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GEO ENeRGY

ENeRG Partners Involved in the European CCS Demonstration Programme (part 1)

The EU Demonstration Programme for CO_2 Capture and Storage (CCS) was proposed by ZEP (European Technology Platform for Zero Emission Fossil Fuel Power Plants) three years ago, declaring an ambitious goal to have 10-12 CCS demonstration projects up and running by 2015. The Programme has received massive support within the EU, and, in fact, has become part of the official EU CCS policy. The first six demonstration projects have been selected for European co-funding from the European Energy Programme for Recovery (EEPR) in 2009. Another important milestone has been achieved in May 2011 when national governments submitted 13 CCS project proposals to the European Investment Bank (EIB) under the first call of the EU's "NER 300" programme, the world's largest demonstration programme for such technologies.

CO_2 geological storage (CGS) is a vital part of all of the prepared demonstrations. Since most ENeRG partners are deeply engaged in CGS-related research, it is no surprise that many of them have become engaged in the storage-related parts of the demonstration projects, both directly and indirectly. This article brings the first part of a brief overview of these activities.

France

The ULCOS-BF CCS demonstration project developed by ArcelorMittal at its Florange steel plant in Lorraine (Eastern France) and supported by a consortium of European steel producers has been proposed by the French Government for the NER300 funding mechanism in the category of industrial applications. It is a key part of the ULCOS II programme (Ultra-Low-CO_2-Steel) that aims to develop innovative technologies to reduce CO_2 emissions from the steel industry by at least 50%. The ULCOS I programme, which established the scientific and technical basis for the ULCOS-BF project, was carried out by a consortium led by ArcelorMittal and comprising of 48 organisations from 15 European countries, including 10 steel and mining companies (ArcelorMittal, ThyssenKrupp, Corus, LKAB, Saarstahl, Dilling, Riva, voestalpine, SSAB, Ruukki), manufacturers (such as Air Liquide), and universities and national research laboratories (such as BRGM).

The project is based on the transformation of a commercial blast furnace (BF) into a new technology concept where CCS is integrated in the Blast Furnace operation by recycling of the Top Gas after decarbonizing it. The ULCOS-BF will operate with pure oxygen and the CO_2 will be fed through a pipeline to a permanent geological storage site in a saline aquifer deeper than 1 km.

BRGM (France) and GEUS (Denmark) are the two ENeRG members that participated in the pioneering ULCOS I programme, a six-year integrated project developed in the 6th Framework Programme of the European Commission (2004-2010). BRGM is currently participating in the second phase, ULCOS II, working on the CO_2 geological storage aspects attached to the industrial demonstrator being prepared. With its competence, BRGM is able to provide assistance for surface and subsurface geological information, research and monitoring on hydrogeological issues, and risk assessment of long-term containment.

The Netherlands

The Rotterdam Maasvlakte CCS demonstration project of E.ON Benelux and Electrabel (as part of GDF-SUEZ), generally referred to as the ROAD project (ROAD standing for "Rotterdam Opslag Afvang Demonstratieproject") is one of the six selected EEPR projects in Europe, aiming at capturing CO_2 from the E.ON Maasvlakte power plant 3 (MPP3) in the Rotterdam harbour and storing it in the depleted gas field P18 offshore the Netherlands. This field is operated by Taqa. Transport from the power plant to the storage location will be executed through a 25 km long pipeline. The duration of the injection for the demonstration phase is scheduled for five years, starting in 2015, at an average injection rate of 1.1 million tonnes per year.

Through the national research program CATO2 (standing for "CO_2 Afvang Transport Opslag"), various groups in the Netherlands including TNO, the national ENeRG representative, are performing dedicated research studies to support the implementation of this project. This includes, besides capture and transport, storage studies to the geological characterisation of the reservoir, model building, simulation of injectivity and long-term behaviour, geochemical and geomechanical analysis, verification of the state of the existing wells and drafting of a suitable monitoring plan. More information can be found at www.cato2.nl.

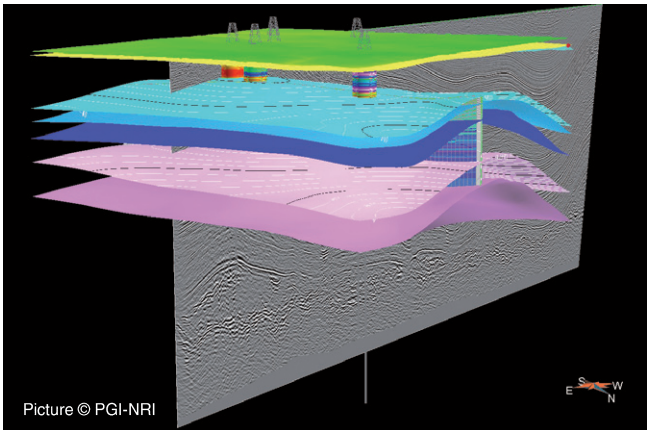

Fig. 1. 3D geological model of Budziszewice-Zaosie structure – a candidate storage site for the Belchatow CCS demonstration project in Poland. Caprock (light blue) and reservoir formations' (medium and dark blue) boundaries are shown, intersecting a vertical seismic section. The size of the model is approximately 10x15x3 km.

Poland

The Bełchatów CCS demo project has been supported by the Polish government since the EU Flagship Programme (by ETP ZEP) was announced in 2007. The project received EEPR support in 2009 and has been proposed by the government for the NER300 financial mechanism. The Bełchatów power plant, located in central Poland and operated by PGE, is the biggest lignite fired plant (4.45 GW) and single emission source (32 Mt CO_2 per year) in the EU. The CCS project includes construction of

a post-combustion capture plant integrated with a new, already completed (2010), CCS-ready lignite–fired block of 858 MW. It is planned that 1.8 Mt of CO_2 per year will be captured and transported by pipeline to a storage site in an onshore saline aquifer (Jurassic sandstones), located within a distance of up to 100 km from the power plant, after 2015.

Assessment of possible storage sites/areas is being conducted under the CCS project of PGE and also within the Polish National Programme on safe CO_2 storage, ordered by the Ministry of Environment and led by PGI-NRI, the Polish ENeRG partner. The PGI-NRI role in the demo project of PGE consists of consultancy and supervising of work in the field of geological storage. Moreover, the work ordered by the Ministry of Environment and led by PGI-NRI within the National Programme supports the CCS demo project indirectly.

(to be continued)

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CO_2CARE – Research Requirements of CO_2 Storage Site Abandonment

CO_2CARE – "CO_2 Closure Site Assessment Research", started in January 2011 and ends in December 2013. It is a collaborative project funded within the frame of the 7th Framework Programme of the European Commission. CO_2CARE deals with the CO_2 storage part of the CCS technology chain focusing on three key areas: a) well abandonment and long-term integrity, b) reservoir management and prediction from closure to long-term and c) risk management methodologies for long-term safety.

The research in CO_2CARE aims at developing the necessary operational and post-closure site management technologies which will ultimately lead to a concept of robust procedures for site abandonment including long-term integrity of the storage complex. In detail, the project objectives will be achieved by carrying out the following activities:

Existing international practices and requirements on CO_2 geological storage and site abandonment will be assessed and compared with up-to-date industrial practices. Legacy data from other abandoned CO_2 sites will also be included into the research.

By means of combining laboratory experiments, numerical modelling and field work, the development of testing technologies to safely abandon CO_2 injection wells and to assess their performance in the long-term will be achieved.

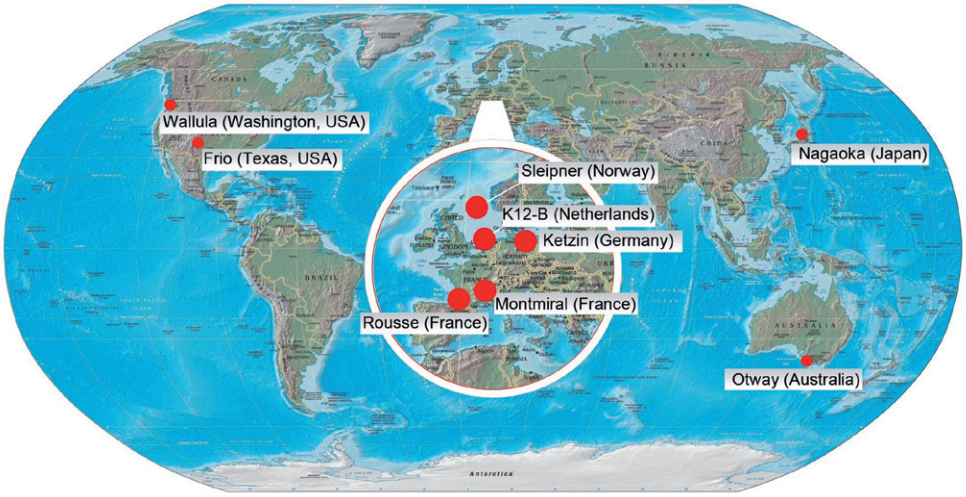

Fig. 2. European and overseas CO_2 injection sites studied in CO2CARE – field site portfolio (GFZ 2011)

One project topic deals with post closure reservoir management of a storage site and focuses on the reservoir, caprock and neighbouring hydraulic units. Key elements are the demonstration of long-term integrity and stability of storage sites, development of an associated monitoring programme and the development and numerical assessment of the feasibility of a number of remediation technologies.

The procedures and criteria for the assessment and mitigation of risk at abandonment and post-closure stages of a CO_2 storage project, including the formulation of monitoring and remediation plans for the transition between site closure and transfer of responsibility will also be developed.

Based on the research findings, guidelines for regulatory compliance and Best Practice for site abandonment will be established. So-called "dry-runs", a tool for hypothetical closure scenarios, will be applied at real storage sites such as Sleipner, K12-B and Ketzin.

The EU CCS Directive (2009/31/EC) does not define technical acceptance criteria for site abandonment in detail. However, the following three criteria are reflecting the essentials for future site abandonment:

- Observed behaviour of the injected CO_2 conforms with the modelled behaviour;
- No detectable leakage is observed;
- Site is evolving towards a situation of long-term stability.

The identification of such criteria and the development of site abandonment procedures and technologies, which guarantee the fulfilment of these criteria, are the main objectives of CO_2CARE.

The CO_2CARE consortium, consisting of universities and research institutes from the EU, USA, Canada, Japan and Australia, as well as industry, will provide best-practice guidelines at the end of the project, for which a worldwide impact is expected.

Project coordinator is GFZ – German Research Centre for Geosciences in Potsdam, Germany. For more information see the project website at www.co2care.org.

Michael Kühn (GFZ)

ENeRG – European Network for Research in Geo-Energy

ENeRG – European Network for Research in Geo-Energy – is an informal contact network open to all European organisations with a primary mission and objective to conduct basic and applied research and technological activities related to the exploration and production of energy sources derived from the Earth's crust.
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Geo-Energy Profile of Turkey

Turkey stands on the junction of strategically and economically important regions, between the Middle East, Central Asia and the Caucasus. With a young and growing population, low per capita electricity consumption, rapid urbanization and strong economic growth, Turkey, for nearly two decades, has been one of the fastest growing power markets in the world. Domestic energy supply accounts for less than 30% of total energy consumption as of 2008.

Turkey has a potential to have almost all of its future energy requirements met by various resources existing in the country. Primary energy sources that are produced in Turkey are hard coal, lignite, asphaltite, petroleum, natural gas, hydroelectric energy and geothermal energy.

Coal is the main energy resource; 24% of the total resources in Turkey. Turkey is one of the biggest producers of lignite in the world. This comes predominantly from deposits of the southwest and the South-eastern Afsin-Elbistan Basin, where 7339 million tonnes of lignite is economically exploitable. The government plans to increase the coal supply up to 120 million tonnes/year by 2020.Turkish lignite reserves are about 12 billion tonnes and hard coal reserves about 1.3 billion tonnes. Domestic coal production in 2004 was 48 million tonnes whereas coal import was 16 million tonnes. Electricity production potential that depends on lignite sources of Turkey is 120 billion kWh/year.

Petroleum resources exploration and exploitation activities are currently conducted by 16 foreign and 3 domestic companies. Up to present, 95 natural gas fields and 17 oil fields have been discovered. Remaining crude oil reserves are about 43 million tonnes. Ninety-nine percent of Turkey's proven oil reserves are in Southeast Anatolian Petroleum Province and the proven natural gas reserves are in the Thrace Basin in North-western Turkey.

Turkeys' natural gas reserves are quite limited, thus production capacity is very low. Total natural gas consumption reached 27 billion m^3; whereas production of natural gas was only about 800 million m^3 in 2005. Projections suggest that Turkey will need about 50 billion m^3 /year natural gas by 2020. Three oil pipelines are in operation in Turkey: Iraq-Turkey crude oil pipeline with a capacity of 70.9 million tonnes/year, Batman-Dörtyol pipeline with a capacity of 3.5 million tonnes/year and Yumurtalık-Kırıkkale pipeline with a capacity of 5 million tonnes/year. Baki-Tbilisi-Ceyhan oil pipeline is a transboundary pipeline transporting the Caspian Sea oil to the Mediterranean Sea coast.

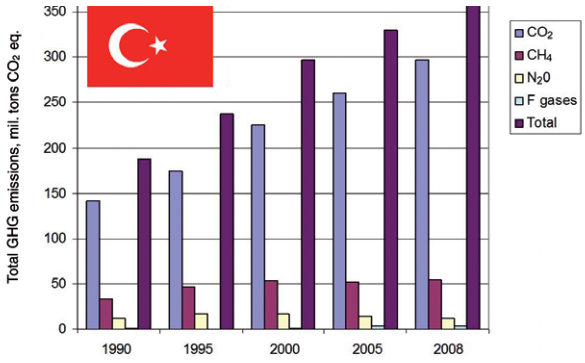

Fig. 3. Greenhouse gas emissions in Turkey in the period 1990–2008 (TUIK, 2009)

Turkey has important potential for renewable energy sources such as hydropower, wind, solar and geothermal energy. Turkey has approximately 170 geothermal areas where temperature of geothermal fluids is above 49˚C. Some of these resources (high enthalpy waters and steams) are suitable for electricity production while the rest are suitable only for direct usage. Furthermore, about 200 thermal springs are available for health tourism, corresponding to 327 MW_t output. Potentially, 30% of the houses (about five million) can be heated by geothermal sources (equivalent to 32 billion cubic meters natural gas). First electricity production by geothermal energy in a pilot plant started in Denizli-Kızıldere area in 1974. Ten years later, a new plant was added and the capacity reached 20 MW_e. In 2005, the capacity reached 185 MW_e with new geothermal electric plants put into operation. Turkey is planning to reach 1000 MW_e in 2020.

Until the end of the 1990s, the energy sector in Turkey was mainly state-owned, thereafter private sector involvement has increased. By the end of 2009, 3727 boreholes have been drilled in Turkey for oil exploration, developments, production, injection and geo-investigation. More than a half of these holes, 2356 of them were drilled by TPAO (Turkish Petroleum Corporation), 961 of them were drilled by foreign companies, 229 by domestic and foreign companies' joint ventures, 104 by MTA (General Directorate of Mineral Research & Exploration) and 77 by other domestic companies.

The geo-energy-related research is governed by the Ministry of Energy and Natural Resources and associated public organisations. The major research institutions in the field of geo-energy are: the Turkish Petroleum Corporation (TPAO), Energy Centres of Universities and the TUBITAK Marmara Research Center in the field of hydrocarbons, Earth Science Departments of Universities and the TUBITAK Marmara Research Center in the area of coal and coal gas, and General Directorate of Mineral Research and Exploration (MTA) and Petroleum Engineering Departments of Universities in the branch of CCS and geothermal energy.

Current priorities related to geo-energy research and development were set to support the Turkish national energy policy. This policy was declared by the Ministry of Energy and Natural Resources (ETKB) as "providing sustainable energy for continuous economic growth, thus supporting social development by providing necessary energy under secure, reliable and economical conditions". The long-term targets declared by ETKB to be achieved in 2023, are as follows:

- To achieve complete use of the potential of indigenous coal and hydraulic resources,
- To achieve maximum use of renewable resources,
- To incorporate nuclear energy into electricity generation until 2020,
- To secure rapid and continuous improvement in energy efficiency in a way that parallels EU countries.

In this way, the energy sector in Turkey, which hitherto stood on three main pillars (natural gas, coal and hydropower), is being redesigned in a sound, five-pillar structure to additionally include renewable resources and nuclear energy.

The First National Communication on Climate Change for Turkey was published in 2007 covering the period 1990–2004. The sources of greenhouse gas emissions were identified and quantified. The CO_2 emissions came to 227 million tonnes in 2000. Future emission estimates were studied for different scenarios and by the year 2020, about 600 million tonnes/year of CO_2 emissions were projected. The main source is the electricity production and industrial applications.

Turkey is an Annex 1 country of the Kyoto protocol. However, CO_2 emissions per capita are only 3.3 tonnes (in 2003) compared to 11.9, 9 and 4 tonnes per capita in OECD, EU-15 and the world respectively. The preparation of the second National Communication on Climate Change is underway and these figures will be updated. A greenhouse gas inventory for 2004-2008 was collected and published by the Statistical Institute of Turkey.

Among the CO_2 abatement options, energy efficiency is expected to have the main impact. Development of the CCS option is in the phase of assessment of potential geological storage sites and their storage capacity potential. Research on aquifer storage modelling, cap rock and well integrity (incl. laboratory research) and geochemical reactions is ongoing at universities.

National know-how on CO_2 production from a natural CO_2 reservoir, pipeline transportation and injection for the purposes of Enhanced Oil Recovery (EOR) dates back to 1985. A CO2-EOR project is still continuing at the Batı Raman oil field in SE Turkey, owned by TPAO. In general, the CO_2 storage potential in producing Turkish oil fields is limited due to their small size. However, the natural CO_2 reservoir (with CO_2 content of 90 %) in the Batı Raman field, which is now used for EOR, can be converted into CO2 storage in future.

Sedat Inan

RISCS – Impacts and Safety in CO_2 Storage

RISCS is a 4 year, EU (FP7) and industry sponsored project, which started in January 2010 and is focussing on the potential environmental impacts that might be associated with CO_2 leakage from a storage site. There are 24 organisations participating in RISCS, which is coordinated by the British Geological Survey.

Facilities for the geological storage of carbon dioxide (CO_2), as part of carbon capture and storage (CCS) schemes will be designed to prevent leakage back to the surface. However, it is important to be able to assess the consequences of leakage, should it occur. The RISCS project is investigating the potential environmental impacts that might be associated with any such leakage.

A set of credible CO_2 impact scenarios will be developed for a range of near surface reference environments. The scenarios will provide the basis for mathematical modelling studies that will be undertaken later in the project, and will help to define experimental studies in both terrestrial and marine environments.

Fig. 4 . Assessment of CO_2 influence on plant species at the ASGARD site, University of Nottingham

Data required to understand, model and evaluate possible impacts of CO_2 entering the marine environment will be obtained from experiments ranging from tests at a small laboratory scale with single species/communities, to those using larger outdoor "ponds" (mesocosms). In addition, field experiments will be performed using a benthic chamber lander (a submersible mini-lab) in Norway and physico-chemical and biological data will be collected at the natural CO_2 leakage site at Panarea in Italy.

Field studies in terrestrial environments will assess the potential impact of a CO_2 leak to the surface. A key focus is to establish generic principles governing environmental responses so that the findings of particular studies in specific environments can be generalised, modelled and applied across a wide range of environments. This will be achieved by both experiments at CO_2 injection sites (at ASGARD, UK and Grimsrud Farm, Norway) and field observations in Greece, Italy and France.

Computer models will be developed to describe the form and impact of potential leakage scenarios. There will be both a terrestrial and marine component, which will use the experimental results to examine the different scenarios. The primary purpose of using mathematical models is to help gain a better understanding of the key processes that are involved if elevated levels of CO_2 entered the biosphere from below, as a result of leakage from a CO_2 storage system.

A key RISCS output will be a Guide to appraising impacts of CO_2 leakage scenarios in Europe. The Guide will combine research results from RISCS with those from other projects and published information to provide operators and regulators with practical criteria to evaluate risk and monitoring strategies. For further information please visit our website www.riscs-CO2.eu.

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