DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2014/55

CO2StoP Executive Summary

Assessment of CO2 storage potential in Europe
European Commission Contract No ENER/C1/154-2011-SI2.611598

Niels Poulsen, Sam Holloway, Filip Neele, Nichola Ann Smith & Karen Kirk

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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GEUS

Project title:

Assessment of CO_2 storage potential in Europe

European Commission Contract No
ENER/C1/154-2011-SI2.611598

Project acronym:

CO2StoP

Instrument: Specific Targeted Research Project
Start date of project: January 2012 (Dec. 19th 2011)
Duration: 24 months

CO2StoP Executive Summary

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By
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Nichola Ann Smith (BGS) and
Karen Kirk (BGS)

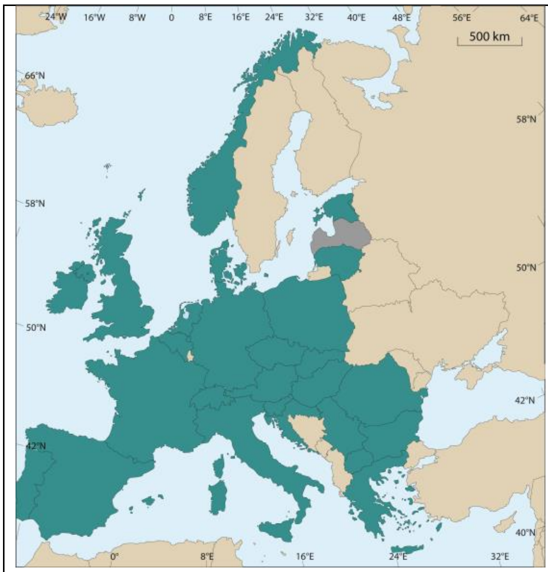
Project funded by the European Commission 2011		
Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential , only for members of the consortium and the Commission Services	

CO2StoP – a project mapping both reserves and resources for CO_2 storage in Europe

By: Niels Poulsen (GEUS), Sam Holloway (BGS), Karen Kirk (BGS), Filip Neele (TNO) and Nichola Ann Smith (BGS)

CO2StoP is the acronym for the "CO_2 Storage Potential in Europe." project. The CO2StoP project, which started in January 2012 and ended in December 2013, was funded by the European Commission (Project N°: ENER/C1/154-2011-SI2.611598). The project covered data from 27 countries[1].

The results of the study are provided as a database of CO_2 storage locations throughout Europe, a Data Analysis/Interrogation Tool and GIS, and a tool to compute storage capacities and injection rates (StoreFit). The database is now housed by the Joint Research Centre - European Commission, Petten, the Netherlands (**http://iet.jrc.ec.europa.eu/**).



27 countries were covered by the CO2Stop project. Latvia was covered by the Estonian-Latvian border project.

Background – methodologies

Introduction to CO_2 storage resource assessment

A resource can be defined as anything potentially available and useful to man. The pore space in deeply buried reservoir rocks is a resource that can be used for CO_2 storage. It is of the utmost importance to be aware that the presence of a resource does not indicate that any fraction of it can be exploited, economically, now or in the future.

A reserve can be defined as that part of a resource that is available to be exploited economically now using currently available technology. Thus, in order to move from a resource estimate to a reserve estimate, a whole series of technical, economic, legal and socioeconomic criteria have to be applied to the resource. These criteria will then identify the fraction of the resource that can actually be economically exploited in a particular jurisdiction using presently available technology. Consequently, a very high level of technical assessment is required to demonstrate the existence of a CO_2 storage reserve. As a result, the resources required to achieve the level of technical assessment needed to define CO_2 storage reserves are, in most cases, only available within a demonstration or commercial storage project. For these reasons, it has not been possible to define any CO_2 storage reserves in the present project.

Storage mechanisms

Carbon dioxide can be retained in reservoir rocks by the following mechanisms: 1) structural and stratigraphic trapping, 2) development of a residual saturation of gas, or supercritical phase CO_2 trapped in the pore space by capillary forces, 3) dissolution into the pore fluids present within the reservoir rock, 4) precipitation of carbonates or other carbon-rich minerals, 5) adsorption onto the surfaces of carbon-rich grains within the reservoir.

In typical porous and permeable saline water-bearing reservoir rocks (commonly described as deep saline aquifers in the CCS literature), mineral reaction and the dissolution of CO_2 into pore fluids are considered to be unimportant on short injection timescales (say 50 years or so) because the kinetics of these processes are relatively slow (van der Meer & van Wees, 2006). Therefore, they are unlikely to greatly affect storage capacity.

Geological and physical constraints on CO_2 storage capacity

Each jurisdiction contains a given amount of pore space within its subsurface. The total resource of pore space that is potentially available for CO_2 storage, in a jurisdiction, is that part of its total pore space that can be filled with, and will retain, injected CO_2. Geology and physics dictate that this will be far less than the total pore space available in a jurisdiction. These limitations mean that only a small fraction of the total resource of pore space can be filled with CO_2. Whilst geology varies greatly between jurisdictions, the underlying physical processes that dictate how much of the total pore space is theoretically available for CO_2 storage does not. Therefore, it is possible to define a common methodology that can be used to estimate the fraction of the total resource of pore space that could be used for storage. If appropriate CO_2 densities at reservoir conditions are applied to this volume, this allows estimation of the theoretical CO_2 storage resource.

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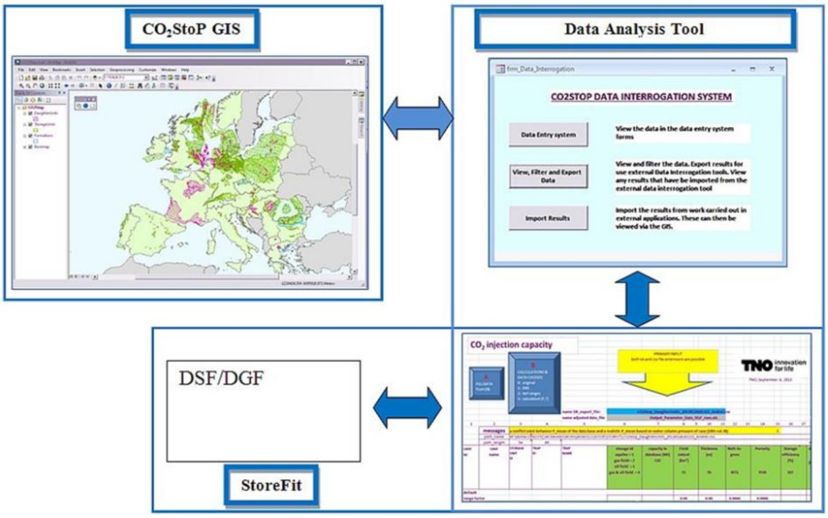
[1] Member States: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and UK.

Non Member States: FYROM, Norway, Serbia, Switzerland.

Technical, legal, economic and social constraints on CO_2 storage capacity

In practice, only a fraction of the theoretical CO_2 storage resource in any given jurisdiction can actually be utilised – for a variety of technical, economic, legal and social reasons. In the CO2StoP project, the pore space in a jurisdiction is subdivided into reservoir formations. These are mappable bodies of rock which are continuous in the subsurface and are both porous and permeable. Each reservoir formation contains one or more storage units. A storage unit is defined as a part of a reservoir formation that is at depths greater than 800 m and which is covered by an effective cap rock. These storage units are considered to have potential for CO_2 storage and they form the basis of the CO_2 storage estimates made in the CO2StoP project. Each storage unit may contain on or more daughter units. Daughter units are defined as structural or stratigraphic traps which have the potential to immobilise CO_2 within them, e.g. domes or proven oil and gas fields. Daughter units have the potential to store CO_2 at higher saturations than the remainder of a storage unit, so their storage potential can be estimated separately in CO2StoP.



Schematic representation of Database Analysis/Interrogation Tool, showing the GIS (at the top) and the StoreFit Monte Carlo analysis tool (bottom). Arrows indicate data exchange between the separate elements of the tool.

Estimating the Technically Accessible CO_2 Storage Resource (TASR)

The CO2StoP calculation engine is capable of producing a resource estimate that is very similar to the Technically Accessible CO_2 Storage Resource estimated by the US Geological Survey (Brennan *et al*., 2010), i.e. the fraction of the theoretical storage resource that can be accessed using all currently available technologies regardless of cost. The IEA has recommended that the first step in all CO_2 storage resource estimates should be to estimate the TASR (Heidug, 2013).

The CO2StoP estimate differs in one main respect from the TASR estimated by the USGS method. It adds the storage capacity of hydrocarbon fields to that of the saline aquifers. This has to be done because the pore volume of the hydrocarbon fields is not provided in the database, so it cannot be subtracted from the pore volume of the storage units before their storage capacity is estimated. There are other minor differences in the constraints and assumptions; nevertheless, it is considered that two methods produce results that are sufficiently similar to allow them to be compared.

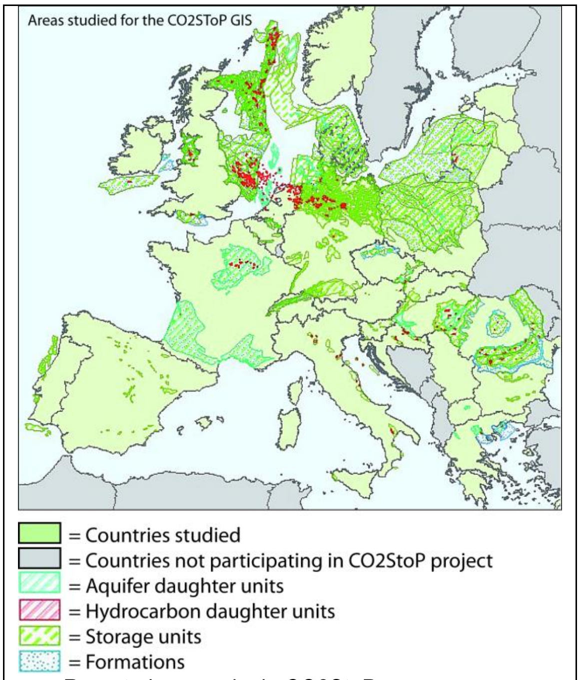
The CO2StoP methodology

The CO2StoP project provides a database, GIS (ESRI's ArcGIS 10) and calculation engine capable of providing probabilistic estimates of CO_2 storage capacity. The Data Analysis/Interrogation Tool is a combination of Microsoft Access (Data Interrogation tool), and Excel (StoreFit tool) with external code (linked to Excel) to perform injection rate calculations. Calculations that can be done with the Database Analysis/Interrogation Tool include: storage capacity, injection rates and stochastic analyses of the storage capacity and injection rates.

The work to establish internationally recognised standards for capacity assessments was initiated by the Carbon Sequestration Leadership Forum (CSLF) about a year before the start of the EU GeoCapacity project and a CSLF Task Force has been active since. The paper "Estimation of CO_2 Storage Capacity in Geological Media - Phase 2" (Bachu *et al*., 2007) published by the CSLF presents comprehensive definitions, concepts and methodologies to be used in estimating CO_2 storage capacity. As in EU GeoCapacity, the CO2StoP methodology complies with the CSLF recommendations. The methods and calculations for determining the fractions of the resource, used in the CO2Stop project, also accord with the recent IEA proposals for harmonising CO_2 storage capacity estimation methodologies (Heidug, 2013). The CO2StoP methodology can calculate the TASR and the storage resource in structural and stratigraphic traps (that latter divided into two subsets – hydrocarbon fields and aquifer daughter units), the storage resource assuming pressure management was not used.

Results

The assessment of the various fractions of the CO_2 geological storage resource, performed in the CO2StoP project, is currently at a provisional level only. Unfortunately, large differences exist between the type and quality of data each country has available. Differences also exist with regards to how much of the relevant data is in the public domain and therefore can be reported. For example, there are major variations between countries where some only have data available from traps for buoyant fluids (where the TASR will be low because potential for storage outside such traps by residual saturation will not be accounted for) and some countries which have included aquifer formation data (where the TASR calculation will be more meaningful). In the great majority of countries, uncertainties also remain related to lack of reservoir parameter data. The acquisition of such data will, potentially, require a sustained campaign of geological mapping and characterisation of storage capacity, or at least significantly more time and financial resources to assemble and enter all available data. These factors limit the results obtained from the CO2Stop project and it is recommended that further resources are targeted on improving the results. Both reporting and data could be improved if greater resources were made available.



Reported reservoirs in CO2StoP

In a European context, the Technically Accessible CO_2 Storage Resource (TASR) or theoretical storage resource should only be used for extra-European international resource comparisons because it is certain that the TASR is several times larger than the practical CO_2 storage capacity. Consequently quoting the TASR can be misleading, giving false impressions of capacity if there is not a critical distinction between resource and reserve estimates.

Conclusions

The calculations made in CO2StoP from the current project database of CO_2 storage locations throughout Europe paint a broad picture, but also identify the gaps in our knowledge. These gaps must be filled by further data entry, and, potentially, new geological studies, seismic surveys and drilling to make more precise data available.

It is critically important to understand the assumptions that lie at the basis of the storage capacity estimates entered in the database. These are especially relevant for saline formations, the capacities of which were derived without taking into account regulatory or economic limitations.

The CO2StoP methodology has made significant progress towards establishing probabilistic estimates of the CO_2 storage resource in Europe in a way that will allow comparisons with other regions of the world to be made, and which will also be useful to policy makers. However, the partial data entry into the project database does make clear that the current project marks the beginning of the process of resource estimation, and certainly not the end.

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