



RESEARCH CONFERENCES

ESF-FWF Conference in Partnership with LFUI

CO₂ Geological Storage: Latest Progress

Universitätszentrum Obergurgl • Austria
22- 27 November 2009

Chair:

Dr. Isabelle Czernichowski-Lauriol, CO₂GeoNet - BRGM, FR

Co-chairs:

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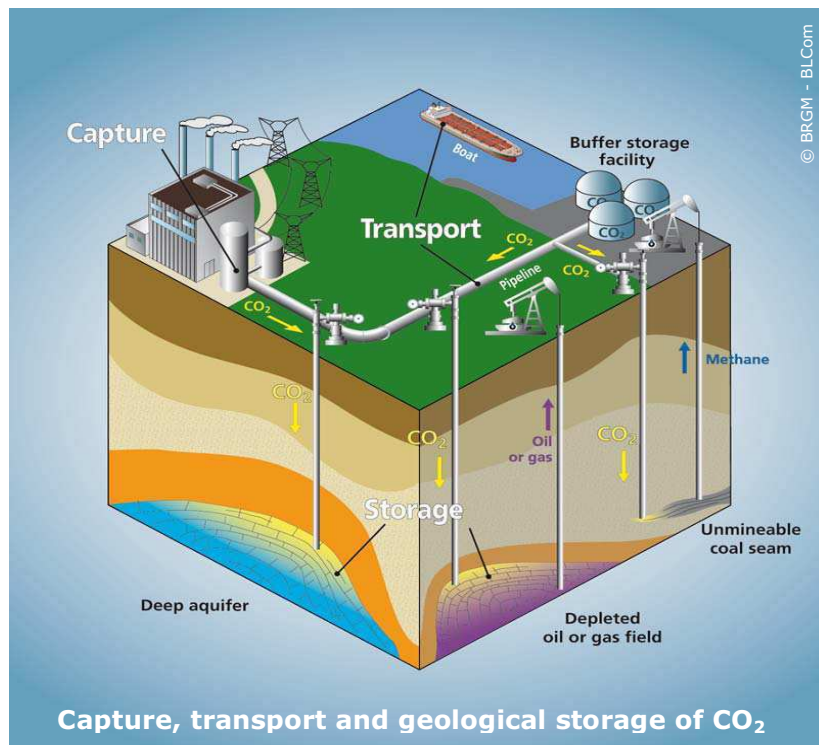
www.esf.org/conferences/09293

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Capture, transport and geological storage of CO₂

Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

Capturing CO₂ at large industrial plants, especially fossil-fuel-based power stations, and storing it underground in deep geological layers is a top priority in the race to significantly reduce atmospheric emissions of greenhouse gases (GHG), thus helping to mitigate climate change and ocean acidification. By storing CO₂ underground, the carbon released through burning coal, oil and gas is returned back to where it was extracted, rather than ejecting it into the atmosphere.

Since the 90's, a huge research effort on CO₂ geological storage, especially in Europe, has led to significant outcomes and the technology has now reached a transition stage between research and worldwide deployment. There is now a need to assess the progress made, to bridge gaps between industry and research, to spread the results to a larger community of scientists, to train young engineers and researchers, and to outline the future challenges to be faced along the road to industrial implementation.

The European Network of Excellence CO₂GeoNet was created in 2004, through the European Commission's 6th Framework Programme (FP6), in order to federate and coordinate the research efforts in Europe to develop efficient and safe CO₂ geological storage. It is now the largest integrated scientific community on the topic, gathering 300 researchers from 13 public institutes in 7 European countries. In March 2009, at the end of the FP6 contract, CO₂GeoNet continued as a legally registered association so as to further develop its activities. Together with the leading scientists in the world, and thanks to the opportunity offered by ESF, it presented the results of the latest research on CO₂ geological storage carried out within the network and throughout the world.

The conference was built around 24 invited talks of roughly 45 min duration each, given by CO₂GeoNet senior scientists and other international experts and covering the subject of CO₂ geological storage in its different aspects. These invited talks were complemented by two poster sessions selected from the submitted abstracts.

In addition, three discussion sessions were organized, where participants could exchange, in small groups, their views on less technical topics such as communication of CO₂ Capture and Storage (CCS), career perspectives and look forward.

In order to foster interaction among the conference participants, everyone dined together at the conference location and at given times. Additionally, social activities, including a get-together, a conference dinner and a dance, were arranged. The two poster sessions (after dinner) were further, excellent opportunities for interaction. Poster display time was generous to allow the young participants sufficient opportunity to discuss their results.

The atmosphere of the conference was relaxed and stimulating. Much exchange took place during the period be it during discussion and poster sessions or during informal time like dinner and social events.

The event gathered 89 participants from the whole world including EU countries, Israel, Russia, Australia, Brazil, USA, Canada and China.

All in all, the conference was a very successful and highly stimulating event as reflected by the productive atmosphere, the continued contacts post-conference and the very high evaluation scores. Top international speakers, highly motivated young scientists, two excellent poster sessions, and a flawless organization by the ESF conference management all contributed to this success.

All the presentations and posters are publicly available on Co2GeoNet website: www.co2geonet.eu

I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

The conference took place in Obergurgl, Austria, from 22-27 November 2009, with the support from the sponsors: IEAGHG, Schlumberger, Statoil.

Conference Participants

89 participants attended the conference, coming mostly from EU (65%). The origin of the participants is shown in Figure 1). Participants were either invited speakers (about 20) or selected applicants. Most were from universities or research institutes, but some, both young and senior, were from industry.

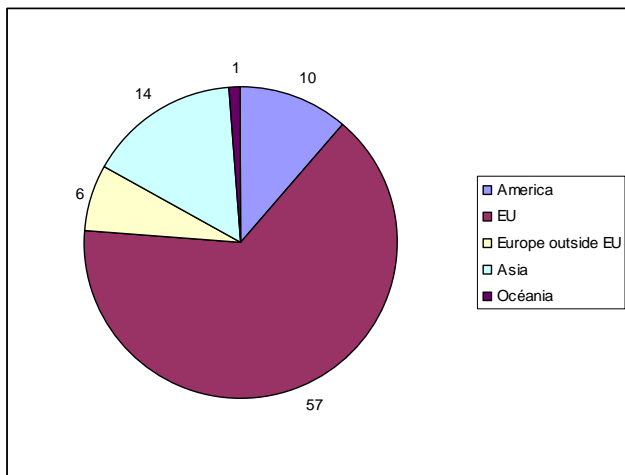


Figure 1: Participants' continent of origin

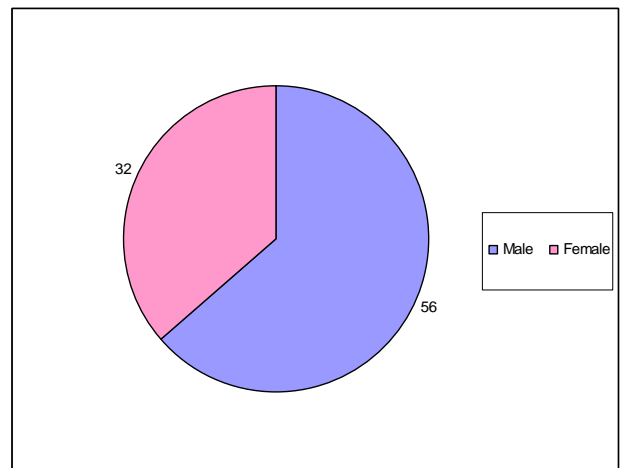


Figure 2: Gender Balance

The gender balance (Figure 2) was good, compared to the usual male-dominated environment of geoscience events: 36% of the participants were females.

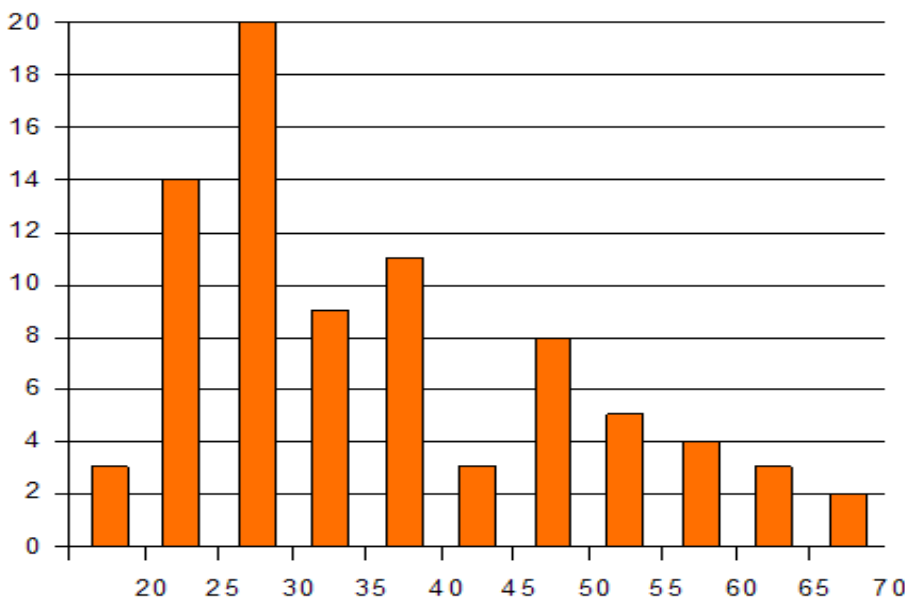


Figure 3: Age balance: number of participants per age class

There was also a good balance in the age of the participants, as shown in Figure 3. About half of the participants were young scientists (below 35 years old), which created an environment for good intergenerational exchange.

Conference Objectives

The aims of the conference were mainly to:

- Present a state-of-the-art of CO2 Geological Storage
- Give a clear overview of CO2 Geological Storage as a whole, encompassing the many geoscience fields and understandable to everyone,
- Enable interaction between specialists from different fields of science working on CCS
- Enable interaction between young and senior scientists
- Enable interaction between different countries so as to foster knowledge sharing and cooperation
- Identify the main research issues to be tackled

The program of the conference was structured around six technical sessions: 1) the characteristics of a good site for geological storage and how to select such sites, 2) the modelling efforts made in order to determine CO₂'s fate in the reservoir, 3) how to assess the risks linked to geological storage, and 4) how to monitor a storage site. In addition to the above generic sessions, two sessions were held on 5) current industrial demonstration efforts worldwide, and 6) the experience gained from pilot projects. These invited talks were complemented by two poster sessions giving the opportunity to young scientists to show their work in this field. The conference managed to give a global overview of the technology of CO2 Geological Storage, where it stands now and what challenges will have to be faced.

In addition, three discussion sessions were organized where participants could exchange, in small groups, their views on communication of CCS, career perspectives and future research perspectives. These sessions enabled the participant to step back from the sole technical perspective and reflect on the future of CCS.

In retrospect, we are confident that all of these objectives were met. A distinguished set of high-profile invited speakers attended the meeting and helped maintain the scientific content of the meeting at a very high level, while being understandable to all participants. The variety of participants, in terms of scientific background, nationality and age, was instrumental in reaching our objectives.

Economy

The ESF/FWF contribution of 60,000 euros was vital to arrange this conference. It was used to cover expenses for invited speakers and the organizing committee (travel, accommodation) on the one hand, and to support a selected number of conference participants on the other hand. Over 35 participants were offered a conference grant covering their accommodation, and 11 of these, who were young participants coming from other continents, also benefited from a travel grant. The selection of grantees was based on criteria such as age, type of organization, distance, scientific quality of the proposed poster, gender etc.

Additional funding for the conference was sought by contacting a number of potential sponsors, three of which gave us their highly appreciated support: IEAGHG, Schlumberger and Statoil. Their contribution of 10,600 euros in total was used to offer additional conference and travel grants to young participants.

Impressions and Conclusions

We consider this conference a great success with respect to both scientific content, level of the presentations, number and quality of applicants, geographical and gender balance, conference location, opportunities for interaction, good atmosphere, and sponsor contributions, and we are thus very satisfied with its outcome. Our view is shared by a large number of conference participants, who have provided us with their formal or informal feedback.

Scientific Content of the Conference

(1 page min.)

- Summary of the conference sessions focusing on the scientific highlights
- Assessment of the results and their potential impact on future research or applications

The conference was divided into six technical sessions, plus introduction and conclusion sessions, and three discussion sessions. There were also two poster sessions.

Introduction session

The technology of CCS was presented briefly, introducing the rationale and its global feasibility. If we want to avoid the

impacts of a drastic climate change, we have to deploy industrially CCS in the short term. For this purpose, the technology has to be tested as a whole chain and with all possible combinations. In the end, whether this becomes reality will depend essentially on political decisions on whether to support the deployment or not.

Site selection and characterization session

The characteristics of a good storage site were presented, especially in the light of the EU directive that came into force this year. Site selection and characterization should consider subsurface properties, but also surface characteristics and economics come into play. Many criteria need to be taken into account and these must be prioritized into “absolute requirements”, “should have” and “good points”. There is no consensus yet on which criteria fall into which category, and this will most likely be decided at national level when deciding on a legal framework.

Modelling CO₂ behaviour in the reservoir

Modelling has to be tailored to the needs and the expected results. Knowledge on the underground is, by definition, patchy, so many assumptions need to be made. These should be stated clearly every time results are presented. In addition, uncertainty go hand-in-hand with modelling, and this must also be dealt with.

Many different parts of the storage complex can be modelled (reservoir, caprock, wells, overburden, etc.) with a different perspective (static model, flow model, geochemical model, geomechanical model). All are key elements in the design of a storage project and all along its life cycle.

In static models, the main issue is to reproduce the complexity of the real geology with disconnected measurements, while in flow models, the aim is to upscale pore-scale effects to the reservoir scale, and increase the knowledge of the multiphase behavior and of the boundary conditions.

Geochemical models suffer from really high uncertainty due to the lack of thermodynamic and kinetic data. Key issues are the processes around the well that can affect injectivity and impacts of impurities injected together with the CO₂ as a result of the capture process. Geomechanical models have to ascertain that the main risks are low: no fault reactivation or the creation of hydraulic fractures in the caprock. Hydrochemical and hydromechanical models can be coupled to assess the impact of the storage and to discover if the effects compensate each other or not.

Local risk assessment

The safety and the efficiency of CCS need to be ensured. For that purpose risks have to be managed and safety criteria need to be imposed to operators.

Terminology and some CCS dedicated risk assessment methodologies have been developed in the recent years, in particular the FEPs (Feature event process) methodology. Examples of its use have been showed during this session. In particular, the main concern lies in the wells as potential leakage pathways. It was presented how this risk can be managed and dealt with in order for them not to be show stoppers.

To assess risks it is necessary to be able to assess the impact of a leakage into the environment. Results of the research of impacts on the marine biosphere have been presented together with the ongoing research.

Safety criteria in order to ensure the safety should take into account the whole life cycle of the storage from design to post closure. Safety assessment will rely on many different points such as different models, knowledge on impacts, vulnerability of the environment and monitoring. Safety criteria will be decided on national level.

Monitoring

Monitoring is necessary for several reasons, such as verification of storage, good operation of the site, safety for human beings, the biosphere, etc. For this, knowledge of what is happening in the deep underground around the reservoir is necessary as well as what is (or is not) happening at the surface.

A range of deep monitoring tools that have been tested in different projects were presented in this session. Each project will be specific and should use the most adapted technologies to monitor the evolution of the CO₂ underground. A combination of different measurements will probably be necessary.

In case of leakage towards the surface, this needs to be detected to avoid any harm to humans or the environment. An understanding of the leakage pathways is necessary to be able to predict where the CO₂ could leak in the case of failure. For this purpose, natural analogues where CO₂ naturally leaks toward the surface have been studied and monitored using surface and airborne monitoring tools, bringing a good understanding of the processes involved and confidence that CCS can be done safely.

For each storage site a monitoring strategy will have to be set up according to the specificity of the site. A strategy will define what will be monitored (CO₂ plume, caprock, potential leakage routes), where, when and how. This will be done taking into account the costs and the risks assessed. Each phase of a project (design, operations, closure, post-closure) will correspond to different monitoring strategy.

Steps toward demonstration worldwide

In this session, the efforts made towards industrial deployment in different countries have been presented. In the USA, a wide federal plan has been set up in the recent years with many projects in seven regional partnerships covering the

US. Three projects of the Southwest regional partnership have been presented.

In Australia as well the government is investing heavily in CCS. An act, ruling CCS, has already been passed and many efforts are made to accelerate the industrial deployment (such as flagship program, foundation of the Global CCS Institute). The CO₂ storage capacity of the country has been assessed and several pilot projects have been launched.

In China, most of the CCS activities concern CO₂-Enhanced Oil Recovery (EOR) and there are several studies for its large-scale implementation.

In Japan, where storage capacity is limited, research focuses on monitoring using the finished pilot project of Nagaoka as a basis.

Learning from experience

This session presented the main lessons learned from the first pilots in the world: Sleipner (Norway) with its “little brothers” Snøhvit (Norway), Weyburn (Canada) and Ketzin (Germany).

These projects were among the first pilots in the world and were built hand-in-hand with extensive research programs. Therefore, their contribution was crucial in understanding CCS. Sleipner, as the first industrial pilot ever, demonstrated the overall feasibility of the concept of storing CO₂ in geological formations, in that case a deep saline aquifer offshore. Weyburn is the first industrial project which demonstrated the feasibility of combining CO₂ storage with CO₂-EOR when injecting CO₂ into an onshore depleted oil field. Ketzin is a research pilot testing the injection of small quantities of CO₂ into a deep saline aquifer onshore close to Berlin.

All the projects tested a wide range of monitoring technologies such as seismics, but also geochemical and other geophysical or remote sensing techniques.

Cancelled session: Industrial development

The concrete plans of an energy company (Vattenfall) to move towards industrial deployment should have been presented. Unfortunately the speaker was unable to attend to the conference due to sickness.

Conclusion session

The main outcomes of the conference were summarized, details were given about the progress towards CCS demonstration in Europe, and the key scientific events on CO₂ storage to be held in Europe during the next ten months were advertised.

Poster sessions

The two poster sessions presented results from the participants on various topics, mainly covering the different aspects of CO₂ Geological Storage.

A group of students presented their joint work (Nuclear fuel and carbon capture as a means for CO₂ mitigation: a comparison of related storage requirements and impacts), and also seized the opportunity to organise a poll on radioactive waste storage vs CCS.

Discussion session 1 – Sharing experiences in communicating on CO₂ storage

Participants had the opportunity to exchange in small groups on their experience in communicating on CCS.

In addition, participants were asked to simply define in few lines what is CCS, and why it is a good idea. Results were analyzed by the psychologist Samuela Vercelli from CO₂GeoNet.

Discussion session 2 – Career perspectives in CO₂ storage for young scientists

Participants exchanged on the future needs of scientists for CCS deployment, in term of numbers and domains of expertise. Various opinions were expressed. It was agreed that, if CCS is to be widely deployed, a lot of education and training of professionals will be needed. Due to the multidisciplinary nature of CO₂ storage, specialized scientists on many fields of science and engineering will be required, as well as generalists able to integrate all the learnings from different disciplines. It was stressed that CCS can be attractive to young people: it presents many challenges and has a positive image as a climate mitigation technology.

Discussion session 3 – Forward Look (see below)

All presentations and posters are available on CO₂GeoNet website at :

<http://www.co2geonet.com/NewsData.aspx?IdNews=46&ViewType=Actual&IdType=18>

FORWARD LOOK

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

The forward look session was organized as a small group discussion around the main research needs for the future. Each group had to identify the most urging matter to deal with in order to be able to operate 12 large-scale demonstrators by 2015 as planned by the EU, then to deploy CCS widely. They were asked to name the three most important technical gaps for each storage option (deep saline aquifers, depleted hydrocarbon reservoirs, coal seams), and to provide suggestions on how to bridge these gaps as fast as possible.

The main issues that came across are:

- **Geochemistry** - knowledge on CO₂-Water Rock interactions about the impacts of impurities and microbiology. For this purpose, more laboratory experiments and modelling should be undertaken.
- **Faults** - knowledge on faults and how CO₂ can/cannot leak through them.
- **For aquifer storage**: the main issue to be studied would be pressure build up and brine displacement
- **For storage into oil and gas fields**: the main issues are the strains induced by unloading then reloading the field and the lack of knowledge on the existing wells (where they are and in what state).
- **For storage into coal seams**: the main issue lies in overcoming the swelling, but also in the definition of unminable (which could become minable in the future).

In order to tackle all these issues, further investment in CCS research is needed as well as the coordination of the different research efforts throughout the world.

A raised hand poll on whether participants believed the 12 demonstrators would be achieved by 2015 (as wished by the EC to enable industrial deployment by 2020) showed that a large majority did not believe it would actually happen in time.

- Is there a need for a foresight-type initiative?

No

Atmosphere and Infrastructure

- *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The atmosphere during the conference was really fruitful and encouraging. All participants were open for discussion and much exchange and contacts were made during the event. Everybody was highly enthusiastic and showed a lot of motivation: discussion about CCS stretched until late into the night and, for example, even though the poster sessions were held at night after diner, they were well attended and lasted for more than 2 hours.

The infrastructure was well adapted: the right size, with a good room for the presentations but also a lobby where to gather and further share discussions during informal time. The service was very good and all our requests were met. A dancing party was organized on the last night after the conference diner, which was attended by most of the participants.

We received very positive feedback from participants stating, for example:

- “One can really feel the passion from the speakers”
- “One can ask all the questions even the “stupid” ones, people just answer with no condescendence” (from a person not familiar with CCS)
- “This event gave me a lot of motivation to go back now to work”
- “The discussion sessions are good to help people realize the different point of view that exist”