Number 79, September 2005

Greenhouse Issues

In this Issue:

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IEA GHG Membership News

We are pleased to be able to announce that another two major energy companies have applied to join the IEA GHG Programme. Formal membership procedures are underway for E.ON AG and BG-Group.

E.ON AG

E.ON AG is the world's largest private-sector energy services company. Its headquarters are in Germany. The company is involved in a number of CO_2 emission reduction initiatives; amongst which are the EC Framework 6, CACHET, DYNAMIS, and CASTOR projects. For more information, visit their website at www.eon.com

BG-Group

The group's focus is on natural gas markets around the world. It operates in 4 key business sectors: Exploration and Production, LNG, Transmission and Distribution, and Power Generation. Visit their website at www.bg-group.com

New Project Officer at IEA GHG

The IEA GHG is pleased to welcome Stanley Santos to the Programme team. Stanley is a Chemical Engineering graduate from De La Salle University in Philippines and has joined the IEA GHG team as a project officer.

Stanley obtained his post-graduate degree from Portsmouth University doing research on the use of biomass fired in small scale boilers. After completing his degree in 2002, he worked for the International Flame Research Foundation for three years where he gained his experience in the development of low NOx burners, oxy-fuel combustion technology and flame measurement techniques for combustion research.

Stanley's work with IEA GHG will include developing the oxy-fuel combustion research network and co-ordination of various other projects and its information generation activities.

Dr Stanley Santos

IEA GHG Annual Report On-Line

The IEA Greenhouse Gas Programme has just released its 2004 Annual Report. The report covers the fourth and last year of Phase 4, from 1st December 2003 to 30th November 2004.

The report is only being made available through our website in PDF format. Please visit our website to download your copy (www.ieagreen.org.uk).

IEA Response to G8 Gleneagles Communiqué

The G8 countries (Canada, France, Germany, Italy, Germany, Russia, UK, USA) met in Scotland on 6-8th July 2005. These 8 countries account for over 65% of global GDP and 47% of global CO_2 emissions. They were joined in their discussions on climate change by the IEA, UN, IMF, World Bank, and leaders of several countries, including China. In their Communiqué following the meeting it was stated that:

"All of us agreed that climate change is happening now, that human activity is contributing to it, and that it could affect every part of the globe.

We know that, globally, emissions must slow, peak and then decline, moving us towards a low-carbon economy. This will require leadership from the developed world.

We resolved to take urgent action to meet the challenges we face."

Leaders take their seats during a meeting at the G8 summit.
Photo: Chris Young/Crown Copyright - H.M. Government Handout Photo.

Her Majesty Queen Elizabeth II hosting a dinner with G8 leaders, front (left to right) President Bush, HRH Prince Philip, President Chirac, HM The Queen, Prime Minister Tony Blair and President Putin, back row (left to right), EC President Barroso, President Berlusconi, Chancellor Schroder, Prime Minister Koizumi and Prime Minister Martin at Gleneagles opening the G8 Summit on 6th July 2005.
Photo: Richard Lewis/Crown Copyright - H.M. Government handout photo.

Section 14 of the Communiqué contains specific proposals which involve the IEA and the IEA Greenhouse Gas R&D Programme. In this section, the G8 agree to work to accelerate the development and commercialisation of Carbon Capture and Storage technology. Amongst the proposals are invites to the IEA to:

(a) Hold a workshop on short-term opportunities for CCS in the fossil fuel sector, including EOR and CO_2 removal from natural gas production.
(b) Work with the Carbon Sequestration Leadership Forum (CSLF) to study definitions, costs, and scope for 'capture-ready' power plant and consider economic incentives.

IEAGHG is assisting the IEA in preparing its response. Other proposals included in section 14 of the Communiqué include collaborating with key developing countries to research options for geological CO_2 storage. IEAGHG has previously studied storage opportunities in Europe and North America and is in the process of following up this work by a study of storage opportunities in India.

The Communiqué is posted at: www.fco.gov.uk/Files/kfile/PostG8_Gleneagles_Communique,0.pdf

International Network on Oxyfuel Combustion

In the last edition of *Greenhouse Issues* (number 78), we announced that the inaugural meeting of the International Network for Oxy-Fuel Combustion was taking place this October. The date has been changed and will now take place on 29th and 30th November 2005.

We are pleased to announce that Vattenfall – an IEAGHG sponsor – has agreed to host the inaugural meeting at their Schwarze Pump Coal Fired Station (future site of the 30MW Oxy-Coal Combustion Demonstration Plant (*Greenhouse Issues*, number 78).

The first meeting aims to provide an international forum to promote dialogue between international research groups active in this field. Technically, the meeting aims to identify the gaps of knowledge in the field, and will eventually establish a large scale demonstration of this technology. Also, this meeting aims to identify areas where pre-competitive research co-operation could be established. The initial meeting shall include a review of the current state of knowledge in the Oxy-Fuel Combustion field and work in progress.

John Topper and Stanley Santos will be co-ordinating the initial meeting. Those interested in attending should contact Stanley Santos by email (stanley@ieaghg.org).

World's First Combined Clean Energy Plant with EOR

BP, ConocoPhillips, Shell and Scottish and Southern Energy (SSE), have just announced that they are to commence engineering design of the world's first industrial scale project to generate 'carbon-free' electricity from hydrogen.

The project would represent a significant new step in providing clean energy to consumers, tackling CO_2 emissions and enhancing the recovery and utilisation of known world energy resources.

The Miller Production Platform in the North Sea (Copyright BP)

The planned project – producing 'decarbonised' fuel and using it for power generation – would convert natural gas to hydrogen and CO_2 gases, then use the hydrogen gas as fuel for a 350MW power station, and export the CO_2 to a North Sea oil reservoir for increased oil recovery (EOR) and ultimate storage. The project would reduce the amount of CO_2 emitted to the atmosphere by the power generation by over 90 per cent. While each of the component technologies making up the project is already proven, their proposed combination in this project is a world first.

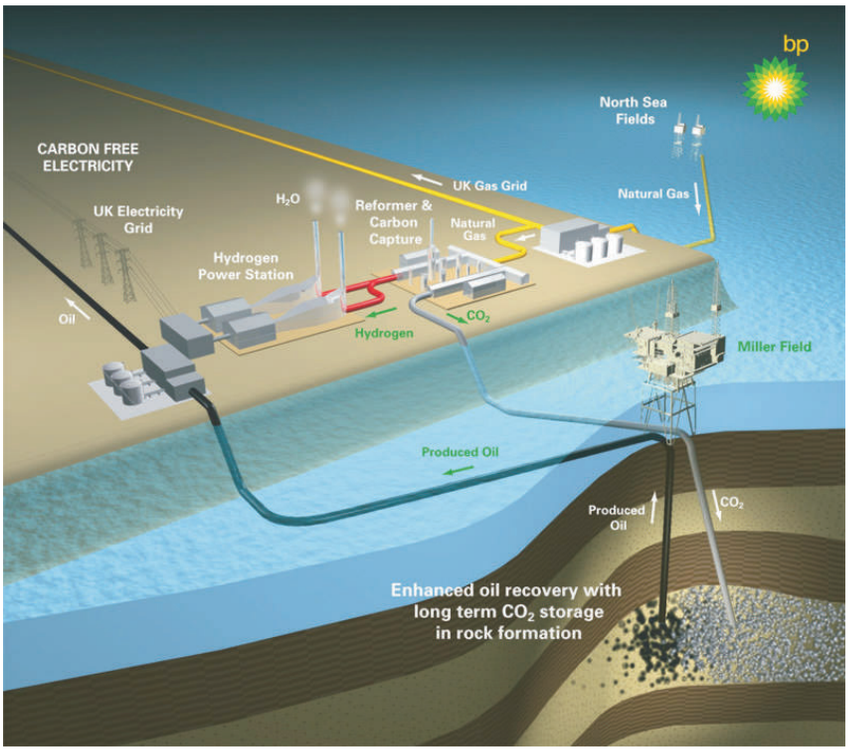
Initial engineering feasibility studies into the project have already been completed. The partners will now carry out further detailed front-end engineering design work with the aim of confirming the economic feasibility of the scheme. This work would be expected to be complete in the second half of 2006. This will allow a final investment decision to be taken next year, subject to which the project would then be expected to commence operation in 2009.

The full project would require total capital investment of some $600million. It would also require an appropriate policy and regulatory framework which encourages the capture of carbon from fossil fuel-based electricity generation and its long-term storage.

When fully operational, the project would be expected to capture and store around 1.3 million tonnes of carbon dioxide each year and provide 'carbon-free' electricity to the equivalent of a quarter of a million UK homes.

Lord Browne, BP Group Chief Executive, said: "This is an important and unique project configured at a scale that can offer significant progress in the provision of cleaner energy and the reduction of carbon dioxide emissions.

"For example, if applied to just five per cent of the new electricity generating capacity that the world is projected to require by 2050, such schemes would have the potential to reduce global carbon dioxide emissions by around one billion



Schematic of the main stages involved with the project. (Copyright BP)

tonnes a year – a material step in the challenge the world faces. The success of this UK scheme will provide invaluable experience for the further application of this concept worldwide.

"In the UK, and Scotland in particular, the project will offer a new, large-scale source of decarbonised electricity to consumers as well as extending the commercial life and contribution of the North Sea to the UK and Scottish economies. BP will look for opportunities to replicate this scheme and apply the associated technologies and experience in other parts of the world where we conduct business."

The project would be located close to Peterhead in north-east Scotland, UK. A newly built reformer plant would convert up to 70 million cubic feet of natural gas a day into carbon dioxide and hydrogen and the hydrogen would be used as fuel for a new 350MW combined cycle gas turbine power station.

Ian Marchant, SSE Group chief executive, said: "The work on which we're now embarking with our partners will enable us to evaluate the benefits of combining a number of technologies in a way which would be a world first. The project demonstrates that the energy sector is continuing to respond to the challenges posed by climate change and by the need for a more sustainable use of natural resources.

"Our work on this development with our partners complements our activities in progressing new and emerging technologies for generating electricity from renewable sources and represents a significant opportunity for the North East of Scotland. Investment in the research, development and demonstration of new and emerging technologies for generating electricity is a key part of SSE's long-term strategy for sustainable electricity generation in the UK."

The carbon dioxide generated by the reformer would be exported through existing pipelines to the mature BP-operated Miller oilfield, 240 kilometres offshore, where the platform would be adapted to allow for injection of the gas into the reservoir four kilometres below the seabed to increase oil recovery from the reservoir and for storage.

The Miller oil field is operated by BP (52 per cent) with partners ConocoPhillips (30 per cent) and Shell (18 per cent). The field, which began production in 1992, is 240 kilometers north east of Peterhead in water depths of 100 metres. Production peaked in 1995 at 150,000 barrels of oil and 220 million cubic feet of gas a day. The field now produces some 10 000 barrels of oil and 15 million cubic feet of gas a day. Oil from the field is exported via the Forties pipeline system and gas is exported in a sour gas pipeline initially to shore at St Fergus and then on to SSE's Peterhead power station.

The Miller field is currently due to cease production in 2006/7 but the injection of carbon dioxide into the reservoir could increase the amount of oil extracted from the field, potentially allowing the production of up to 40 million additional barrels of oil and extending the life of the field by 15 to 20 years.

For further information, contact David Nicholas - BP Press Office: +44(0)20 7496 4708

Zero Emissions Technology

ZETs are a range of fossil fuel technologies that contribute to environmental sustainability whilst supplying adequate energy to meet society's needs. At a meeting of the IEA's Working Party on Fossil Fuels on 23rd-24th June 2005 the second phase of its ZETs initiative was discussed. The second phase builds on work of the 1st phase and various IEA projects. It implements the priorities set by IEA Ministers in their meeting of 3rd May 2005.

Key activities in phase II of ZETs will improve public and political awareness of the options and assist in advancing all the elements of sustainability. Carbon Capture and Storage (CCS) is a central component of ZETs but also recognised is the trend towards tighter limits on other emissions such as SO_2, NO_x, particulates and trace elements.

IEAGHG is conducting a study focussed on 3 specific aspects of the ZETs concept:

1. Definition of a specification for 'near zero' emissions and an examination of the technology and cost implications.
2. The 'life-cycle' implications; in particular the implications on other parts of the fuel cycle of ZETs targets at the power station.
3. The extent to which ZETs might influence the choice of competing technologies.

The results of the study will be available in early 2006.

The World's Cleanest Fossil Fuel Power Plant

Clean Energy Systems, Inc. (CES) has completed commissioning of its 5 MW Kimberlina power plant, which is now the world's cleanest fossil fuel power plant. The Kimberlina power plant is the demonstration facility for CES' oxy-combustion, zero-emissions power generation system, which is derived from rocket propulsion technology.

In the CES system, natural gas and oxygen are combusted with recycled water in a "gas generator" to produce a high-temperature, high-pressure drive gas for turbines. Following expansion in the turbines, the steam in the drive gas is condensed, and the remaining non-condensable gas stream of virtually pure carbon dioxide is compressed and readied for storage.

When first reported last year in *Greenhouse Issues* (number 74), CES, a privately funded California company, had completed renovation of the original biomass power plant systems that would be incorporated into the new oxy-combustion system. At that time, installation of the new systems was underway, including the CES Gas Generator, a high-pressure feed water pump, a natural gas system, and an oxygen system.

Installation work on these systems was completed in the 3rd Quarter of 2004, and commissioning activities commenced shortly thereafter. The gas generator testing began in December 2004, with gas generator tests of up to 3 hours duration successfully completed. Prior to installation at the Kimberlina power plant, the gas generator was operated at a dedicated test facility in Southern California. The main purpose of the Kimberlina project is to demonstrate the complete power cycle by adding the turbine, condensing the steam, recycling the condensate, and capturing the CO_2 at a nominal 5 MW_e scale.

In January 2005, a new stainless steel condenser was installed, along with a CO_2 removal system consisting of a liquid ring vacuum pump. The steam turbine was successfully synchronized to the local grid in February, with the first power export from the plant occurring in March 2005. Since then, the plant has logged more than 400 operating hours. The CO_2 is captured off the condenser and then released to atmosphere at this time, but future plans include either liquefaction or injection into nearby oilfields or an underlying saline aquifer.

Future plans include long-term durability testing over the next 18 months. Later this year, work is planned at the Kimberlina facility to integrate gas turbine technology into the CES cycle. The development of turbines capable of operating at high temperatures on a steam/CO_2 mixture is required in order to achieve high efficiency and a competitive cost of electricity without atmospheric emissions.

Other plans include the development of a gas generator capable of operating on synthetic gas produced from coal and/or biomass. CES was recently selected by the California Energy Commission for a contract to develop a small combustor operating on syngas, and this work will also begin in the second half of this year.

The first commercial projects are now under development, with emphasis on Europe and California. These commercial plants will be approximately 50 MW in size, and will take advantage of various government programs supporting clean energy and the use of the captured carbon dioxide for enhanced oil or gas recovery. A critical step to this commercial deployment of the technology, has been the successful operation of the Kimberlina demonstration plant.

The partners in the Kimberlina project are: the California Energy Commission, US Department of Energy (NETL), America Air Liquide, and Mirant Corporation.

Further information can be found at www.cleanenergysystems.com or by contacting Keith Pronske, Chief Executive Officer, CES, e-mail klpronske@cleanenergysystems.com

The gas generator at Kimberlina power plant. Natural gas and oxygen are combusted with recycled water to drive the turbines. (Image courtesy of CES)

Field Experiment of ECBM-CO_2

By Frank van Bergen and Henk Pagnier, TNO

Following the reports in earlier editions of *Greenhouse Issues* (numbers 76 & 78), an update is presented of the RECOPOL project. The main goal of this project, co-funded by the European Commission, is to demonstrate in the Upper Silesian Coal Basin in Poland, that CO_2 injection in coal under European conditions is feasible.

CO_2 Injection

After the development of the pilot site in 2003, injection tests in the newly drilled well started in summer 2004. The principal targets for CO_2 injection are coal seams between 1 and 3 m thick of Carboniferous age in the depth interval between 900-1100 m. Several actions were taken to establish continuous injection, which was eventually reached in April 2005, following a frac job of the coal seams. Stimulation was required because the permeability of the coal seams reduced in time, presumably due to swelling as the result of contact with the CO_2. Similar observations were made in Canada and the United States, where they were also attributed to swelling of the coal seams. After fraccing circa 12-15 tonnes per day were injected in continuous operation from late April to early June. In total circa 760 tonnes of CO_2 were injected between August 2004 and the end of June 2005.

Gas Production

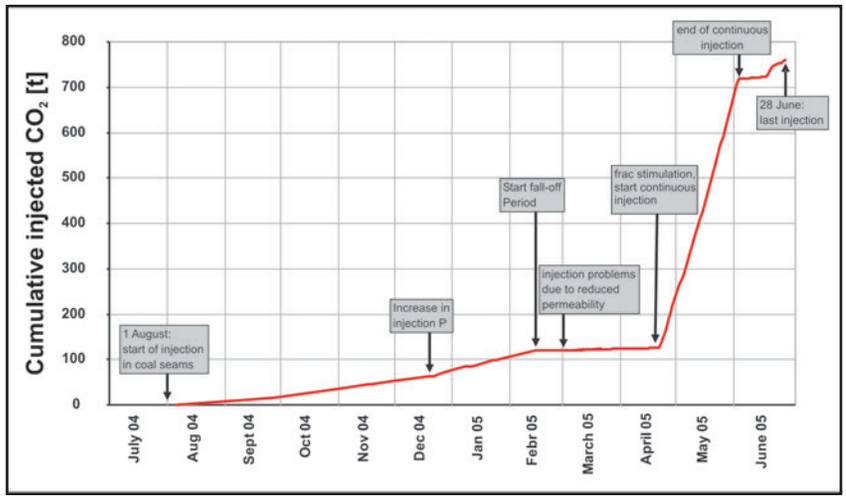
An existing coalbed methane production well at circa 150 m distance was cleaned, repaired and put back into production at the end of May 2004, to establish a baseline production. Gas was produced from the production well to evaluate possible enhancement of the gas rates. The anisotropy of the permeability due to the cleat orientation was thought to hamper an early breakthrough, because the highest permeability is perpendicular to the flow direction. Unexpectedly, a slow rise in the CO_2 content in the production gas was observed since November 2004 which could be attributed to the injected CO_2. In addition, a decrease in total gas production was observed during longer fall off periods in the injection well. This indicates a clear response of the production well on the injection activities.

In April 2005, after stimulation of the injection well, the gas production increased rapidly after a few days. The CO_2 concentration in the production gas also rapidly increased, clearly indicating the breakthrough of the gas. However, the amount of daily produced CO_2 was much lower than the amount of daily injected CO_2, indicating a clear sink of CO_2 in the reservoir. This was confirmed by the rapid decrease of production rates after continuous injection stopped in June 2005. The concentration of methane in the production gas, initially around 95%, dropped significantly after the breakthrough of CO_2 in April 2005. Nevertheless, first evaluation of the data indicates that the absolute amounts of CH_4 that were produced are significantly higher than the baseline production with conventional production. Shut-in tests of the production well in June 2005 showed that the reservoir pressure around the production well was slightly increased due to the injection. Probably, the pressure in the reservoir will decrease once the CO_2 will be adsorbed on the (undersaturated) coal. The gas that was produced after the shut-in test showed a significant increase in the methane concentrations, indicating that the exchange of CO_2 for methane is taking place in the reservoir. However, it appears that sufficient time is required to allow for diffusion of the gas into and out of the coal matrix. Along with the field activities, an extensive monitoring programme has been set-up to detect any possible, but unlikely, leakage of CO_2 to the surface or the adjacent mine. Continuation of the monitoring programme in the next months is currently under evaluation.

Preliminary Conclusions

Several months of injection showed that injection without stimulation is difficult under the local field conditions. The injected amounts after stimulation of the injection well provide a good basis for a future upscaling of the operations. The consortium showed that it is possible to set up an on-shore pilot in Europe and to handle all "soft" issues (permits, contracts, opposition, etc.) related to this kind of innovative projects. The lessons learned in this operation can possibly help to overtake start-up barriers of future CO_2 sequestration initiatives in Europe.

For further information on the RECOPOL project, please contact Henk Pagnier (Henk.Pagnier@tno.nl) or Frank van Bergen (Frank.vanBergen@tno.nl).



Cumulative amount of injected CO_2 in time in the RECOPOL project

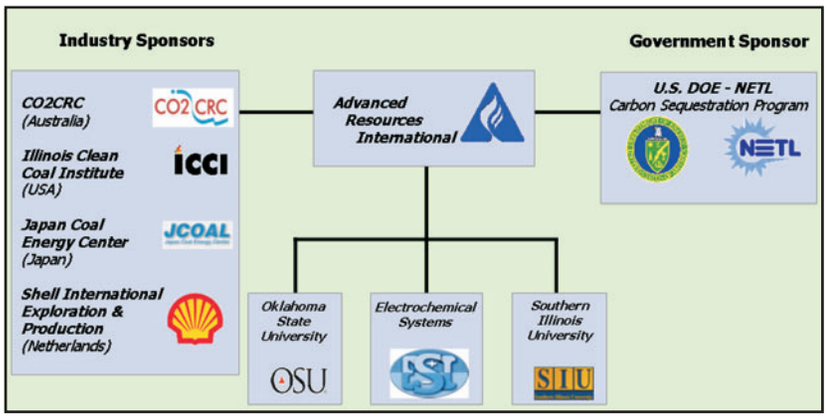
Coal-Seq II Consortium Launched

Technology for CO_2 Sequestration and Enhanced CBM Recovery

By Scott Reeves, Advanced Resources International, Inc.

In early 2005, Advanced Resources International (ARI) launched the Coal-Seq II Consortium as a follow-up to the highly successful Coal-Seq project. Active from 2000 to 2004, the original Coal-Seq project team – ARI, the U.S. Department of Energy, Burlington Resources and BP - studied the feasibility and potential of CO_2 sequestration in deep, unmineable coalseams with concomitant enhanced CBM (ECBM) recovery. It was found, through detailed study of existing ECBM projects in the San Juan basin (Allison and Tiffany Units), that CO_2 sequestration is not only feasible, but because of the associated ECBM recovery, can be profitable. In the U.S. alone, the CO_2 sequestration capacity was assessed at 90 Gt (billion tons), with an associated ECBM resource of 150 Tcf.

However, due to the swelling effect that CO_2 has on coal, injectivity reduction can occur, potentially limiting sequestration capacity. Industry observers have therefore questioned the applicability of the technology outside of high-permeability environments such as the San Juan basin. To address this issue, ARI has formed the Coal-Seq II consortium, a government-industry collaboration with the objective of developing better models to simulate the process of CO_2 injection in coal, and use them to determine which coal reservoir environments are most suitable to sequestration and ECBM, as well as to determine what are the best well completion strategies to employ.



Coal-Seq II Consortium Organization

Objectives

The specific objectives of the Coal-Seq II consortium are to:

- Develop and validate reliable predictive models for ECBM/sequestration.
- Identify the best geologic/reservoir environments and operating strategies for such projects.
- To provide an internet-accessible knowledge base on global R, D & D activities for the consortium members.
- Continue hosting the highly successful annual Coal-Seq forums.

Project Team

The Coal-Seq II project team consists of:

Advanced Resources International, who will provide overall management for the consortium. ARI will also be responsible for all simulation and technology transfer activities associated with the project.

Oklahoma State University who will perform multi-component isotherm experiments and develop advanced equations-of-state for modeling their performance.

Electrochemical Systems who will perform laboratory experiments and develop theories for bi-directional diffusion and CH_4-CO_2 PVT behavior.

Southern Illinois University who will perform laboratory flow experiments in coal.

Member Profile

Participants in the consortium include:

- US government agencies and other international R&D sponsoring organizations seeking to leverage their R&D funds by partnering with industry.
- Companies interested in value-added CO_2 sequestration.
- Coalbed methane producers that may enhance the value of their assets via the application of ECBM technology.
- Forward-looking organizations seeking a competitive advantage by staying on the cutting edge of this promising technology.

Funding

As of June, 2005, the project is 70% subscribed. Six additional industry sponsors are being sought to bring the project to full subscription. Membership fees are U.S. $25 000 per year for the three-year project duration.

For More Information

Scott R. Reeves, Executive Vice President, Advanced Resources International, Inc., 9801 Westheimer, Ste 805, Houston, TX 77042, USA. Tel: +1 713 780 0815 sreeves@adv-res-hou.com or go to www.coal-seq.com

GHGT-8 Update

The call for papers for GHGT-8 closes on 23rd September 2004; there will be no exceptions for late submissions. If you are considering submitting an abstract please do so by the deadline date. Abstracts are to be submitted on line at www.ghgt-8.no. Authors will then be notified by December 16th 2005.

Online registration for the conference will commence in January 2005.

In addition, to our major sponsorship from Norway and The European Commission, a number of organisations have also now expressed their interest in sponsoring/supporting GHGT-8. These include RITE and NEDO, BP, Shell, IFP and Schlumberger.

RITE/NEDO has been supporters of the conference series since it started in Interlaken in 1994. RITE also hosted the very successful GHGT-6 conference held in the lovely old city of Kyoto, Japan in 2002.

We must also recognise our industrial support, namely BP who has also been a loyal sponsor of the GHGT series since 1994. Shell sponsored GHGT-4 and GHGT-7. Equally we welcome support from new sources such as IFP and Schlumberger.

3rd Trondheim Conference on CO_2 Capture, Transport and Storage

The Third Trondheim Conference on CO_2 capture, transport and storage is to be held 10th-11th October 2005 at the Radisson SAS Royal Garden Hotel, Trondheim, Norway. The conference series primarily targets promotion of Norwegian effort, but international participation is also welcomed and included. The second conference in the series was held in October 2004 and attracted some 105 people from 10 countries.

The scope for the third conference in the series has been extended. Norway's efforts within the CO_2 capture, transport and storage are significant and the conference will aim to highlight work being performed within the R&D institutions, universities and industries in Norway. This work is funded partly or wholly by the Klimatek programme and its successor.

Scope

The main sections for the conference are:

- Capture of CO_2
- Transport of CO_2
- Storage and use of CO_2
- Novel zero emission technologies-new developments
- Other topics, such as legal aspects, international agreements, CO_2 trading systems, and climate research

Trondheim offers many tourist attractions and is also well suited as a starting point for regional trips and tours to Norway, Sweden and Finland. It is the third largest town in Norway with 150 000 inhabitants.

For further information on the conference, or on abstract submittal, visit www.energy.sintef.no/arr/CO2_2005/ or contact the Conference Secretariat SINTEF Energy Research -
Tel: +47 73 5925 14/73 5938 02
Fax: +47 73 5928 89 or
email Henny.E.Olafson@sintef.no

Ravnkloa in Trondheim is a harbour area and the cities main fish market
Photo: Jørn Adde © Trondheim kommune

EPA Modeling Workshop Outcomes

By Anhar Karimjee, US EPA

As indicated in *Greenhouse Issues* number 78, the US Environmental Protection Agency (EPA) conducted a Workshop on Modeling and Reservoir Simulation in Houston, TX on April 6-7, 2005. The primary focus of the workshop was to facilitate an informal exchange of information and discussion on the role and application of reservoir models and reservoir simulation to injection and long-term storage of CO_2 in geologic formations. The workshop discussion was not structured to drive the group towards specific outcomes or consensus. However, some key points which are summarized below were raised in the presentations and during the discussion sessions at the workshop. There appeared to be

general agreement among speakers and participants with many of these key points; however, this summary should not be construed as a consensus product from the workshop.

With regards to modeling tools and capabilities, workshop participants expressed the view that geologic modeling concepts and reservoir simulators are highly developed; however, existing reservoir simulators need to be successfully adapted to simulate geologic CO_2 storage. Most research in modeling is focussed on the integration of hydrological, thermal, geochemical, and geomechanical modeling of multiphase CO_2 movement in saline aquifers, accounting for complex effects such as formation permeability heterogeneity, CO_2 phase changes, buoyancy-driven upward migration, chemical interaction between CO_2 and caprock minerals, and stress-induced reactivation of existing faults. Future work should focus on CO_2-specific improvements to reservoir simulators in order to capture features relevant for detailed process modeling, as well as creating simpler, more flexible but adequate and validated versions for analysis over various temporal and spatial scales. In order to do this, more research is needed to assess the sensitivity of reservoir simulation of geologic CO_2 storage to various input parameters, and to identify and verify simplifying assumptions.

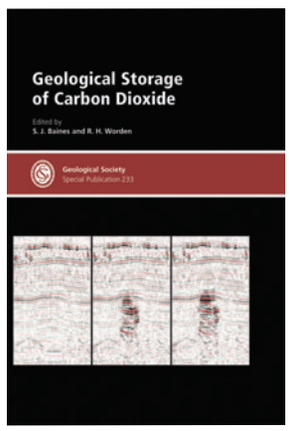
Some uncertainty exists around model input parameters. For example, there is a lack of data for critical reservoir and fluid properties needed for simulation of CO_2 geologic storage systems. This is the case for all storage reservoir types including saline aquifers, EOR-CO_2 sequestration, and CO_2 injection for enhanced coal bed methane production (ECBM). Relative permeability and residual CO_2 saturation were also cited as important input parameters with large impacts on model results. Additional experimental studies and field data are needed to reduce this uncertainty and to calibrate model performance.

The role of numerical modeling as a basis for risk characterization was also discussed at the workshop. Modeling tools can be extremely useful for predicting performance from a risk management standpoint and for demonstrating the predicted fate of CO_2 to policymakers and the public. Numerical modeling can be used to make quantitative predictions of the impacts of various features, events, and processes (FEPs) associated with CO_2 migration, to quantify aspects of the injection site risk, and to explore complex system response associated with CO_2 injection. The quality of site assessments and quantification of FEPs are extremely important to building confidence in model outputs. Some participants noted that potential migration paths along annuli between formation rock, cement, and casing, and also along subvertical faults and fractures, should be integrated with large-scale models of plume movements. A number of participants emphasized that risk assessment for human health effects of exposure to CO_2 should be kept in perspective and considered in the context of the risks of climate change.

A consistent message conveyed at the workshop was that geologic CO_2 storage should be based on careful selection of a geologic storage site and reservoir simulation of injection and storage, supported by geologic-petrophysical data. Proper characterization of site structure (conceptual) model, appropriate choice of model input parameters, uncertainty and sensitivity analysis, and calibration of model results with field observations, as well as an optimal monitoring program, are extremely important. Several participants indicated that continuous improvement of numerical models is needed to move toward widely understood and broadly accepted "CO_2 storage reservoir models" or simulation tools, similar to widely accepted modeling tools used in hydrology such as MODFLOW, or in petroleum reservoir engineering such as GEM® and ECLIPSE®. However, it is also important to note that several participants felt that detailed numerical simulation may not be the most cost effective method for evaluating certain FEP scenarios. For example, some geologic CO_2 storage sites require predicting leakage through a large number of abandoned wells, in which case analytical and semi-analytical models should be developed as the more efficient alternatives to numerical reservoir simulation.

Special Publication on Geological Storage of CO_2

The Geological Society of London have produced a special publication on the "Geological Storage of Carbon Dioxide". The publication was edited by S J Baines and R. H. Worden and released in November 2004 as a hardback volume.



Geological storage of CO_2, or the injection and long-term stabilization of large volumes of CO_2 in the subsurface in saline aquifers, in existing hydrocarbon reservoirs or in unmineable coal seams, is one of the more technologically advanced options available for mitigating climate change. A number of studies have been carried out and are reported here. They are aimed at understanding the safety, physical and chemical behaviour and long-term fate of CO_2 when stored in geological formations. Until efficient, alternative energy options can be developed, geological storage of CO_2, the subject of this volume,

provides a mechanism to reduce carbon emissions significantly whilst continuing to meet the global demand for energy.

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- Monitoring experience associated with nuclear waste disposal and its application to CO_2 sequestration projects

Other Information

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GSL members - £37.50 / $63.00

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NCGG-4 Conference Highlights

Science and Policies Of Non-CO_2 Greenhouse Gases

By Han van Dop

With a new record of 160 presentations and posters, non-CO_2 greenhouse gas issues were addressed at the fourth NCGG symposium in Utrecht, The Netherlands (4-6 July 2005). The symposium was attended by two Nobel prize winners, Sherwood Rowland and Paul Crutzen, the latter as honorary chairman of the conference.

It was the fourth conference in the series on non-CO_2 greenhouse gases, this time not as usual in Maastricht but in Utrecht at the university campus. Some 200 scientists and policy makers gathered to discuss the progress in science, policy and implementation. 120 presentations were given in three parallel sessions. In addition there was a poster session of 40 posters and a small exhibition. The number of participants was somewhat less than at the last conference (NCGG-3), mostly due to limited funds to facilitate participation from developing countries.

The Dutch association for environmental professionals (VVM) was again the organiser of the symposium which was opened by its chairman, Jaap Jelle Feenstra.

A number of representatives of (inter)national organisations followed. Peter Horrocks clarified the EU initiative for F-gases and Bert Metz, co-chair of IPCC Working Group III stressed the importance of this conference as one of the sources for input to the fourth assessment report of IPPC (to appear in 2007).

Two remarkable lectures were presented in Monday morning's plenary session. The first by Mark Thiemens (UCLA) who elucidated a method to detect the history of (oxygen containing) greenhouse gases. Oxygen consists in majority of ^{16}O with small fractions of the isotopes ^{17}O and ^{18}O. As the standard for these fractions the oxygen in ocean water is taken. Since evaporation and condensation processes are mass dependent, small deviations in the standard composition in atmospheric oxygen or oxygen in glacial or polar ice masses reflect the phase transitions which on its turn are temperature dependent. This is a well-known way to infer climate records from the oxygen composition of accumulated ice. There is, however, a second isotope effect which does not depend on the difference in mass, but to differences in chemical reactivity of the isotopes. In this way small deviations in isotope composition of e.g. stratospheric ozone reveals part of its origin and pathway. The method is applicable to all trace gases which contain oxygen and provides information on geochemical cycles of carbon and nitrogen.

The second plenary lecture was given by Kornelis Blok (Utrecht University) who investigated the effects of governmental policy on emission reductions. In The Netherlands roughly 20% of achieved reductions

can be attributed to a specific reduction plan on NCGGs that has been introduced in 2000. He furthermore suggested that the threat of government regulation already leads to reductions of greenhouse gas emission, as firms want to avoid regulatory risks (e.g. the current shift towards alternative blowing agents and refrigerants).

In the following parallel sessions much attention was given to methane. Emission inventories tend to be more accurate, partly due to satellite data and mathematical techniques which infer emission estimates from measured concentrations ('inverse modelling'). It is confirmed that the world-wide increase in CH_4 concentrations has come to a halt, and is more or less stationary since 2000. These findings are in line with decreased emissions in developed countries caused by improved waste treatment and a reduction of losses during extraction and transport of natural gas.

In tropical regions, where in situ measurements are scarce, large uncertainties in emission estimates remain.

There are no grounds for fear that degradation of permafrost regions due to global warming may result in a 'methane catastrophe'. Nevertheless it is desired that these areas will be under constant survey.

Ozone and NO_x are the key components in troposphere and stratosphere. They are chemically reactive and have an impact on virtually all NCGGs. Satellite observations (GOME, Sciamachy, OMI) are getting more and more important for the detection of these gases. It was noted that NO_x emissions in South East Asia increased by 15 % in the last ten years and it is expected that this tendency will continue in the coming decades.

It was emphasized that tropical regions will start to play a significant role in NCGG emissions. It is an area with a high bioactivity and the (expected) growth of economic activities and population is considerable. Exactly in these regions observations are still scarce. It would be recommended to involve more scientists and policymakers from developing countries in environmental issues. Conferences like NCGG-4 could be very useful in promoting the dialogue between developed and developing countries. When it is considered to organise a follow-up meeting it is recommended to give more support to participants from developing countries.

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CO_2SINK – The First Year

By the CO_2SINK Project Team

It is over a year since April 2004 when this EU Framework 6 research project CO_2SINK was commenced. Significant progress has been made by the consortium, which now consists of 15 members, in investigating the selected site at Ketzin near Berlin (Fig 1) and in preparing plans for CO_2 injection

Fig 1 - Ketzin, near Berlin

and monitoring

Major objectives of the project are:

- To advance understanding of the science and practical processes involved in underground storage of CO_2 in an onshore saline aquifer to reduce emissions of greenhouse gases to atmosphere.
- To build confidence towards future European carbon dioxide geological storage.
- To provide real case experience for use in development of future regulatory frameworks for CO_2 geological storage.

In the first year, much of the research effort has been directed to the first of these objectives. The project calls for extensive investigation of the site prior to any injection of CO_2 to fully understand the geological setting, the risks and how to effectively monitor and control the injection activities.

Site Characterisation

An extensive database of previous exploration at the Roskow-Ketzin double anticline has been set up and is now available online. This data includes seismic profiles and stratigraphic and lithological information from many boreholes drilled in the area in the past.

The database has been used to develop a first structural and lithological model of the Ketzin anticline to be verified by a 3-D seismic survey.

Stratigraphic analysis was done for baseline reservoir/aquifer and cap rock/ aquitard characterization. The analysis was targeted on predicting deterministically and statistically the spatial occurrences, geometries, continuity, and frequencies of rock properties between and beyond well control.

The locations for the injection and observation wells have been selected. The boreholes will be drilled within the site of the existing industrial area of a former natural gas storage facility and will meet the CO_2SINK reservoir formation between 620m and 720m depth below ground level.

The area for the baseline 3-D seismic survey, planned for autumn 2005, has been delineated. A field test was carried out to compare various vibration sources that may be used in the larger scale survey. The seismic survey will substantially contribute to better explore the reservoir geometry and to evaluate the risk by faults that may cross the anticline.

Drilling

Three wells will be drilled at the Ketzin site: One for injection, two for observation. All wells will penetrate the Stuttgart Formation and will reach final vertical depth at about 800m. An arrangement of the well locations in a triangle (with a spacing between the wells in the order of 50m and 100m) allows in situ monitoring of the CO_2 migration within the reservoir. Key challenges for well engineering are borehole integrity and behind-casing sensor applications. The latter require new systems that are in the process of development and testing. Work is in progress to design the wells and to specify the detailed drilling programme. The work will be performed according to industry-accepted standards and regulations. This specifically applies to health, safety and environmental issues.

Baseline Geochemistry and Geomicrobiology

Work also commenced on characterizing the conditions prior to injection at and below the ground surface of the site. Multi-function sensors have been installed at 35-40m depth in two boreholes, one of them close to the rim of a channel, where the uppermost aquitard in the anticline has been eroded and upward fluid flow from the deeper levels might occur. Another sensor is installed in a shallow well south of the main structure also to trace possible upward flow of fluids that may be enriched in CO_2. In addition, a grid of 16 soil sampling locations has been set up, and first measurements of soil CO_2 fluxes have been made. Thus an overview was gained on the background level of CO_2, methane and other substances present in the groundwater. Isotopic analysis identified their biogenic origin. This is an indication that the existing natural gas storage reservoir at shallower depth above the cap rock of the Stuttgart Formation has an effective top sealing layer.

Local microflora that could act as biological monitors have been sampled and examined. Studies so far suggest that a sensing organism will be chosen from the population of aerobic bacteria.

Monitoring

A design for innovative in-casing, down-hole triple axis accelerometers (TAA) has been finalized, and prototypes are in process of fabrication and testing.

These devices will allow continuous detection of small seismic signals from pressure changes in the reservoir and mass displacements along faults. In combination with vertical seismic profiling, the TAAs allow accurate location of signals. Further monitoring systems (optical pressure gauge for the injection well, optical temperature sensing system, electrical resistivity downhole array) are under development. This multi-method concept, which comprises a number of seismic and non-seismic surface and down-hole techniques, will provide an image of the reservoir at different length- and time-scales and facilitates the assessment of petrophysical parameters and processes during and after the injection of CO_2.

Risk Assessment

The consortium is progressing with the risk assessment for the project, which involves identifying all of the potential hazards to persons or environment and ensuring that adequate controls are in place to prevent any undesirable consequences. This is a systematic process that makes use of information about similar activities being conducted worldwide. The major risks for the project have now been identified, and models to evaluate different scenarios are developed. Risk assessment for CO_2 geological storage is an area of intense co-operation in the scientific community at present, and information is freely shared.

Laboratory Experiments

Petrophysical investigations of reservoir and cap rocks have been conducted on core samples from various wells drilled into the Stuttgart Formation. The investigations comprised both standard petrophysical analysis and long-term CO_2 flow and exposure experiments at simulated in situ conditions. Geophysical parameters, such as resistivity and ultrasonic velocity, were monitored during the long-term experiments. First exposure experiments over 2-3 months resulted in chemical alterations, which could be the reason for significant reductions in permeability during the flow experiments.

The laboratory experiments provide fundamental insights into the effect of CO_2 injection on rock properties. They yield parameters for formation evaluation and interpretation of geophysical monitoring methods and allow an initial calibration of numerical models. However, detailed investigations using fresh cores are needed to substantiate the first results.

Numerical Simulations

Simulations of CO_2 injection at Ketzin rely heavily on the geological information. Modelers and geologists are working very closely. Several injection scenarios have been simulated and are providing constraints on the injection pressure for CO_2 as well as on the quantity of CO_2 that needs to be injected to be detected by well instruments and surface surveys. Furthermore, depending on the permeability distribution that will be encountered in the wells, the time frame for injected CO_2 to reach observation wells can vary widely. It is important that well and field experiments can be planned accordingly.

Different simulation tools are being employed and a set of simulation problems have been to compare different modeling codes such as MUFTE_UG, ECLIPSE etc.

Preliminary 3D modeling of the natural temperature and flow in the reservoir in the absence of CO_2 has been completed . The results agree well with a recently taken temperature log and also indicate a very small natural fluid flow in the storage reservoir of about 0.5 meters every 1000 years. After injection

very slow migration of the CO_2 to the NE is predicted. The largest driver for the subsurface flow of CO_2, however, is expected to be the buoyancy of CO_2, because its density is much less than that of the saline brine already residing in the reservoir.

Regulations and Permitting

On the regulatory front, preparations for the submission of the basic schedule of operations (Hauptbetriebsplan) to the regional mining authority (Bergamt) are well underway. However, for future commercial operations, clarification is being sought as to which other authorities will need to be involved and which authority will have overall responsibility for plan approval.

CO_2 Supply

The EU-funded portion of the project is limited to the injection and basic monitoring of CO_2 storage. The supply of CO_2 is to be funded separately, and there has been extensive investigation of a number of options. The CO_2 will be transported in liquid phase to the storage site by road tankers. Final planning on CO_2 supply and on joint financing by industry and government are underway. A proposal to the COORETEC Program of the German Ministry of Economy and Employment (BMWA) has been prepared emphasising R&D in the following areas:

- Purity specifications for CO_2 storage
- Separation and liquefaction of CO_2 from refinery exhaust gases
- Optimisation of truck transport and temporary storage
- Surface Operation of CO_2 injection

Other Activities

A number of additional research activities, with funding from other sources, are expected to be added to the scientific investigations at Ketzin. Final agreements have yet to be made, but the trend towards more extensive use of the Ketzin site for CO_2 capture and storage technology development is most encouraging.

In summary, the CO_2SINK at Ketzin has been moving forward on all fronts during the first year. The project is attracting more support and is starting to act as an international catalyst for scientific research in the area of CO_2 capture and storage.

Further information is available at www.co2sink.org.

Statoil Laying CO_2 Pipeline to Snøvhit Field

Reprinted with permission, from July 18, 2005, edition of Oil & Gas Journal

Statoil ASA is laying a 151km, 8in. CO_2 injection pipeline from the Melkøya gas terminal in northern Norway to Snøvhit natural gas field in the Barents Sea.

The CO_2 injection pipeline is being reeled onto the seabed in five stages from the pipelay vessel Skandi Navica. This provides a laying speed of 10-20km per day. (Photo courtesy of Statoil)

The CO_2 separated from Snøvhit gas at the terminal, will be injected back to a storage structure beneath the gas-bearing layers on the Statoil-operated field. The pipelay is being accomplished in five stages. The Skandi Navica pipelay vessel began work on the line in early June, laying 10-20km/day of pipe, and work is slated for completion by the end of July.

Statoil has been separating CO_2 from its Sleipner West natural gas production facility and storing it in a subsurface formation in the North Sea since 1996. The injection and storage, Statoil said, will reduce total carbon dioxide emissions from the two fields by at least 1.7 million tonnes/year, including 700 000 tonnes/year from Snøvhit.

Statoil said the pipeline to Snøvhit marks the first offshore injection of CO_2 from a land-based plant.

Technology Platform for Zero Emission Fossil Fuel Power Plants

The European Commission, in consultation with industry, has launched a new initiative to establish a technology platform for zero emission fossil fuel power plants. The aim of this initiative is to identify and help remove obstacles to the development of highly efficient fossil fuel fired power plants. Through this technology platform it is planned to drastically reduce the environmental impact of fossil fuel use, in particular coal. The platform includes the use of CO_2 capture and storage and the development of clean conversion technologies leading to substantial improvements in power plant efficiency, reliability and costs.

The establishment of this Technology Platform will contribute to the goal set for 2010 at the European Council in Lisbon in March 2000. The Platform will also contribute to the European strategy for increasing R&D investment in the Member States to 3% of GDP by 2010, as stated at the Barcelona Council and in the Commission's Communication on "Investing in research – an action plan for Europe". It will also be a key element in developing the specific European Research Area in this field, which is a major EU research policy objective.

To begin the process of establishing the Technology Platform, the European Commission is inviting

organisations, through an open call, to register their interest in participating in an Advisory Council.

The outline concept for the technology platform and its guiding principles can be found at: http://europa.eu.int/comm/research/energy. The web site also includes the call for participation in the advisory committee.

Greenhouse Cuttings

Cities Lead The Way to a Greener World

On June 5th mayors from 12 major cities met in San Francisco for World Environment Day. The Mayors from: Seattle, Sacremento, San Diego, Bogota, Curitiba (Brazil), Toronto, Boston, London, Berlin, Vienna, Delhi and Melbourne pledged to cut their cities greenhouse gas emissions by 7% in line with the Kyoto Protocol guidelines. Under what is called the Urban Environment accord cities will be awarded points for meeting specific targets for cutting greenhouse gases and improving the local environment. These targets range from: supplying 10% of peak load electricity from renewables, to putting locally grown organic food in schools.

Full details can be found in New Scientist, 4th June 2005 or at www.newscientist.com

China's First CDM Project

China has been given the green light for it's first Clean Development Mechanism (CDM) project. The 25.8MW Huitengxile windfarm in Inner Mongolia is the first project in China to be registered under the Clean Development Mechanism. It is also the first windfarm in the world to become a CDM project.

The owners of the project Huitengxile windfarm, the Inner Mongolia Long Yuan Wind Power Development Company, will now receive approximately €2.75 million (£1.9 million) over the next 10 years from SenterNovem who are buying the certified emission reductions on behalf of the Dutch Government.

The Huitengxile project involves the installation of 22 wind turbines, 12 of which have a capacity of 900 kW, and 10 have a capacity of 1500 kW, providing a total of 25.8 MW. Despite the good wind resource in Inner Mongolia, windfarm projects can only compete with the cheap large scale coal-fired power generation by obtaining additional income via the CDM.

IT Power, a UK renewable energy consultancy, was therefore employed to assist the owner of the windfarm obtain CDM funding and prepare all the documentation needed for the project to be registered as a CDM project.

For further details contact Christiaan Vrolijk, Senior Energy and Climate Specialist, IT Power, christiaan.vrolijk@itpower.co.uk or Rebecca Gunning, Chief Representative, IT Power's China Office, Beijing. rebecca.gunning@itpowergroup.com

For further details of the Huitengxile CDM project see http://cdm.unfccc.int/Projects/TUEV-SUED1113481234.64/view.html

Japanese Environment Ministry Promotes 'Team Minus 6%' Global Warming Campaign

The Ministry of the Environment (MOE) of Japan launched a national campaign called "Team Minus 6 Percent" on April 28, 2005 to achieve Japan's greenhouse gas reduction target of 6 percent below 1990 levels by 2012 under the Kyoto Protocol. The concept is that all Japanese people should tackle global warming together as a team. Prime Minister Junichiro Koizumi has assumed the role of team leader and the team administration office has been established at MOE.

Details can be found at Japan for Sustainability's 2005 at www.japanfs.org

UK Announces CAT Strategy

In June 2005 the UK published a report on its Carbon Abatement Technologies (CAT) strategy. The objective is to ensure that the UK takes a leading role in the development and commercialisation of CATs that can make a significant and affordable reduction in CO_2 emissions from fossil fuel use.

The CAT report recognises that fossil fuels are expected to continue to dominate energy supply for decades. A range of options for reducing CO_2 emissions is covered including: higher efficiency conversion, fuel switching to lower carbon alternatives, and CO_2 capture and storage (CCS). The UK government will provide the CATs funding package over four years commencing 2006/7 of about £25 million ($44million, €36million).

Quote: "The strategy identifies a number of actions ranging from R&D, through demonstration projects, facilitation of international collaboration, and a review of measures to encourage commercial deployment of CCS, to taking forward the social, economic, legal, and regulatory issues around the introduction of these technologies."

The DTI report is entitled 'A Strategy for Developing Carbon Abatement Technologies for Fossil Fuel Use' DTI/Pub URN 05/844.

IGCC With CO_2 Storage Being Considered in Australia

Stanwell Corp. are considering building a new IGCC plant based on Shell dry feed technology in Queensland. The Shell gasification technology has been demonstrated at Buggenham in the Netherlands. The IGCC plant would be the first of its kind to incorporate CO_2 storage. A feasibility study for the project is now underway and will be completed in October 2005.

Oil and Gas Journal, June 27, 2005

Progress on Post-Combustion CO_2 Capture

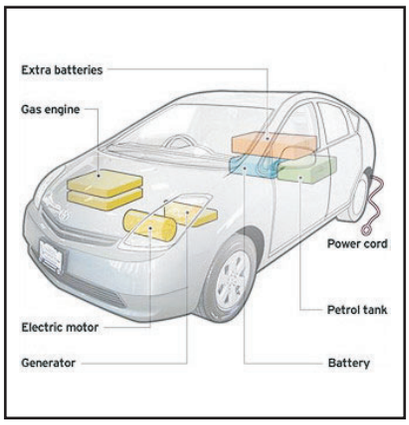
Under the EU's 6th Framework Programme, the CASTOR project is to build a pilot plant to capture about 1 tCO_2/hr at the Esbjerg 3 coal-fired power plant in Denmark. The contract for the pilot plant was signed in February 2005 and site construction work scheduled to start in July. The formal test programme is scheduled to start in early 2006.

The flue gas to be treated is taken from a slip-stream at the outlet of the flue gas desulphurisation unit. The SO_x content is low i.e. about 10ppm_v. It is planned to operate the plant for 1000hrs on MEA to establish baseline data and then move to testing at least one new solvent.

(Condensed from an article in *Modern Power Systems*, August 2005)

Hybrid Cars with Ultra-Low CO_2 Emissions

It is reported that Toyota Prius owners in California are modifying their cars with extra batteries to achieve 100mpg (3 litres/100km) or more. These enthusiasts are adding additional batteries and recharging them overnight using off-peak mains electricity. If the electricity were to be produced using carbon dioxide capture and storage (CCS) this would result in extremely low CO_2 emissions for the full 'well-to-wheel' cycle. (A standard Prius emits about 100gm CO_2/km.)



An artists impression of the modified hybrid car (Courtesy of the Daily Telegraph)

One enthusiast is said to have spent $1,600 customising his car with bicycle batteries and to typically achieve 96mpg. A Californian firm, Energy CS, is reported to have converted two Prius cars to get up to 276mpg on lithium ion batteries. Toyota and DaimlerChrysler are reported to be interested in this aspect of hybrid car technology.

(Based on an article from Catherine Elsworth printed 16th August in the Daily Telegraph.)

IEA GHG Report

IEAGHG is to publish a report towards the end of this year that builds on work by the European Commission, CONCAWE, and EUCAR that assesses the potential impact of CCS technology on emissions from transport fuels. CONCAWE is the oil companies' European association for environment, health, and safety, in refining and distribution. EUCAR is the European Council for Automotive R&D.

News for IEA GHG Members

This section is provided specifically for readers in member countries and sponsor organisations (see list on the back page). Reports on IEA GHG studies are freely available to organisations in these member countries and sponsor organisations. Please contact IEA GHG for further details. For Non-Member countries, reports can be made available by purchase at the discretion of IEA GHG. Reports recently issued include:

- **Oxy-Combustion Processes for CO_2 Capture from Power Plant (Report No. 2005/09)**
  Conservative designs for oxy-combustion power plants with CO_2 capture are described. Construction of such plants appears to be feasible using well proven power industry design limits and materials of construction. The costs of such power plants firing coal and gas have been assessed and their economics compared. An overview of future developments which might improve performance has been made.

  The coal fired oxy-combustion CO_2 capture power plant described is competitive with other capture options and has certain advantages. The gas fired oxy-combustion NGCC plant described is less competitive than other gas fired options, one reason being the large oxygen requirement per ton of CO_2 captured. Such a plant would also require development of a completely new model of gas turbine..

- **Carbon Dioxide Storage by Mineral Carbonation. (Report No. 2005/11)**
  Developments in CO_2 mineralisation research since 2000 are reviewed and the most promising process routes are described. An extensive survey of recent literature on CO_2 mineralisation processes is presented.

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Conferences & Meetings

GHGT-8. International Conference on Greenhouse Gas Control Technologies. 19th-22nd June 2006, Norwegian University of Science and Technology (NTNU), Trondheim, Norway. Contact: GHGT-8 Secretariat, Mrs. Mari Sæterbakk, NTNU videre, Pavilon A, Dragvoll, 7491 Trondheim, Norway . Tel: +47 73 59 52 65 Fax: +47 73 59 51 50 info@ghgt-8.no www.ghgt-8.no

18th World Petroleum Congress. 25th-29th September 2005, Sandton Convention Centre, Johannesburg, South Africa. Contact: Tel: +44 20 7596 5080 info@18wpc.com www.18wpc.com

International Conference on JI Projects in Ukraine "Climate Change and Business". 3rd-5th October 2005, Presidium of the National Academy of Sciences of Ukraine, Kyiv, Ukraine. Contact: Dr. Tetyana Suprun, PO Box 66, 03067, Kyiv, Ukraine. Tel/Fax: +38 044 453 28 56, Fax: +38 044 456 94 62 jiconference@biomass.kiev.ua www.biomass.kiev.ua/jiconference/index_e.php

Fourth Mediterranean Combustion Symposium. 6th-10th October 2005, Lisbon, Portugal. Contact: Federico Beretta, Istituto di Ricerche sulla Combustione - CNR, P.le V. Tecchio, 80, 80125 Napoli - Italy. Tel: +39 081-768 2247; Fax: +39 081-593 6936; beretta@irc.cnr.it www.combustioninstitute.it/next/MCS4/firstMCS4.htm

The Third Trondheim Conference on CO_2 Capture, Transport and Storage. 10th-11th October 2005, Radisson SAS Royal Garden Hotel, Trondheim, Norway. Contact: Conference Secretariat, SINTEF Energy Research, Tel: +47 73 5925 14 Henny.E.Olafson@sintef.no www.energy.sintef.no/arr/CO2_2005/

New Energy Asia Forum and Exhibition. 24th-26th October 2005, Beijing International Convention Center, PR China. Contact: Marco Wang, Unique International Exhibition Ltd, Rm. B-209, Jinru Commercial Plaza, No. 13 Beiyingfangdongli, Xicheng District, Beijing 100037, China. Tel: +86-10-68362640, Fax: +86-10-68360949 marcowang@unique-expo.com

Bioenergy 2005. 25th-27th October 2005, Radisson SAS Royal Garden Hotel, Trondheim, Norway. Contact: Norwegian Bioenergy Association, Wergelandsveien 23b, 0167 Oslo, Norway. Tel:+47 233 65 870 post@nobio.no www.nobio.no www.bioenergy2005.no

Austrian JI/CDM Programme's 2nd technical workshop on JI/CDM. 27th-28th October, Vienna, Austria. Contact: Clemens Ploechl, Austrian JI/CDM Programme, Kommunalkredit Public Consulting GmbH, Climate and Energy, Tuerkenstrasse 9, A-1092 Vienna, Austria. Tel: +43 (0)1/31 6 31-244, Fax: -99244 or -104 c.ploechl@kommunalkredit.at www.ji-cdm-austria.at

International conference "climate or development?" 28th-29th October 2005, Hamburg Institute of International Economics, Hamburg, Germany. Contact: Ms. Heike Kern, Tel: +49 40 42834 337, Fax, +49 40 42834 367, heike.kern@hwwa.de www.hwwa.de/Forschung/Klimapolitik/Veranstaltungen.htm

Carbon Finance 2005. 31st October – 1st November 2005 London, UK. Contact: Tel: +44 (0)20 7251 9151 Fax: +44 (0)20 7251 9161 info@environmental-finance.com www.environmental-finance.com/envfin/CF2005.pdf

Gas-Fuel 05. 14th-15th November 2005, Belgium. Contact: Gas-Fuel 05, c/o Technologisch Instituut, Ingenieurshuis K VIV, Desguinlei 214, BE - 2018 Antwerpen, Belgium. Tel: +32 3 260 08 40 Fax: +32 3 216 06 89 info@gasfuel05.com

5th International CBM/CMM Symposium. 30th November - 1st December 2005, Kunlun Hotel, Beijing, China. Contact: cbmc@public.bta.net.cn

International Symposium "Strengthening Climate Cooperation, Compliance & Coherence". 2nd-3rd December 2005, Montreal, Canada. Contact: Emily Wheeler, CISDL Assistant Manager, Climate Law Symposium, Centre for International Sustainable Development Law, 3661 Peel St. McGill Law Faculty, Montreal Quebec, Canada H3A 1X1. ewheeler@cisdl.org www.cisdl.org

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