Carbon Capture & Storage Opportunities in a New Europe

Workshop Summary Report

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Reported by:
Ceri Vincent, British Geological Survey

Event organised and sponsored by:

UK Energy Research Centre

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BRITISH GEOLOGICAL SURVEY

The British Geological Survey (BGS) was established in 1835 and is the United Kingdom's national geological survey and one of the world's major centres of geoscientific knowledge, expertise and excellence. BGS has approximately 800 staff, of which some 500 are professional scientists and technologists. It is the nation's foremost supplier of geoscience solutions and custodian of much of the country's geoscientific information. It is responsible for advising the UK government on all aspects of geoscience as well as providing impartial geological advice to industry, academia and the public in the UK and internationally. BGS forms part of the Natural Environment Research Council (NERC), responsible for basic, strategic and applied research in the environmental sciences. BGS was involved in the pioneer EU Joule II project and has been involved since in many other CO_2 capture and storage projects including SACS, GESTCO, NASCENT, WEYBURN, CO2NET, NGCAS, SAMCARDS, CO2STORE, CASTOR. BGS is co-ordinator of the Network of Excellence "CO2GeoNet".

CORE ORGANISING TEAM

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Workshop Background

This workshop was organised by Mr. Jonathan Pearce (chair) and Dr. Sam Holloway of the British Geological Survey (BGS) and Jane Palmer of UK Energy Research Centre (UKERC) Meeting Place, with assistance from Rudra Kapila (UKERC). Ms Ceri Vincent (BGS) was the reporter for the event. Clair Gough (Tyndall Centre) facilitated the open discussion session in the afternoon.

The workshop followed on from the 'New Europe, New Energy' conference on the 26th September, co-sponsored by the UKERC, the Open University, DTI and EPSRC. The purpose of the workshop was to bring together key individuals from the Central and Eastern European countries with leading figures from the UK energy research community, government and specialist agencies.

The objectives of this workshop were to:

1) Facilitate discussion, debate and information-sharing on the potential role that clean coal technologies, in particular Carbon Capture and Storage (CCS) could play in developing a secure and sustainable European energy system.
2) To identify potential challenges in implementing CCS and how it could fit in with other low carbon, clean energy sources
3) Formulate recommendations for stimulating future opportunities in CCS in Central and Eastern Europe Countries.

The workshop included representatives from Lithuania (two delegates), the Ukraine (two), Croatia (one), Romania (one), Poland (one) and France (one). The majority of the delegates (17) were from the UK. Unfortunately, for reasons beyond the control of the meeting organisers, there were fewer Central and European country representatives than anticipated, which regrettably impacted on the discussion of potential opportunities and barriers to implementing CCS in Central and Eastern Europe. However, there was still interest and support for the workshop, with positive discussion on the future of CCS in Central and Eastern Europe and potential for forming links in the future.

Five presentations were given in the morning to introduce the concept of Carbon Capture and Storage (CCS) and opportunities for CCS in Romania, Croatia and Poland. The afternoon was dedicated to open discussion on opinions of CCS and the potential opportunities and challenges.

The agenda, a list of participants and presentations from the workshop are available on the UKERC website (http://www.ukerc.ac.uk/content/view/344/443). Summaries of the presentations and relevant discussions are set out below.

Morning presentations

An overview of the need for CO_2 capture and storage, and capture technologies applicable in Eastern Europe

Dr. Jon Gibbins, Imperial College London

Dr. Jon Gibbins has worked on coal gasification and combustion for over 25 years. He is the Principal Investigator for the UK Carbon Capture and Storage Consortium (www.ukccsc.co.uk) and is also involved with academic, industrial and government activity on CCS in Canada, China and India as well as in the UK.

Given the expected reserves of fossil fuels and the anticipated effects of emissions on the climate, CCS is a favourable option for continuing to use fossil fuels. Carbon capture from large point sources, such as power plants, can be carried out with either pre- or post-combustion (e.g. amine absorption) capture systems, or via the oxyfuel process, where coal is burned in a highly oxygen-enriched air stream and CO_2 and water are the main products. Options for USCPC (Ultra Super-Critical Pulverised Coal) and IGCC (Integrated coal Gasification Combined Cycle) fossil fuel power stations with and without capture were considered. Improvements in technology and efficiency would be expected, reducing cost and lessening the 'capture efficiency penalty'.

A number of carbon capture and storage projects are planned to start during the next decade. Eastern Europe may have slightly different requirements to those discussed for Western Europe e.g. a higher proportion of lignite coal. But security of energy supply and economics, such as using imported coal and CCS or imported LNG (liquid natural gas), are relevant to everyone. Each situation must be considered independently and local expertise is essential.

Principal requirements to make a plant 'capture-ready' are: available space for bulky capture plant; a design study for adding CO_2 capture and optional pre-investments to reduce future costs, improve performance (e.g. locating plant near storage site). Allowance must be made for rapid technology changes and the cost of replacing plants compared to adding expensive capture technology later must be considered.

Discussion

Following this presentation, the cost of carbon capture and the efficiency penalty were discussed. The main interest in CCS for industrial partners was from a financial point of view; cost was considered to be more important than efficiency of power generation. The cost/performance ratio is important; the proportion of CO_2 captured could be rapidly varied with the price of electricity: if electricity prices increased, the amount of CO_2 it would be economical to capture would also increase. Potential approaches to taxing CO_2 were discussed: it could be based on CO_2 emitted or tax incentives could be offered on emissions avoided. The question was raised: does the cost of capture increase rapidly above 80% capture? To get high capture rates, current technology, other than oxyfuel, would be pushed to its limits. Essentially, an optimum balance between cost and lost electricity would be sought.

Carbon dioxide capture and geological storage

Dr. Sam Holloway, BGS

Dr. Sam Holloway is a principal geologist at the British Geological Survey. He has worked on the geological storage of carbon dioxide since 1991. From 1992 – 1996 he was co-ordinator of the Joule 2 project 'The Underground Disposal of Carbon Dioxide'. He is a lead author of the IPCC Special Report on Carbon Capture and Storage.

If emissions continue with 'business as usual', the CO_2 concentration in the atmosphere could be expected to rise sharply and gradually decline to an equilibrium level after the 'fossil fuel era'. If CO_2 could be stored for 1,000-10,000 years, this would be expected to significantly lower the peak atmospheric concentration and final CO_2 equilibrium level. Geological storage could potentially store CO_2 for thousands to millions of years. Potential storage sites considered for the UK are saline aquifers, oil fields (including EOR – enhanced oil recovery), gas fields (minor potential for EGR – enhanced gas recovery) and coal seams (limited potential with present technology).

Monitoring of a CO_2 storage site is very important. A site considered for storage would require a thorough geological characterisation, modelling, and simulations of CO_2 injection. Each storage site is different; the most important issue to consider is long-term stability of storage. Surveys of the injection site would be collected before and then during injection, and the results would be used to predict the long-term fate of injected CO_2. Following the site closure, it is possible that long-term responsibility would be handed over to the State. If injected CO_2 leaked, there could be adverse environmental effects, depending on the size of the leak. The possibility of leakage and potential remediation steps need to be considered further.

CO_2 storage is technically possible and indications are that it can be undertaken on a sufficiently large scale to make an impact on CO_2 emissions. Experience is being gained from early opportunities and demonstration projects. It may represent a bridging technology to a low or no-carbon energy system.

Discussion

Potential damage from leakages in terms of the environment and public opinion was discussed after this presentation. An example of a well blowout where 10,000 tonnes/day escaped was given. The well could be worked on with breathing equipment and in some ways was less dangerous than natural gas leaking from a well where the risk of fire is extreme.

Restructuring the energy sector in Romania

Christian Tanatreanu, ENERO (Centre for the Promotion of Clean and Efficient Energy in Romania)

Cristian Tantareanu is the Director of the Centre for Promotion of Clean and Efficient Energy-ENERO, expert in distributed power generation and renewables. He has worked in the renewable energy sector since 1980 and has published about 30 papers on renewables. Between 1991 and 1992 he completed his professional experience as visiting researcher in Rutherford Appleton Laboratory, UK and Folkecenter, Denmark. In 1998-1999 he was Scientific Director of ICEMENERG (Power Research Institute). In 2000, he was one of the founders of the ENERO centre, a non-profit consultancy focusing on energy analysis, renewables and energy policy issues, and participating in a number of international projects. A significant part of ENERO budget is provided by EU projects within FP6 and Intelligent Energy for Europe programmes.

Romania was recently confirmed as part of the EU, as of January 2007. Romania has 22 million inhabitants and an area of 237,000 km^2. Oil reserves are estimated at around 200Mt, with production decreasing since 1997. Gas reserves are estimated at 335Gm^3 and gas is also imported. Estimated reserves are 800 Mt coal and 2.8 Gt lignite. The potential for hydropower is estimated at 40 Twh pa, with 16 TWh pa currently implemented. Biomass provides around 7% energy for heating purposes. In 2004, energy dependency was at 28% and is expected to rise. It is expected that energy use could be decreased by thermal rehabilitation of buildings and increasing the efficiency of district heating systems.

Romania is the largest oil and gas producer in the area and has the second largest number of inhabitants in the area. Romania promotes important trans-European networks. It is part of the Nabucco project, a £3.2bn 3,300km gas pipeline through Turkey, Bulgaria, Romania, Hungary and Austria due to be built in 2008. Romania has underground natural gas storage facilities.

Electricity is mainly produced from hydroelectric or coal-fired plants. An important quantity of electricity is produced by cogeneration technology: old back pressure steam turbines and condensing steam turbines fuelled mainly by oil and gas. National policies consider nuclear power as a priority and hydroelectricity as important. As yet, Romania is not above its Kyoto level and so there is little incentive for carbon capture. However, investment in renewable energy sources has begun. In the short term, investments in biofuels, small hydro and wind plants are expected. Geothermal energy is another option with exploratory wells proving reserves. Romania may benefit from the biofuels promotion in Europe. The Green Certificate (GC) Trade mechanism is in place and operational, regulating electricity operators, suppliers and renewable energy resource producers.

Discussion

Following this presentation, energy supply and the need for a national allocation plan for CO_2 when joining the EU were discussed. Continuation of the European Emission Trading Scheme after 2012 when phase 1 will expire were considered and a similar extension was anticipated.

An overview of CO_2 capture and geological storage potential in Croatia: opportunities and barriers

Professor Bruno Saftic from the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb (RGNF)

Professor Bruno Saftic is a member of the Faculty of Mining, Geology and Petroleum Engineering at Zagreb University. He is project leader for the Croatian contribution for the EU GeoCapacity project and was involved in the CASTOR project. In 2005 he was president of the ENeRG Network.

The annual CO_2 emissions in Croatia reached their agreed Kyoto level in 2002. CO_2 represented 77% of the major greenhouse gases emitted in 2003. The majority of the emissions are from the energy sector. Twenty-one percent of the CO_2 emitted in Croatia is from seven power plants and one natural gas processing plant in the north of the country. As part of the GeoCapacity project, the Ivanic oilfield has been studied in detail for carbon capture and storage. Simulations have been run on injection. It is hoped the large gas processing plant at Molve (with a fairly high CO_2 concentration in its flue gas) can be connected with this through adaptation of an existing pipeline for Enhanced Oil Recovery (EOR). Although aquifer storage capacity is theoretically large, there is a lot more uncertainty in the estimates compared to explored hydrocarbon fields. Offshore storage in the Adriatic is also to be studied. In general, storage in coalfields is not an attractive proposition as there are little reliable data available. Croatia is quite seismically active, earthquakes of magnitude 6-7 on the Richter scale are not uncommon in parts of Croatia and earth tremors of 3-5 are frequent.

State regulatory bodies responsible for environmental protection, science and technology are fulfilling commitments within the UNFCCC in controlling and reducing CO_2 emissions and produce a bi-annual report. Geological storage is only addressed through RGNF-led research, funded by European Framework 6 projects. However, government contacts have generally shown a positive attitude to CCS. The national oil company (INA Oil Co.) is looking at CO_2 storage but have not yet begun to implement it. The energy industry (HEP) has not yet indicated an interest in CCS. At present, there is a programme to contribute to the public and political awareness of climate change and carbon capture and storage. Community concerns on safety and the potential impact of this on the environment need to be discussed. Tourism is more important and desirable than heavy industry in Croatia and so a clean environment is essential.

Discussion

After this presentation, potential future lowering of permitted CO_2 emissions was discussed. Again, financial incentives for companies to inject CO_2 into hydrocarbon fields were highlighted as an important factor. The national oil company of Croatia has been partly bought by the Hungarian national oil company. Only the national oil company of Croatia can own oilfields. Previously the national oil company closed many small fields which have not been considered for CCS. However, now the oil price has risen, they may become economic again. The Croatian Government is interested in oil as an energy source; the concept of CCS is relatively new and not currently given consideration. In some hydrocarbon fields, CO_2 concentrations can be as high as 15-20%. Representatives from UK industry commented that this CO_2 could be supplied at 5 Euros/tonne to oil companies external to Croatia, for profit.

CCS opportunities and barriers in Poland, based on CASTOR WP1.2 report

Dr. Adam Wójcicki, Przedsiebiorstwo Badan Geofizycznych – Geophysical Exploration Company (PBG)

Adam Wójcicki has worked at PBG as a geophysicist, team and project manager since 1996. He has been involved in CCS applied research activities supported by the Sixth Framework Programme since 2004 (responsible for the Polish part of CASTOR WP1.2, participant of EU GeoCapacity and now responsible for the Polish part of CO2NETEast). He has published results from these Framework 6 projects in Polish periodicals (in 2005 and 2006). He is also responsible for developing the interactive map of emission sources and possible sinks and other related features in Poland, available on the PBG website (http://www.pbg.com.pl/castor_eng.htm), based on CASTOR WP1.2 results as a possible advance contribution to CO2NETEast. He is the Polish national representative in the ENeRG network.

In 2004, CO_2 emissions in Poland were 87% of the 1990 Kyoto Protocol level. It is expected that Poland will reach their Kyoto levels (92% of 1990 level) at the end of 2007 at which point measures for CO_2 reduction will be implemented. CO_2 emissions are dominated by the energy sector. Large point sources were catalogued for the CASTOR project, with these industrial sources responsible for over 100 kt CO_2 pa, about 62% of total emissions for the country.

There are also some natural seeps of CO_2. The largest source emits around 11 kt pa. Seismic risks are not considered significant, although many earth-tremors of 4-5.5 magnitude have been recorded during the last eight centuries.

Potential geological storage sites include deep saline and geothermal aquifers, depleted/depleting gas and oil fields (studied in the CASTOR and GEOCAPACITY projects) or coal seams (ECBM – enhanced coal bed methane). Storage in regional aquifers may represent a potential conflict of interest with planned geothermal localities. Storage potential in oil fields is currently limited as there are only three relatively mature (and sizeable) oilfields, including one offshore. Gas fields offer a more promising option at present (though some may be considered for gas storage instead), in southeast and west Poland. Coalfields in the Upper Silesian Coal Basin have been considered: total storage potential is estimated to be up to 2 Gt. An experimental ECBM site is located in the southern part of this basin, at Kaniow. Absorption by vegetation and reforestation is another possibility (LUCF – land-use change and forestry – absorption is currently 8% of Poland emissions). Future technological development in the energy industry and other sectors currently emitting CO_2 are also a possibility. CCS could also be encouraged by administrative measures such as emissions trading. From initial research (CASTOR), the storage capacity of Poland has been estimated at 3,752 Mt for 12 structures in regional aquifers (11.4 years storage), 572 Mt in 28 hydrocarbon fields (1.7 years storage), 470 Mt in 23 coalfields 470Mt (1.4 years storage). These figures will be updated in the GeoCapacity project.

Discussion

Following this presentation, aspects of ECBM were discussed. When CO_2 is injected into coal seams, it is preferentially adsorbed onto the coal, releasing methane in the coal, which can then be collected via boreholes. Underground Coal Gasification (UCG) was also mentioned (oxidants are injected into an underground coal seam, gasifying the coal). Another topic of discussion was a difference between storage potential of regional aquifers (to be assessed in the GeoCapacity project) and storage capacity of certain structures within these aquifers (initial estimates given in CASTOR WP1.2).

Open Discussion

Before lunch, Clair Gough of the Tyndall Centre facilitated a brief discussion on energy policy and carbon capture.

Energy Policy and Carbon Capture

The EU Emissions Trading Scheme (EU-ETS) was initiated in January 2005. Companies were given licence to emit a certain amount of CO_2. Under the trading scheme, a company emitting more CO_2 than their allowance would be allowed to purchase further allowances from a lower-emitting company. The trading scheme only covers certain industry sectors such as electricity generation and excludes others such as transport. From discussion at the meeting, it was generally believed that the policy does not currently provide sufficient financial incentive for CCS and the framework for application and regulation was inadequate.

One disadvantage of the ETS recognised by the delegates was that the price of trading units was very unstable and that it was only set to the end of the Kyoto Protocol period in 2012. Industry requires considerable more security and clarity before it will make the necessary capital commitments.

Open discussion

Following lunch an open discussion was facilitated by Clair Gough. The main topics of discussion were:

1) Brief discussion of how CCS is viewed by the delegates and relative importance to other energy policy goals in Central and Eastern Europe.
2) Discussion on key challenges/barriers to implementing CCS in Central and Eastern Europe.
3) Identification of key ideas, recommendations and actions to implement CCS.

The main ideas from the discussion were noted on flip charts to allow delegates to make any amendments they felt necessary. The discussion, based on the flip charts, is summarised below under the following themes:

- Opinions of CCS
- CCS/energy challenges in Central and Eastern Europe
- Key ideas and actions/recommendations

Opinions of CCS

It was generally believed to be a good time to test CCS technology using large-scale demonstrations to test the technologies in an integrated system and to ‘learn by doing’. There was however concern that CCS could be seen as a rival to renewable energy and that it could draw attention and financial resources away from developing more sustainable, cleaner and/or renewable energy sources. The response to this was that it needed to be presented as a ‘bridging technology’ between current practice and developing future cleaner energy sources.

It was generally agreed that renewables could form part of the energy budget, but with present technology it would be unworkable to rely only on renewables. One example given was of wind power – it only works when the wind blows! Another aspect of energy supply is allowing some capacity for backup and, more importantly, for load following (i.e. more energy made available during peak usage on short timescales). At present, coal with CCS and potentially biofuels were believed to offer the best realistic options for ‘cleaner’ base load energy.

Nuclear power as part of the energy budget was considered. Croatia has one nuclear power plant and seems unlikely to build any in the foreseeable future. The Ukraine has nuclear power plants. The main concerns raised concerning nuclear power were storage of nuclear waste and the inability of nuclear power stations to load-follow on a suitably short timescale.

For countries such as the Ukraine, whose emissions are below their Kyoto limits, there is less incentive to develop CCS, as it is currently an expensive option. The question of raising CCS on the political agenda was discussed. The identified drivers for each country varied on political and economic grounds. For example, Croatia is keen to promote tourism rather than concentrating on heavy industry and CCS could potentially reduce CO_2 emissions. For Romania, security of supply and support for local industries were seen as important and CCS may offer a method of using native lignite within the Kyoto protocol. It was stated that in general, security of energy supply is important, in Eastern Europe as well as elsewhere.

The main concern with CCS amongst delegates was safety. Key questions that were raised included: can the injected carbon escape and cause environmental damage or harm? Is there an acceptable leakage level, particularly considering that in some sites CO_2 is naturally leaking (e.g. some springs)?

In some Eastern European countries such as Croatia, earthquakes are not uncommon, the issue of this potentially affecting CO_2 storage sites was discussed. An example was given of the Japanese Nagaoka storage site where an earthquake magnitude 6 on the Richter scale had had no effect on injected CO_2.

A major concern amongst delegates was the effects of a large/catastrophic leak. A large leak could cause environmental damage, harm to people/animals and damage to public perception of CCS. Onshore storage of CO_2, particularly in populated areas, could be considered more risky and may require additional regulations. One point raised concerning injected CO_2 was that since it is injected into deep reservoirs, if the seal were breached it would still have to migrate through a great thickness (likely to be over 700m) of overlying rock. This raised the issue of how long storage sites would be monitored and who would be responsible for the long-term monitoring. It is unlikely that a company would be available for monitoring over thousands of years; responsibility would most likely have to be handed over to the State, which could cause legislative issues.

CCS/energy challenges in Eastern European countries

The next topic discussed was potential barriers and challenges to CCS, with particular consideration given to Eastern European countries.

The first consideration was the requirement for sufficient storage capacity. Projects such as EU GeoCapacity are providing initial estimates of theoretical storage capacities in many European countries. One concern with geological storage of CO_2 was potential conflicts of interest with other underground projects, such as geothermal projects or gas storage. Storage capacity varied widely between countries. Eastern Europe appeared to offer a lot of onshore storage capacity and it was recognised that local expertise and studies are essential.

It was generally agreed that assessing wells and site characterisation present a challenge. The cost of a full site appraisal is high. ECBM appears to be a good option for some Eastern European countries with deep coal seams, but there is more uncertainty about well integrity and site characteristics than with explored and tapped hydrocarbon fields. There was also the issue of a lack of current funding to investigate less understood sites such as aquifers.

The best approach to CCS appeared to be to start with 'easy', well understood storage sites to obtain experience and develop technological advances to gain confidence and expertise before using more challenging sites. It is expected that once CCS has begun on a large scale, technological advances will assist in lowering the price and uncertainties in CCS.
In the UK, the Carbon Capture and Storage Association (CCSA), a consortium of interested companies who lobby the UK Government about CCS, has been established. It was suggested that a similar international organisation could be established to lobby governments, facilitate knowledge transfer and advise on policy. However, it was generally felt that such an organisation would be best formed first by a collection of interested organisations with similar interests and then formalised as a Europe-wide association.

It was noted that the timescale for changing regulations is long; if policy-makers can be involved and influenced now, then CCS could be implemented within a reasonable timescale. Public opinion was considered very important, and communication with the public to promote understanding of CCS, energy policy and climate change was also considered to be extremely important. CCS would increase the price of electricity and other products.

The EU-ETS is supposed to allow ‘burden sharing’. Under the Kyoto protocol, some countries were given the status ‘country in transition’ with more generous allowances as they were rapidly developing – this could be stifled by too strict emissions limits. The UK intends to market 7% of its CO_2 allowance. In general, it was agreed that there was not sufficient financial (‘bankable’) incentive. Money from EOR is a financial incentive for some oil and energy companies. Policy affects CCS: for example, if it is to be stored as a ‘waste’ product, it is governed by a different set of regulations than if it is used as a ‘working fluid’ for EOR. Regulations can cause confusion and could make CCS more complex and unattractive to implement.

Another potential barrier to CCS discussed was the ‘window of opportunity’, for example, timing for EOR is important. In some cases, existing infrastructure could be adapted for CCS; this may also have a limited timescale.

Another issue raised was that CCS is often associated with the energy sector and other sectors, such as cement manufacture, are not considered. Given that it is more expensive to extract CO_2 from low-concentration streams and that typical flue gases from cement manufacture have a higher concentration (25%) than coal-fired power stations (12%) and ammonia plants have an almost 100% CO_2 flue gas, other sectors should also be considered. It was generally agreed that it is important to look at all industries that produce large quantities of CO_2. However, the cost of CCS needs to be taken into account: for example, implementing CCS in cement manufacture could cause companies to become uncompetitive with imports from countries where CCS is not used.

Actions/Recommendations

From the afternoon discussion, the following actions/recommendations were identified:

- The storage capacities across CEE countries need to be mapped out. This has begun within the FP6 GeoCapacity project but needs to be expanded significantly.
- Site selection is fundamental to building confidence, especially during early demonstrations.
- Consideration of early opportunities across the region to undertake demonstration projects, building local confidence, capacity and expertise.
- The need to facilitate experience and knowledge transfer from the research community (largely based in Western Europe) and oil companies to the following groups at a national and regional level:
    - regional associations;
    - big industry;
    - voluntary sectors.

  This will help to initiate policy development in this area.
- Engagement with other industries in Central and Eastern Europe, e.g. cement, ammonia, refineries.
- Public opinion should be investigated in Central and Eastern Europe: public acceptance of CCS is important if it is to be adopted, particularly as it will increase electricity prices.
- Financial incentives for CCS are important to encourage industry to implement relatively expensive technology and this should be explored further.