carbon capture journal

March / April 2008 Issue 2

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Front cover:

Alstom will use the carbon capture plant under construction at We Energies' Pleasant Prairie plant to test its chilled ammonia capture method (See pg. 16)

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Contents

Carbon Storage in Depleted Gas Fields: Key Challenges

Injecting and storing CO_2 in highly depleted gas fields could prove a major technical challenge. This article describes a case study based on the characteristics of a South North Sea gas field.

David S Hughes, Technical Head Carbon Storage, Senergy Ltd

It is recognised that most of the available geological storage capacity for CO_2 is in saline aquifers.

The best aquifers are likely to be in sedimentary basins (and in many cases near to fossil energy sources). However, unless the formations have been explored for hydrocarbon potential, it is likely that little data exists so significant work will be required to evaluate the realistic storage potential.

Depleted hydrocarbon reservoirs offer more limited capacity but are better characterised, and may offer a shorter route to practical implementation for early projects.

Oil fields present the opportunity for enhanced oil recovery (and a revenue stream from the additional oil produced) although so far there have been no offshore applications.

Depleted gas fields are usually well characterised and have seals that have successfully retained hydrocarbon gas for millions of years.

Bentham, 2006 and Kirk, 2006 estimate that depleted gas fields in UK waters could store 2.8 billion tonnes of CO_2 in the Southern North Sea (SNS) fields and 1 billion tonnes in the East Irish Sea (EIS) fields respectively

This article explores the issues around injecting and storing CO_2 in highly depleted gas fields using a case study based on the characteristics of a SNS gas field.

Pressure Response During Depletion

When a gas field is produced the characteristic of its pressure response can fall into three broad categories (Figure 1).

If there is no aquifer support (Type 1) then the pressure will deplete more or less linearly with the cumulative gas produced, the recovery will be in excess of 90%, and the abandonment pressure will be very low.

If there is limited or weak aquifer support (Type 2), then the normal pressure decline in response to gas production is reduced somewhat by small amounts of water influx and the recovery factor is limited to around 70% with significantly higher abandonment pressures.

Once production has ceased the pressure increases (albeit relatively slowly) in response to further aquifer influx. Gas fields with a strong aquifer response (Type 3) have relatively poor recoveries (of order 40%) as the invading water chokes the wells. Any pressure decline during the production phase is quickly made up by the aquifer.

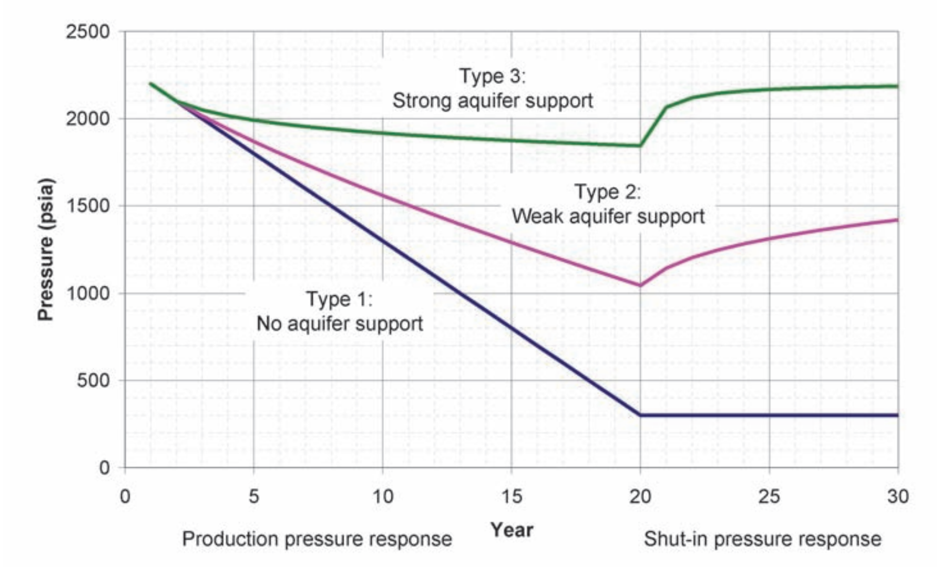

Figure 1 - Typical gas field pressure responses

Gas fields with Type 1 and Type 3 pressure responses are likely to provide the best candidates for CO_2 storage.

Type 1 because there is clearly a pressure 'sink' into which to inject the CO_2; and it is a generic field of this type that is the subject of the rest of this article.

Type 3 because by analogy if the water can flow quickly into the pressure sink created by produced hydrocarbon gas, then the water should flow away quickly in response to the pressure spike from the injected CO_2.

A Type 2 response is much more problematic when considering CO_2 disposal.

There will be some initial capacity compressing up the remaining hydrocarbon gas but after this additional capacity will depend on the rate at which the aquifer will relax in response to the CO_2 injection which may be too low for practical application.

'Pack-up'

The density of CO_2 by comparison with hydrocarbon gas means that a lot can stored in the pore space from which hydrocarbon gas has been produced, particularly at shallower depths.

We can define 'pack up' as the ratio of surface volumes of CO_2 and hydrocarbon gas (principally methane) that can be stored in the same volume of pore space at the same temperature and pressure.

Figure 2 shows pack-up with depth for

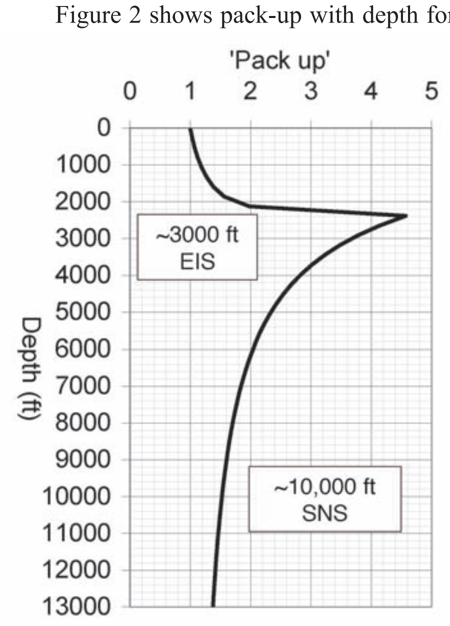

Figure 2 - 'Pack up' with depth for typical UK continental shelf geothermal and hydrostatic gradients

typical UK Continental Shelf geothermal and hydrostatic gradients. The pack-up is around 3.5 at the depth of the EIS gas fields (~3,000 ft or ~914 m), and about 1.5 at the depth of the SNS gas fields (~10,000 ft or ~3,048 m).

Generic SNS Gas Field Used for Case Study

The study reported here uses a representative SNS Gas Field. This is at a depth of 10,000 ft (3,048 m), has an initial pressure (prior to hydrocarbon gas production) of 4,500 psia (310 bara) and a reservoir temperature of 200°F (93°C).

The porosity and permeability are assumed to be constant at 15% and 50 milli-Darcy respectively.

The original gas in place is around 1 trillion standard cubic feet or scf (28 billion standard cubic metres or scm), with a recovery factor to an abandonment pressure of 350 psia (24 bara) of 90%.

The objective is to see if the field can be used to inject 200 million scf per day of CO_2; the amount that would be captured at a 500-800 MW coal fired power station depending on the load factor. This is equivalent to 5.7 million scm per day or ~3.9 million tonnes per year.

Simulation Model

The injectivity and storage capacity were investigated using a 1D single well compositional model with a radial grid (Figure 3).

Based on the field dimensions and permeability, two injection wells each injecting 100 million scf/d (2.8 million scm/d) are likely to be sufficient, so the model was set up to represent half the volume of the field.

The CO_2 is injected into the small amount of hydrocarbon gas remaining. Figure 3 shows the situation after one year of injection.

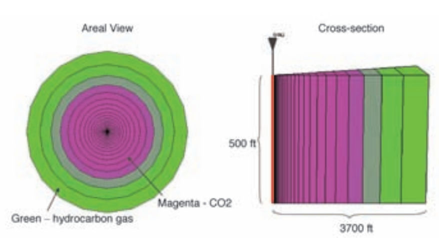

Figure 3 -Simulation model showing CO2 distribution after one year

Of course the behaviour is somewhat simplified in this simulation as in practice it is likely that heterogeneity would cause the CO_2 and hydrocarbon gas to mix to some extent.

There would also be a tendency for the gases to segregate under gravity. However, it is believed that the model is sufficient for a first pass determination of injectivity and storage capacity.

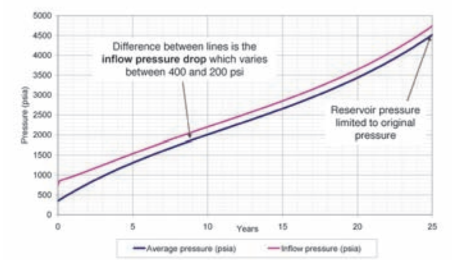

Figure 4 - Reservoir pressure responses to CO2 injection

The simulations show that for two injectors it is possible to inject 200 million scf/d (or 5.7 million scm/d) for 25 years and store a total of 97 million tonnes.

During this time the average field pressure (Figure 4) rises from the field abandonment pressure of 350 psia (24 bara) to the original field pressure of 4,500 psia (310 bara).

The pressure at the point of injection (also shown in Figure 4) is always higher than the average pressure.

Initially the inflow pressure drop is around 400 psi (28 bar) while the CO_2 is being injected as a low density gas but this decreases to around 200 psi (14 bar) later on when the CO_2 is being injected in the dense phase.

Thus the CO_2 injection system has to be designed to deliver the CO_2 bottom hole at a pressure of around 750 psia (52 bara) initially, rising to 4,700 psia (324 bara).

Injection System

For practical and economic reasons, it is normal to transport CO_2 in surface and seabed pipelines in the dense phase.

At the seabed temperature of around 40°F (4.4°C), and allowing for a safety margin, the CO_2 would need to arrive at the injector well heads at a pressure of 1,000 psia (69 bara) or higher.

The behaviour of the CO_2 in the injection well can be modelled using well flow performance software. Note, however, that in the main this software is designed to model the flow of hydrocarbons and needs to be used with caution when modelling CO_2.

The result of a typical calculation is shown in Figure 5. The CO_2 is assumed to flow down the well in a 7 inch pipe (known as tubing) at a rate of 100 million scf/d (2.8 million scm/d).

As the CO_2 flows down the well there is a pressure increase from the weight of the column negated by friction losses. In addition the CO_2 heats from the injection temperature of 40°F (4.4°C) to around 100°F (38°C) at the base of the tubing.

This is as a result of heat flux from the geological formation around the well, although the CO_2 does not equilibrate with the external temperature.

This would only occur in the tubing at very low injection rates. The CO_2 does, however, heat up to the reservoir temperature of 200°F (93°C) after injection although this process is not straight forward.

The bold blue and red lines in Figure 5 show the pressure along the tubing for tubing head pressures of just under 970 psia (67 bara) and 1,100 psia (76 bara) respectively.

Even with the friction losses this delivers the CO_2 at the base of the tubing (10,000 ft, 3048 m sub sea) at pressures of 4,500 psia (310 bara) and 4,750 psia (328 bara) respectively.

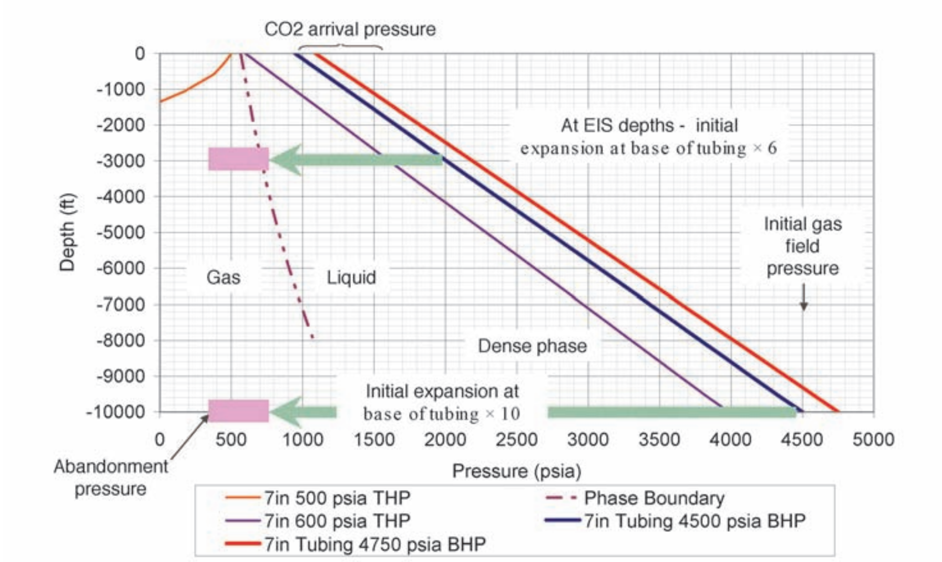

Figure 5 - Pressure in injection well tubing during CO2 injection

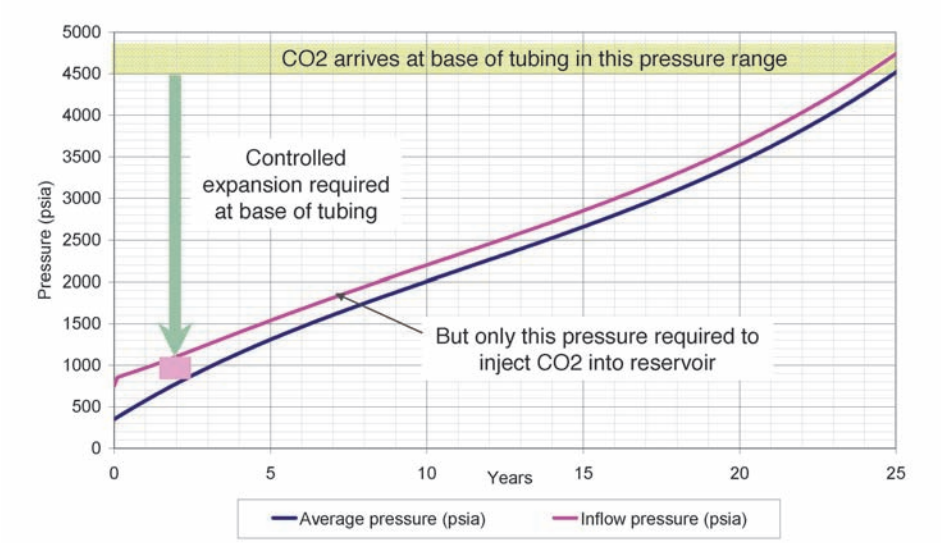

Figure 6 - Pressure at base of tubing compared to reservoir pressure response

David Hughes, Technical Head Carbon Storage, Senergy

Initially this is much higher than the bottom hole pressure required to inject the CO2 into the reservoir which is only 750 psia (52 bara), although this mismatch in pressure will decline in time as the reservoir fills up with CO2 and the pressure increases.

It would be possible to lower the tubing head pressure such that the bottom hole pressure is reduced to 4,000 psia (276 bara) - shown by the purple line, but this would take the surface pressure dangerously near to the pressure below which the CO2 in the tubing would become gas.

It is not possible to inject the CO2 in the gaseous state as the friction would far outweigh the pressure head as indicated by the orange line.

The broken line shows the dividing line between the CO2 in the tubing being in the gaseous or liquid state; beyond the base of the line it is supercritical.

If the high pressure dense phase CO2 is discharged directly into the low pressure reservoir without a controlled expansion, then the low pressure in the reservoir would reflect back up the tubing and choke-off the flow.

Thus in order to store the CO2 in the initially low pressure reservoir it will be necessary to fit an expansion cum flow control device at the base of the tubing which would need to be adjustable with time.

The expansion will need to be done against friction in order to counter the Joule Thomson cooling effect which could potentially result in the formation of ice and gas hydrate.

Such a flow control device is quite high-tech so disposal in depleted gas fields is not going to be easy with serious attention needing to paid to flow assurance.

The volumetric expansion required initially at a typical SNS depth of 10,000 ft (3048 m) is around ten times. At the shallower reservoir depths in the EIS this factor is around six times.

Figure 6 shows that the amount of expansion required reduces with time. A CO2 delivery pressure at the base of the tubing of 4,500-4750 psia (310-328 bara) is sufficient to repressurise the reservoir to near its original pressure and store around 97 million tonnes of CO2 and there could be some additional capacity if the delivery pressure were raised.

Comment

Previous estimates indicate that there is significant capacity to store CO2 in depleted Southern North Sea (SNS) and East Irish Sea (EIS) gas fields.

However, this case study shows that assessing and managing the flow control aspects of CO2 injection, particularly initially when the reservoirs are at very low pressure is going to be a major technical challenge.

The challenges include a requirement for a high-tech flow control device at the base of the tubing to allow the dense phase CO2 to be expanded in a controlled manner.

Also the requirement for CO2-specific well flow performance software as conventional software, designed to model the flow of hydrocarbons, is not necessarily sufficiently rigorous when modelling a complex fluid like CO2, particularly the thermodynamics aspects.

Understanding and mitigating Joule Thomson effects is necessary to avoid the possible formation of ice and gas hydrates.

Without a comprehensive understanding of CO2 flow systems and accurate modelling of the thermodynamic effects it may not be possible to realise the potential that gas field storage offers.

References

Bentham, Michelle, 2006, An assessment of carbon sequestration potential in the UK - Southern North Sea case study, Tyndall Centre for Climate Change Research, Tyndall Centre Working Paper No. 85

Kirk, Karen 2006, Potential for storage of carbon dioxide in the rocks beneath the East Irish Sea, Tyndall Centre for Climate Change Research, Tyndall Centre Working Paper No. 100

About the author

David Hughes is an oil reservoir engineer with 28 years' experience, and is Technical Head of Carbon Storage at Senergy Ltd.

He is an expert in the scientific, technical and engineering aspects of enhanced oil recovery processes including CO2 injection, and was first involved in such projects in the 1980s.

He is principal investigator or project manager on a variety of carbon storage assessment studies currently ongoing at Senergy which cover the full range of storage options.

Previously he was a member of the Senergy team that undertook the subsurface design and performance assessments for the proposed CO2 enhanced oil recovery and storage project in the Miller field (offshore UK) for BP.

David is past editor of BERR's (UK Department for Business) online periodical 'Improved Oil Recovery Views' (http://ior.senergyltd.com), and from September 2008 will be a Society of Petroleum Engineers 'Distinguished Lecturer' on the subject of carbon storage and its significance to the oil industry.

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Projects and Policy

Carbon capture projects

DOE restructures FutureGen emphasising industry involvement

www.fossil.energy.gov

The US DOE has emphasised the role of the private sector in FutureGen, will now fund only the CCS component of future plants, and does not include hydrogen production in its restructured plan.

U.S. Secretary of Energy Samuel W. Bodman has announced a restructured approach to the FutureGen project. Under the new strategy, the U.S. Department of Energy (DOE) will aid industry in its efforts to build IGCC plants by providing funding for the addition of CCS technology.

Multiple plants, to be operational by 2015, will be considered for the $156 million funding, part of the president's budget request of $648 million for the DOE Office of Fossil Energy's advanced coal technology research, development and demonstration program for Fiscal Year (FY) 2009.

The FY09 budget requests $407 million for coal research, including development of more efficient gasification and turbine technologies, innovations for existing coal power plants, and large-scale CCS injection tests; and $241 million to demonstrate technologies for cost-effective carbon capture and storage for coal-fired power plants, including $156 million for the restructured FutureGen approach and $85 million for DOE's Clean Coal Power Initiative.

This $648 million request represents a $129 million increase from the President's FY2008 request and is the largest amount requested for DOE's coal program in more than 25 years.

The DOE has issued a Request for Information (RFI) that seeks industry input by March 3, 2008, on the costs and feasibility associated with building clean coal facilities that achieve the intended goals of FutureGen.

Following this period of industry comment, DOE intends to issue a Funding Opportunity Announcement to provide federal funding under cooperative agreements to equip IGCC (or other clean coal technology) commercial power plants that generate at least 300 megawatts, with CCS technology.

Initial input from industry will assist in determining how many demonstrations can be commissioned.

This restructured approach allows DOE to maximise the role of private sector involvement and provide a ceiling on federal contributions.

Under this plan, DOE's investment would provide funding for no more than the CCS component of the power plant - not the entire plant construction, compared with the FutureGen concept announced in 2003 where the federal government would incur 74% of rising costs.

This would allow for commercial operation of IGCC power plants equipped with CCS technology to begin as soon as the plants are commissioned, between 2015 and 2016.

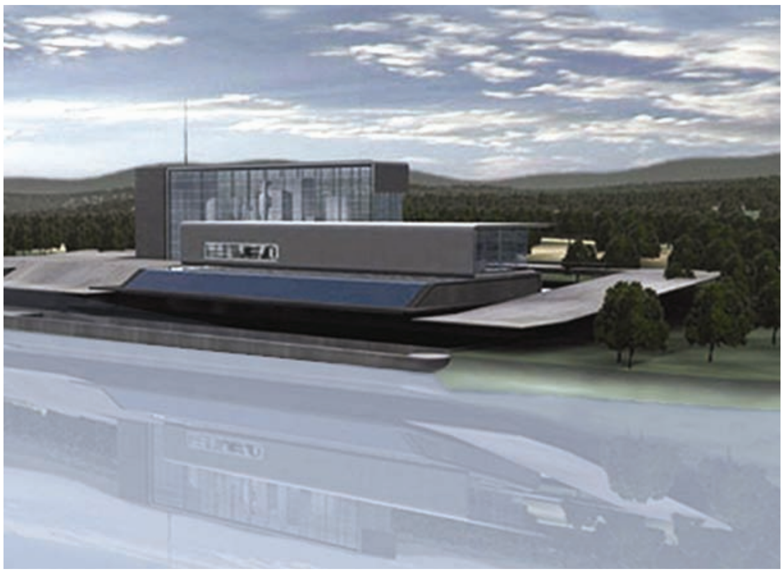
The FutureGen concept announced in 2003 planned the creation of a near-zero emissions, 275 MW power plant that produced hydrogen and electricity from coal on a smaller-than-commercial-scale, serving as a laboratory for technology development.

The restructured approach will focus on separating carbon dioxide (CO2) for CCS, and does not include hydrogen production, although hydrogen production for commercial use will remain an important component of DOE's other energy initiatives.

The four sites - two in Illinois and two in Texas - evaluated in the Department's Environmental Impact Statement issued in November 2007, including the site announced by the FutureGen Alliance in December 2007, Mattoon, IL, may be eligible to host a commercial-scale IGCC plant with CCS technology.

The site analysis and characterisation data at these sites may be applicable to future environmental analyses under this restructured approach.

More than one site may be selected and DOE says it encourages applicants to include these four sites in their consideration.



Plans for FutureGen have been restructured by the DOE, but the FutureGen Alliance remains committed to the original site

FutureGen Alliance remains committed to Mattoon site

www.futuregenalliance.org

FutureGen Alliance Chief Executive Officer Michael J. Mudd released a statement reiterating its commitment to progress at the Mattoon site.

This was in reaction to the January 29 meeting between the Department of Energy (DOE) and the Illinois congressional delegation.

He said FutureGen's progress had been remarkable and it is America's best hope for near-zero emission coal technology.

"FutureGen can deliver the needed technology with urgency." he said. "It will take four to five years for DOE to evaluate new proposals, place contracts, andconduct environmental reviews for new projects. FutureGen has crossed these hurdles and is positioned for success."

"The Alliance remains committed to keeping FutureGen on track. We owe it to the people of Illinois, to the Alliance members who have contributed significant funds and resources to bring the project to this stage and to society which depends on technology to provide clean, affordable and secure energy."

Doosan Babcock Oxycoal 2 project approved

www.doosanbabcock.com

Doosan Babcock Energy will go ahead with Oxycoal 2, a UK project to demonstrate oxyfuel technology for carbon capture on coal-fired power plants.

The £7.4 million project is the next

stage in a programme to investigate oxyfuel technologies for CCS and bridges the gap between R&D and a full scale pilot.

It is the first project to be supported by the UK Department for Business Enterprise and Regulatory Reform (BERR) under its Hydrogen Fuel Cells and Carbon Abatement Technologies (HFCCAT) Demonstration Programme.

BERR contributed £2.2 million and the remaining funding was from a group of industrial sponsors and university partners led by Scottish and Southern Energy, who gave £1 million.

The other partners were E.ON UK PLC, Drax Power Limited, ScottishPower, EDF Energy, Dong Energy Generation, Air Products Plc, and Imperial College and University of Nottingham.

In the project, Doosan Babcock will conduct a demonstration on a full scale 40 MW burner at its test rig at Renfrew. The boiler will be modified to accommodate oxyfuel firing on pulverised coal with recycled flue gas.

The upgrade of the burner test facility is expected to be complete early in 2009, with the first oxyfuel combustion demonstration by the end of March that year.

The project will be used to gain experience relating to materials and corrosion, and fouling and slagging problems. The technology is suitable both for new plant and for retrofit applications.

Shell / StatoilHydro Tjeldbergodden plant shelved

www.shell.com

Shell and Statoil have abandoned their planned gas power station with carbon capture in Tjeldbergodden, Norway.

The project plans to capture carbon dioxide emitted from a 860 mw power station and inject it in Shell's Draugen field and Statoil's Heidrun field, for 'enhanced oil recovery' (EOR).

The two companies stated earlier this year that initial studies had shown that the additional oil gained from the EOR would not justify the investment, but agreed further study.

On December 20, Shell and StatoilHydro stated that although the technology worked, it could not be made economic, if the costs need to be covered by the additional oil produced from the EOR alone.

"It is a combination of economics and lack of response from authorities in regard to CO2 storage and purification that causes the project to be scrapped," said project leader Kai Bjarne Lima at StatoilHydro, speaking to Norway paper Afternposten.

Mongstad CCS prohibited state aid by Brussels

euobserver.com/9/25481

The Norwegian government has been prohibited from providing aid to the proposed carbon capture and storage plant connected to StatoilHydro's refinery in Mongstad, due to EU state aid rules, according to EU news service EUobserver.com.

Norway is not part of the EU, but it is part of the European Economic Area.

While letters are going between Norway and Brussels, a decision on the project has been delayed until the end of 2008, ostensibly to try to find foreign investors for the project, EUobserver.com says.

Dong, Shell, StatoilHydro and Vattenfall have agreed to co-operate during the planning phase but not provide all of the money.

The project might be labelled a 'project of common European interest' in order to win permission for the state aid.

Masdar and Hydrogen Energy plan clean energy plant in Abu Dhabi

www.masdaruae.com

Masdar and Hydrogen Energy have announced they will work together on the front-end engineering design of an industrial-scale hydrogen-fired power generation project with CCS, to come into commercial operation in 2012.

Masdar is Abu Dhabi's initiative for renewable and alternative energy and clean technology, and Hydrogen Energy is a joint venture between BP Alternative Energy and Rio Tinto.

The plant would be located in Abu Dhabi, where natural gas would be processed to create hydrogen and CO2. The CO2 would be injected into a producing oil field where it could replace natural gas currently being injected into the field to maintain pressure and potentially enhance oil recovery.

Work has already started and front-end engineering and design of the project which is planned to be completed by the end of 2008, at a cost of around US$45 million.

The plant would generate around 420MW of electricity, enough to provide more than 5% of all Abu Dhabi's current power generation capacity.

The project would limit greenhouse gas emissions by capturing aroud 90% of the CO2 generated, and safely and permanently storing up to 1.7 million tonnes of CO2 per year - the equivalent of decarbonising Abu Dhabi's entire domestic transport sector.

The CO2 would replace the natural gas currently being injected into oilfields, allowing the gas to be used to fuel Abu Dhabi's continued growth, or to be exported.

The overall project would require total capital investment (excluding the investment in CO2 transportation and sequestration) of about AED7 billion (US$2 billion).

Subject to the completion of the engineering design and agreement on an enabling commercial structure, the partners are hoping to make the decision to proceed with construction by early 2009.

Coal gasification plant in North Dakota

www.bismarcktribune.com

Great Northern Power Development is planning a coal gasification plant (which will allow carbon dioxide to be stored) in South Heart, North Dakota, according to an article in the Bismarck Tribune.

The company owns a large amount of coal reserves in North Dakota.

It had been planning a new power plant for many years, but decided to build a coal gasification plant instead, to meet anticipated carbon capture and storage requirements, according to the Bismarck Tribune.

The company also found the coal gasification plant met much less regulatory hurdles.

There are plenty of buyers for the synthetic gas, and the carbon dioxide can be sold to Canadian oil producers for use in Enhanced Oil Recovery (EOR).

The company will submit a new planning application for the plant in late summer 2008.

Washington State power plant permit revoked

seattlepi.nwsource.com

A permit application for a new coal power plant near Portland, Washington State (USA) has been revoked because the builder did not address how it would bury the carbon dioxide, according to an article in Seattle Post and Intelligencer.

The application to build the power plant was made by Energy Northwest, and it was suspended by Washington State Energy Facility Site Evaluation Council.

A law was passed earlier this year in Washington, stating that utilities cannot sign long term contracts with coal fired power plants that produce 'excessive' carbon dioxide.

New power plants would have five years to sequester carbon dioxide emissions, or they would have to offset their

Projects and Policy

emissions through more drastic measures than buying carbon offsets - such as buying a dirtier plant and closing it down.

Energy Northwest had argued that carbon sequestration is still 'unworkable in real world practise', according to Seattle Post and Intelligencer, and wanted to pay to offset emissions until it considered it to be workable.

This was not good enough for the Council, which said that Energy Northwest had a plan to implement carbon sequestration at 'some indefinite later date', not today, as required by the legislation.

The proposed plant was 793 megawatts and was going to gasify coal and burn the gas to make power.

Bill Braudt, Tenaska general manager of business development, explains the choice to locate the Tenaska Trailblazer Energy Center near Sweetwater, Texas.

Tenaska proposes new coal-fired plant with CCS

www.tenaskatrailblazer.com

Tenaska is developing a site near Sweetwater, Texas, upon which to construct a 600MW conventional coal power plant with CO2 capture.

The CO2 would be captured and transported via pipeline to oil fields in the Permian Basin where it will be used in enhanced oil recovery and stored in the Basin's geologic formations.

An air permit application, the first formal step in gaining approval to build the plant, has been filed with the Texas Commission on Environmental Quality (TCEQ), according to David Fiorelli, president and CEO of Tenaska's Business Development Group.

The proposed construction site is a 1,919-acre tract east of Sweetwater and north of Interstate 20 in Nolan County.

The final decision to proceed with the $3-billion project will be made in 2009 based on a number of factors, including the availability of local, state and federal incentives; final project cost estimates; and projected market prices for electricity and CO2.

Current estimates of these factors make the project appear to be economically feasible. Construction could begin in late 2009 and be completed in 2014.

Tenaska is working with Sweetwater area officials to determine the feasibility of the project and to provide accurate and timely information to Sweetwater area residents.

If built, the plant will be the first new commercial coal-fueled power plant, other than small research projects, to capture and provide for storage of CO2.

The volume of CO2 expected to be sold to oil producers could be used to recover enough oil to add more than $1 billion a year of oil production to the Texas economy.

Saskatchewan plans carbon capture project

www.saskpower.com

SaskPower will perform a CND $1.4 billion retrofit of its Boundary Dam 130MW coal-fired power plant to add carbon capture technology, according to a report in Reuters.

The plant is expected to be constructed by 2015 and would produce 100 megawatts (MW) of base load power, while capturing around 1 million tonnes of CO2 a year.

The Saskatchewan government has committed CND $240 million to a major carbon capture project in the region.

SaskPower says it has been assessing the viability of a major carbon capture project for some months, but concluded the federal government needed to come to the table with significant financial support to make further progress possible.

Policy, company and regulation news

Abu Dhabi fund - $15bn for clean energy

www.masdaruae.com

The government of Abu Dhabi has announced a $15bn (GBP 7.5bn) fund for developing clean energy projects, including the world's largest hydrogen power plant with carbon capture according to BBC reports.

The power plant will make the hydrogen by burning natural gas.

Abu Dhabi will then use the hydrogen to generate electricity.

The announcement was made at the Abu Dhabi World Future Energy Summit (Jan 21-23).

The project also includes a "sustainable city" for 50,000 people, with no cars and which produces no greenhouse gases.

The government described the initiative as the "most ambitious sustainability project ever launched by a government". It hopes to use the money to set up international joint ventures, which will lead to even more money being invested.

The investment vehicle is the Abu Dhabi government's Masdar Initiative.

"As global demand for energy continues to expand, and as climate change becomes a real and growing concern, the time has come to look to the future," said Masdar CEO Dr Sultan Al Jaber.

"Our ability to adapt and respond to these realities will ensure that Abu Dhabi's global energy leadership as well as our own growth and development continues."

Electricity prices may rise, but other industries will pay less for emissions under new EU legislation

euobserver.com/9/25500

Electricity prices may increase by 10%-15% by 2020 as the electricity generation sector in the EU will in the future be forced to buy the right to emit carbon dioxide by auction, reports EUobserver.com.

The news comes ahead of a major raft of climate change legislation due on 23rd January including reform of the EU Emission Trading Scheme (ETS).

The electricity generation industry will have to pay for a fifth of pollution credits in 2013, rising by 10% each year to 100% in 2020, says EUobserver.com.

According to Reuters, Europe's steel, aluminum and cement industries will have a special, less strict regime for greenhouse gas emissions however.

After weeks of intense lobbying by business and governments, EU sources said on Sunday those three energy-intensive industries would be introduced more slowly into a new system for auctioning permits to emit CO2 from 2013, Reuters reported.

Norway 'carbon neutral by 2030'

www.norwaypost.no

Norway has brought its target for being 'carbon neutral' forward from 2050 to 2030, following discussions between government coalition parties, according to an article in the Norway Post.

'Considerable' government funds will be allocated for promoting renewable energy, strengthening public transport and reducing transport emissions, whilst diesel and petrol taxes will be increased, the article says.

In 2008 the Government will set aside additional NOK 70 million (US$12m) for research on renewable energy and carbon capture and storage, to increase to NOK 300m (US$55m) in 2009 and NOK 600m (US$110m) in 2010.

Other government measures will include a ban on oil fired heating systems on public and commercial buildings of over 500 square metres from 2009, which will apply for new buildings and when systems on old buildings are replaced.

Scotia Securities introduces first climate change fund in Canada

www.scotiabank.com

Scotia Securities Inc. (SSI) has launched the Scotia Global Climate Change Fund, a first of its kind in Canada, designed for investors looking for exposure to environmentally responsible companies, without compromising solid returns.

The fund's investment strategy is long-term and designed to benefit from those companies adopting technological and environmental practices that mitigate and address the implications of climate change.

The fund diversifies across nine climate themes that cover 10 economic sectors, enabling the fund to capitalise on a broad scope of opportunities while reducing the risk associated with investments in only one or two of these areas.

The nine themes include clean fuels such as bio diesel, and clean technology such as carbon capture and storage and Integrated Gasification Combined Cycle (IGCC) power production.

HSBC sets up climate-change fund

www.asianinvestor.net

HSBC Investments is launching a new climate change investment fund, focusing on renewable power, sustainable agriculture and forestry, carbon capture and storage, low-carbon vehicles, energy efficiency, and water, according to an article on Asian Investor.net.

According to the article, HSBC expects large amounts of money to be put into these sectors over the 'medium term,' from governments and the private sector.

A HSBC executive is quoted as saying that the fund has a good performance and risk/return profile, and is also well diversified.

It will only invest in companies that derive at least 10 per cent of their revenue from climate change related activites.

Carbon Management Council formed

www.carboncouncil.org

An initial group of eight leading companies have formed the Carbon Management Council, a nonprofit educational association dedicated to helping organisations develop solutions to managing their carbon emissions.

The Council was officially incorporated in the District of Columbia on December 17, 2007.

The founding member companies of the Council are: Alliance Technical Services; Arizona Public Service Company; CH2M HILL; The Entech Group; Entergy Services; HyRadix; Schlumberger Carbon Services; and SunTrust Banks.

The founding members welcome other organisations to join them in determining how to best move forward in a carbon-constrained world.

Total and Indonesia sign MoU on CCS

www.total.com

Total has signed a Memorandum of Understanding between Total E&P Indonesia and the Indonesian Ministry of Energy and Mineral Resources.

Under this agreement, which was concluded on the sidelines of the UN Climate Change Conference, Indonesia's Agency of Research and Development for Energy and Mineral Resources will be allowed access to data from Total's pilot project which is being implemented near Lacq in the SouthWest of France.

This project, one of the first in the world to include the whole chain from combustion to CO2 geological storage, is primarily intended to prove the technical feasibility of an integrated carbon capture and storage scheme.

It should enable Total to contribute to the fight against global warming, and provide an efficient solution to help limiting the footprint of Total's activities in Exploration and Production, Refining and Chemicals.

Indonesia will thereby be able to develop its technical and economical understanding of such a CO2 storage scheme, especially concerning the geological aspects.

In turn, this may assist the Indonesian Government to establish an appropriate regulatory framework for similar projects that maybe proposed in Indonesia.

Governments of Canada and Alberta release CCS Task Force report

www.nrcan.gc.ca

The report, entitled Canada's Fossil Energy Future: The Way Forward on Carbon Capture and Storage, provides advice on how governments and industry can work together to facilitate and support the development of carbon capture and storage opportunities in Canada.

The Honourable Gary Lunn, Minister of Natural Resources, and the Honourable Mel Knight, Alberta Minister of Energy, released the final report written by the Canada–Alberta ecoENERGY Carbon Capture and Storage Task Force.

The recommendations from the Task Force include: incorporating carbon capture and storage into Canada's clean air regulations; allocating new funding to projects through a competitive process; and targeting research efforts to lower the cost of this technology.

BP commits further to China CCS efforts

www.bp.com

BP has announced a series of agreements to enhance its commitment to China. These include strategic integration and commercialisation of clean coal conversion technologies.

BP and the China Academy of Sciences (CAS) signed an agreement to undertake a feasibility study into a proposed Clean Energy Commercialisation Centre (CECC) joint venture.

Under the agreement, CECC is intended to integrate individual clean energy related technologies - coal gasification, coal to liquids, coal to chemical, CCS, coal bed methane and underground gasification from CAS institutes and other organisations both within and outside the People's Republic of China (PRC).

The CECC would also serve as an international platform to foster collaboration among research institutes, enterprises and other institutions to improve indigenous Chinese innovation capabilities and market applications in areas such as clean coal conversion, zero emission and CCS.

BP and CAS have also agreed that the CECC would act as a cooperation platform be-

tween the two parties in order to support the development of the Sino-UK clean coal conversion related near zero emission initiative, including technology development and demonstration projects.

BP and CAS believe that the commercialisation of clean coal conversion and other clean energy conversion technologies will make an important contribution to China's future energy security whilst also helping to reduce CO_2 emissions and address China's future energy security and environmental sustainability issues.

A full time working team drawn from both BP and CAS has been established to progress the feasibility study and the joint venture contract, with the aim of establishing the CECC joint venture by the end of 2008.

Luminant IGCC Initiative: 14 companies respond

www.luminant.com/igcc

Luminant has received 14 expressions of interest in response to its request for proposals (RFP) from companies offering IGCC or other coal gasification technologies with the ability to capture CO_2.

Mike Greene, Luminant's Chief Executive Officer, said that due to the interest Luminant is extending the period for clarifying questions from Jan 30 to the end of Feb..

Luminant's timeline calls for detailed proposals to be submitted by June 2008. The company's IGCC RFP is the first step in the planning process for two commercial demonstration plants to be located in Texas, fulfilling a commitment made by the company.

Subsequent to the submission of proposals, Luminant will undertake a detailed evaluation of the proposals before proceeding to phase two, which will include preliminary engineering designs.

StatoilHydro and ONGC cooperate in India

www.statoilhydro.com

StatoilHydro and Indian oil company ONGC have agreed to jointly explore the potential of developing CCS and CDM (Clean Development Mechanism) projects in India.

The companies signed a memorandum of understanding at a special event organised by TERI (The Energy and Resources Institute) and the Norwegian Embassy prior to the Delhi Sustainable Development Summit (DSDS) in New Delhi.

Norway's Prime Minister Jens Stoltenberg and Nobel Peace Prize winner Dr Rajendra Pachauri were also present at the signing.

The two companies have agreed to jointly screen possibilities for developing CCS and CDM projects within ONGC's operations in India.

The cooperation could result in CO2 emissions reduction projects as well as the promotion of energy efficiency and growing use of renewable energy under the mechanisms of the Kyoto Protocol.

The DSDS is an annual event that has matured into India's most important gathering of international leaders concerned with global sustainable development.

This year's conference attracted the prime ministers of India, Norway, Denmark and Finland, as well as numerous ministers and government officials from several countries.

EU should budget €1 billion for pilot plant - Alstom

www.alstom.com

Alstom says the EU lacks up to €18 billion in funding to build its planned 12 CCS pilot projects, according to an article from Bloomberg.

Bloomberg interviewed Joan MacNaughton, environmental policy adviser, Alstom, who said that the issue of incentives for being the first to develop the technology, "had been slightly ducked at the European level and just left to individual member states."

She said that a realistic cost for a pilot plant was several hundred million up to €1 billion.

Leading Wall Street banks establish 'The Carbon Principles'

www.citigroup.com

Three of the world's leading financial institutions have formed The Carbon Principles, climate change guidelines for advisors and lenders to power companies in the United States.

The Principles are the result of a nine-month effort to create an approach to evaluating and addressing carbon risks in the financing of electric power projects.

It is the first time a group of banks has come together and consulted with power companies and environmental groups to develop a process for understanding carbon risk around power sector investments.

Power companies from across the US broadly welcomed the Principles as a positive step in meeting the demands of power production in a carbon constrained market.

The need for these principles is driven by the risks faced by the power industry as utilities, independent producers, regulators, lenders and investors deal with the uncertainties around regional and national climate change policy.

The Principles were developed in partnership by Citi, JP Morgan Chase and Morgan Stanley, and in consultation with leading power companies American Electric Power, CMS Energy, DTE Energy, NRG Energy, PSEG, Sempra and Southern Company.

Two NGOs, Environmental Defense and the Natural Resources Defense Council, also advised on the creation of the Principles.

"Leading utilities and financial institutions understand that the rules of the road have changed for coal," said Mark Brownstein, managing director of business partnerships for Environmental Defense.

"These principles are a first step in facilitating an honest assessment of electric generation options in light of the obvious and pressing need to substantially reduce national greenhouse gas pollution."

The consortium has developed an Enhanced Diligence framework to help lenders better understand and evaluate the potential carbon risks associated with coal plant investments.

The Principles recognise the benefits of a portfolio approach to meeting the power needs of consumers, without prescribing how power companies should act to meet these needs.

However, if high carbon dioxide-emitting technologies are selected by power companies, the signatory banks have agreed to follow the Enhanced Diligence process and factor these risks and potential mitigants into the final financing decision.

"There was full and frank dialogue around the table," said Matt Arnold, director of Sustainable Finance, which helped co-ordinate the development of the Principles and Enhanced Diligence process. "The dialogue resulted in a rigorous analysis of the carbon risks in power investments..."

Citi, JP Morgan Chase and Morgan Stanley have pledged their commitment to the Principles to use as a framework when talking about these issues with clients.

This creates a consistent approach among major lenders and advisors in evaluating climate change risks and opportunities in the US electric power industry.

The Principles are (in summary):

Energy efficiency

An effective way to limit CO2 emissions is to not produce them. The signatory financial institutions will encourage clients to invest in cost-effective demand reduction, taking into consideration the value of avoided CO2 emissions.

Renewable and low carbon distributed energy technologies

Renewable energy and low carbon distributed energy technologies hold considerable promise for meeting the electricity needs of the US while also leveraging American technology and creating jobs.

Conventional and advanced generation

In addition to cost effective energy efficiency, renewables and low carbon distributed generation, investments in conventional or advanced generating facilities will be needed to supply reliable electric power to the US market.

This may include power from natural gas, coal and nuclear technologies. Due to evolving climate policy, investing in CO2-emitting fossil fuel generation entails uncertain financial, regulatory and certain environmental liability risks.

It is the purpose of the Enhanced Diligence process to assess and reflect these risks in the financing considerations for certain fossil fuel generation.

We will encourage regulatory and legislative changes that facilitate carbon capture and storage (CCS) to further reduce CO2 emissions from the electric sector.

University of Nottingham launches CCS research centre

www.nottingham.ac.uk/carbonmanagement

Experts in clean energy technologies and carbon capture spoke at the launch event,

Edinburgh University offers CCS courses

www.geos.ed.ac.uk/carbon

Edinburgh University is offering new courses in the areas of CCS and carbon management.

They are designed for professionals – existing and aspiring – who wish to be able to tackle climate change in practice, through developing new skills to meet the challenge of finding new technological and business solutions to the problem of climate change.

Already on the go is a CPD (Continuing Professional Development) course called Geology for Engineers. The one-day course aims to enable participants to work and have dialogue with geoscientists while engaged on CCS projects.

It is aimed at engineering and science professionals without geology degrees, and so covers basics of geology with an orientation towards practical CO2 storage applications.

Companies and organisations who have already sent staff to this course include: ConocoPhillips, Shell, EON and the Scottish Environmental Protection Agency. The next available course will run this summer.

A new MSc in Carbon Management has also been launched. It provides high-level interdisciplinary skills and training in the business, economics and science of carbon management.

The course boasts lecturers of international standing and excellent links to business. It covers practical approaches like carbon audits, carbon footprints and carbon trading, as well as provides a detailed understanding of climate science and economics.

Edinburgh university is also in the process of planning an MSc on CCS, to start in 2009. It is intended to cover issues from capture plant design to carbon storage monitoring, and target science and engineering professionals and students.

Together with Heriot-Watt University and British Geological Society, it has formed the Scottish Centre for Carbon Storage. Heriot-Watt is also planning a CPD course on engineering aspects of carbon storage, including injection and EOR.

For further information on any of these courses contact Stuart Simmons:

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E: stuart.simmons @ ed.ac.uk

including Lord Ronald Oxburgh, President of the Carbon Capture and Storage Association, Dr David Clarke, Director of the Energy Technologies Institute, Martin Maseo, Technical Director of the Energy Institute and Dr Keith Burnard, Chief Technical Consultant of AEA Energy and Environment.

The centre will be led by Professor Mercedes Maroto-Valer, of the University's School of Chemical and Environmental Engineering. The research will be cross-disciplinary, bringing together engineers, mathematicians, bioscientists, geographers and geologists.

Research projects conducted in the centre will include the storage and conversion of CO_2 into materials and fuels.

The Engineering and Physical Sciences Research Council (EPSRC) will fund the centre over the next five years through its Challenging Engineering initiative.

Wyoming approves carbon capture regulations

Wyoming has approved two bills to regulate carbon capture and sequestration in Wyoming.

The first bill regulates CCS and imposes the requirement for a permit in the state, but does not apply to enhanced oil recovery programmes which will remain subject to regulation by the Oil and Gas Conservation Commission.

Specific pilot projects would be able to apply for a temporary permit.

It also gave $250,000 to develop a panel of experts on the technology to advise the state.

The second bill gives land owners the property rights to underground storage sites.

University of Wyoming and GE to develop advanced coal technology Center

www.uwyo.edu

GE Energy has signed a letter of intent with the University of Wyoming, countersigned by Gov. Dave Freudenthal, to develop an advanced gasification research and technology center in Wyoming.

The proposed center would consist of a small-scale gasification system that would allow UW and GE researchers to develop advanced coal gasification technology solutions for Powder River Basin (PRB) and other Wyoming coals.

"GE Energy and the University of Wyoming recognize that IGCC provides a cleaner alternative for power generation and has significant cost and efficiency advantages when integrated with carbon capture and sequestration," said John Lavelle, general manager of GE Energy's gasification business.

GE is a leader in cleaner coal integrated gasification combined cycle (IGCC) and gasification technology, which has been in use at the 230-megawatt TECO Polk I Station in Florida for more than 10 years.

Wyoming has the nation's largest coal reserves capable of supporting a substantial portion of the nation's energy needs. In 2006, Wyoming's coal industry produced 420 million tons of coal, fueling more than 30 percent of the national electrical power generation needs.

Eni and Enel launch CCS feasibility study

www.eni.it

The chief executives of Eni, Paolo Scaroni, and Enel, Fulvio Conti, have signed a letter of intent to develop a joint feasibility study on CCS.

Eni possesses skills in the sequestration of CO_2 in geological sites, such as depleted hydrocarbon deposits, deep saline aquifers, etc., while Enel is skilled in the capture of CO_2, having launched two CCS demonstration projects.

Enel is also studying the potential of geological storage in areas near its power plants. If the feasibility study is successful, Eni and Enel will jointly develop a draft "National Plan" for the capture, transport and sequestration of CO_2 to be submitted to the government and to the competent Italian and European institutions.

In particular, they are committed to conducting a joint assessment of national off-shore and on-shore CO_2 sequestration options and the implementation of one or more pilot projects involving the integration of CCS facilities.

Pilot Projects update - focus on European projects

Recent pilot project announcements from Vattenfall, RWE, Total and Erdgas Erdöl

Vattenfall - Schwarze Pumpe

The 25 MW lignite and hard coal powered oxyfuel Schwarze Pumpe pilot plant in Germany in cooperation with Gaz de France will be operational by 2008; the CO2 will be used to enhance oil recovery in the nearly depleted Altmark field.

"Vattenfall is the second largest CO2 emitter in Europe and has committed to halving emissions by 2030 based on the 1990 base," said Lars Stromberg, director, Vattenfall.

"Our vision is to show that it is possible to create a 'zero emission' coal fired power station at a cost of less than $20/ton of CO2."

"We are assuming that the primary technology options are commercially available in 2020, with better technologies available after that date. CCS is one of several solution but probably the most powerful one. This will allow us to reduce carbon emissions by 60%-80% within 35 years."

"We are planning a 250MW demo plant by 2013-15 with the commercial concept ready in 2020. A pipeline to transport the CO2 across Germany to a storage site is being planned but regulatory constraints mean that this will not be possible by 2015 as it is taking over four years to get planning permission."

"We are working with all the technologies available, post combustion, pre combustion and oxyfuel. Post combustion is commercially available on the medium scale, at present it is the most expensive, but could be a winner if costs can be reduced."

"Pre combustion might be competitive - IGCC at present exists in five demo plants without capture. An optimised turbine is still in the lab stage. The plant produces hydrogen as an intermediary product."

"Oxyfuel has the most potential and is the most competitive and preferred technology for coal. It need development, pilot and demo plants to validate design data. It is possible to process the CO2 after the boiler to reach 95% capture rate with 98% purity, 100% is possible but not economical."

"The gases contained in the off gas besides CO2 are mainly argon, nitrogen and water vapour - no sulphur dioxides and no nitrogen dioxides will be emitted. Also all particulates will be removed including all solid metals and submicron particulates."

RWE - German IGCC plant and Tilbury

RWE is building a zero CO2 450MW coal fired power plant based on IGCC technology including CO2 transport and storage in Germany with start of operation planned for 2014. Potential storage sites in northern Germany, under the German North sea and in central and eastern parts of the country.

In parallel, RWE will develop the technology of CO2 scrubbing for future advanced coal-fired steam power plants and as a retrofit option for modern installations.

RWE Power will focus on CO2 scrubbing for lignite while RWE npower in the UK will carry out CO2 scrubbing in hard coal (HC) plants and will build a "capture ready" HC power station in Tilbury.

The first pilot plant for HC is in operation at the Esbjerg power plant in Denmark as part of the EU CASTOR project. A CO2 scrubbing pilot is currently at the planning stage in Niederaussem.

Tilbury will consist of a 2 x 800MW plant with CO2 scrubbing by 2014. Linde has agreed to develop new solvents for the CO2 scrubbing projects.

Total - Lacq plant

The Lacq 30MW oxycombustion demonstration plant in southwest France involves revamping an existing boiler and injection into a nearby depleted gas reservoir, starting in 2008.

The pilot aims at a 50% reduction of direct and indirect CO2 emissions assuming indirect emissions coming from sources outside the plant, for example from manufacturing pure oxygen, are not captured. It also aims at a 50% reduction in capture costs compared to classical post combustion capture technologies.

"We are also developing and applying geological storage qualification methodologies, monitoring and verification techniques on a real operational case to prepare future larger scale long term storage projects," said Nicolas Aimard, Project Director, TOTAL.

150k tonnes of CO2 will be injected into the depleted reservoir at a depth of 4500m over two years in the first storage project in France. Scientific studies will be conducted before, during and after injection in collaboration with bodies such as the IFP and BRGM.

Public consultation was an important part of the project development, including open dialogue with stakeholders and public meetings open to the public. The objective was to provide transparent information about the CCS technology and to gain public acceptance through understanding of the benefits of the project to the local area.

Air Liquide is providing the technology for the oxyburners and the air separation unit as well as supplying the pure oxygen required at a rate of 240 tonnes per day.

The proposed plant at Tilbury will be 'capture ready'

Erdgas Erdöl, Altmark project

The Altmark pilot in Germany involves injecting 100k tonnes of CO2 over three years (2008-2011) into a partially depleted gas reservoir with an estimated capacity of 508M tonnes.

The reservoir is around 78% depleted and the opportunities for enhanced gas recovery are being investigated.

The pilot includes the completion of 2 existing wells for injection, the design and construction of a pilot injection facility, the implementation of a comprehensive monitoring program, and the implementation of a joint R&D program with partners & research facilities.

The target is to demonstrate the technical and economic feasibility of enhanced gas recovery and CO2 injection into the Altmark. The selected site is a small area, isolated from other compartments in the field with weak to no water drive.

Wells will be used for injection (four wells), observation (five wells) and production (one well) and are representative of general Altmark conditions.

The CO2 will be captured from a power plant and transported by truck. The field is the only one in Germany with the capacity to store the entire output of a large power plant over its lifecycle.

"Our target for 2012 is a reliable statement on the suitability of Altmark for large-scale CO2 sequestration," said Heinz Wendel, Erdgas Erdöl.

platts

2nd Annual European Carbon Capture & Storage

Development, Cost and Feasibility

April 10-11, 2008
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New CCS projects are under way but how can the cost of CCS be reduced to make these projects more attractive? What are the risks and rewards open to new projects - Will CCS be applicable for CDM status? What will be the impact of carbon trading developments on CCS?

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Capture Technology

Alstom and partners launch chilled ammonia capture project

www.power.alstom.com

Alstom, together with its US partners the Electric Power Research Institute (EPRI) and We Energies, has launched a pilot project that uses chilled ammonia to capture CO2 from coal-fueled power plants.

Alstom will operate a 1.7 MW process that captures CO2 from a portion of coal-fired boiler flue gas at We Energies' Pleasant Prairie Power Plant, a 1,224 MW coal-fired generating station.

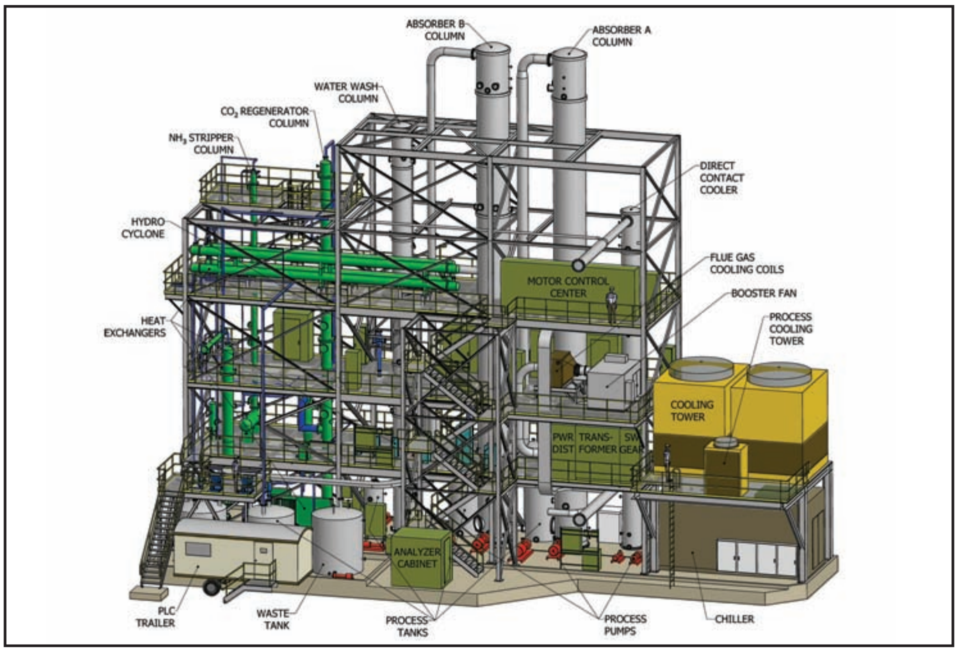
Alstom's process uses chilled ammonia to capture CO2 and isolates it in a concentrated, high-pressure solution. In laboratory testing it has demonstrated the potential to capture more than 90 percent of CO2 at a cost that is less than other currently commercialised carbon capture technologies.

The demonstration project will provide the opportunity to test the process on a larger scale and to evaluate its potential to remove CO2 while reducing the energy used in the process.

EPRI will conduct an engineering and environmental performance and cost analysis during the project, which will last at least one year.

Through EPRI's collaborative research and development program, more than 30 organisations representing a large portion of the coal-fueled utilities in the United States have committed to support this project.

EPRI will conduct an extensive evaluation of the system's performance and support the development of technological and economic analyses associated with applying the carbon capture process on a commercial scale, primarily to larger coal-fueled power plants.



The carbon capture plant under construction at We Energies' Pleasant Prairie plant - Alstom will operate a 1.7 MW process that captures CO2 from a portion of flue gas (see front cover image)

Alstom and Dow Chemical partner on amine scrubbing

www.alstom.com

www.dow.com

Alstom and The Dow Chemical Company (Dow) have made a joint development (JDA) and commercialisation agreement for advanced amine scrubbing technology.

The process is suitable for the removal of CO2 from low pressure flue gases, in particular fossil fuel fired power plants and other major industrial plants.

Under the agreement, Alstom will commercialise and manage the installation of carbon capture solutions using the developed process.

Dow will support Alstom by using its technical capabilities to co-develop an optimised capture system.

The world's largest producer of amines, Dow cites the agreement with Alstom as part of the company's efforts to address energy efficiency and climate change through technology.

Siemens and E.ON to cooperate on developing CCS technology

www.siemens.com/energy

www.eon-energie.com

Siemens and E.ON Energie will kick off a cooperation agreement by developing a solvent with special characteristics which provide the basis for a process to capture CO2 from the flue gases of power plants.

A pilot installation on an E.ON power plant site in Germany will be operational by 2010. Further unspecified developments will follow until 2014, with a mid-term target of developing a large-scale, commercial deployment by 2020.

"One of the most promising CCS technologies is post-combustion CO2 capture," said Tobias Jockenhoevel, head of the innovative power plant concepts division and project manager at Siemens Energy.

"The goals are development of advanced ecologically compatible CO2 solvents, optimization of the capture process and intelligent integration into the power plant.

The real challenge is to attain high power plant efficiency and to avoid negative impact on the environment, for example, by emitting solvent," he said.

"This is exactly the strategy and purpose of the technology initiative 'innovate.on' pursued by E.ON," added Joerg Kruhl, head of the new technologies division at E.ON Energie.

"Besides the mid-term development of beneficial technologies, the fast transfer of promising post-combustion capture processes to real power plant operation is what counts in particular for E.ON today.

This is the necessary next step on the way toward large-scale deployment of CCS in the energy sector. "

The new process and the identification of the optimum parameters for integration into conventional power plants will be verified in 2010 in a small pilot plant under real operating conditions, with particular considerations of the significance for a full-scale plant.

The new process will be developed so as to be feasible not only for new power plants, but it will also be appropriate for retrofitting existing plants, which opens up significant application potentials worldwide.

The project is being funded by the German Federal Ministry of Economics and Technology (BMWi) within the framework of the COORETEC initiative.

FirstEnergy pledges $2M to University of Akron

www.uakron.edu

The money will be used to establish the FirstEnergy Fund for Advanced Energy Research which will be used to create the FirstEnergy Advanced Energy Research Center at the University to support develop-

ment of carbon capture and coal-based fuel cells.

FirstEnergy has also secured a $250,000 contribution to the fund from CONSOL Energy, one of the nation's leading coal producers and a major fuel supplier to the electric power industry in the northeast United States.

The Advanced Energy Research Center will initially focus on development of carbon capture technologies that could be used by fossil-fueled power plants and the development of coal-based fuel cells for commercial use.

The University also plans to expand the center's work over time to include development of new electric grid technologies needed for end-use efficiency, demand response, distributed generation, plug-in hybrid electric vehicles and energy storage, as well as advanced generation technologies such as renewables, clean-coal and other low-or zero-emissions technologies.

FirstEnergy and CONSOL have agreed to provide expertise in technology related to power generation and energy delivery, and to serve on an advisory committee for the Advanced Energy Research Center.

Aker Kvaerner expands CO2 capturing business

www.akercleancarbon.com

Aker Clean Carbon plant

Aker Kvaerner has transfered its Just Catch technology for CO2 capture to the company Aker Clean Carbon, which will focus on developing CO2 capture projects.

Aker Kvaerner will own 30 percent of the shares in Aker Clean carbon, while Aker ASA will own 70 percent. Aker Kvaerner will also be responsible for supplying engineering and construction for the coming CO2 capturing facilities.

Aker Clean Carbon, in an agreement with the Norwegian government, will complete a first plant at Kårstø on the West Coast of Norway in early 2009.

The new CO2 capturing unit at the gas power plant at Kårstø is likely to become the world's first and largest CO2 capture facility of its kind, according to the company.

The plant will have a capacity to remove 100,000 metric tons of CO2 annually from exhaust gasses. Facility investments are estimated at about NOK 725 million. Operating costs are estimated at NOK 150 million over a three-year period.

It will be connected to both the natural-gas-fired power plant and gas processing facilities at Kårstø, so that continuous CO2 removal can take place, even if the gas-fired power plant is shut down for periods.

In recent years, Aker Kvaerner and Aker have worked on developing new CO2 capture technology.

The main purpose of the new Kårstø plant is the development of construction methods and effective execution models that make carbon sequestration so inexpensive that it becomes cheaper to clean emissions than to pollute.

Parallel to the construction of the first carbon capture plant, Aker Clean Carbon will work closely with the SINTEF research center and the Norwegian Institute of Technology (NTNU) in Trondheim concerning their efforts to develop new and improved aqueous amine solutions.

Aker Clean Carbon is participating actively in the development work, and will also contribute funding to this development project, which has a total budget framework of about NOK 250 million over a eight-year period.

Various aqueous amine solutions function as an absorbent that binds CO2 for removal from exhaust gasses. Such amine scrubbing will be used in the facility.

More effective amine scrubbing solutions can be a factor that helps cut investment and operating costs for CO2 capture facilities installed at industrial sites and electric power generation plants even further.

MHI to license flue gas CO2 recovery technology to GPIC in Bahrain

www.mhi-ir.jp

Mitsubishi Heavy Industries (MHI) has signed a license agreement for CO2 recovery technology with Gulf Petrochemical Industries Company (GPIC), a manufacturer of fertilizers and petrochemicals in Bahrain.

GPIC will use the technology to recover CO2 from flue gas emitted at its existing petrochemical plant and use the captured CO2 to increase urea and methanol production. The CO2 recovery plant is due to be completed by January 2010.

The technology recovers CO2 from flue gas emitted during the methanol production process by absorbing CO2 into the KS-1 proprietary solvent, which MHI jointly developed with Kansai Electric Power Company.

Captured CO2 will be used as feedstock for urea and methanol synthesis processes. The technology can recover approximately 90% of the CO2 in flue gas and up to 450 metric tons of CO2 per day.

Previously MHI delivered a urea fertilizer production plant with 1,700 mtpd (metric tons per day) production capacity to GPIC in 1998. The CO2 recovery system will also be used to increase production of that plant.

MHI's CO2 recovery technology, officially known as the "KM CDR Process" (Kansai-Mitsubishi Carbon Dioxide Recovery Process), was jointly developed with Kansai EP. MHI says it requires considerably lower energy consumption compared with other technology processes.

The first CDR plant, with a recovery capacity of 200 mtpd, was installed at Petronas Fertilizer in Malaysia in 1999.

In addition, MHI has provided technology to Indian Farmers Fertiliser Cooperative Limited (IFFCO) for two 450 mtpd CDR units for its two urea production plants completed at the end of last year.

Last year, MHI also signed an agreement with Ruwais Fertilizer Industries (FERTIL) of the United Arab Emirates to provide CDR technology for urea production enhancement.

UCLA reports on new materials that can selectively capture CO2

www.ucla.edu

Omar M. Yaghi, UCLA's Christopher S. Foote Professor of Chemistry, with some of the ZIF structural models that can selectively capture CO2

UCLA chemists have developed new materials that can selectively capture and trap CO2.

The research is reported in the Feb 15 issue of the journal Science.

The scientists have demonstrated materials that can successfully isolate and capture CO2 and store it like a reservoir, so that no CO2 escapes.

The CO2 is captured using a new class of materials called zeolitic imidazolate frameworks (ZIFs), designed by Omar M. Yaghi, UCLA's Christopher S. Foote Professor of Chemistry and co-author of the Science paper, and his group.

Separation and Capture

These are porous and chemically robust structures, with large surface areas, that can be heated to high temperatures without decomposition and boiled in water or organic solvents for a week and still remain stable.

Rahul Banerjee, a UCLA postdoctoral research scholar in chemistry and Anh Phan, a UCLA graduate student in chemistry, both of whom work in Yaghi's laboratory, synthesized 25 ZIF crystal structures and demonstrated that three of them have high selectivity for capturing CO2 (ZIF-68,ZIF-69, ZIF-70).

"The selectivity of ZIFs to CO2 is unparalleled by any other material," said Yaghi.

Flaps that behave like the chemical equivalent of a revolving door allow certain molecules - in this case CO2 - to pass through and enter the reservoir while blocking larger molecules or molecules of different shapes.

"We can screen and select the one type of molecule we want to capture," Phan said. "The beauty of the chemistry is that we have the freedom to choose what kind of door we want and to control what goes through the door."

"ZIFs in a smokestack would trap carbon dioxide in the pores prior to its delivery to its geologic storage space," said Yaghi.

In ZIFs 68, 69 and 70, Banerjee and Phan emptied the pores, creating an open framework. They then subjected the material to streams of gases - CO2 and carbon monoxide, for example, and another stream of CO2 and nitrogen - and were able to capture only the CO2.

"For each litre of ZIF, you can hold 83 liters of carbon dioxide," Banerjee said.

BASF funded the synthesis of the materials, and the U.S. Department of Energy funded the absorption and separation studies of CO2.

WI Environmental offers clean air solution for smokestacks

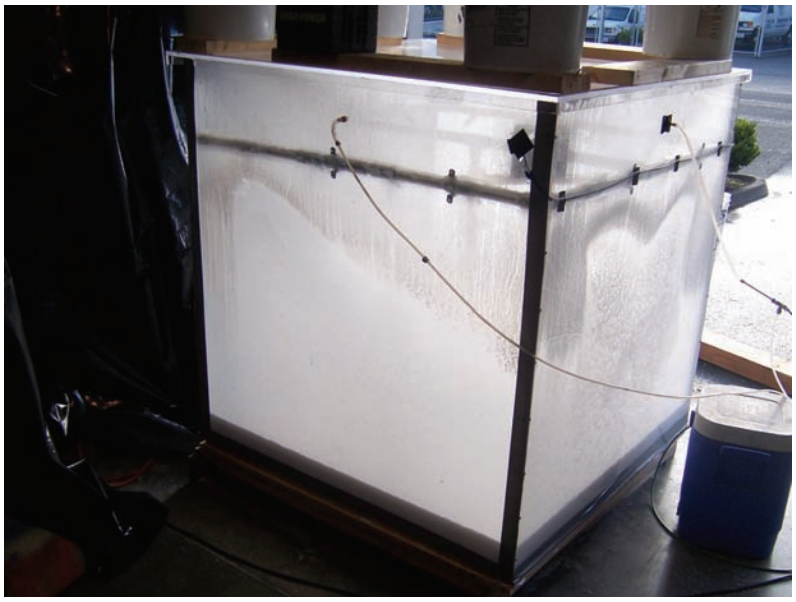
wandellindustries.com

WI Environmental, a leading environmental solutions company, has developed a new technology for removing pollutants from smokestack emissions.

The process can eliminate the release of CO2 as well as heavy metals, small particles, and NOx and SOx contamination into the atmosphere.

It can be applied to emissions from the smokestacks of coal and diesel-fired new or existing power plants and other smokestack and exhaust emitting devices including in the shipping industry.

As an added benefit, the sludge resulting from the process can be used for building materials, and nitrogen compounds from the NOx removal can be extracted from the resulting FGD (Flue Gas Desulfurisation) gypsum for use as fertilizer.



WI Environmental tests its chemical - CO2 was added into the sealed container until the concentration of CO2 ranged from 20% to 24% WI's treatment chemical was in a slurry at the bottom of the tank. The testing company confirmed that CO2 was not leaking from the tank and then a pump was turned on so that the slurry was sprayed into the air within the tank while CO2 readings were taken by an EPA certified technician. Readings showed that over 90% of the CO2 was removed by reacting with the chemical.

WI Environmental has engineered the Clean Smokestack Solution (CSS) by combining two worldwide patented, trademarked, tested and applied technologies it has developed: Wandell Industries' Air System Technology (AST) Solution and WI Environmental's XR-88.

The AST solution

The AST Solution is an air purification technology that does not require the use of solid filters. It applies a patented aqueous filtering system with a combination, as needed, of electrostatic filtering, UV sterilization, germicidal sterilization and additional features.

It can be used to capture and eliminate CO2, particulates, smoke, bacteria and viruses, mold and mildew, pet dander, pollen and grasses, odors, chemical vapors, other allergens, and oil mists.

According to WI, a proprietary water-based solution is used to eliminate contaminants without solution leakage and unwanted humidification, and it does not re-circulate contaminants like some other systems.

It can be scaled from small household portable or fixed systems, to retrofitted systems to new or existing HVAC (Heating, Ventilation and Air Conditioning) systems, to large multi-stage systems for industrial purposes including any exhaust emitting device.

An advantage of the AST Solution, the company says, is that there are no filters to change or clean; it only requires refilling the storage tank with the water system every few weeks.

In most areas, old formula in the tanks will be safe for discharge into a sanitary sewage system, WI says.

The XR-88 component

XR-88 is a WI Environmental propriety product that stabilises and renders benign a wide variety of metals (such as uranium, copper, hexavalent chromium, nickel, zinc, lead, arsenic and many others) that are found in industrial waste, acid mine drainage and nuclear power plant radioactive waste waters.

It has been extensively tested in the United States and China.

Wastes treated with XR-88 have passed tests including the US Environmental Protection Agency Toxicity Characteristic Leaching Procedure (US EPA TCLP) test for leachability of trapped metals in the remaining sludge, thus yielding a non-hazardous waste.

CO2 removal is accomplished at the same time that heavy metals, small particles, NOx and SOx are removed.

A major advantage to removing CO2 with XR-88, WI says, is that it chemically reacts with the CO2 to form a chalk-like material with a high silica content that can be filter pressed and used for beneficial uses.

Carbon sequestering of CO2 is thus obtained by chemically binding the CO2 in a material that will not dissolve in water or release CO2 with time. This eliminates the need to sequester pure CO2.

Before applying the Clean Smokestack Solution to existing and new coal-fired power plants, feasibility, economic and preliminary engineering design analyses will need to be performed to determine the target treatment levels which will then determine the details and cost of applying the technology.

ccj2alt:Layout 1 11/03/2008 08:55 Page 19

Coal-to-liquid technology is a natural partner for CCS

CTL technology could be a major source of investment for CCS, as carbon capture would be necessary for the industry to be commercially viable in an environmentally constrained world.

Lifecycle greenhouse gas emissions from CTLs, which includes all emissions from mining of the coal to delivery to the consumer are nearly twice as high as petroleum alternatives, according to the World Resources Institute.

"Obviously, due to the high carbon/hydrogen ratio of coal compared to other fossil fuels, CO2 emission is identified as a major stake of CTL," said Serge Perineau, Chairman of World CTL 2008.

"Clearly, the CTL industry has an interest in CCS", Mr Perineau continued.

"Reciprocally, for CCS, CTL is more than a customer. CTL is a partner serving CCS, as CO2 is already captured."

"Given the importance of capture costs in CCS economics, the CTL and CCS industries have a mutual interest in their common developments. CTL could be among CCS' launch customers."

CTL technology

There are two main route under which coal can be converted to liquid fuels.

The "Indirect Coal Liquefaction" route

In principle, the molecules contained in coal are "broken" and hydrocarbons are "built" from elementary molecules. Physically, coal is first gasified to a synthetic gas (mainly carbon monoxide and hydrogen), similarly as in IGCC power plants; the synthetic gas (or syngas), after purification, is converted to liquid products either under a catalytic process called "Fisher-Tropsch", also used in Gas-To-Liquids, or through a first conversion to methanol followed by classical methanol petrochemistry;

The "Direct Coal Liquefaction" route

The basis of this route is that coal is a hydrocarbon with less hydrogen than oil. The principle then is to add hydrogen to coal. Coal is first pulverized, then dissolved in a slurry coming out of a recycled process, where hydrogen is added under pressure. So produced liquids are further refined to commercial hydrocarbons.

Filling up on coal - Liquid fuels derived from coal would need to use CCS to be environmentally viable

Progress on CTL

Several nations and companies are already active in CTL.

In South Africa, 30% of the fuels consumed are produced from coal. In the US, the Air Force has started a program of tests using similarly produced fuel for which its entire fleet will have been checked by the end of 2011.

China's leading coal producer (China Shenhua) will start up its first CTL unit this year with a capacity of 20,000 bbl/day.

"Coal conversion to oil can bring strategic advantages to a nation and, at the current price of crude oil, financial profits," said Mr Perineau.

World CTL 2008, the first world conference on the liquefaction of coal devotes a full session to environment and CCS.

Several energy routes will be compared under a well-to-wheels analysis. CCS will be presented as a whole and illustrated by the specific case of the Great Plains (US) / Weyburn (Canada) operation.

The results of R&D investigations on the reduction of CO2 emissions will also be presented.

World CTL 2008 will be held at the Méridien Montparnasse Hotel in Paris (France) from 3 to 4 April 2008.
www.world-CTL2008.com

Transport and storage projects news

Canada energy companies unite for CO2 sequestration project

www.enbridge.com

Enbridge Inc. will lead a group of 19 energy industry participants in the Alberta Saline Aquifer Project (ASAP), the first of its kind in Canada.

ASAP is an industry-supported initiative to study CO2 storage in Canada.

Phase 1 will involve identifying suitable locations for the long term storage of CO2 in deep saline aquifers. It is expected to be completed by the end of 2008.

Phase 2 will involve a pilot project during which sequestration sites will be designed to receive injected CO2. Later phases will involve expanding the project to a large-scale, long-term commercial sequestration operation.

ASAP participants represent a wide range of expertise in the energy sector, including EPCOR Utilities Inc., which builds, owns and operates power plants and electrical transmission and distribution networks in Canada and the U.S.

KGS and Partners plan CO2 storage and EOR projects

www.kyccs.org

The Kentucky Geological Survey at the University of Kentucky plans to research the potential for enhanced oil and gas recovery (EOR) in Kentucky using CO2.

The KGS has held meetings with public and private partners to begin planning for projects to meet the goals of House Bill 1, passed by the special session of the Kentucky General Assembly last summer.

The legislation directed KGS to research the potential for CO2 EOR as well as the state's capacity for permanent storage of CO2 in deep geologic formations.

The bill, which allotted $5 million for the research, also encourages KGS to use the allocation to match federal and private funding. The Survey has set up the Kentucky Consortium for Carbon Storage (KYCCS) as an umbrella organization to oversee these efforts.

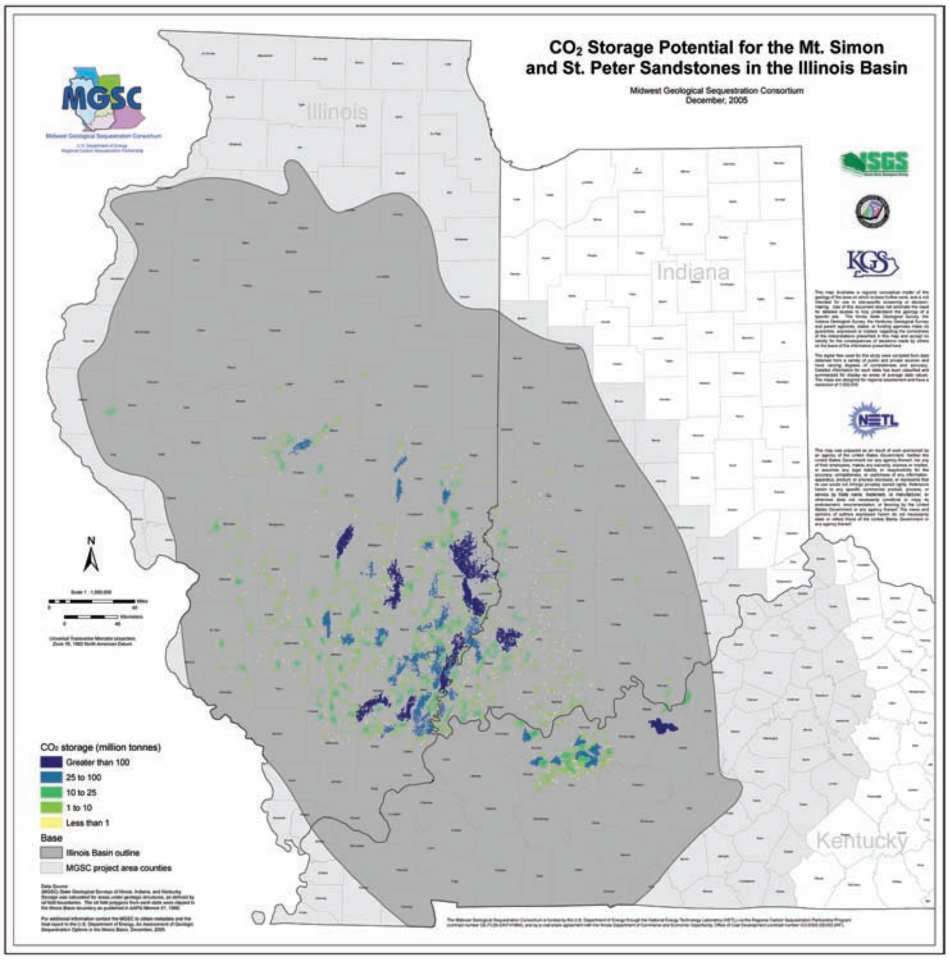
KGS and the Governor's Office of Energy Policy held an initial meeting to invite energy-industry interest in early December, followed by meetings on January 9 - 11 with potential partners in the projects to be funded by the $5 million and other matching funds.

Representatives from energy-related

companies, other UK research centers and other state universities attended the meetings. KGS staff outlined the expectations of HB-1 and current energy research by the Survey.

The discussions involved technical and legal issues related to drilling deep wells for carbon storage research and criteria for selecting existing wells to test the use of CO2 to increase the recovery of natural gas or oil.

They also considered options for adding private donations of funding, in-kind services and well sites to the projects. Project advisory committees were also set up to continue working with the organisational and technical issues related to the projects.



The Midwest Geological Sequestration Consortium will verify the safe storage of over 1 million tonnes of CO2 in the Mt. Simon sandstone

ADM, MGSC and ISGS announce carbon sequestration project

www.admworld.com

Archer Daniels Midland Company (ADM), the Midwest Geological Sequestration Consortium (MGSC) and the Illinois State Geological Survey (ISGS) are working together on a carbon sequestration project in Illinois.

The project, which has received funding from the DOE as its fourth large-scale carbon sequestration project, will involve the capture and storage of carbon dioxide from ADM's ethanol plant in Decatur, Illinois in a nearby saline acquifer.

The project is designed to confirm the ability of the Mount Simon Sandstone, a major regional saline-bearing rock formation, to accept and store 1 million tons of CO2 over a period of three years.

Wells will be drilled into the Mount Simon Sandstone at an expected depth of more than 6,500 feet. The safety and effectiveness of the storage will be monitored by the MGSC through an extensive monitoring, mitigation and verification program.

The $84.3 million project will be funded by $66.7 million from the U.S.Department of Energy over a period of seven years, supplemented by cofunding from ADM and other corporate and state resources.

The project will begin in spring 2008 with the drilling of the injection well. Environmental monitoring will begin in October 2008 to collect a year of background information.

The sequestration and injection of CO2 is scheduled to begin in October 2009 and should conclude in 2012.

Schlumberger manages storage for US MGSC project

www.slb.com
www.isgs.uiuc.edu

Schlumberger will manage the storage for the Midwest Geological Sequestration Consortium, recently awarded a contract by the US DoE for the CCS project in Decatur, Illinois.

The project involves storing around 1 million tons of CO2 from an ethanol plant in a saline formation.

Schlumberger Carbon Services will manage the complete design, construction, and operation of the storage portion of this project, using its oilfield subsurface evaluation and integrated project management solutions.

The Illinois State Geological Survey and Archer Daniels Midland are also major partners.

The CO2 will be captured from an Archer Daniels Midland ethanol plant and injected into the Mount Simon formation, a geological structure spanning the states of Illinois, Kentucky, Indiana, and Ohio, over a period of three years.

The project is designed to test and demonstrate the ability of a geological formation to safely, permanently, and economically store considerable amounts of CO2. It will help to form design and safety regulations for future CCS projects.

Schlumberger Carbon Services was the only oil- and gas-related company selected as a project partner.

Among the Schlumberger services proposed are:

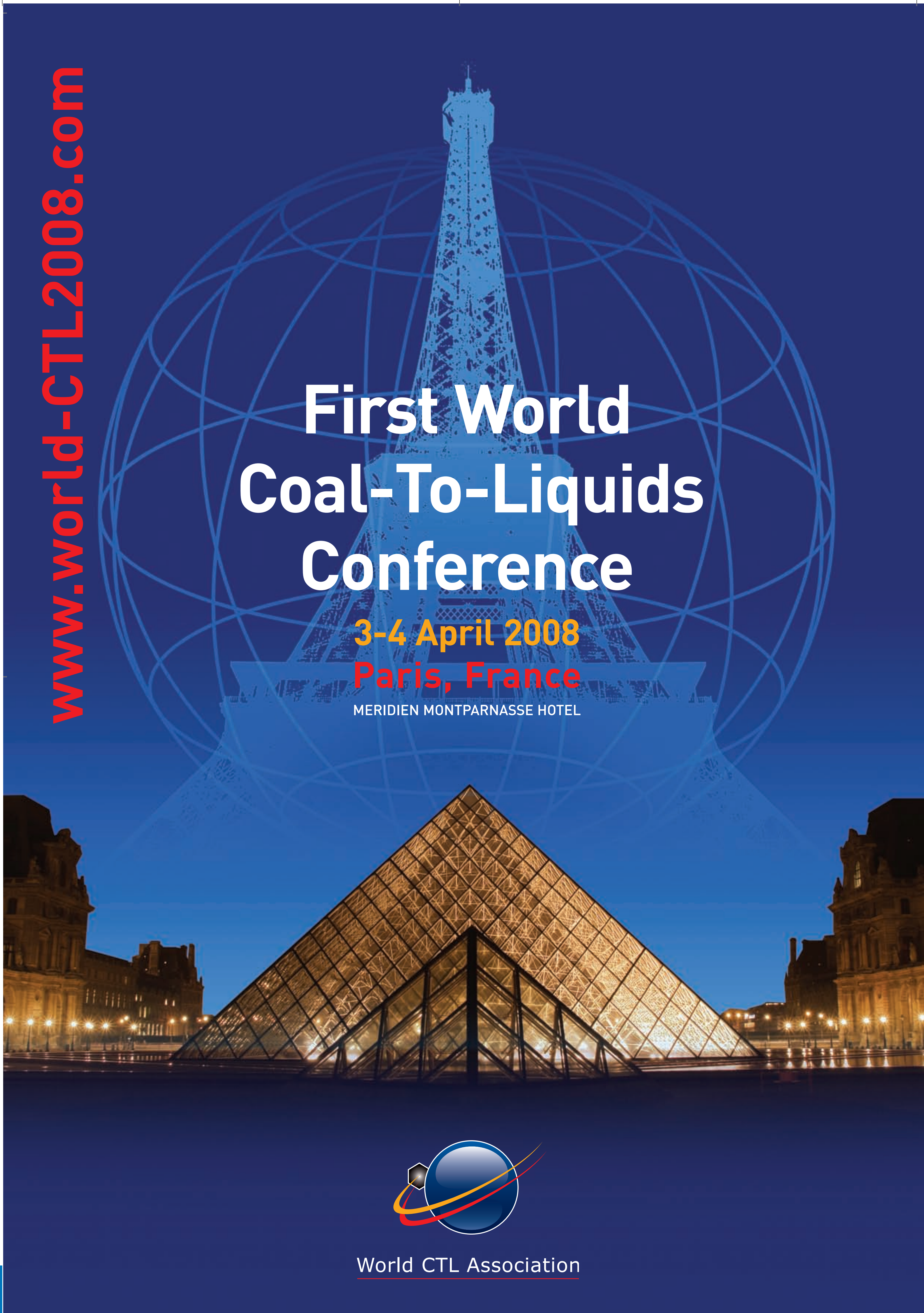
Q technology for simultaneous acquisition of surface and borehole seismic data to be used before, during, and after the injection phases to sharply image the fluid movement in the reservoir

CO2-resistant cements for long-term hydraulic wellbore isolation during the injection phase and after decommissioning of the site.

A "Westbay" modular, multilevel groundwater instrumentation system to allow for more comprehensive CO2 monitoring and protection of drinking waters.

Petrel and ECLIPSE software packages to model and simulate scenarios to understand CO2 injection behavior, migration over time, reservoir integrity, and associated risks.

Data & Consulting Services providing geotechnical support in the evaluation of existing data, strategies for new data acquisition, and ongoing interpretation.



www.world-CTL2008.com
First World
Coal-To-Liquids
Conference
3-4 April 2008
Paris, France
MERIDIEN MONTPARNASSE HOTEL
World CTL Association

Transport and storage research

Carbon study could help reduce harmful emissions

Injecting CO_2 into natural geological traps is the safest and most economic means to store CO_2 captured from industrial sources.

However, it is extremely difficult to predict or asses the long term effects of increasing the CO_2 concentration in the subsurface from short term observations from existing engineered sites.

Research conducted at the University of Manchester and ongoing work at the University of Edinburgh has revealed that storing carbon dioxide beneath the earth may be a safer and longer term method of reducing emissions in the atmosphere than previously thought.

This work has been recently published in the Geochemistry Journal Geochimica et Cosmochimica Acta.

The researchers collected CO_2 samples from five natural gas fields located in the Colorado Plateau and Rocky Mountain regions of the USA and measured their noble gases. Their findings allowed them to 'fingerprint' the Colorado CO_2 for the first time.

Dr Stuart Gilfillan, the researcher running the project said, "We know that oil and gas have been stored safely in oil and gas fields over millions of years, but when it comes to CO_2 our knowledge is limited."

"This is because there are several different ways that CO_2 is produced within the Earth. Unless we know how the stored gas formed, it's difficult to be sure how long it has been underground."

"There are two main sources of CO_2 in the high concentrations found in these gas fields: 'degassing' from magma (lava which doesn't reach the surface), and the breakdown of carbonate rocks (e.g. limestones) through heating."

"The ratio of heavy and light carbon atoms (isotopes 13C and 12C) within the gas can usually tell these two origins apart. However whilst both sources have a distinct range of values, their ranges overlap slightly, so the method doesn't work in this case."

"A better test is to use helium, one of the noble gases, renowned for being unreactive, or inert. This inertness makes it suitable for tracing the origins of underground CO_2.

"The isotope 3He only comes from deep within the Earth, and is transported within magma. So if a lot is mixed into the CO_2, then the gas came from magma. If there is only a small amount, then the CO_2 came from carbonates."

"Our results show that the gas in the fields has been released from molten magma within the Earth's crust. In all of these fields, the last time the magma melted and CO_2 was released was more than eight thousand years ago."

"In three of the fields, it last occurred over a million years ago, and in one it was at least 40 million years ago. This proves that the CO_2 has been stored naturally and safely in the earth for periods between eight thousand years and 40 million years."

"We hope this study will pave the way for selection of similar safe sites for storage of CO_2 from power plants in both the UK and abroad. A suitable storage place for the UK could be in the North Sea, where similar rocks to those in the US gas fields can be found."

Prof. Chris Ballentine and Dr. Greg Holland of the University of Manchester collecting CO_2 samples from Sheep Mountain gas field, Colorado

The paper, 'The noble gas geochemistry of natural CO_2 gas reservoirs from the Colorado Plateau and Rocky Mountain provinces, USA', appears in Geochimica et Cosmochimica Acta, 15 February 2008, Vol 72, No. 4, p1174-1198.

Dr Stuart Gilfillan is a Geochemist who gained his first degree in Earth Science from the University of Glasgow and his PhD in Geology from the School of Earth, Atmosphere & Environmental Science at The University of Manchester in 2006. He is now a Research Fellow at the University of Edinburgh.

Ohio - $1m carbon sequestration study

www.reviewonline.com

$1m of US Federal government funds are being invested into a study into suitable carbon storage sites in Wellsville, Ohio, according to local newspaper The Review of East Liverpool, Ohio.

A proposal is on the table to add carbon sequestration to a proposed new goal gasification plant in Wellsville, with carbon storage starting in 2009.

The announcement was made by Congressman Charlie Wilson and Baard Energy President/CEO John Baardson.

In the proposed plant, 85 per cent of the carbon dioxide from the coal gasification process will be captured and injected into oil reservoirs in North East Ohio, and used in 'enhanced oil recovery'.

The total CO_2 lifecycle reduction, from mining the fuel to burning it in an engine, is anticipated to be over 46 per cent.

The study will also look at engineering issues and modelling the effect of the CO_2.

The funding is part of $1.5m in total to support economic development in Mahoning and Columbiana counties, which is part of $6.3m total federal investment in Ohio's sixth district, which is part of George Bush's $555bn Omnibus Spending bill.

Coolimba and CO2CRC in major CO2 storage study

www.coolimbapower.com.au

Coolimba Power has commissioned the Co-operative Research Centre for Greenhouse Gas Technologies (CO2CRC) to undertake a study to assess the potential for the underground storage of CO_2 in Western Australia's Mid West region.

On behalf of Coolimba, an Aviva Corporation initiative, CO2CRC is investigating sites for the potential sequestration of CO_2 as part of its proposed power station near Eneabba, in the Mid West.

The Coolimba Power Project is a one billion dollar investment based on a 400MW coal fired power station 20km south of Eneabba, designed to be capture ready.

Dominion supports Virginia Tech storage research

www.dom.com

Dominion has donated $500,000 to the Virginia Center for Coal & Energy Research at Virginia Tech to study CO_2 storage.

The Virginia Tech center is planning a full-scale storage demonstration project in Southwest Virginia.

The additional funding will make it possible for the research program to qualify for funding from the U.S. Department of Energy.

Dominion is one of the nation's largest producers of energy in the US and is investing widely in CCS research.

Variable Saturation Model and Application of Carbon Sequestration in Coal-Beds

Guoxiang Liu, Andrei Smirnov, West Virginia University

In this study, a variable saturation model was developed with a engineering application purpose of simulating CO2 transport in the environment of a typical unmineable coal seam with two fluid phases of water and CO2 present. The variable porosity and relative permeability were tracked for pumped CO2 and existing water in coal seams, as well as the concentration of CO2 adsorbed on the coal surface. The results show that the porosity and relative permeability are increasing with the injection of CO2. That is more CO2 can be saved in the coal seam before the pressure exceeds the saturation limit.

The injection of CO2 into a depleted coalbed can have the benefit of enhanced residual coalbed methane (ECBM) production, which adds more value to the carbon dioxide sequestration operation.

There are several pilot projects focusing on this subject in the world. For example, CO2 enhanced coalbed methane recovery was studied at the Fenn Big Valley in Alberta 1997.

Also, researchers in the Netherlands have completed a technical and economic feasibility analysis of using CO2-ECBM and sequestration in Dutch coals.

Scientist in Belgium have begun to consider the possibilities of sequestering CO2 in coals in the Westphalian Campine coal basin.

Potential of deep unmineable coal seams in Japan was evaluated and found a capacity of CO2 sequestration as much as 10 billion tons (5000 billion m3) while obtaining nearly 2540 billion m3 of coalbed methane.

British Columbia has a measured coal resource of over 3 billion tonnes based on an estimate of coal available for surface and underground mining. It is estimated that ECBM could be used to sequester more than 225 Gt of CO2 in coal basins worldwide.

The success of CO2 sequestration depends on the understanding of gas-coal interactions and how they affect the properties of CO2 transport in coal seams.

Prediction concerning long-term stability of the sequestered gas requires experimental data of gas absorption and storage inside a reservoir.

However, studies of the CO2 absorption capacity in coals with in-seam conditions have been rather limited.

In order to ensure the optimal relationship between sequestration costs for a particular coal reservoir and its storage efficiency, detailed simulations of gas-coal interaction need to be performed.

Most importantly simulations need take into account geological properties such as density and rank of coal, porosity and permeability, as well as physical and chemical processes, including fluid flow and thermodynamics varying with CO2 injection.

With CO2 injected into a coalbed, the pressure balance is maintained by water being driven out from coal cleat and CH4 being replaced from the coal surface.

Since adsorption of carbon dioxide onto the coal surface is stronger than CH4, it results in a more rapid displacement of CH4 from the coalbed by CO2.

In view of the importance of these processes on CO2 sequestration, this study focussed on the activity of CO2 and water in a coalbed. Some of the typical coal seam parameters were used to simulate CO2 sequestration with the purpose of analysing long term containment characteristics of the reservoirs.

Theory and Method

In this study, the COMSOL package (www.comsol.com) based on the finite-element method was used to predict CO2 transport in the porous media of a coal-bed. The geophysical module of COMSOL is widely used to solve a wide range of problems related to earth sciences and porous media, such as freezing soil, solute transport, heat transfer, etc..

Governing Equations

The summarised equation system related to the transport process of CO2 in a coal seam consists of the following equations sets.

Momentum equations

- Gas phase:

$$\frac{\phi_g \partial Se_g}{\partial t} + \nabla \cdot \{\frac{-k_{abs} k_{r,g}}{\mu_g} \nabla (p_g + \rho_g g H)\} = S_g \quad (1)$$

- Water phase:

$$\frac{\phi_w \partial Se_w}{\partial t} + \nabla \cdot \{\frac{-k_{abs} k_{r,w}}{\mu_w} \nabla (p_w + \rho_w g H)\} = S_w \quad (2)$$

With three additional equations, capillary pressure $p_c = p_g - p_w$, total saturation ,$Se_g + Se_w = 1$and relationship between effective saturation and capillary pressure $\gamma_{p,w} = -\gamma_{p,g} = \frac{\phi_w \partial Se_g}{\partial p_c}$

the above two phase equations become:

$$\frac{\gamma_{p,w} \partial (p_g - p_w)}{\partial t} + \nabla \cdot \{\frac{-k_{abs} k_{r,w}}{\mu_w} \nabla (p_w + \rho_w g H)\} = S_w \quad (3)$$

$$\frac{-\gamma_{p,w} \partial (p_g - p_w)}{\partial t} + \nabla \cdot \{\frac{-k_{abs} k_{r,g}}{\mu_g} \nabla (p_g + \rho_g g H)\} = S_g \quad (4)$$

With the definition of capillary pressure head $H_c = \frac{p_c}{\rho_{water} g}$ and work of van Genuchten [29], the relationships among the saturation, relative permeability and specific capacity are obtained as follows:

- For the wetting phase:

(i) $H_c > 0$

$$\phi_w = \phi_{r,w} + Se_w(\phi_{s,w} - \phi_{r,w}) \quad (5)$$

$$Se_w = \frac{1}{[1 + |\alpha H_c|^n]^m} \quad (6)$$

$$\gamma_w = \frac{\alpha m}{1-m}(\phi_{s,w} - \phi_{r,w}) Se_w^{\frac{1}{m}} (1 - Se_w^{\frac{1}{m}})^m \quad (7)$$

$$k_{r,w} = Se_w^{L}(1 - (1 - Se_w^{\frac{1}{m}})^m)^2 \quad (8)$$

(ii) $H_c < 0$

$\phi_w = \phi_{s,w}$, $Se_w = 1$, $\gamma_w = 0$, and $k_{r,w} = 1$.

The specific moisture capacity, $\gamma_{p,w}$, is the slope of the curve of q and H_c , which can be calculated as $\gamma_{p,w}(p_w) = \gamma_w \rho_w^{-1} g^{-1}$
.

- For the wetting phase:

$$\phi_g = \phi_{s,w} - \phi_w \quad (9)$$

$$Se_g = 1 - Se_w \quad (10)$$

$$\gamma_g = -\gamma_w \quad (11)$$

$$k_{r,g} = 1 - Se_w^{L}(1 - Se_w^{\frac{1}{m}})^{2m} \quad (12)$$

For boundary conditions, inlet and outlet are given pressure, other sides are normal gradient.

Concentration equation

Considering the case of CO2 sequestration, the transport equation used here is:

$$\frac{\partial(\phi_\beta c_\beta)}{\partial t} + \frac{\partial(\rho_b c_p)}{\partial t} + \nabla \cdot [-\phi_\beta D_L \nabla c_\beta + u_\beta c_\beta] = \sum R_L + \sum R_p + S_c \quad (13)$$

Since $k_p = \frac{\partial c_p}{\partial c_\beta}$, $c_p = k_p \cdot c_\beta$
above equation becomes:

$$[\phi_\beta + \rho_b k_p] \frac{\partial(c_\beta)}{\partial t} + c \frac{\partial(\phi_\beta)}{\partial t} + \nabla \cdot [-\phi_\beta D_L \nabla c_\beta + u_\beta c_\beta] = \phi_\beta \phi_L + \rho_b k_p \phi_p c_\beta + S_c$$

Where $Ø_L$, $Ø_p$ denote the decay rates

for the dissolved and adsorbed solution concentration, respectively.

Except the inlet which is given concentration, other sides are normal gradient for boundary conditions.

Langmuir and Extended Langmuir equations

For the pure adsorption, the Langmuir equation is:

$$V = \frac{vpb}{1+bp} \quad (15)$$

For multi-components system, the extended Langmuir equation can be used as:

$$V = \frac{v_j p y_j b_j}{1+p\sum_{j=1}^{n} y_j b_j} \quad (16)$$

Coupling of the Governing Equations

Darcy's velocity, momentum equation and mass equation need to be coupled together. Two phases, wetting and non-wetting were coupled by capillary pressure which is the pressure head difference of these two phases.

Between momentum equation and concentration equation, the densities of the two phases served as the coupling term because they vary with the time-dependent concentration.

The simulations based on this variable saturation model were validated on cases for pure and binary adsorption. The model was then applied to simulate the behavior of a typical coal-bed of the Appalachian Basin. The results are represented in the following sections.

Table 1
Parameters of coal-bed

Parameter	Value
Coal-bed size, ft	7500X7500
Coal layer thickness, ft	30
Reservoir temperature, ^0F	86
Coal bulk density, kg/m^3	1360
Initial coal-bed pressure, psia	800
Permeability, md	5
Porosity, %	6.9%
Initial water saturation, %	99%
Initial CO_2 saturation, %	1%

Model Validation and Application

The properties and parameters of a typical coal-bed were taken from the literature and are presented in Tab. 1. The validation was done based on the data set of [37].

In all studies of this representation, the injection point was located in the middle of the computational domain and the rate of the pressure driven injection was 1.15 psi/hour, to provide the flux of CO2 into the coal-bed. A basic representation of CO2 injection used in the simulation is shown in Fig. 1 with the injection well at the center.

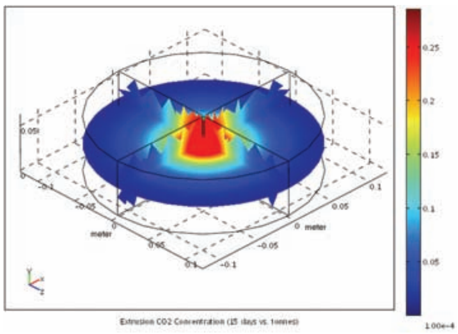


Figure 1

Model Validation

Since four Van Genuchten constants, α, m, n, L, are unknown initially, they must be determined by matching with the history data. In this study three sets of constants were corresponding to three cases given in Table 2.

With comparing of capillary pressure and relatively permeability versus water saturation curve, the results in Figures 2, 3 shows that the case 3 is more matched with literature data than other two. So the Van Genuchten constants picked for following studies are 2.0, 0.77778, 4.0 and 2.0 respectively.

Table 2
Cases of Van Genuchten constants for three tests

Case	α	$m = 1 - 1/n$	n	L
Case 1	1.89	0.77778	4.8	0.5
Case 2	2.5	0.60000	4.5	2.5
Case 3	2.0	0.77778	4.0	2.0

In the validation of the fluid flow model, two aspects were important for a variable saturated model.

Firstly, with the pressure injection, saturation of the gas phase is increasing with the partial pressure going up while water saturation is decreasing with its partial pressure going down as a result of water escaping from the coalbed.

At the same time the capillary pressure increases with the decreased amount of water, which agrees with the literature data as shown in Fig. 2.

On the other hand, the relative permeability of water is decreasing with the decrease of the water situation. Fig. 3 shows that this varying relative permeability of water is in agreement with the literature data as well.

Another validation of the model was conducted for the adsorption data. In this study, two adsorption cases were considered as pure and binary adsorption for CO2, CH4 and N2 with different mole combinations.

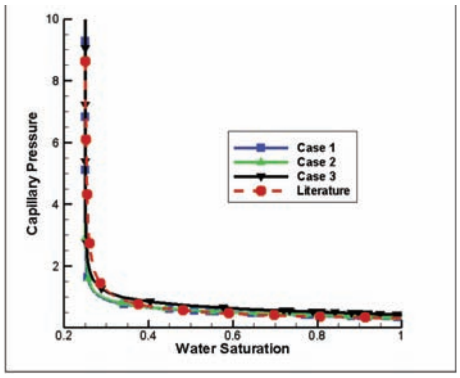


Figure 2

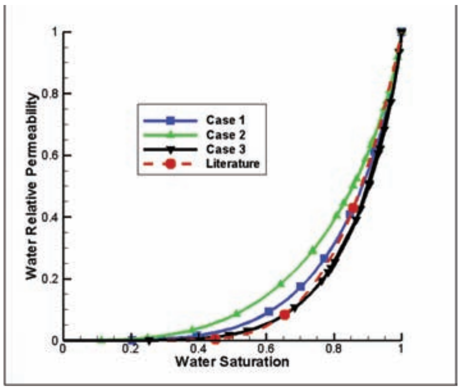


Figure 3

Two binary cases considered combine CH4 -N2 and CO2 -CH4 with the varying fraction of the CH4 and CO2 respectively, increasing from 0 to 1 by step 0.1.

For the pure adsorption case, the literature date comes from experiments and Toth adsorption model computations in [37] The validations for CO2, CH4 and N2 were tested with this literature data and look matched to each other.

Binary adsorption validation of CH4 -N2 and CH4 -CO2 show a reasonably good agreement between the model and literature data. Here, the literature data comes from experiments and IAS adsorption model in [37].

Model Application

With this model, a typical reservoir of an Appalachian basin was simulated. The corresponding properties are listed in Table 3.

Table 3
Parameters of Appalachian Basin

Properties	Value
Basin size, ft	15,000X15,000
Thickness, ft	20
Basin temperature, ^0F	86
Coal bulk density, kg/m^3	1400
Initial basin pressure, psia	700
Absolute permeability, md	20
Coal-bed porosity, %	1%
Initial water saturation, %	99%
Initial CO_2 saturation, %	1%

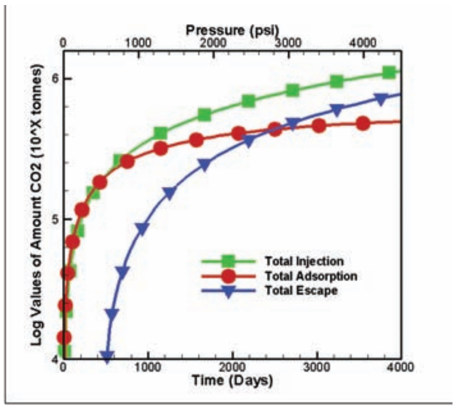


Figure 4

Fluid Flow Profile

The profile of gas phase, such as porosity, saturation, relative permeability and density increases with the pressure while the water phase is being depleted.

Pure Adsorption

For the pure adsorption application, the gases CO2, CH4 and N2 were computed with the injection pressure increasing.

Binary Adsorption

In the case of binary adsorption, with changing CH4 and CO2 fractions in the CH4 -N2 and CO2 -CH4 systems respectively, both the specie fraction and total adsorption are increasing with the fraction of CH4.

The simulations for the case of the Appalachian basin can help to predict trends in the CO2 storage capacity, which is shown in Fig. 4.

The total concentration of CO2 in Appalachian coal-bed can reach about 106 tons after around 2600 days for the modeled reservoir size 15000*15000*20 feet coal seams which is a typical size of an Appalachian reservoir, and the pressure can increase to around 2800 psi.

Fig. 4 shows that the adsorption pressure of the CO2 in coalbed reaches the upper limit as the total concentration of CO2 tends to saturation as shown on the curve of the total CO2 adsorption.

The amount of escaped gas becomes considerable after about 5 years of operation, which will set a limit for the duration of injection in this particular case.

A crossing point between the injection and the adsorption lines can be considered as the limit on the CO2 injection, when the reservoir becomes fully saturated.

The actual limit can be even shorter depending on the high pressure effects, such as fractures, coal and CO2 phase transitions, etc, which may be caused by prolonged injectinon. The investigation of these effects was outside of the scope of this study.

As can be seen from the above results the simulations for the Appalachian Basin show a good agreement with the validation cases. The prediction of the total concentration of the CO2 in Appalachian coalbed was computed with the increasing time and partial pressure of CO2 during a specific period of time.

The results show that the adsorption capacity of coalbed also depends on the partial pressure of CO2. This is due to the fact that the CO2 concentration tends to reach the equilibrium state when the pressure exceeds 2800 psia.

It is known that the increase of the partial pressure of CO2 over this saturation pressure results in CO2 seepage. For the case of Appalachian basin, the injected CO2 was absorbed before the maximum pressure was reached while a significant CO2 escape resulted for pressures above the saturation pressure.

In other words, CO2 adsorption can not increase appreciably under pressures higher than the critical equilibrium pressure, which leads to CO2 escape and/or swelling of the coalbed.

If the upper layer acts as an effective seal, the above situation can eventually cause its fracture and CO2 release to the surface. The investigation of structural and phase transition effects is planned as a continuation of this work.

Conclusions and Future Work

Computational fluid mechanical modeling for simulating CO2 sequestration in geological formations can provide valuable long-term forecasts of capacity, durability and containment characteristics of reservoirs with different properties and operation conditions such as pressure, saturation etc.

Especially, with the lack of accurate data on CO2 injection, the simulation can help to investigate the feasibility of sequestration of CO2 in a reservoir by designing and playing different scenarios as well as accounting of statistical uncertainties, and analysing extreme and high risk cases based on the suitable error estimates and efficient modelling techniques.

As shown in the validation study, the variable saturation model used in this study for predicting CO2 sequestration can trace the saturation variability correctly between wetting and no-wetting phases under CO2 injection.

Using this variable saturation conditions, the relative permeability and partial pressures of two phases was computed, which represents the key capability in simulating CO2 absorption on the surface of coal.

Moreover, the saturation state is also an important indicator in the process of the CO2 sequestration since the adsorption equilibrium relies on the saturation state of the phases.

As Fig. 4 shows, the CO2 concentration is primarily affected by the saturation. Thus, the variable saturated model is a useful tool in the study of CO2 sequestration, which will be extended in the continuation of this study even for saturation-dependent engineering application problems.

The results of simulations of CO2 injection into coal seam provide for a given injection rate a reasonable estimate for the optimal duration of injection and can determine the limits on reservoir capacity.

In particular, for the reservoir model based on Appalachian coal basin parameters the simulations predict the the appropriate injection times for a single injection operation of about 3-5 years based on a saturation limit, which is in a reasonable agreement with related studies on CO2 sequestration [45,46,47].

A more comprehensive approach would include structural and phase transition effects, which will help in the risk analysis of reservoir integrity, and improve long term forecasting for CO2 sequestration, which is the subject of the ongoing work.

References

[29] M. van Genuchten, A closed-form equation for predicting the hydraulic of conductivity of unsaturated soils, Soil Sci. Soc. Am. J. 44 (1980) 892-898.

[37] J. Manik, Composition modeling of enhanced coalbed methane recovery, P.hd. dissertation, Department of Energy and Geo-Enviroment Engineering, The Pennsylvania State University (1999).

[45] G. S. Bromhal, W. N. Sams, S. A. Jikich, T. Ertekin, D. H. Smith, Assessing economics for sequestration co2 in coal seams with horizontal wells, in: 3rd Annual Sequestraion Conference, Alexandria, VA, 2004, pp. 142-151.

[46] D. McVay, W. Ayers, J. Jensen, Co2 sequestration potential of texas low-rank coals (quarterly report, july to september, 2005), Tech. rep., Texas A &M University, TX, USA (2005).

[47] T. Sato, S. P. White, Z. Xue, Numerical modeling of co2 injection test at nagaoka test site in nigata, japan, in: Proceedings, TOUGH2 Symposium 2006, Lawrence Berkeley National Laboratory, Berkeley, California, 2006, pp. 278-

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