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OUTCOMES OF THE INTERNAL KNOWLEDGE SHARING WORKSHOP 1

"Legal and Regulatory Issues for the Implementation of the
EU Directive on the Geological Storage of CO_2"

San Servolo Island, Venice, Italy, 11th May 2011

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Organisation name of lead for this deliverable: TTU GI (Tallinna Tehnikaülikooli Geoloogia Instituut)

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Version 1

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1. Workshop report

The first CGS Europe internal knowledge sharing workshop "LEGAL AND REGULATORY ISSUES FOR THE IMPLEMENTATION OF THE EU DIRECTIVE ON THE GEOLOGICAL STORAGE OF CO2" took place in Venice, San Servolo Island, Italy, on 11th May 2011 after the 6th CO2GeoNet Open Forum. The topic of the workshop is one of the "hottest" current CCS-related themes in Europe, considering the ongoing national transposition of the CCS Directive and the deadline of 25th June 2011.

The workshop was organised by TTU GI and the Workshop Scientific Committee (Annex 1).

The detailed agenda of the workshop is given in Annex II. The workshop was organised into three sessions, all chaired by members of the Workshop Scientific Committee.

- Session 1. Legislation Process in Europe (three presentations).
- Session 2. National legislation in the CGS Europe countries, including:
  -three presentations by project partners (Session 2a),
  -two presentations by national regulatory authorities (Session 2b).
- Session 3. Open discussion "Sharing experience on the CCS Directive transposition process in Europe" initiated by five short presentations and followed by audience discussion focusing on two topics:
  -Transposition of CCS Directive: the most problematic issues (Session 3a),
  -Issues not covered (or not sufficiently) by the Directive (Session 3b).

Most of the workshop presentations are available on the public website:
http://www.co2geonet.com/NewsData.aspx?IdNews=60&ViewType=Actual&IdType=18.

Participants (see the detailed list in Annex III)
108 participants took part in the workshop from 28 countries (26 CGS Europe countries and 2 other – Japan and USA):
Italy – 21, UK – 14, France – 11, Germany – 7, Belgium – 6, Turkey – 6, Norway – 5, Poland – 5 , The Netherlands – 4, Finland – 4, Spain – 3, Austria – 2, Croatia – 2 , Denmark – 2, Greece – 2, Hungary – 2 , Lithuania – 2, Slovenia – 2, Bulgaria – 1 , Czech Republic – 1, Estonia – 1, Ireland – 1, Japan – 1, Portugal – 1, Romania – 1, Slovakia – 1, Sweden 1, and USA – 1.

Detailed summaries of the presentations and open discussions are given according to the agenda in Annex III.

Workshop Conclusions:

- Status, progress and problems in CCS directive transposition were monitored in all CGS Europe partner countries at two intervals (end of January 2011 and end of April 2011) and the results were reported at the workshop as original project study.
- Most of the CGS Europe partner countries are moving towards the transposition of CCS Directive and implementation of CCS technology, and made significant progress since the beginning of the project.
- Many project partner institutions participate in the preparation of CCS laws, guidelines or decrees, or at least in consulting their national authorities.

- Partners have common interests, several common, but also specific problems, which could be solved step by step.
- All countries need more communication between geologists and lawyers at national and EC levels.
- Partners need to share their experience with each other, and to share their knowledge with the public and stakeholders.
- Some of the project partner countries have not yet started transposition of the CCS Directive and some are planning to forbid CO_2 storage within their territories due to various, often strong, reasons.
- We believe that the CGS Europe project, supported by the EC, will help start the transposition process and reach positive results in CCS, either nationally or through international cooperation.

Annex I – Workshop Scientific Committee

Alla Shogenova (TTU GI, Estonia)
Kris Piessens (RBINS-GSB, Belgium)
Hubert Fabriol (BRGM, France)
Adam Wojcicki (PGI-NRI, Poland)
Isabel Suarez Diaz/Roberto Martinez (IGME, Spain)
George Hatziyannis (IGME, Greece)
Sergio Persoglia (OGS, Italy)

Annex II - Workshop agenda

Wednesday May 11, 2011

1st CGS EUROPE KNOWLEDGE SHARING WORKSHOP

LEGAL AND REGULATORY ISSUES FOR THE IMPLEMENTATION OF THE EU DIRECTIVE ON THE GEOLOGICAL STORAGE OF CO_2

Session 1. Legislation Process in Europe
Chair: Roberto Martinez, S-IGME

9.00 **Introduction**
Alla Shogenova, TTU GI

9.10 **Overview of the national CCS regulatory developments in the CGS Europe countries: progress and problems**
Alla Shogenova, TTU GI

9.40 **Carbon capture and storage regulatory test toolkit**
Derek Taylor, Global CCS Institute

10.10 **Public information issues related to the legislation process**
Samuela Vercelli, CO_2GeoNet-URS

10.20 Coffee break

Session 2a. National legislation in the CGS Europe countries: case studies
Chair: Adam Wojcicki, PGI-NRI

10.50 **Geological Carbon Storage: towards a Danish implementation plan**
Niels E.Poulsen, CO_2GeoNet-GEUS

11.15 **Implementation of the CCS directive when geological storage options do not exist: two case studies from Belgium**
Kris Piessens & Wouter Stroobants, RBINS-GSB

11.40 **Implementation of the CO_2 Geological Storage Directive in Hungary: experiences, problems and their solutions in a new EU country**
Gyorgy Falus, ELGI

12.05 Lunch

Session 2b. National legislation in the CGS Europe countries: case studies
Chair: Hubert Fabriol, CO2GeoNet-BRGM

13.30 **EC Directive on CCS: roadmap for its implementation in Italy**
Marcello Capra, Ministry of Economic Development, Italy

13.50 **Practical experience in transposing the 2009/31/EC directive: The French case**

Lionel Perrette, Directorate General for Energy and Climate, French Ministry of Ecology

Session 3. Open discussion – Sharing experience on the CCS Directive transposition process in Europe
Chair: Kris Piessens & Wouter Stroobants, RBINS-GSB

Session 3a. Transposition of the CCS Directive: the most problematic issues

14.10 **Assessment of storage capacity: organization and standardization**
Niels E.Poulsen, CO_2GeoNet-GEUS

14.30 **Conflicts of interests/interaction with other underground use**
Adam Wojcicki, PGI-NRI

14.50 **Monitoring issues**
Ananth Chikkatur, ICF International

15.10 Coffee break

Session 3b. Issues not covered by the CCS Directive:
Chair: Alla Shogenova, TTU GI

15.40 **Cross-border transport and storage**
Tuija Vähäkuopus,GTK

16.00 **Competent Authority: are they ready to evaluate applications?**
Kris Piessens, RBINS-GSB

16.20-17.00 Conclusions and Summary
Workshop Scientific Committee: Alla Shogenova (TTU GI), Kris Piessens (RBINS-GSB), Hubert Fabriol (CO_2GeoNet-BRGM), Adam Wojcicki (PGI-NRI), Roberto Martinez (S-IGME), George Hatziyannis (G-IGME), Sergio Persoglia (CO_2GeoNet-OGS)

Annex III – Summaries of Workshop Presentations and Open Discussion

Session 1. Legislation Process in Europe

Overview of the national CCS regulatory developments in the CGS Europe countries: progress and problems

Alla Shogenova, Institute of Geology, Tallinn University of Technology, alla@gi.ee

Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide was published on 5 June 2009, and entered into force on **25 June 2009**. This directive established a legal framework for the environmentally safe geological storage of carbon dioxide (CO_2) to contribute to the fight against climate change. In article 39 "Transposition and transitional measures" it is stated that "Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by **25 June 2011**", that they "shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive" and they "shall ensure" that the storage sites "are operated in accordance with the requirements of this Directive by **25 June 2012**" [1].

Status, progress and problems in CCS directive transposition process were monitored in all CGS Europe project countries in the end of January and end of April 2011. Data were collected using questionnaires compiled by the Workshop Scientific Committee (Alla Shogenova (TTU GI, Estonia), Kris Piessens (RBINS-GSB, Belgium), Hubert Fabriol (BRGM, France), Adam Wojcicki (PGI-NRI, Poland), Isabel Suarez Diaz (IGME, Spain), George Hatziyannis (IGME, Greece) and Sergio Persoglia (OGS, Italy)). 30 institutions from 28 European countries (including 7 CO_2GeoNet partners), participating in CGS Europe project, took part in the study. Information for Switzerland and Iceland (not CGS Europe participants) were taken from published sources [2, 3]. Altogether 30 European countries were covered.

At present, the status of transposition of the CCS Directive in the European countries differs considerably, often complicated by different situations (political, national, economic, geology, etc.) and public awareness and acceptance of CCS being absent (or almost).

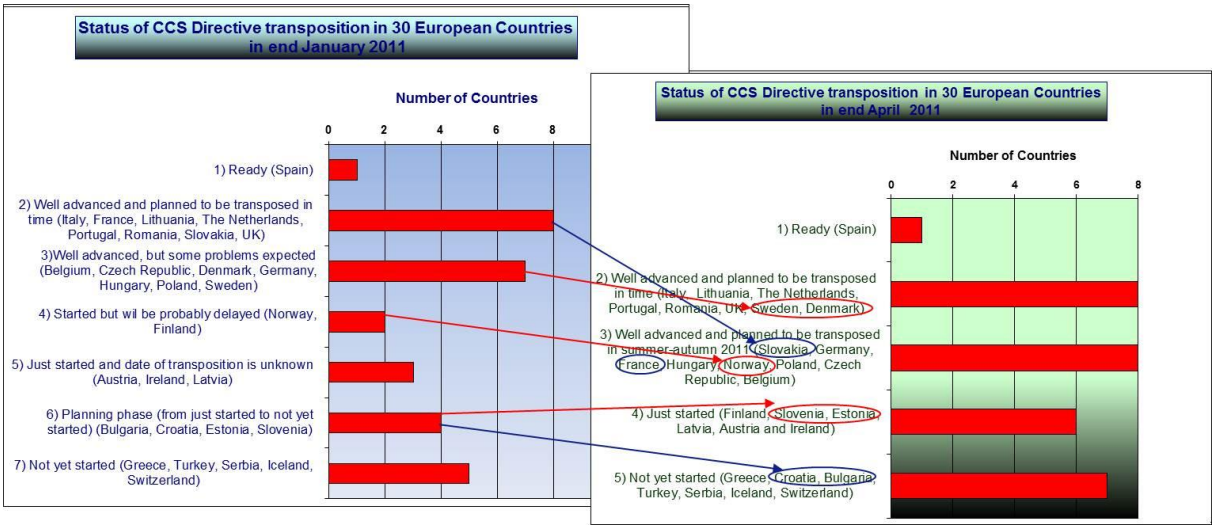

Figure 1. Status of CCS Directive transposition in 30 European countries at end January 2011 (left) and end April 2011 (right).

Only Spain reported the status of CCS Directive transposition as "ready" (the law has been already published by the Official State Bulletin on December 29th 2010). Both in end January and end April 2011 the status was "well advanced and planned to be transposed in

time" in Italy, Lithuania, The Netherlands, Portugal, Romania and UK. In January, France and Slovakia were also in this group, while Sweden and Denmark joined this status in April. Seven countries (Belgium, Czech Republic, Denmark, Germany, Hungary, Poland and Sweden) reported in January their status as "well advanced, but some problems expected". Five countries from this group are still "well advanced" and "planned to be transposed in summer-autumn 2011" – group (3) in April, when Slovakia, France and Norway also joined this status. In January, four countries had uncertain status "planning phase (from just started to not yet started)", while in April, the status of these countries became more certain. Estonia and Slovenia moved to the status "just started", also reported in April by Finland, Latvia, Austria and Ireland. Another two countries, Croatia and Bulgaria, joined in April the status "not yet started", also reported by Turkey and Serbia, and applicable to Iceland and Switzerland (the last two are not CGS Europe participants) (Fig.1).

The process of CCS Directive transposition was evaluated as "successful" by 10 countries (Italy, Spain, Denmark, UK, Lithuania, Portugal, Romania, Slovakia, The Netherlands and ¼ of Belgium (successful only in the Flemish Region)); "fair" in 6 countries (France, Sweden, Hungary, Norway, Finland and Ireland) and "problematic" in 7 countries (Czech Republic, Germany, Belgium (3/4), Poland, Estonia, Latvia and Slovenia, Fig.2). Among the common national problems reported, the most frequent were (1) CCS is not a part of the official national policy (Denmark, Slovenia, Sweden, Latvia and Estonia), (2) public acceptance being absent (Denmark, Germany, Poland and Sweden), (3) on-going public and political debates (Germany, Poland, Czech Republic and Latvia), (4) probable insufficient storage capacity (Czech Republic), or absent storage capacity (Estonia, Finland, Belgium (2/4)), (5) financial matters (Czech Republic, Latvia and Estonia) (6) complexity in competent authorities because of the complexity of the country, or different situations in the different regions (Spain and Belgium), (7) translation problems (Spain, Lithuania and Hungary), (8) cross-border storage and transport and mineral carbonation are not described (or sufficiently) in the CCS Directive, or guidance documents (Estonia and Finland). Only two specific national problems are reported (change of ministerial structure after elections in Hungary, and Russian Territory in the Baltic Sea next to Swedish territory in connection to potential storage).

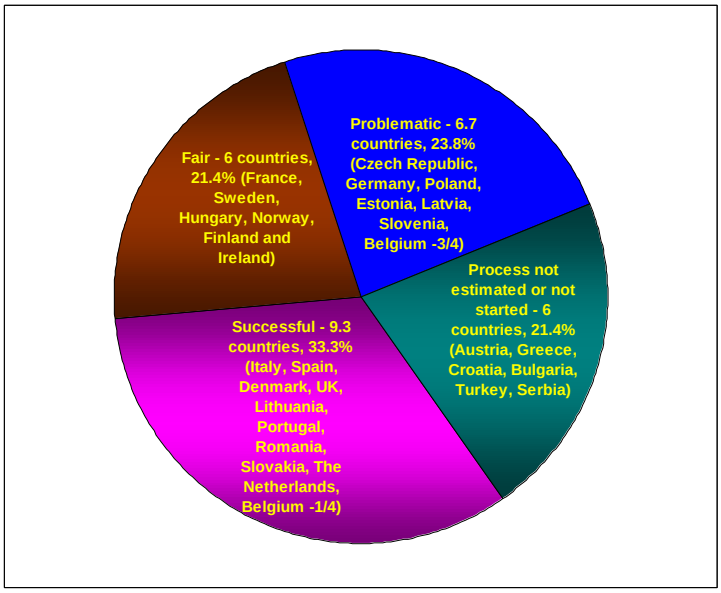

Figure 2. Evaluation of the CCS Directive transposition process in 28 CGS Europe project countries.

Some countries are going to forbid CO_2 storage for various reasons (Estonia, Sweden onshore, Belgium in two regions and offshore – explained by absent storage capacity). Latvia is discussing now to forbid fully or partially, giving priority to natural gas storage and geothermal resources. The Climate and Energy Minister of Denmark decided to postpone onshore storage until 2020, but to start with EOR offshore, in the North Sea, explained by absent public acceptance. Finnish energy company Fortum Oyj stopped the Finncap carbon capture and storage (CCS) project in autumn 2010, due to the technological and financial risk

(the project was not able to get national funding from Finland). The German government has agreed upon a draft CCS law (which has to pass Parliament), while some of the Federal states can forbid storage within their territories.

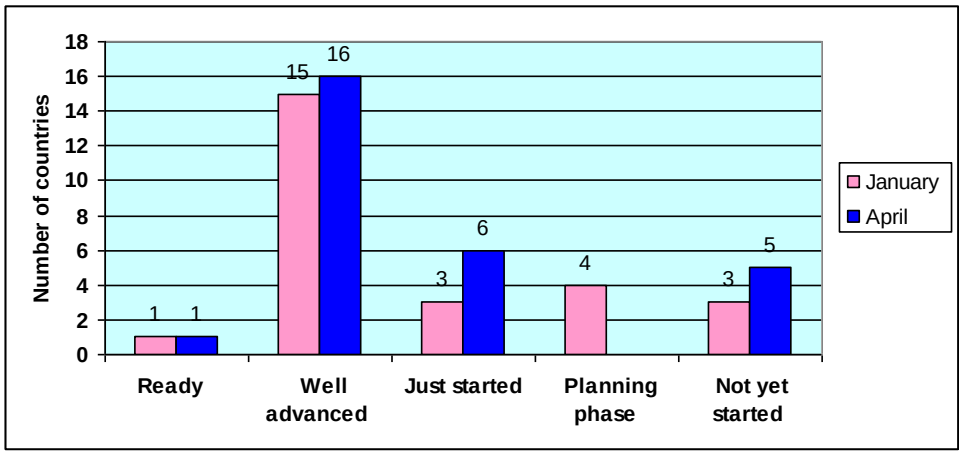

Figure 3. Progress in the CCS Directive transposition process during 3 months (end January - end April 2011) in 28 CGS Europe countries.

From end January to end April 2011, progress was observed in the CCS Directive transposition process in CGS Europe project countries, resulting in 16 "well-advanced" and 6 "just started" countries in April compared to respectively 15 and 3 countries in these status in January (Fig.3). Unfortunately some countries, planned in January to transpose the Directive in time, or to start the transposition process, reported in April that they would be able to finish transposition later, or respectively that they had not yet started the process.

Conclusions

- Among the 30 European countries included in this study, 17 (56.7%) are "well advanced" in CCS regulations (ready or will be transposed during this year), 6 (20%) have already started the transposition process, and only 7 (23.3%) have not yet started.
- Among the 28 CGS Europe project countries, 55% estimated the transposition process as "successful" and "fair", 24% as "problematic" and 21.4% could not estimate the process (1 country) or have not started (5 countries).
- All countries with on-going and planned CCS demo and industrial projects reported the transposition process as "successful" and "fair".
- At least 6 countries reported that CCS storage could be prohibited at their territories (either onshore or offshore) nationally, or by regional governments, due to various reasons (including absent storage capacity, public acceptance and conflict with other use).
- In most countries, the guidelines to laws in CCS are not yet written or prepared, and only 6 countries have reported already proposed guidelines.
- A lot of work remains to be done in all countries by regulators, stakeholders and researchers.

References

[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 (1). Official Journal of the European Union 2009; L140:114-35.
[2] Carbon Capture and Storage. Legal and Regulatory Review (Edition 1). 2010. IEA Report, 61 p.
[3] S. Teir, et al. 2010. Potential for Carbon capture and storage (CCS) in the Nordic Region. VTT, Helsinki, 188 p.+ app.28 p.

CCS Regulatory test toolkit

Presented by Derek Taylor, Global CCS Institute, France,
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Executive Summary

Large point sources of carbon dioxide are responsible for a significant proportion of the world's greenhouse gas emissions – with fossil fuel power stations and other large-scale industrial activities responsible for around half of the total. Carbon Capture and Storage (CCS) is expected to make a major contribution to reducing these emissions.

Few CCS projects currently exist in the world – and a lack of experience in regulatory agencies and commercial entities of how regulatory systems would apply to such projects increases risk – potentially leading to delays and increased costs for emerging CCS projects.

This toolkit has been produced by Scottish Carbon Capture and Storage (SCCS) researchers on behalf of the Scottish Government and sponsored by the Global CCS Institute. It guides users through a regulatory test exercise, which provides a low-cost, low-risk approach to testing regional and national legislation and regulatory systems for CCS projects, and gaining the benefits in follow-up activities.

The toolkit recommends use of a real or simulated CCS project as part of this exercise to assist government agencies and other stakeholders to work together to test and improve understanding of regulatory systems. It explains how a simulated or real CCS project can be taken through the regulatory process from inception to decommissioning – a test of the regulatory process at much lower cost, time and risk than would be incurred under a real project application.

Implementing this toolkit will assist users to:

- improve understanding of their local regulatory process
- the permits and consents necessary for a CCS project
- the information required
- the likely timescales for planning and approval
- the organisations that need to be involved
- identify gaps, contradictions, and potential revisions to regulatory systems
- identify gaps in skills, knowledge and resources
- ensure a viable regulatory process is in place for potential CCS projects
- help to speed up the management of projects to meet demanding timescales for funding
- raise awareness amongst the key stakeholders of their role in the regulatory process

The test exercise seeks to be realistic and to maximise learning opportunities, by involving the actual organisations and people that would be involved in effective handling of a CCS project. The exercise should be led by a government body with the intensive involvement of relevant regulatory agencies. Other stakeholders to involve will include commercial organisations, NGOs, and advisory bodies in the context of regional, national, or cross-jurisdictional project planning.

By working together towards a common vision, and ensuring strong participation and input by key stakeholders, this toolkit will assist users to run a successful regulatory test exercise, identify follow-up actions, and gain the benefits sought.

This exercise will inform government policy and developing CCS regulatory frameworks. Additionally, it should reduce the regulatory risk to CCS project developers – accelerating the

consenting process and reducing the burden to all participants involved in that process – as well as ensuring an appropriate balance with other policy objectives.

Acknowledgements

This toolkit was researched and written by Benjamin Evar and Hannah Chalmers from the University of Edinburgh's SCCS research group, and Richard Bellingham from the University of Strathclyde.

The research and writing team would like to thank the following individuals (key organisers, workshop facilitators and reviewers for a Scottish CCS regulatory test exercise in 2010, see Appendix F) for their contributions, including in interviews:

- Professor Russel Griggs, Scottish Government Regulatory Review Group;
- Meade Harris, Global CCS Institute;
- Eric Drosin, EU Zero Emissions Platform;
- Carolyn Vannan, Scottish Environment Protection Agency;
- Ross Loveridge, Scottish Government;
- Howard Steele, Scottish Government;
- Derek Saward, UK Department of Energy and Climate Change; and
- John Arnott, UK Department of Energy and Climate Change.

Additionally, a substantial amount of background documentation and feedback from the Scottish 2010 CCS regulatory workshop event was made available by the Scottish Government.

The authors gratefully acknowledge comments received on earlier versions of this document from a number of expert reviewers. They are, however, entirely responsible for its content.

In no event will the Scottish Carbon Capture and Storage, the Global CCS Institute or the Scottish Government be liable for any consequences or unintended implications resulting from the use of this toolkit.

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Public information issues related to the legislation process

Samuela Vercelli, University of Rome "La Sapienza"-CERI, Samuela.vercelli@uniroma1.it

The legislation process, which extends from the EU Directive to national legislation down to specific agreements at local level, consists of a number of steps that, one after the other, create the legal conditions for CO_2 storage to actually happen. The sequence and characteristics of these steps will influence and affect the final result. Public information is part of this legislation process and the final outcome of the process will be influenced by the way public information has been considered all along the line.

Public information issues related to carbon capture and storage (CCS) legislation concern both the legislation process and the content of the new regulatory framework. The legislation process, at this stage, involves first of all the transposition of the European Directive on the geological storage of CO_2; in addition and in some countries, a number of other regulations might need to be updated and coordinated with the regulations on CO_2 storage. First of all, we have to consider that the public will probably not be aware of these processes going on: it is nevertheless relevant that, when requested, access is given to the history and roll out of the legislation process, from the very beginning, in this case at European level, with changes to international regulatory frameworks to enable CCS, to the drafting of the Directive, then its release, to the assistance for its transposition at national level, etc. An understanding of how the regulations have been or are being developed can also help approach their actual content. In relation to content, it will be important to support the explanation of those implications that are behind the single legislation decisions and requirements, especially highlighting how the law guarantees public health and safety. Informing the public on the legislation process and its content is of the utmost importance, since the public is the main stakeholder who will influence the applicability of the technology. It is well known that a good regulatory framework not only facilitates the developers of the technology, but it also generates trust in the population that feels protected with regard to possible adverse outcomes of the technology itself. Therefore, the sooner public information takes place, the better. First of all, this will help making the whole process clear and transparent. Secondly, it will provide ample opportunities of participation and input to the legislation process, especially through civil society organisation that might have a general or more specific interest. The contribution from civil society cannot be underestimated, since people with a high level of expertise often lose sight of relevant problems that, on the contrary, can appear quite evident to lay people. Direct involvement of the public, in whatever form, is also highly desirable for receiving feedback on how to improve information activities. In general, it has to be remembered that all issues most important for the public, such as fairness of decisions, reliability, honest and balanced consideration of the different interests and perspectives, can be better addressed when the public perspective is taken into account from the beginning or at least as soon as possible.

Important documents which could form the basis for public information on CO_2 geological storage regulation:

- The European Directive
- The EC Guidance Documents on the Directive

- GCCSI and Scottish Government Regulatory toolkit
- National transpositions or drafts for transposition

The situation with CCS:

Some of the key issues that might be of interest for the public are those related to 1) permits; 2) monitoring; 3) transfer of responsibility. In general, both public information and public awareness about CCS are low. Although the capture technology and research on geological storage have been going on for a number of years, this has been with minimal input from civil society. This means we have a "fragile" process, since it is the expression of a top layer of society in the absence of awareness on the part of the majority of society. Therefore, regulators should be even more careful in considering public interest when creating new legislation. This would also ease any potential public information issue. Given this situation, those countries, like Germany, who are currently facing conflict over the implementation of CCS, might be better placed than those countries where no exchange is taking place. Debate at social level gives more solid foundations to the legislation, once it is adopted.

Conclusions:

- Pay attention to the process as a whole: public information on CO_2 storage regulation needs to incorporate public perspectives, public interest and should be a clear top priority for all involved.
- Awareness of fragility: the information gap calls for an increase of exchange opportunities on the legislation process and outcomes, improvement is always possible.

Figure 1. One of CO_2GeoNet's Dialogue sessions at the 2008 European Science Open Forum in Barcelona, Spain. This was an interesting opportunity to gain insight into people's perspectives and to introduce CO_2 geological storage. The topic was new to the great majority of participants, including teachers and journalists and, by providing explanations with the help of posters, we even managed to overcome the language barrier!

Session 2a.

National legislation in the CGS Europe countries: case studies

Geological carbon storage: towards a Danish implementation plan

Niels E. Poulsen, Geological Survey of Denmark and Greenland, GEUS, nep@geus.dk

The existing Danish Subsoil Act addresses the use of the subsoil. The first Subsoil Act was adopted in 1932 and has been amended several times since. The Subsoil Act lays down the basic framework for petroleum exploration and recovery. The Act is formulated as a 'general terms act' allowing for adaptations and more detailed regulations. It regulates exploitation and recovery activities in the Danish subsoil and the Danish Continental Shelf concerning minerals, and specifically hydrocarbons. The Act covers: Prospecting, exploration for and recovery of raw materials, and hydrocarbons in particular, government rights for purchasing liquid hydrocarbons, other manners of exploration, supervision and other provision. The Danish subsoil is used for more than just the production of oil and gas. The subsoil is used to extract salt and geothermal heat and to store natural gas.

The Danish parliament has May 25th 2011 implemented the storage directive (Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide was published on 5 June 2009) into Danish legislation. The implementation was made by an amendment of the Danish Subsoil Act, which was amended at several points. It implements the EU directive on geological storage of CO_2, exploration for and production of geothermal power, injunction third party access to facilities for extraction, processing and transportation of oil and gas, etc. It also introduces the power to refuse considering unsolicited applications for permission to explore and produce raw materials. This gives Denmark the opportunity to prioritize the use of subsoil and revises rules on injunction coordinated to extract and exploit infrastructure to extend the life of existing fields and to ensure production from new and marginal fields.

The amendment of the Danish Subsoil Act was brought in the Parliament on February 9th 2011, the 1st treatment in Parliament was on the Feb. 25th 2011 and the 2nd treatment was on May 5th and the 3rd and final treatment in Parliament is scheduled for May 24th 2011, where the Subsoil Act passed the division in the Parliament with 110 vote in favour to 0 votes against and 69 left blank.

During the preparation of the act, the local Non-Governmental organisation "Foreningen Nej til CO_2 Lagring" (Association No to CO_2 storage), an organization, that is clearly and unequivocally opposed to CCS. Their position seems to be non-negotiable. They have described unrealistic CO_2 leakage as bombs and geological models.

Their website represents their position to prevent all feasibility studies and possible storage of CO_2 in the geological Vedsted structure, Northern Jutland. The storage project is based on Vattenfall's plan for a full CCS demonstration plant in Denmark on Nordjylland Power Station.

Their protest was heard in the Parliament and subsequent the Minister of Climate and Energy Lykke Friis decided to dropped plans for CO_2 storage at Vedsted with the decision, that Denmark should not implement CO_2 storage onshore in the foreseeable future. The decision can be reconsidered in 2020, when there is more experience in other countries with onshore storage.

It is the energy company Vattenfall, which for years has worked towards establishing a CO_2 storage underground in parts of Northern Jutland (Vedsted project), but the minister calls to a halt for the project now.

The minister believes that interest must now unite for CO_2 storage under the seabed (off shore). According to the minister, the technology is here more thoroughly tested.

The Danish company Maersk Oil and its partners want to get started with a project, where CO_2 will be used for EOR (Enhanced Oil Recovery) in the North Sea. The project will be implemented around 2015, according to the minister.

Implementation of the CCS directive when geological storage options do not exist: two case studies for Belgium

Kris Piessens[1] & Wouter Stroobants[2]

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[2] Flemish Government, Department of Environment, Nature and Energy, Wouter.Stroobants@LNE.vlaanderen.be

Introduction

Belgium is a federal state with competences distributed between the federal government, the regional and the community governments. While onshore storage of CO_2 is a competence of the three regions (the Brussels-Capital Region, the Flemish Region and the Walloon Region), offshore storage of CO_2 is a competence of the federal government.

The CCS directive (European Parliament and Council of the European Union 2009) is therefore being transposed four times in Belgium, which leads to some interesting case studies, two of which form the topic of this short communication. It is the intention of both the Brussels-Capital Region and the Federal State (for offshore storage) to demonstrate that no storage options exist in their territory. As a result, the transposition of the directive would be reduced to those articles not directly related to storage.

The intention of this publication is to share the experiences in Belgium with the international community, and explicitly not to provide a strategy to avoid transposition of this or any other directive. Our conclusion is rather the contrary: if a member state wishes to prove the lack of storage capacity in its territory, the argumentation needs to show that its geology rules out any current or future capacity for storing CO_2. This argumentation is usually very complex, even for regions or member states for which this conclusion seems straightforward at first. The line of reasoning leading to the conclusion that no storage is feasible in the Brussels-Capital Region or in offshore Belgium has not yet been commented on by the European Commission.

Options for geological storage of CO_2 in Belgium

Belgium was one of the first countries worldwide for which a detailed geological map became available. The deeper subsurface of Belgium however remains relatively poorly explored compared to countries that have oil and gas reserves. The Belgian CO_2 storage potential is therefore a theoretical potential, and includes several aquifers and coal related storage options. Both are located in sedimentary basins which are located in the Flemish Region and in the Walloon Region. Based on these numbers, the practical storage potential of Belgium is estimated at around 625Mt with a 95% uncertainty range of 150 to 1400Mt (Piessens 2011). The deeper subsurface of the Brussels-Capital Region and of offshore Belgium is composed of Lower Palaeozoic rocks of Cambrian to Silurian age. These rocks are commonly not

believed to possess any reservoir properties that would allow for geological storage of CO_2, and are therefore not included in the national inventory (Welkenhuysen et al. 2011).

Legal context

To find out under which circumstances a member state is released from its obligation to transpose a directive, it is necessary to look into the case law of the European Court of Justice.

The European Court of Justice has stated repeatedly (e.g. C-339/87, C-214/98, C-372/00, C-441/00, C-343/08) that the mere fact that an activity which is regulated by a directive does not (yet) exist in a member state cannot release that member state from its obligation to transpose this directive. Therefore, a political decision by a member state not to allow CO_2 storage in its territory, does not release that member state from its obligation to fully transpose the CCS Directive. According to the case law of the European Court of Justice, the sole exception to the obligation to transpose a directive is when the transposition of a directive is pointless, for reasons of geography (see C-420/85). Only when a member state can prove that it has absolutely no CO_2 storage capacity whatsoever in its territory, can it be partly released from its obligation to transpose the CCS Directive. If a member state can prove the total absence of geological storage capacity in its territory, only the provisions of the directive not directly related to storage need to be transposed.

General approach

The CCS directive (European Parliament and Council of the European Union 2009) describes the purpose of geological storage of CO_2 in article 1, paragraph 2 using words such as *permanent, environmentally safe, elimination...of risk to the environment and human health*. Article 4, paragraph 4 more specifically describes the minimum requirements of a storage site, specifying that there should be no significant risk of leakage, nor any significant risk to the environment and human health.

- Article 1, paragraph 2: *The purpose of environmentally safe geological storage of CO_2 is permanent containment of CO_2 in such a way as to prevent and, where this is not possible, eliminate as far as possible negative effects and any risk to the environment and human health.*
- Article 4, paragraph 4: *A geological formation shall only be selected as a storage site, if under the proposed conditions of use there is no significant risk of leakage, and if no significant environmental or health risks exist.*

A case could in principle be built by proving that storage in a member state would unavoidably lead to risks for the environment and human health. However, such risks would already implicate the escape or release of CO_2 into the biosphere. Therefore, the most direct approach is to prove instead that the requirements of *'permanent containment'* and *'no significant risk of leakage'* are not fulfilled. This also limits the discussion to a geological and geotechnical evaluation of the situation, which as such aligns better with the 'geographical' argumentation that was accepted by the European Court of Justice (C-420/85).

Transposition of the CCS directive can only be limited to certain articles if no geological storage opportunities exist. This means that economic arguments (expenses, risks, low

injection rates...) can not be used. Furthermore, not only the commonly cited storage options should be evaluated, but also the conceptual ones of which the viability is yet to be proven. The shortened discussion below is limited to aquifers, but following options were also explicitly studied and rejected in the Brussels-Capital Region and offshore Belgium: active and abandoned hydrocarbon fields, unmined coal, coal mines, salt caverns, mines or engineered solutions, mineral sequestration and clathrate storage.

Case studies for Belgium

The case studies below attempt to highlight some of the main elements of the lines of reasoning that would lead to the conclusion that the Brussels-Capital Region and offshore Belgium lack geological storage capacity for CO_2. This is a very condensed and necessarily incomplete overview, and should therefore not be used as the basis for any discussion.

Case study 1: Brussels-Capital Region

The Brussels-Capital Region comprises a small area (162km²) and is considered to be a relatively well explored part of Belgium, although no deep drillings (over 200m) are available and the subsurface is seismically transparent in the depth-range of interest. The geology relevant for CO_2 geological storage is relatively uniform. The subsurface is formed by a Lower Cambrian succession of mainly sedimentary and relatively intensively deformed rocks characterised by anchizone to epizone metamorphism. The stratification is steeply dipping (60° to slightly overturned) over the whole area and the turbidite succession regularly contains permeable intercalations. Given this configuration, injected CO_2 would migrate relatively quickly in an upwards direction and leak out of the storage complex.

Case study 2: Offshore Belgium

The offshore part of Belgium resides under federal jurisdiction. It comprises the Belgian continental shelf and its exclusive economic zone, and has a total surface of 3454km². The Lower Palaeozoic basement, evaluated for the Brussels-Capital Region, also forms the deeper subsurface of offshore Belgium. The geology is however not uniform, and several settings need to be considered in terms of differences in structure, lithology, metamorphic grade, etc. Also the reliability of data and the extrapolation of information and concepts is a considerable burden in the evaluation, and leads to a discussion that is not absolute, but probabilistic. The detailed discussion on each of the geological settings concludes that geological storage of CO_2 anywhere in offshore Belgium is not a realistic option, either because of the absence of a trapping configuration or because of the reservoir itself.

Discussion and conclusion

In Belgium, the CCS directive, at least the part relevant to CO_2 storage, needs to be transposed separately for the three Belgian regions and the offshore territory. Potential storage options identified in national studies are not located in the Brussels-Capital Region or offshore Belgium. However, disproving that storage options exists requires an in-depth analysis of the geology for all potential storage techniques.

For the Brussels-Capital Region this was done in a relatively straightforward way. This was possible because of the uniformity of the geology over this small area, in which the structure

of the deep underground favours rapid vertical migration and leakage of CO_2, which is clearly incompatibility with the concept of permanent containment.

The area of offshore Belgium is, although much smaller than in most countries, still large enough to cover different geological settings. Each of these needs to be evaluated in detail. Also the low data density is a complicating factor in the argumentation. It is actually remarkable how just a few complications inevitably seem to result in a cumbersome argumentation, even when the case for non-storage a priori seems easy and clear-cut.

Apparently, putting down geology into words is a hard task when absolute conclusions are intended. Proving that no storage options exist is certainly not an 'easy' alternative for transposition of the whole directive. It is doubtful whether it is feasible for larger countries or small countries with a complex geology.

References

European Parliament, and Council of the European Union. 2009. *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*. April 23.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF.

Piessens, K. 2011. Quantifying the CO_2 storage potential in Belgium: Working with theoretical capacities. In *Energy Procedia*, 8. Amsterdam, The Netherlands. www.ghgt.info/index.php/Content-GHGT10/conference-proceedings.html.

Welkenhuysen, K., K. Piessens, J.-M. Baele, B. Laenen, and M. Dusar. 2011. CO_2 storage opportunities in Belgium. In *Energy Procedia*, 8. Amsterdam, The Netherlands. www.ghgt.info/index.php/Content-GHGT10/conference-proceedings.html.

Implementation of the CO_2 Geological Storage Directive in Hungary: experiences, problems and their solutions in a 'new' EU country

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The Directive on the Geological Storage of Carbon Dioxide (2009/31/EC) of the European Parliament and of the Council (CCS Directive) was published on 5th June 2009 in the Official Journal of the EU, and entered into force on 25th June 2009. This Directive, in close interrelation with the ETS Directive (2009/28/EC), established a legal and financial framework for the environmentally safe geological storage of carbon dioxide (CO_2), hence the application of the CCS technology value chain to contribute to the fight against climate change. Pursuant to article 39, Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 25th June 2011.

The following paper summarizes the agenda, obstacles and their solutions to transpose and implement the CCS Directive in Hungary, a 'follower' country in adaptation of the CCS-concept.

At present, the situation with transposition of the CCS Directive is at an advanced stage in Hungary. The inter-service (intra-governmental) consultation is currently taking place, which was preceded by professional stakeholders' consultation. The harmonization of the Directive will be most likely realized in a single executive decree pursuant to the Mining Law that was modified recently (25th March 2011) in accordance with the transposition procedure. The implementation of the Directive in the national legislation is expected to be on time. The competent licensing and supervisory authority will be the Hungarian Office for Mining and Geology.

The transposition process, however, took a slow start in 2009. A long debate had taken place between the former Ministry of Environment and Water and the Ministry of Transport, Communication and Energy about the roles in the implementation process. Nevertheless, following the national elections in 2010, the Governmental structure was fundamentally reorganized. Consequently, climate and energy issues were embodied under the State Secretary for Climate and Energy Affairs within the Ministry of National Development.

A further legal discussion concerning exploration licences has also delayed the transposition of the Directive. Since 1998, until the fall of 2010, exploration licences were awarded on a first-come-first-served basis, the so-called liberalized approach. However, in 2010, this approach was reconditioned to a concession tender type of exploration license awarding procedure. The changes in the process were published in the Official Journal of the European Commission [1]. The following text is a brief section of the revised awarding procedure from the OJ (2011/C 124/11):

"The Hungarian Office for Mining and Geology...classified the entire territory of Hungary as a closed area with regard to hydrocarbons, **carbon dioxide**, coal-bed methane, hard coal and ores (including bauxite)..."

The publication of the above statement enabled the acceleration of the transposition procedures as no further legal obstacles remained. Furthermore, the inclusion of carbon dioxide in the decision indicates the significance of carbon geological storage as a future process, seen by the Hungarian Office for Mining and Geology.

The transposition of the procedure was actively consulted with the Eotvos Lorand Geophysical Institute of Hungary. The regular discussions started already from the professional Hungarian translation of the Directive and has been continuous since.

Conclusions

- Hungary is well advanced and is expected to transpose the Carbon Geological Storage Directive in time.
- Most of the legislation will be concentrated in a single executive decree that is currently under inter-service consultation. A public consultation will follow.
- The acceleration of the transposition procedure in Hungary was related to the establishment of The Secretary of State for Climate and Energy Affairs within the Ministry of National Development.
- Excellent cooperation has been going on between the Hungarian Office for Mining and Geology and the Eotvos Lorand Geophysical Institute during the whole transposition procedure.

References

[1] Notification by the Hungarian Government under Directive 94/22/EC of the European Parliament and of the Council on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons. (2011/C 124/11).

Session 2b.

National legislation in the CGS Europe countries: case studies

EC Directive on CCS: roadmap for its implementation in Italy

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(Presented and summarized by Sergio Persoglia, OGS)

The application in Italy of the Directive 2009/31/EC on the geological storage of carbon dioxide is an important component of a wider strategy to reduce CO_2 emissions. Such a strategy implies:

- ➢ to reduce carbon intensity
- renewables
- fuel switching
- ➢ to improve efficiency
- demand side
- supply side
- ➢ to sequester carbon dioxide
- capture and storage (CCS)
- enhance natural sinks.

In the short term, the goal is to keep the existing fleet in service by switching from oil to coal and by reducing carbon intensity and pollutants; in the longer term, the transition to near-zero emissions may be reached by adopting advanced materials, ultra-high efficiency systems and CCS.

In Italy, the Ministry of Economic Development and the Ministry of Environment are in charge of the CCS Directive implementation procedure.

The figure here below summarizes the status and timing of such implementation.

The main provisions are related to: analysis of the storage site potential in the national territory and development of an associated database; a licensing process through a comprehensive approval procedure for storage permit conditions; obligations for operators of CCS storage sites; liabilities during injection, after decommissioning and up to the transfer of responsibility; conditions for decommissioning and long-term monitoring; condition for transfer of responsibilities from operator to State; modification of existing regulatory framework for Environmental Impact Assessment.

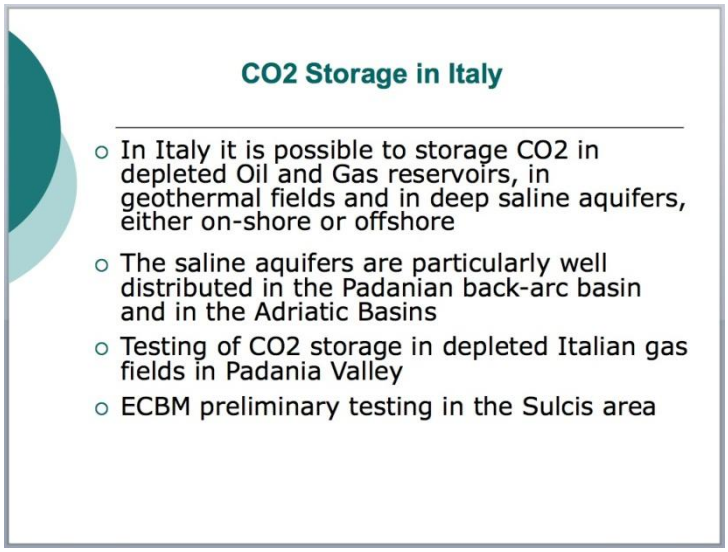
The draft CCS law foresees that a CO_2 storage site can be closed after authorization from the Ministry of Economic development in partnership with the Ministry of the Environment if the conditions set out in the authorization as regards closure are fulfilled, or on the reasoned request of the operator or in consequence of the withdrawal of the storage permit.

It is also expected that the operator has the right, after **a period of at least 20 years after closure** of the CO_2 storage site permit , to transfer the site and associated responsibilities back to the State.

The operator shall submit a detailed report **demonstrating the long-term safety of the CO_2 storage site, the payment of a financial contribution to the post-closure phase, the sealing of the site and the decommissioning of injection plants.**

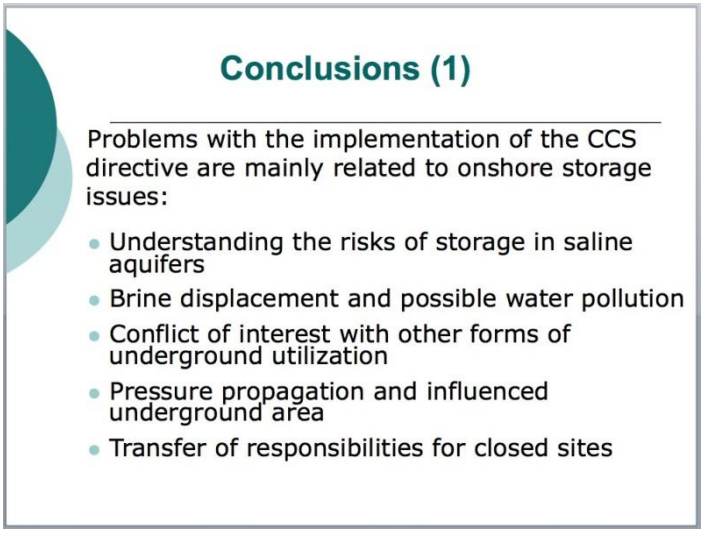
The Ministry of Economic Development provides the European Commission reports that motivate the transfer of responsibility and any other related information taken into account when approving the transfer. It is expected that **after the transfer of responsibility**, periodic inspections and monitoring, which can be reduced to a level that allows the recognition of leakages or significant irregularities, will **be carried out by the supervisory bodies.** In the event of a fault of the operator, including incomplete information provided, concealment of useful information, negligence, fraud or failure to exercise due diligence, **the Ministry recovers the costs incurred by the operator after the transfer.**

Some studies performed thanks to the financial support of the electricity sector, and in the context of the European project **GeoCapacity**, have performed an initial evaluation of the storage potential of CO_2 in the national territory. The most promising areas are summarized in the figure to the right.



Regarding the next steps, also in Italy there is a great consensus on the importance to develop as soon as possible large demo and industrial projects making use of CCS techniques.

The European Energy Program for Recovery (EEPR) has financed three projects in Italy, including Porto Tolle. It consists in the retrofitting of one 660 MW_e coal fired unit, of Porto Tolle power station, with CO_2 post combustion capture equipment and CO_2 underground storage in an offshore saline aquifer by 2015 (injection rate 1Mt/y for 10 year). Regarding additional funds, 300 M EUA (Million EU Emission Allowances) of the New Entrants Reserve (NER) are available until 31 December 2015 to support commercial demonstration projects in CCS. The Italian Government has received **2 post-combustion CCS proposals** and intends to propose one of these for the NER 300 competition.



The figure here above summarizes the main conclusions: additional problems refer to huge difficulties with the public acceptance for new coal power, energy penalty of CCS and severe questioning from the public about the concept of onshore storage.

Practical experience in transposing the 2009/31/CE directive: the French case

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(Summarized by Alla Shogenova)

French context & commitment

France supports the development of CCS technologies. CCS is considered a high-potential solution and is identified as one of the key green technologies. France supports the development & deployment of CCS as a complementary solution in order to accelerate the reduction of CO_2 emissions in France and in the world. The country is active in the process of transposing the 2009/31/CE directive.

Geological considerations

Storage potential is mainly available in deep saline aquifers. Important site characterization is required to demonstrate site suitability for CO_2 storage. The granting of exploration permits will probably be required over large areas, making this potentially more sensitive to public concerns.

Legal considerations

The subsurface belongs to the owner of the surface, unless it contains resources. Therefore, a research permit or concession to access the subsurface resource must be granted by the State before any activities can take place. As a consequence, storage needs two decisions: the right to access the subsurface and a storage permit according to the directive.

Implementing the directive

The transposition process is a two-step approach (at law and regulatory levels).

Key expectations (permit, guaranties, transfer, etc.) are transposed at law level:

- Transposition by means of an ordinance in 2010
- Usual approach when transposing a directive (compulsory provisions with little room for debate) modifications
- Ordinance includes a public consultation through the internet
- Quick process that allows to meet the transposition deadline: 25 June 2011
- Law provisions can be found in article L. 229-27 to L. 229-54 of the environmental code

Secondary information and procedures transposed at regulatory level:

- Transposition by mean of an executive decree (always at government level)
- Process under way: industrial and public consultation completed
- Next and final step: examination by the State Council to check conformity with existing legislation and with the directive

Technical options taken by France when transposing

Exploration is a necessary step for most storage projets in France. Entire territory left open for storage: no dedicated area from which storage sites may be selected. No priority sets for the usage of the underground: conflict of interest sorted out in the granting process. Assessment of the storage capacity is undertaken on a case-by-case basis by operators within the framework of exploration permits delivered at ministers' level. Permit granted for a 5 year

period. This period can be extended if necessary. Exploration can include injection tests under specific authorization delivered by the local representative of the government.

The core of the directive

The scope of the directive has been expanded to include all CO2 storage activities below 100,000 T. **Concession** granted at ministers' level. **Storage permit** delivered by local government representative. **Revision** of the post-closure period and transfer of responsibility decision necessarily taken at minister's level. Post-closure period prior to transfer set at 30 years.

Areas where complementary rules have been introduced

Storage permit

- Storage permit delivered for a given period of time, necessarily limited to 50 years.
- This time period can be expanded under new authorization.
- **5 years periodical update** of plans including corrective measures plan and post-closure plan
- **Permit review** includes environmental performance assessment (2008/1/EC)
- Specific emphasis is put on the protection of drinking water aquifers

Operation, closure and post closure obligations

- In case of transfer, the "**financial contribution**" includes the transfer to the member state, on a cost free basis, of equipment and data
- If transfer obligations are not met by the operator, the **post-closure period** prior to transfer is expanded (10 years max each time)

Public consultation

- *In addition to usual public information mechanisms, a local public committee is set up whenever CO_2 is injected (exploration and storage)*

CCS Ready

- **New coal power stations** must be CCS ready, accompanied with a full scale demonstration program.
- **Combustion plants** with rated electrical output of 300 MW or more shall keep sufficient space to capture and compress CO_2

Some of the difficulties are connected with the understanding of geological terms (storage site, geological formation, storage complex, leakage) and some expressions, and with financial security (30 years long monitoring is a critical period).

Conclusion

- CO_2 storage shows great potential.
- It however exhibits some specific issues: permanent storage / limited reversibility, potentially large area, potential impact on water resources, which requires high level guaranties.
- The directive sets these guaranties for safe and permanent CO_2 storage.
- The transposition process is not as simple as 'copy and paste' (merging, vocabulary, etc.), transposition requires adaptation.
- Workshops and practical experience are now necessary. The involvement of experts is essential for technical back up of competent authorities.
- Permitting will be a challenging task for competent authorities. Periodic reviews, inspections are key safeguards for competent authorities and for the State who will ultimately hand over the storage site.

Session 3. Open discussion – Sharing experience on the CCS Directive transposition process in Europe

Session 3a. Transposition of the CCS Directive: the most problematic issues

Assessment of storage capacity: organization and standardization

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Methodology and problems in site selection and characterization, the basic criteria were presented. The storage capacity in the EU Geocapacity project was in the beginning of the project period calculated as theoretical capacity; however, in the final report the effective capacity was calculated and reported for the participating countries.

CSLF Methodology: The European Union (EU) has supported the on-going research in the CCS method for more than a decade, with focus on capture techniques, transport and geological storage. The results of numerous EU-funded research projects on geological storage are summarised in a comprehensive EU best practice manual for geological storage of CO_2 by Chadwick *et al*. (2008). Contemporary internationally recognised standards for capacity assessments were established by the Carbon Sequestration Leadership Forum (CSLF) in 2004–2005 and a CSLF Task Force on capacity estimation standards has been active since. The CSLF presents comprehensive definitions, concepts and methodologies in papers published by Bachu *et al*. (2007a, b).

The criteria for selection of CO_2 storage structures were shortly summarized: Storage capacity assessment begins with identifying sedimentary basins. Once the suitable sedimentary basins in a region or country have been outlined the next step is to identify potential reservoir and sealing units for CO_2 storage and characterization of their geological and physical properties. At this point, regional CO_2 storage estimates based on the bulk volume of aquifers (oil and gas reservoirs (EOR/EGR) or coal beds (ECBM)) can be calculated. More precise or effective estimates can be provided if stratigraphic or structural traps with suitable reservoir and sealing properties are identified within the aquifers and the storage potential of the individual trap is calculated. Regional estimates can now be calculated as the sum of storage potential of all the traps identified.

The goal with the establishing the EU Geocapacity database is to identify predictable, laterally continuous, suitable permeable reservoir rocks overlain by potentially good quality caprocks at a suitable depth based on existing data. The overview given in the database therefore narrows the search at an early stage so that costly and time-consuming supplementary investigations such as colleting and interpreting seismic data is confined to potentially prospective areas only.

The bulk volume for storage capacity in the EU Geocapacity database (based on 20 countries) is around 360 Gt CO_2 of which 326 Gt is in deep saline aquifers, 32 Gt in hydrocarbon fields and 2 Gt in unmineable coal beds. The effective estimates for storage capacity in the EU Geocapacity database is however much smaller, 117 Gt CO_2 of which 96 Gt is in deep saline aquifers, 20 Gt in hydrocarbon fields and 1 Gt in unmineable coal beds.

How important is it at this level to know the precise storage capacity in Europe? The emissions from large point sources in the EU database are 1.9 Gt CO_2/year. The effective estimates for storage capacity estimates will therefore correspond to more than 62 years of storage of emissions from all large point sources.

Conclusions: The present calculated storage capacities in EU Geocapacity database represent a more conservative estimates, mainly based on calculate volume for regional aquifers, hydrocarbon fields and coal beds. More precise data where data are based on identified traps need to be identified in future work.

References:

Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Christensen, N.P. Holloway, S., & Mathiassen, O.M. 2007a: Estimation of CO_2 Storage Capacity in Geological Media – Phase 2. Work under the auspices of the Carbon Sequestration Leadership Forum (www.cslforum.org). Final Report from the Task Force for Review and Identification of Standards for CO_2 Storage Capacity Estimation. 43 pp.

Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Holloway, S., Christensen, N.P. & Mathiassen, O.M. 2007b: CO_2 storage capacity estimation: Methodology and gaps. International Journal of Greenhouse Gas Control 1, 430–443.

Chadwick, A., Arts, R., Bernstone, C., May, F., Thibeau, S. & Zweigel, P. (Eds) 2008: Best practice for the storage of CO_2 in saline aquifers. Observations and guidelines from the SACS and CO_2STORE projects. British Geological Survey Occasional Publication **14**, 270 pp. Keyworth, Nottingham, UK.

Conflicts of interests/interaction with other underground use

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Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide was published on 5 June 2009 [1], and entered into force on **25 June 2009**.

In the Annex I (CRITERIA FOR THE CHARACTERISATION AND ASSESSMENT OF THE POTENTIAL STORAGE COMPLEX AND SURROUNDING AREA REFERRED TO IN ARTICLE 4(3)) to the Directive, the following characteristics of the storage complex vicinity shall be documented:

- domains surrounding the storage complex that may be affected by the storage of CO_2 in the storage site;
- population distribution in the region overlying the storage site;
- proximity to valuable natural resources (including in particular NATURA 2000 areas pursuant to Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (1) OJ L 103, 25.4.1979, p. 1. and Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora(2) OJ L 206, 22.7.1992, p. 7., potable groundwater and hydrocarbons);
- activities around the storage complex and possible interactions with these activities (for example, exploration, production and storage of hydrocarbons, geothermal use of aquifers and use of underground water reserves);
- proximity to the potential CO_2 source(s) (including estimates of the total potential mass of CO_2 economically available for storage) and adequate transport networks.

Especially the items 'proximity to valuable natural resources' and 'activities around the storage complex and possible interactions with these activities' are important from the viewpoint of location of a storage site because of possible conflicts of interests and/or interaction with other underground use.

In case of natural resources, the use of the subsurface might be limited in NATURA 2000 protected areas. A large part of territory of EU states is covered by these protected areas (onshore and coastal areas) where injection facilities certainly cannot be located. However, storage permits, which shall match the extent of the storage complex in case of a particular site, might enclose these areas onshore. It means that the CO_2 plume would be located under protected areas and it should be decisively proven that no leak or migration of carbon dioxide may occur. The pipeline routes might cross these areas onshore - otherwise the routes would be far longer and transport costs significantly higher. Also exploration permits onshore or on coastal areas might include protected areas, so relevant permits required in the member state in question are to be applied for.

An important issue is protection of onshore groundwater resources. Though it can be proved CO_2 migration into shallow groundwater reservoirs is not possible, CO_2 storage would (indirectly) definitely affect deep **groundwater** resources. Usually, we have proof that a good primary caprock exists under the possible reservoir and then a couple of caprock formations above, separated by saline aquifers of decreasing mineralization. But, as a result of injection within the storage complex, the pressure increases even in the case of an open aquifer. Farther from the injection facility and above the storage complex, pressure also increases and, as a result, the boundary between potable water and brine (of low mineralization) moves up. For example, a possible storage site in Poland is within the Lower Jurassic, which is overlain by an Upper Jurassic aquifer containing potable water (Fig. 1). Here, injection could make the

latter slightly salty at the bottom, despite the existence of three caprock complexes between the saline reservoir and the potable aquifer.

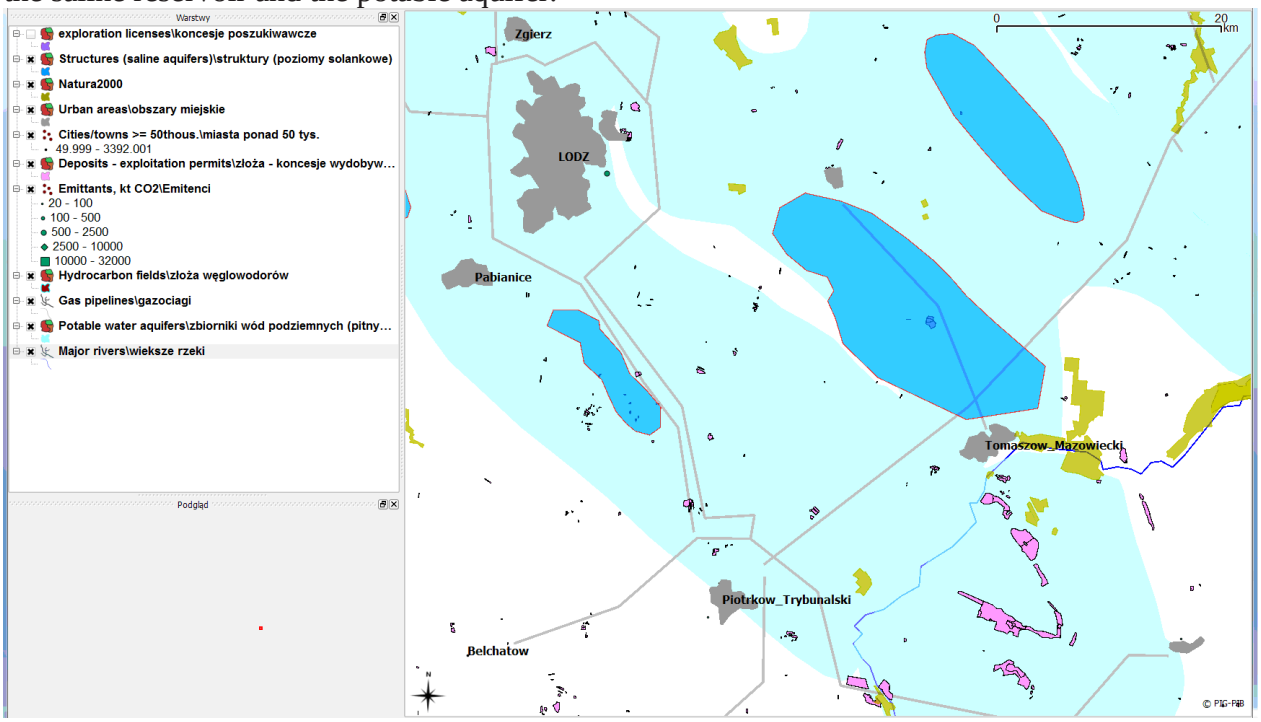

Fig. 1 Deep potable groundwater resources (Cr3-J3) around a possible CO_2 storage site (J1) onshore, in central Poland.

In the case of hydrocarbon production, the situation is quite simple. If there is already a hydrocarbon production permit, the new CO_2 storage permit usually cannot overlap it regardless of which reservoirs both permits are exploiting. However, if the field is in a state of depletion, CO_2 injection might be used as an enhanced hydrocarbon recovery measure. Also, the use of CO_2 injection within the same reservoir where hydrocarbon production is ongoing nearby might enhance hydrocarbon production of the field in question.

The production of other mineral resources matters if these are within a comparable depth range and deeper than a CO_2 storage complex in question. Shallow use of the subsurface is not an obstacle to CO_2 storage and vice versa (practically any activities occurring above the uppermost secondary caprock shall not pose a problem for CO_2 storage).

The situation is slightly different where we consider exploration permits. It is usually assumed, after the Directive and national practices, that hydrocarbon resources have a precedence, so if we suspect new gas fields might be discovered where a storage site is planned, the permitting authority would not issue a storage permit. However, in the case of exploration permits, the issue is less strict – the exploration for possible CO_2 storage sites shall not be banned where the exploration for hydrocarbons is ongoing or planned. It is basically an issue between the CCS project sponsor and the owner of the license for hydrocarbon exploration. On the other hand, shale gas exploration is in its infancy in Europe and it cannot be determined now how large the areas of gas production permits will be. The area currently covered by exploration permits is huge (e.g. in Poland - see Fig. 2) and partly overlap with possible CO_2 storage sites and areas. It should be also noted that shale gas resources might be usually located in formations deeper than those suitable for CO_2 storage. Whether CO_2 storage could be a measure of enhanced recovery of shale gas is not known yet or at least not announced.

Last but not least, geothermal applications might constitute conflict with the use of saline aquifers onshore. For example, a large (southern) Permian-Mezozoic basin which

stretches from eastern Britain to central Poland is a promising area for both geothermal and carbon geological storage. Because of relatively low geothermal gradient (Fig. 3) and the lack of recent volcanic activity, the temperature at a depth of 1 km within this area is insufficient for direct heat use of geothermal resources (heat pumps are required to use the geothermal energy for district heating). Nevertheless, geothermal energy seems to be quite an appealing option for local communities, despite the economic considerations, and some people prefer this option to CCS. Whether CGS and geothermal exploitation could be allowed close to each other and within the same reservoir (neighbouring sites, geothermal at a slope of area where CO_2 storage site is located, etc.) is not solved by national legislation. However, a number of studies have been published worldwide proposing the joint use of geothermal exploitation and CGS in the same place.

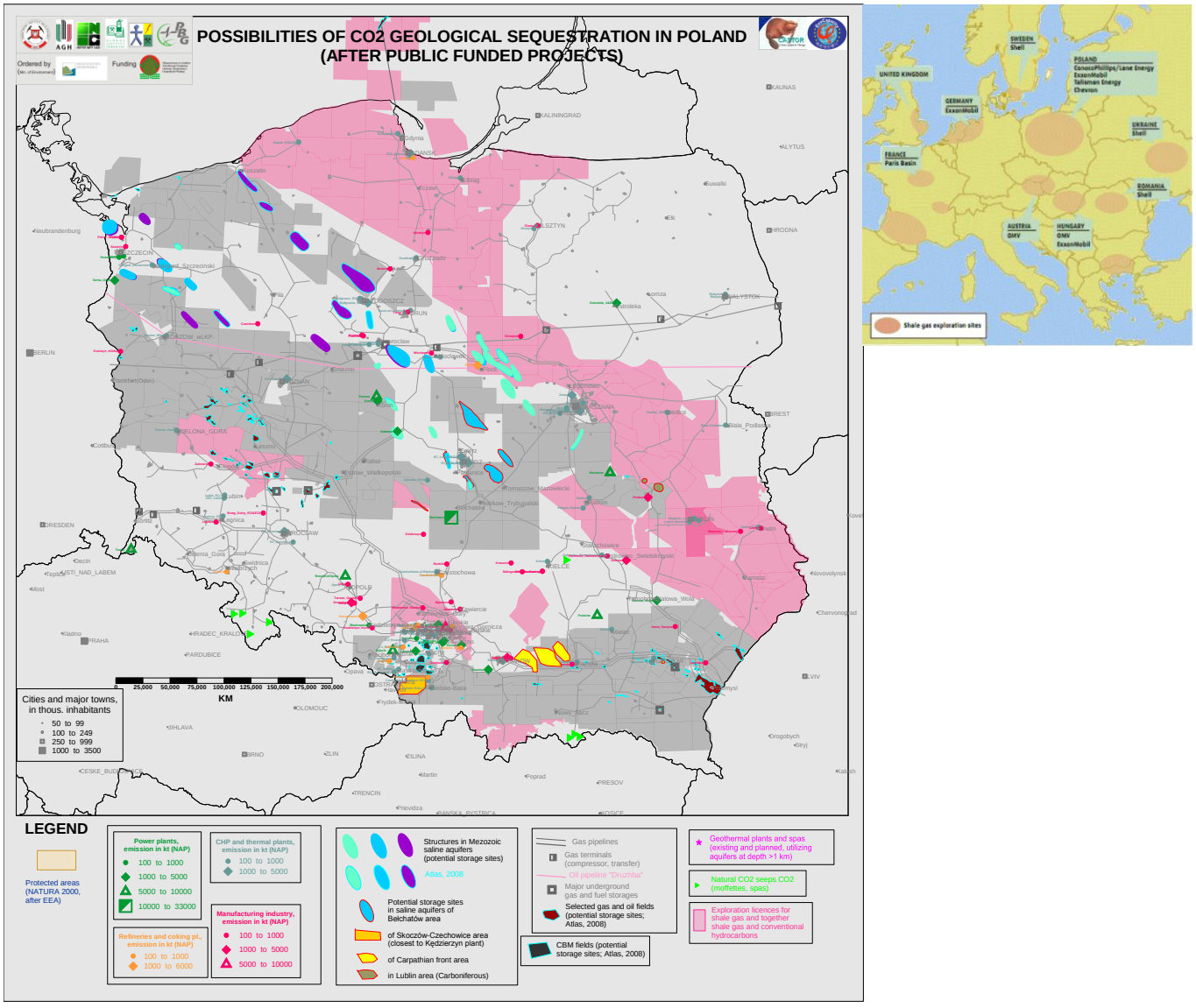

Fig. 2 Hydrocarbon exploration permits (salmon - shale gas, grey - other/conventional hydrocarbons) and possible storage sites (smaller multicoloured areas) in Poland and shale gas prospects (upper right) in Europe.

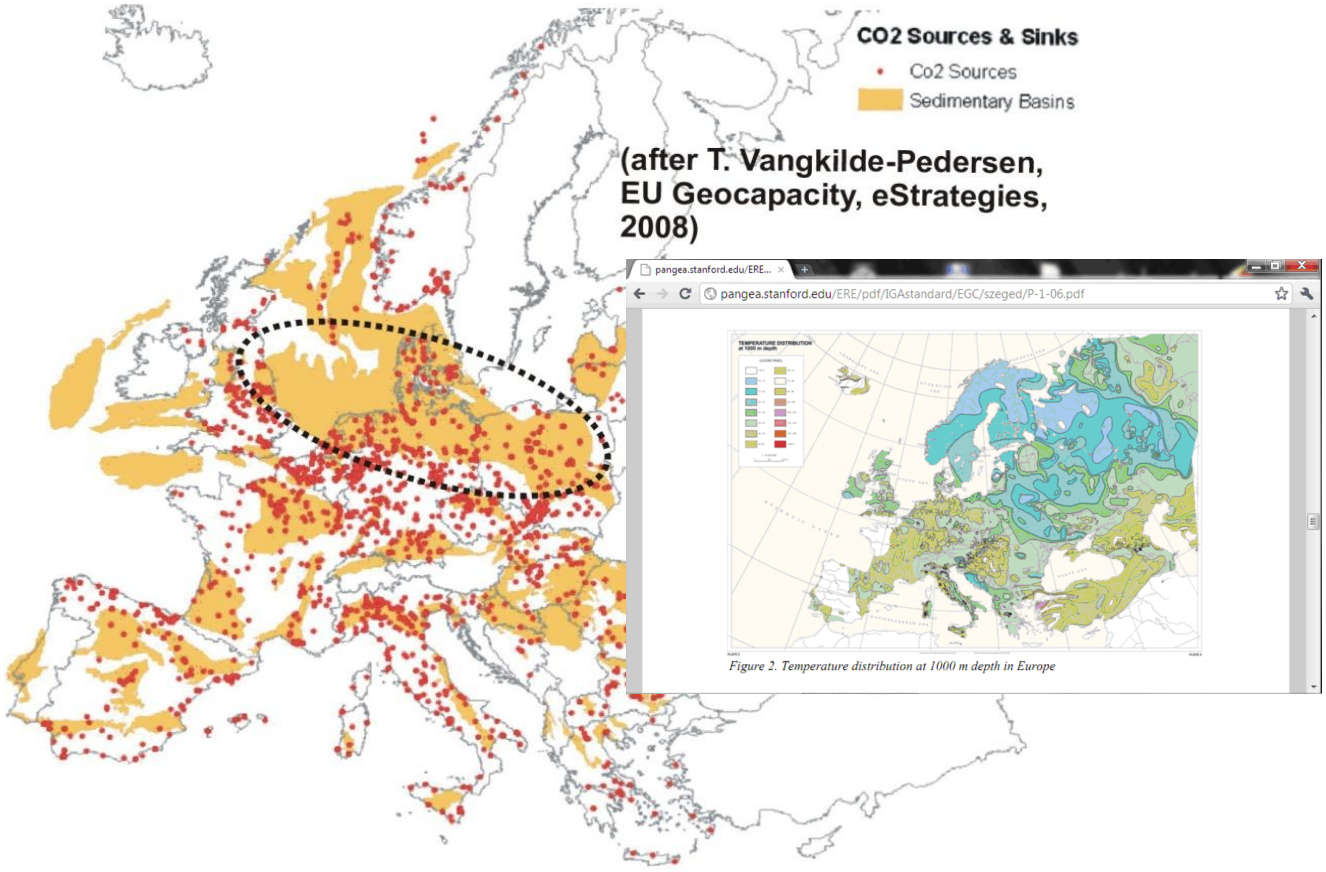

Fig. 3 EU GeoCapacity map of sedimentary basins perspective for CO_2 storage in Europe and map of temperature at a depth of 1 km (blue-green colours denote low temperature, violet to red denote high temperature).

Conclusions

- In the case of onshore and coastal environmental protection areas (Natura 2000) - no injection facilities, but exploration and transport activities might overlap with these areas.
- Onshore groundwater resources are not to be affected with the exception of the deepest potable aquifers.
- Hydrocarbon production might benefit from rather than suffer from CO_2 storage activities.
- Hydrocarbon storage and CO_2 storage could cause a conflict.
- Exploration for hydrocarbons is a matter of priority of the member state and two cases are distinguished: shale gas (probably large future production licenses), other hydrocarbons (smaller production areas).
- Other mineral resources matter provided they appear within the depth range of storage complex.
- The use of low enthalpy geothermal resources and CO_2 storage could cause a conflict.

References

[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 (1). Official Journal of the European Union 2009; L140:114-35.

Monitoring Issues: CCS Directive and Beyond

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The presentation focused on key monitoring issues in the context of the CCS Directive 2009/31/EC. ICF International has supported the European Commission in the development of the Guidance Documents (GDs), and continues to support the Commission on various CCS-related initiatives. However, presentation at the Workshop *does not reflect* the views of the European Commission and is only meant to foster discussion on monitoring related issues in the context of the CCS Directive.

Key highlights from the GD2 on monitoring were presented. It was noted in particular that the Monitoring Plans need to meet the goals of the CCSD, covering different areas, with different scales/intensities, at different times; and the permit applicant is free to select appropriate best-available cost-effective technologies, as long as it meets the specific objectives based on identified risks at a particular site.

The presentation highlighted different boundaries relevant to monitoring:

a) *Exploration Permit area*, where site characterisation and baseline monitoring will take place
b) *Storage Site*, where monitoring will focus on CO_2 plume migration, geochemical changes, and model calibration.
c) *Storage Complex*, where monitoring will aimed at ensuring that the pressure increases do not have any adverse impacts, and the CO_2 does not leak out of the complex
d) *Surrounding area of the Complex,* where monitoring will be focused on verifying and quantifying the amount of leakage and leaked emissions (if any), the environmental impact of leakages and pressure increases. Specific boundaries within the surrounding area were highlighted.

Finally, the importance of baseline monitoring was highlighted, with the focus on statistical analysis needed to ensure the significant irregularities and leakages are identified, verified, and quantified.

In summary, the presentation concluded that:

- The Guidance Documents provide a framework for developing monitoring-oriented regulations in different member states
- Monitoring regulations needs to consider specific site/complex/surrounding area boundaries
- CAs will need to work with permit applicants to ensure that appropriate boundaries for monitoring are selected
- Baseline data and analysis, along with rigorous and statistically valid monitoring plan, is critical for determining how leakages can be detected and for assessing their impacts

References

[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 (1). Official Journal of the European Union 2009; L140:114-35.
[2] Guidance Document 2, European Commission. See:
http://ec.europa.eu/clima/policies/lowcarbon/docs/gd2_en.pdf

Session 3b. Issues not covered by the CCS Directive

Cross-border transport and storage
Issues not (or not entirely) covered by the Directive

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In Finland, all deep rocks are expected to be crystalline basement rock and not suitable for CO_2 storage. The same situation applies for the near Finland water in the Baltic Sea. The closest potential storage sites for Finland are the formations in the southern Baltic Sea, but these can not be considered Finnish territory (Teir et al., 2010). There is some interest to investigate the southern Baltic Sea in cooperation with Finland, Sweden and other Baltic Sea region countries within the Bastor project.

Cross-border transportation seems to be one of the future possibilities. One alternative solution for storage could be mineral carbonation, which is intensively studied e.g. in Åbo Akademi University, University of Turku and Aalto University in Finland.

The future role of CCS in the Nordic countries has been assessed in the CCS Finland -project, partly by energy system modeling and partly by studying regional options for CCS application to existing facilities. Some regional potential for CCS adaptation is noted. The figure 1 shows identified CO_2 emission clusters.

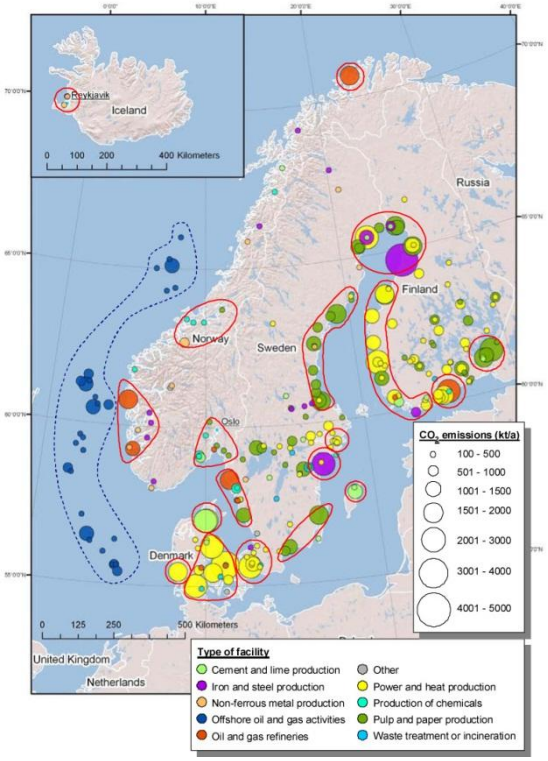

Fig. 1. Identified CO_2 emission clusters (total CO_2 emissions, i.e. fossil plus biogenic sources) (Teir et al., 2010)

For example, several large point sources of CO_2 exist along the Northern shore of the Gulf of Bothnia (Finland, Sweden). The potential for common transport infrastructure, probably by ship, could be promising. Although the emitting facilities are located on the perimeter of a half circle with a radius of about 100 km, the facilities are all located close to the coast line, allowing for ship transportation of CO_2. However, the transportation distance by ship for instance to the Utsira formation is over 2000 km. Another storage option is the Melkøya Liquefied natural gas plant, which is located about 600 km to the north of the area and has an

existing CO_2 pipeline connection for storage at the Snøhvit formation. This could provide an opportunity for joint pipeline transportation of captured CO_2 (Teir et al., 2010)

The role of CCS in the Nordic energy systems has been studied with a bottom up energy system model called Nordic TIMES, which has been created by VTT. Just a point from the study, the figure 2 shows the competition of the Norwegian storage capacities at an emission allowance price of 90 €/t by 2040. Y-axis shows amount of CO_2 stored annually.
Finland and Sweden are expected to need to export their CO_2 to the North Sea due to either lack of own storage sites or due to storage options nearby emission sources being more expensive . The scenario results indicate that with the assumed inputs for CO_2 transport and storage the competition of the Norwegian storage capacities with Central European countries could be minor by 2050 due to large enough storage capacities in the Western and Eastern Europe. The whole study can be found from the VTT report.

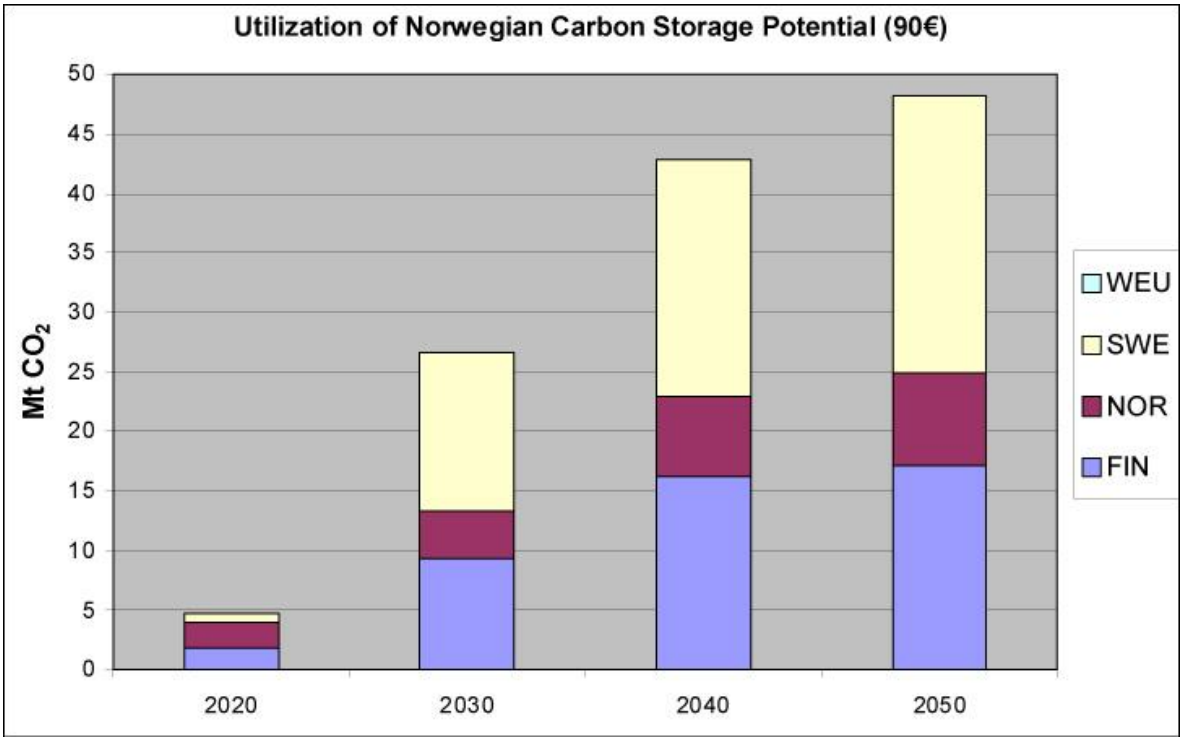

Fig. 2. Competition of the Norwegian storage capacities. (Teir et al., 2010).

Full and cost effective deployment of CCS in the Nordic countries would require a large scale transport and storage infrastructure including cross-border transport. For the Finnish CO_2 sources, and a large part of the Swedish sources as well, the distance to a mature storage site exceeds 1000 km. Large pipeline infrastructures that cross international borders are unlikely to occur before 2030 without strong political agreements to tackle climate change and appropriate legislation needed for transferring CO_2 between countries. It is unlikely, that any CCS plant cluster sharing a common CO_2 transportation pipeline would exist by the year 2020, or during the CCS demonstration phase. Point-to-point pipelines for minimal distances from the CO_2 source to sink and shipping for longer distances would be the most likely options in the first phase of CCS deployment. After the implementation and operation of CCS demonstration projects, larger networks could become feasible between 2020 and 2030. Still, the required infrastructure would still at this stage be very local and site specific. (Teir et al., 2010)

EC Directive on cross-border transport and storage: 1) In case of transboundary transport of CO_2, storage sites or storage complexes, the competent authorities of the Member States concerned shall jointly meet the requirements of the Directive and of other relevant Community legislation. 2) In the event of cross-border disputes, the dispute settlement arrangements of the Member state having jurisdiction over the transport network/storage site to which access has been refused shall be applied. (EC 2009)
It is noted in the Review chapter of the Directive that reports transmitted by 31 March 2015, that the Commission shall assess in particular, on the basis of experience with the implementation of the Directive, in light of the experience of CCS and taking into account technical progress and the most recent scientific knowledge:

- experience with the provisions on CO_2 stream acceptance criteria
- experience with the provisions on third-party access and with the provisions on transboundary cooperation pursuant
- the need for further regulation on environmental risks related to CO_2 transport

From the VTT report some good recommendations are presented for the discussion. There were several actions recognised in the economic and political field. Emphasized topic was for example the need for "Research programs that analyze to what degree co-ordinated CCS infrastructure (foremost pipelines) development in the Nordic countries will be essential for CCS deployment, and how in this regard state intervention should best be designed and co-ordinated across countries". Also important topics for future research on the role of European-level policy for development of a CCS system in the Nordic Region:

- What is the need for EU-level coordination and planning with respect to transportation and storage infrastructures? Including questions like
  - Are current national and EU level initiatives sufficient to develop the required infrastructure for a major CCS system (in the Nordic region) on the required timescale?
  - Is improved coordination, planning or regulation from the EU required?
  - Does the need for EU coordination, planning or regulation increase if the geographic scope is extended (to include storage of CO_2 captured in, e.g., in the UK, Germany and the Netherlands under the North Sea)?

The directive raises many questions. For example, in the pipeline network with multiple sources, what are the purity requirements of the stream? Of course, regarding cross-border transport and storage, what should be included in the national laws? Will there be guidance documents on the matter and, if yes, when, and will it be too late?

In the discussion, topics raised include a demo project from North Sea area which concerns cross-border transport. Transportation by ship was noticed as a promising option, as it would be easier to choose the storage site due to needs. Additionally, when ships are used for transport, the use of necessary intermediate tempory storage sites would be flexible (in case some storage site refuses to accept CO_2 at the moment).

Acknowledgements

EC 2009. Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide. Official Journal of the European Union, L140/114-135. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF.
Teir, S., Hetland, J., Lindeberg, E., Torvanger, A., Buhr, K., Koljonen, T., Gode, J., Onarheim, K., Tjernshaugen, A., Arasto, A., Liljeberg, M., Lehtilä, A., Kujanpää, L. and Nieminen, M. 2010. Potential for carbon capture and storage (CCS) in the Nordic region. VTT Research Notes: 2556. ISBN 978-951-38-7661-6 (soft back ed.); 978-951-38-7662-3. 188 p. + app. 28 p.

Competent Authority: are they ready to evaluate applications?

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The Competent Authority (CA) is defined in article 23 of the CCS Directive (European Parliament and Council of the European Union 2009) as:

Member States shall establish or designate the competent authority or authorities responsible for fulfilling the duties established under this Directive. (incomplete quote)

The practical role of the CA is detailed in Guidance Document (ICF International, 2011). Starting from the observation that Member States in general are basing their future CA's mainly on environmental and energy administrations, and only rarely consider involving institutions with practical expertise in CO_2 storage such as geological surveys, universities, other research institutes or consultants, a deliberately slightly provocative plead was made demonstrating that the future CA's would not be up to the task as outlined in Guidance Document 1. The discussion was focussed on following five questions:

Is/will a CA be able to:

- Assess storage potential? (Phase 1: Assessment)
- Review exploitation permits? (Phase 2: Characterisation)
- Oversee monitoring and reporting? (Phase 4: Operation)
- Take on operator responsibilities? (Phase 5: Post-Closure/Pre-Transfer))
- Assume long term stewardship? (Phase 6: Post Transfer)

References

European Parliament, and Council of the European Union. 2009. 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. April 23.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF.
European Commission 2011. Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide - Guidance Document 1: CO2 Storage Life Cycle Risk Management Framework, 54 p. Available at:
http://ec.europa.eu/clima/policies/lowcarbon/ccs_implementation_en.htm.