]](#)
- GRASP**: Greenhouse-gas Removal Apprenticeship and Student Program. The main objective of GRASP is to provide a multidisciplinary training platform to build a group of young researchers ab ... [\[read more\]](#)
- SiteChar**: Characterisation of European CO₂ storage. SiteChar will facilitate the implementation of CO₂ storage in Europe by improving and extending standard site characterisation workflows, ... [\[read more\]](#)
- CO2CARE**: CO₂ Site Closure Assessment Research. CO2CARE aims to support the large scale demonstration of CCS technology by addressing the research requirements of CO₂ storage site abandonme ... [\[read more\]](#)

At the bottom of the page, there is a "News from CGS Europe" section.

Figure 3 – List of the EU and National projects that are involved in CCS research and technologies.

By clicking on the project names in the left menu, all the information included for the project appears (see **Figure 4**). In general they consist of the logo and the extended name of the project, a short description, a list of downloadable reports (see **Figure 4b**), a link to the website and a contact person.

Regarding the reports produced by the various projects, we have contacted the coordinators of these, offering them to store in the CGS Europe website the downloadable files. In the majority of cases, we have been allowed to include just a link to other websites, where the reports are available; for some projects, we have got the files. Because it is our intention to guarantee also in the future the accessibility to the reports available now, we have declared to the various projects coordinators to be ready to store in our website the files of all of them, if and when their websites would be discontinued.

By clicking on a report name, it is in any case available, by downloading it from the CGS Europe website or through the link stored in our data base.

The image shows two parts of a website interface. Part (a) is a 'KNOWLEDGE REPOSITORY' page for the 'EU Geocapacity' project. It features a breadcrumb trail: 'You are in: CGS Europe > ... > EU & National project reports > EU Geocapacity'. The main heading is 'EU Geocapacity' with the subtitle 'Assessing European Capacity for Geological Storage of Carbon Dioxide'. A circular logo with a globe and the text 'GeoCapacity' and '地质埋存潜力' is displayed. Below the logo, the project's main objective is described: 'The main objective of the project is to Assess the European Capacity for Geological Storage of Carbon Dioxide...'. A list of 'Available reports' is provided, including 'WP1 report - Inventories and GIS', 'WP2 report - Storage capacity', 'WP3 report - Economic uses of CO2', 'WP4 report - Standards and site selection criteria', 'WP5 report - DSS and economic evaluations', 'WP6 report - International cooperation', 'GeoCapacity final report', and 'Publishable final activity report'. Contact information is listed at the bottom: 'Website: www.geology.cz/geocapacity', 'Contact person: Thomas Vangkilde-Pedersen', and 'E-mail: tvp@geus.dk'. Part (b) shows a report deliverable titled 'EU GeoCapacity' with project number 'SE6-518318'. It includes logos for 'EU GeoCapacity' and '6', and specifies 'D16 WP2 Report Storage capacity'. The organization name is 'Geological Survey of Denmark and Greenland'.

Figure 4 – Example of the European EU Geocapacity project: a) short description of the project, list of reports and link to the website, and a contact person; b) example of a report (here deliverable) directly available by clicking on the corresponding link.

2.3 Scientific publications

Scientific publications dealing with various aspects of the CO₂ geological storage are presented in this section (see **Figure 5**). Each publication is stored in the data base with:

- title,
- type of publication (paper, report, book, web page...),
- year of publication,
- bibliographic references,
- authors,
- citation code,
- abstract (if available),
- external link to the publication.

A search tool enables to find specific publication according to search criteria (free text, year or publication type).

There is as well the possibility to be automatically notified when a new publication is added by subscribing to the notification.

Access to the publication information is provided by clicking on the title of the publication (see **Figure 6**) where, if available, a link to the abstract and the full text of the publication is specified.

KNOWLEDGE REPOSITORY

EU & National project reports
Key Reports
Scientific publications
CO2 Storage Glossary

You are in: CGS Europe > KNOWLEDGE REPOSITORY > Scientific publications

Scientific publications

Free text search:

Search by year:

Search by publication type:

SEARCH...

Subscribe to the newsletter to be notified automatically when a new publication gets added

2013 - JOURNAL ARTICLE - GREENHOUSE GAS CONTROL TECHNOLOGIES (GHGT-11), ENERGY PROCEEDIA 37(0) PAGES: 6317-6325 ISSN: 1876-6102.
Key Messages from Active CO2 Storage Sites
Ton Wildenborg, Andy Chadwick, Jean-Pierre Deflandre, Ola Eiken, Allan Mathieson, Richard Metcalfe, Conny Schmidt Hattenberger, Jens Wollenweber

2012 - REPORT - WWW.CO2CARE.ORG
CO2CARE D1.2 Report on the current site abandonment methodologies in relevant industries, report
J. Wollenweber, T. Benedictus, S. Durucan, A. Korre, N. Quisel, G. Baumann, S. Martens, Liteanu E.

2012 - BOOK - ISSN: 3642253881. PUBLISHED BY: SPRINGER.
Microseismic monitoring and geomechanical modelling of CO2 storage in subsurface reservoirs
James P Verdon

2012 - JOURNAL ARTICLE - INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL 7(0) PAGES: 115-126 ISSN: 1750-5836.
Assessment of carbon dioxide plume behaviour within the storage reservoir and the lower caprock around the KB-502 injection well at In Salah
Ji-Quan Shi, Caglar Sinayuc, Sevket Durucan, Anna Korre

Figure 5 – Free list of the scientific publication. There is the possibility to search for a publication on the basis of search criteria.

You are in: CGS Europe > KNOWLEDGE REPOSITORY > Scientific publications

Key Messages from Active CO2 Storage Sites

PUBLICATION YEAR: 2013
PUBLICATION TYPE: Journal Article
BIOGRAPHICAL DETAILS: Greenhouse Gas Control Technologies (GHGT-11), Energy Procedia 37(0) pages: 6317-6325 ISSN: 1876-6102.
AUTHORS: Ton Wildenborg, Andy Chadwick, Jean-Pierre Deflandre, Ola Eiken, Allan Mathieson, Richard Metcalfe, Conny Schmidt Hattenberger, Jens Wollenweber
CITATION CODE: Wildenborg et al., 2012
ABSTRACT: CO2 storage; operational and post-operational performance; monitoring; verification;
EXTERNAL LINK: <http://www.sciencedirect.com/science/article/pii/S1876610213008035>

a)

b)

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Energy Procedia
Volume 37, 2013, Pages 6317-6325
GHGT-11
Open Access

Key Messages from Active CO₂ Storage Sites[☆]

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^d Statoil Research Centre, Rotvoll, Arktiskt Ebbells vei 10, 7005 Trondheim, Norway
^e BP, Alternative Energy, Chertsey Road, Sunbury on Thames, United Kingdom
^f QUINTESSA, The Hub, 14 Station Road, Henley-on-Thames, Oxfordshire, United Kingdom
^g GFZ German Research Centre for Geosciences, Centre for CO₂ Storage, Potsdam, Germany

Abstract

An extensive programme of modelling, monitoring and verification activities was deployed at a set of active storage sites worldwide including Sleipner, In Salah, Ketzin, Weyburn, K12-B and Snøhvit (EU CO2ReMoVe project). All investigated storage sites were well managed and did not have a negative impact on humans or the environment. Time-lapse seismic and pressure monitoring are key in verifying the deep subsurface performance of the storage sites. Evidence gathered during the site characterisation and operational phases is key to handover responsibility of the storage site to governmental authorities after injection has definitively ceased, which is the focus of the follow-up EU project CO2CARE.

Keywords

CO₂ storage; operational and post-operational performance; monitoring; verification

References

Figure 6 – Information about the publications: a) references and, if available, link to the b) abstract and full text of the publication.

2.4 CO₂ Storage glossary

The CO₂ Storage glossary lists key words related to and that may be used in the context of CCS research and technology. Each key word is defined by a short sentence, which can be read by clicking on the +/- box. These key words and the related definitions are used and may be seen directly in the Key Reports (see **section 5.5**).

KNOWLEDGE REPOSITORY

EU & National project reports
Key Reports
Scientific publications
CO₂ Storage Glossary
References and sources

You are in: CGS Europe > KNOWLEDGE REPOSITORY > CO₂ Storage Glossary

Glossary

- + Abandonment
- Absorption
Chemical or physical take-up of molecules, atoms or ions into the bulk of a solid or liquid, forming either a solution or compound
- + Acid gas
- + Adsorption
- + Amine
- + Anthracite
- + Anticline
- Aquifer
An underground layer of fluid-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) with significant permeability to allow flow
- Atmosphere
The layer of gases surrounding the earth; the gases are mainly nitrogen (78%) and oxygen (around 21%)
- + Barrier formations
- + Basalt formations
- + Basin
- + Benthic
- + Abatement
- + Accounting
- + Adiabatic
- + Aluminosilicate mineral
- + Anhydrite
- + Anthropogenic source
- + API
- + Assessment unit
- + Bamako Convention 1991
- + Basalt
- + Basel Convention
- Bathymetric
Pertaining to the depth of water
- + Bicarbonate ion

Figure 7 – Upper part of the glossary list. The description of some key words (e.g. Absorption, Aquifer, Atmosphere, Bathymetric) have been extended by clicking on the +/- box.

2.5 Key reports

The key reports treat three main topics, of great importance for the geological storage of CO₂ (see **Figure 8**):

- Directive and regulatory regimes related to operational aspects and safety criteria
- State-of-the-art of CO₂ storage site selection and characterisation methods
- State-of-the-art of monitoring methods to evaluate storage site performance

Title of the key reports has been shortened in the website menu.

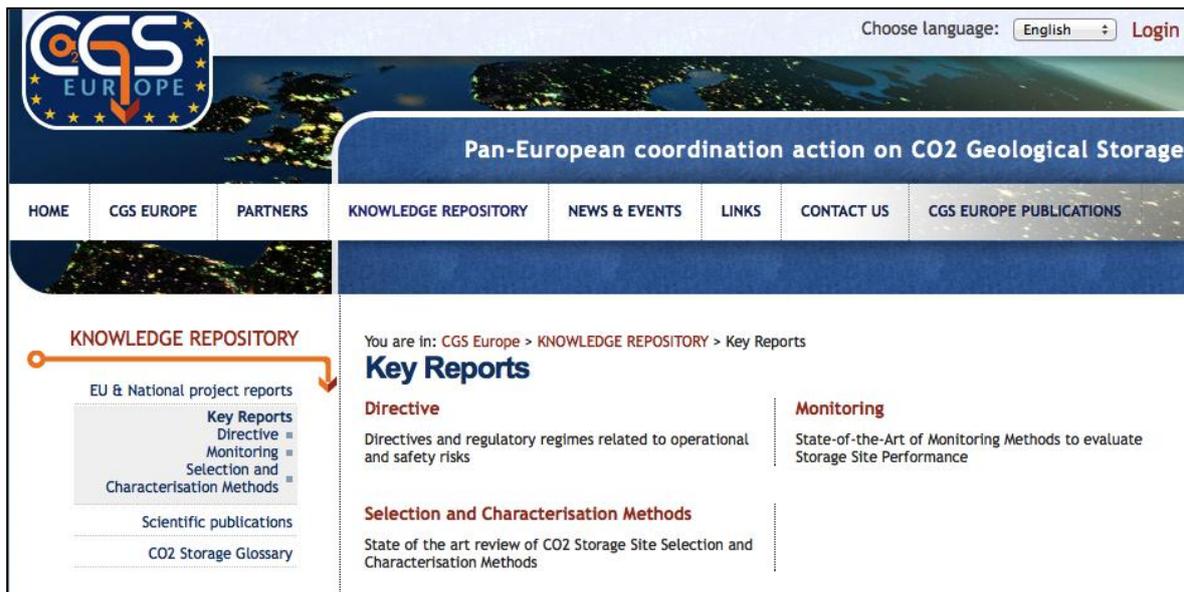


Figure 8 – Main page of the key reports section, with a short description and a link to each report.

Each key report is accessible by clicking on it on the left menu or on the centre list. When doing so (see **Figure 9**), a summary abstract appears, and it is possible to “navigate” through the various parts of the report. There is also the possibility to download the Full Text Document or the Executive Summary, by clicking on the links below the abstract.

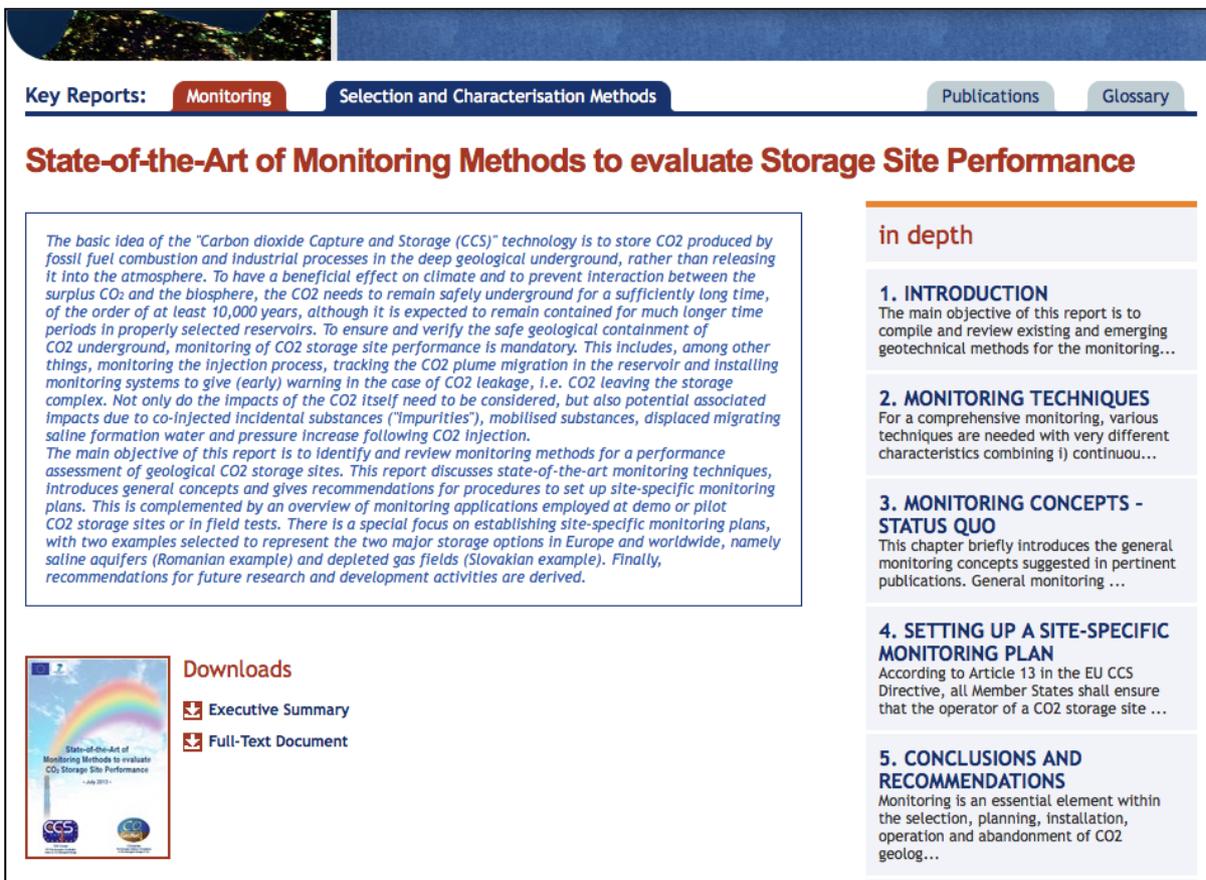


Figure 9 – First page of the key report on the state-of-the-art of monitoring methods to evaluate storage site performance.

The “Monitoring” full report is organised in five chapters and two levels of sub-chapters, each one with texts and figures.

When a chapter or a first level sub-chapter is selected, above its content a “navigation” tool appears, and an “in depth” menu, on the right, lists the titles of the following sub-level chapters, with a short text (see **Figure 11**).

The “navigation” tool, just below the title of the key report, consists in a series of arrows, which indicate the route until the chapter content that appears below.

The menu on the right part is not active when a chapter with no sub-chapters is reached and displayed (see **Figure 10**).

The screenshot shows a web interface for a report. At the top, there are navigation tabs: "Key Reports:", "Monitoring" (selected), "Selection and Characterisation Methods", "Publications", and "Glossary". Below the tabs is the main title: "State-of-the-Art of Monitoring Methods to evaluate Storage Site Performance". Underneath the title is a navigation bar with three arrows pointing right. The first arrow is labeled "2. MONITORING TECHNIQUES", the second is labeled "2.2 Surface uplift", and the third is labeled "2.2.3 Interferometric Synthetic Aperture Radar (InSAR)". Below the navigation bar is the content for the selected sub-chapter, "2.2.3 Interferometric Synthetic Aperture Radar (InSAR)". The content includes a paragraph of text, a sub-section titled "InSAR works by taking readings at regular intervals and comparing changes from month to month (see Fig. 2-8). Accuracy with just two scenes is in the centimetre range but millimetre accuracy can be achieved by stacking many months of data to eliminate atmospheric errors. Accuracy can also be improved through integration of DGPS and tiltmeter data, which can provide finer resolution over smaller areas (McColpin, 2009). Differences between scenes are usually represented as coloured bands with each band representing an interval of ground movement.", and a diagram labeled "Fig. 2-8: Principle of the InSAR method (McColpin, 2009)". The diagram shows two satellite passes over a ground area with "ground uplift". It illustrates the "satellite first pass" and "satellite second pass", the "reflected signals", and the resulting "PHASE SHIFT".

Figure 10 – A sub-chapter of the monitoring key report with text, illustration and classification tree evidenced by the arrows on the upper part.

When reading a part of the key report, it is possible, by clicking on one of the arrows of the “navigation” tool, to go directly to one of the chapters pertaining to the “same level” (see **Figure 11**), or to jump to a chapter of the “upper level” (see **Figure 12**). For reading a sub-chapter, the right menu has to be used.

CGS EUROPE
Pan-European coordination action on CO₂ Geological Storage

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Key Reports: **Monitoring** Selection and Characterisation Methods Publications Glossary

State-of-the-Art of Monitoring Methods to evaluate Storage Site Performance

2. MONITORING TECHNIQUES

2.2 Surface uplift

Surface uplift can represent an (undesirable) accompaniment of shallower storage sites with higher pressure increase in excessive or uneven uplift can result in damage to installed infrastructure. The phenomenon of surface distortions is well known from oil and gas fields or at natural gas storage sites (e.g. Gierke, 2001). It has long been recognised that the withdrawal of fluids from the subsurface will generate displacement zones and in turn cause ground surface deformations. Such subsurface deformation is measurable in terms of volumetric changes. Such subsurface deformation is measurable in terms of horizontal displacements and tilts, which are the gradient of surface deformations. Injection of CO₂ for geological storage purposes induces ground surface deformations. An overview of methods suitable for monitoring of surface uplift, or surface deformation in general, is provided, e.g. by McColpin, 2009. According to this author, the methods in question fall under the general term Surface Deformation monitoring (SDM) that is defined as "the process of monitoring ground dilatation and/or subsidence caused by the injection or extraction of fluids and gases". Tiltmeters, Differential Global Positioning Systems (DGPS) and Interferometric Synthetic Aperture Radar (InSAR) are the main monitoring techniques available for these purposes.

- 2.1 CO₂ plume migration in the storage reservoir
 - 2.2 Surface uplift
 - 2.3 Induced seismicity and mechanical reaction of overburden
 - 2.4 Faults
 - 2.5 Abandoned wells
 - 2.6 Overlying and adjacent aquifers
 - 2.7 Freshwater aquifers
 - 2.8 Near surface eco-compartments

in depth

2.2.1 Tiltmeters
A tiltmeter is in principle a high-tech carpenter's level firmly fixed to the ground and able to measure tilt movements ...

2.2.2 Differential Global Positioning Systems (DGPS)
DGPS is a monitoring technique which uses a minimum of two GPS receivers and sophisticated Kalman filtering to achieve m...

2.2.3 Interferometric Synthetic Aperture Radar (InSAR)
InSAR is a satellite-based radar measurement technique able to survey large areas of the earth's surface and provide, at...

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Figure 11 – Navigation menu, listing chapters in the same level.

CGS EUROPE
Pan-European coordination action on CO₂ Geological Storage

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Key Reports: **Monitoring** Selection and Characterisation Methods Publications Glossary

State-of-the-Art of Monitoring Methods to evaluate Storage Site Performance

1. INTRODUCTION

2. MONITORING TECHNIQUES

3. MONITORING CONCEPTS - STATUS QUO

4. SETTING UP A SITE-SPECIFIC MONITORING PLAN

5. CONCLUSIONS AND RECOMMENDATIONS

6. REFERENCES

any consequence of CO₂ storage, especially at in the storage reservoir. In the worst-case scenario, installations and real estates on the surface.

from the oil and gas industry, especially at producing oil revich and Chilingarian, 1993; Kühn *et al.*, 2009; Nagel, al or injection of any kind of fluid or material from or into underground deformations, which can be described in ations induce ground level movements. These induced es that are typically measured as vertical displacements, dent of surface deformations (Monfared and Rothenburg, ses does not defy these rules.

An overview of methods suitable for monitoring of surface uplift, or surface deformation in general, is provided, e.g. by McColpin, 2009. According to this author, the methods in question fall under the general term Surface Deformation monitoring (SDM) that is defined as "the process of monitoring ground dilatation and/or subsidence caused by the injection or extraction of fluids and gases". Tiltmeters, Differential Global Positioning Systems (DGPS) and Interferometric Synthetic Aperture Radar (InSAR) are the main monitoring techniques available for these purposes.

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The CGSEurope Web Site is designed by OGS

Figure 12 – Navigation menu, listing chapters in the “upper” level.

Key words as described in the CO₂ Storage glossary are blue-highlighted in the text and linked to the short definition of the glossary by drifting on with the mouse (see **Figure 13**). On the same way, references to publication are highlighted with the possibility to retrieve the publication information and, if available, the link to the abstract and the full text of the publication as illustrated in **section 5.3**.

Key Reports: [Monitoring](#) [Selection and Characterisation Methods](#) [Publications](#) [Glossary](#)

State-of-the-Art of Monitoring Methods to evaluate Storage Site Performance

2. MONITORING TECHNIQUES → ~ 2.2 Surface uplift

2.2 Surface uplift

Surface uplift can represent an (undesirable) accompanying consequence of CO₂ storage, especially at shallower storage sites with higher pressure increase in the storage reservoir. In the worst-case scenario, excessive (CO₂) A process for retaining captured CO₂, so that it does not reach the atmosphere installations and real estates on the surface.

The phen and gas fie down from the oil and gas industry, especially at producing oil (Gurevich and Chilingarian, 1993; Kühn et al., 2009; Nagel, 2001). It has long been recognised that the withdrawal or injection of any kind of fluid or material from or into the subsurface will generate displacement zones and underground deformations, which can be described in terms of volumetric changes. Such subsurface deformations induce ground level movements. These induced ground surface deformations are measurable quantities that are typically measured as vertical displacements, horizontal displacements and tilts, which are the gradient of surface deformations (Monfared and Rothenburg, 2011). Injection of CO₂ for geological storage purposes does not defy these rules.

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2.2.3 Interferometric Synthetic

a) **KNOWLEDGE REPOSITORY**

- EU & National project reports
- Key Reports
- Scientific publications**
- CO₂ Storage Glossary

b)

You are in: [CGS Europe](#) > [KNOWLEDGE REPOSITORY](#) > Scientific publications

Surface deformation monitoring as a cost effective MMV method

PUBLICATION YEAR: 2009
PUBLICATION TYPE: Journal Article
BIOGRAPHICAL DETAILS: Energy Procedia. 1 (1): 2079-2086. ISSN: 1876-6102 ;
AUTHORS: G. R. McColpin
CITATION CODE: McColpin, 2009

Figure 13 – Example of a subchapter of the monitoring key report with a) highlights of the glossary key words and b) link to the publication information.

2.6 How to have access to the content of the key reports

The key reports have been written with the purpose to provide correct scientific information to a variety of potential website visitors.

We have also considered that groups of people with a different technical background could be interested or in getting just an overview of the various chapters or in reading more details and even the referred scientific papers.

To tackle this problem we have adopted the following solution:

- make available the download of the full key reports;
- make available an Executive Summary for each key report;
- upload the three key reports as hyper text;

- have two “navigation” tool: a right menu to access the sub-chapters and an “upper” menu (the “arrows”) to quickly jump to chapters of the same level or of “upper” levels;
- the “first level” chapters (1. Introduction, 2. Monitoring techniques, etc...) start with a box, in which the content of the chapter is summarized;
- the meaning of many “technical” words used in the text is explained in the Glossary and small “pop-up windows” appear by clicking on these words (in bold blue in the texts);
- other “pop-up windows” appear by clicking on the bibliographic references in the texts. By clicking on “see more” in these small windows, the complete entry in the Scientific publications data base is shown, with the possibility to access the abstract and, through an external link, the full text, if available.