EXPERT WORKSHOP ON FINANCING CARBON CAPTURE AND STORAGE: BARRIERS AND SOLUTIONS

Technical Study

Report Number: 2007/9

Date: July 2007

INTERNATIONAL ENERGY AGENCY

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The report should be cited in literature as follows:

IEA Greenhouse Gas R&D Programme (IEA GHG), "Expert Workshop on Financing Carbon Capture and Storage (CCS): Barriers and Solutions, 2007/9, July and 2007".

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Table of Contents

List of Acronyms

£ – Pound Sterling
A$ – Australian Dollar
AR4 –Fourth Assessment on Climate Change
BAT – Best Available Technology
bn – Billion
CBM – Coal Bed Methane
CCS – Carbon Capture and Storage
CCSA – Carbon Capture and Storage Association
CCT – Clean Coal Technology
CDM – Clean Development Mechanism
CER – Certified Emissions Reduction
CO_2 – Carbon Dioxide
CO2CRC – Cooperative Research Centre for Greenhouse Gas Technologies
CTL – Coal-to-Liquids
DEFRA – Department for Environment, Food and Rural Affairs
DF1 – BP Decarbonized Fuel 1 - Peterhead
DF2 – BP Decarbonized Fuel 2 - Carson
DF3 – BP Decarbonized Fuel 3 - Kwinana
DTI – Department of Trade and Industry
ECBM – Enhanced Coal Bed Methane
ECN – Environmental Change Network
ECX – European Climate Exchange
EIL – Environmental Impairment Liability
EOR – Enhanced Oil Recovery
ETIS – Victorian Energy Technology & Innovation Strategy
ETS – Emissions Trading Scheme
EU – European Union
EUA – EU Emissions Allowance
GHG – Greenhouse Gas
GMO – Genetically Modified Organisms
IDGCC – Integrated Drying Gasification Combined Cycle
IEA CCC – International Energy Agency Clean Coal Centre
IEA GHG – International Energy Agency Greenhouse Gas R&D Programme
IGCC – Integrated Gasification Combined Cycle
IPCC – Intergovernmental Panel on Climate Change
JI – Joint Implementation
kW - Kilowatt
kWh – Kilowatt Hour
LETDF – Low Emissions Technology Development Fund
MMV – Monitoring, Measuring and Verification
MS – European Union Member State
Mt – Megatonne
MW - Megawatt
MWh – Megawatt Hour

NAP – EU National Allocation Plan
OBPP – CO2CRC Otway basin Pilot Project
OSPAR – Commission for the Protection of the Marine Environment of the North-East Atlantic
FGD – Flue Gas Desulphurization
p – Pence
UNFCCC – United Nations Framework Convention on Climate Change
US$ – US Dollar
WCI – World Coal Institute
WEO – World Economic Outlook
WG – Working Group
WWF – World Wildlife Fund

Executive Summary

The expert meeting provided an opportunity for discussion on the issues that are restricting the development of carbon capture and storage (CCS) from a financial perspective. The meeting also enabled a discussion of the options to overcome these issues as well as ways to facilitate and encourage more CCS projects. However, there are still a number or unresolved issues and potential difficulties in the use of CCS, such as creating a viable policy and regulatory framework.

Many of the speakers thought that although issues surrounding CCS can be resolved and it is now a financially viable option, it will require additional financial measures, beyond the EU ETS and Kyoto Protocol, to accelerate the use of CCS projects.

The conference discussion provided the following points of note:

- Even with a price for carbon credits generated through CCS other financial incentives are needed to make CCS projects viable.
- CCS is not supported by a policy framework except in Norway and Holland.
- There is a perception that climate change and energy security supply issues will be drivers in the development and commercialization of CCS.
- More research is needed into the whole CCS value chain and to identify viable responses to deal with liability issues as well as undertaking projects using different technologies.
- If the required rapid large scale commercial deployment of CCS is going to happen, then the installation of significant GW capacity of CCS is needed as building demonstration plants alone is unlikely to bring costs down quickly enough.
- The financial sector is interested in CCS but needs to have more information on CCS and also the mechanisms available for financing the projects and what rate of return each generates.
- Liability is seen as an enormous issue which insurance companies do have several models for however there is no actual template available and there needs more work to be done on quantifying the actual liability in dollar terms to allow insurance companies a better means of assessing what underwriting is needed.

It was proposed that this event should be followed up by a second exploratory meeting in New York. This venue was proposed as New York, like London, is a hub for the financial community. The general consensus from the attendees was that this is a good idea and should be organized for sometime in 2008.

1.0 Introduction

The CCS Expert Meeting on Finance took place over two days in London. The Meeting was by invitation only and limited to 80 people that included representatives from Governments, industry, the financial sector academia and research organizations.

The main purpose of the conference was to provide a clearer picture of the options available to finance CCS projects and to increase the involvement of experts from the financial sector and to discuss financial instruments with industry and Government representatives. The ultimate outcome of this work will be to identify, encourage and develop world-wide collaboration and practical development of financial mechanisms to accelerate the progression of CCS projects from R&D to commercial reality.

The objectives of the meeting were to explore the options of:

- Identifying key drivers for financing CCS projects by the financial sector
- Contributing to building financial mechanisms for demonstration CCS projects
- Gaining access to financial information relevant for industry and Government investors in CCS projects
- Financing and business planning for CCS demonstration plants
- Developing options for consortium arrangements for CCS demonstration plants
- Use of futures, derivatives and insurance markets to reduce financial risks of CCS demonstration plants
- Determining whether to establish an International Network for Carbon Capture and Storage Financial Instruments to encourage and develop world-wide collaboration and practical development of financial instruments to accelerate the use of CCS projects from R&D to commercial reality.

The IEA Clean Coal Centre (IEA CCC) and the IEA Greenhouse Gas R&D Programme (IEA GHG) with their global links are both in the unique position to facilitate co-operation between leading research groups on greenhouse gas (GHG) mitigation. IEA GHG R&D already has experience in coordinating a number of international research networks. The proposed new network would bring together existing expertise and experience of organisations at the forefront of research, development and demonstration into GHG mitigation technologies as well as financial institutions which to date have not been greatly involved in the development and implementation of CCS projects.

The IEA GHG R&D Programme have held several technical workshops with members and invited experts to discuss technical, scientific and other issues surrounding the implementation of carbon capture and storage projects. In 2006 two workshops were held to discuss CDM methodologies for CCS projects. The objectives of the workshops were to establish co-operation between parties interested in carrying out Carbon Capture and Storage (CCS) projects under the Clean Development Mechanism (CDM). The main

aim was to develop methodologies for CCS so that they are widely useable and do not introduce conflicts.

The objectives of this report are:

1. To pass on information about the CCS Expert Meeting on Finance;
2. Give an overview of each of the presentations
3. To outline the conclusions and recommendations of the meeting

2.0 Session on the Status of CCS: Welcome and Introduction by Managing Director of the IEA CCC and IEA GHG R&D Programme

John Topper the Managing Director of the Operating Agent for both the IEA CCC and IEA GHG R&D Programme welcomed participants and outlined the objectives of the meeting before introducing Preston Chiaro the Chairman for the meeting.

2.1 Opening Address by Preston Chiaro, Chairman of the World Coal Institute and Chief Executive of Rio Tinto: Energy.

Preston Chiaro the Chairman of the meeting gave an opening address outlining the issues surrounding CCS including the growing contribution of CO_2 emissions from power stations as well as giving an overview of what companies were doing internationally in relation to CCS projects. His presentation outlined the purpose of the meeting including what the major drivers for financing CCS are, what makes the financing CCS projects unique, are their options for consortiums of CCS projects and should we establish a network on financing CCS projects.

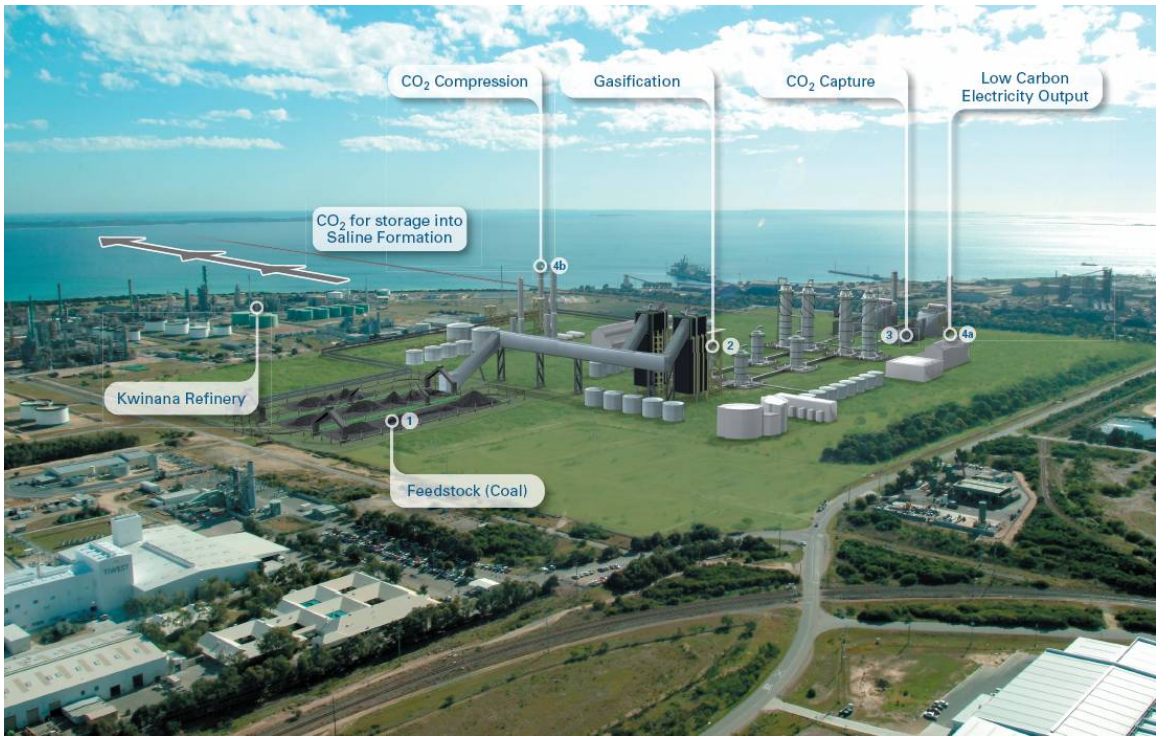
He also outlined the drivers for energy demand as described in the IEA WEO 2006 reference scenario which puts average energy growth at 1.6% for primary energy demand up to 2030 with coal remaining the second largest energy source in 2030. There are approximately 150 years of coal left with usage rates increasing. Between 1970 and 2004 GHG emissions have increased by 70% with CO_2 being the largest and fastest growing contributor. By 2030 there is a projected increase in CO_2 emissions of 14 gigatonnes (annually?) with new power stations providing half of the projected increase. China is estimated to contribute 39% of the increase.

He stressed the importance in recognising that power stations are built to last for many decades which will mean carbon lock-in. It is important to deploy CCS technology as quickly as possible if we are going to have a serious attempt at mitigating GHG emissions. Looking at deploying CCT and CCS prior to 2030 offers a huge opportunity to mitigate CO_2 emissions.

Mr Chiaro briefly outlined the Hydrogen Energy 50-50 joint venture between Rio Tinto and BP. DF1 and DF2 will be included in this venture, however, DF1 (Peterhead) has had to be cancelled. The projects they are investigating include DF2: Carson Hydrogen Power Project which will use petroleum coke as the feedstock, DF3 which has been announced is the Kwinana Hydrogen Power Project using coal as the feedstock and

sequestering the CO_2 emissions offshore in a saline aquifer. The size of the challenge is massive, if we consider that a 1000MW utility would produce 22, 500 tonnes of CO_2 per day to sequester and to scale this up on an international level will be a huge challenge.

Proposed Kwinana Hydrogen Power Project



Source: Mr Preston Chiaro, Rio Tinto & World Coal Institute, *Carbon Capture and Storage Projects and Financing*, London, May 31, 2007

How much will CCS cost is a difficult question to answer. The IEA WEO 2006 reference scenario puts the required cumulative investment in energy up to 2030 at 20 trillion dollars. In the electricity sector 11.3 trillion is required. Interestingly to note these numbers do not include CCS. He concluded that action needs to be taken now to prevent dangerous climate change, with Governments needing to take the lead. One of the most crucial government inputs will be to set up a policy framework that will allow all technology options to compete including CCS. CCS will be a key technology and it's not going to be easy or cheap to achieve rapid deployment.

2.2 The Role of CCS as a Mitigation Option within the IPCC Fourth Assessment on Climate Change Report

Leo Meyer, Head of the Technical Support Unit for the Intergovernmental Panel on Climate Change (IPCC) WG III: Mitigation, gave a presentation on the latest findings from WG III in regard to CCS. His presentation put forward the major outcomes from the special report on CCS and also the recently finished Fourth Assessment including the WG III contribution. Dr Meyer outlined the key issues the IPCC Special report on CCS addressed including the sources of CO_2 , the different CO_2 capture systems including from energy production and industrial processes

where natural gas, ammonia, or steel are produced. Other issues to consider with CCS are the additional energy requirements for capture and transport which are estimated to be between 10-40% for the same level of output. There are four options to store CO_2: in depleted oil and gas fields, EOR, deep saline formations and use of CO_2 in enhanced coal bed methane. Also mentioned were ocean storage and mineral carbonation however both of which are still in only the research phase.

He outlined the maturity of CCS technology and illustrated how different CCS technologies are at different stages. In terms of costs, it is estimated that electricity prices will rise by between 0.01-0.05 US$/kWh with the addition of CCS, depending on how you express the costs.

Dr Meyer outlined the CCS component and then the possible cost range for each component.

CCS component	Cost range
Capture from a power plant	15 - 75 US$/tCO2 net captured
Capture from gas processing or ammonia production	5 - 55 US$/tCO2 net captured
Capture from other industrial sources	25 - 115 US$/tCO2 net captured
Transportation	1 - 8 US$/tCO2 transported per 250km
Geological storage	0.5 - 8 US$/tCO2 injected
Ocean storage	5 - 30 US$/tCO2 injected
Mineral carbonation	50 - 100 US$/tCO2 net mineralized

Scenario studies indicate an increasing role for CCS in CO_2 mitigation. It is said that the use of CCS could result in cumulative CO_2 mitigation of between 15-55% of total required CO_2 reductions up to 2100 i.e. 220-2200 $GtCO_2$ reduction. This however will require a price of 25-30 US$/$tCO_2$.

IEA 2006 World Energy Outlook sees CCS as a transitional technology peaking at 2050 and declining afterwards with renewables and nuclear growth taking over. IPCC 2005 outlines an expansion towards 2100. The Fourth Assessment on Climate Change (AR4) discusses making power plants CCS-ready if rapid deployment is required.

His final key messages were:

- Potential 15 -55 % of mitigation effort to 2100 , but no silver bullet - portfolio needed to address climate change
- Reduce overall mitigation costs (30%) by increasing flexibility in achieving greenhouse gas emission reductions
- Energy requirements still considerable (10-40 %)
- No substantive deployment unless CO2 market price over 25-30 US$/tonne CO_2 to offset costs

- Risks comparable to current industrial activities, but more experience is needed

2.3 Options for Incentivizing CCS: The EU ETS versus Additional Policy Instruments

Heleen Groenenberg from ECN in the Netherlands outlined the findings of a recent report she completed with ERM and Norton Rose for the EU on the use of CCS within the EU. A key finding was that if the price in the EU ETS for a European emissions allowance (EUA) remains low then the preference will be for low cost abatement options and so ETS unlikely to lead to CCS deployment. If this is the case, other policies will be needed for CCS incentivisation. These include:

- Public financial support (most likely member state (MS) level)
  - Investment support
  - Feed-in subsidies
  - CO2 price guarantee
- Low-carbon portfolio standard with tradable certificates (most likely EU level)
- CCS obligation (EU level)
- (Public-private partnerships)

Investment support is likely at the MS level targeting specific sectors.

Feed-in subsidies have been used to promote renewables and could also apply to CCS. CO_2 price guarantees, where a member states would buy CCS generated EUAs at fixed price, are an option as long as the price is high enough to encourage the deployment of CCS. A low carbon portfolio standard where an operator would have to produce a fixed share of its power from a plant that has CCS enabled is an option and could also be combined with tradable certificates. However, this would create another trading scheme on top of the EU ETS and could be quite complicated. CCS obligation (2020-) would require all new built fossil fuel plant built beyond a certain point to be fitted with CCS. There could be a mandatory requirement to make all power plants capture ready after 2012 and to retrofit all power plants with CCS after 2020.

It is important to recognize that any additional instrument will reduce demand for EUAs so it must be carefully designed with the EU ETS in consideration. This could mean restricting the national allocation plan (NAP) in conjunction with the additional instrument to avoid affecting the existing carbon price. Consideration must also be given to other interactions such as diversion of resources from renewables. This could be avoided by having a set percentage renewables contingent on CCS implementation. Innovation, the electricity market and CCS as a baseload option and also security of supply will be key factors if gas prices spur a shift to coal.

The key conclusions from the report were:

- The EU ETS is a cost-effective incentive for CO_2 reduction, however market failures and low or unstable prices may hinder CCS deployment
- Additional incentives are needed to advance large-scale CCS deployment

- MS policies may tend to divert resources from renewables, place financial risk with national governments and not provide incentives for innovation
- EU-wide structural policies are preferable, possibly complemented by MS policies in the demonstration phase
- Revision of State Aid rules are required and are ongoing
- Interaction of additional instruments with the ETS will require cap adjustment

There are also some remaining questions:

- What is the most efficient way of building CO2-transport infrastructure in the EU?
- Where would an obligation leave EU countries without much CO_2 storage potential?
- How would companies deal with costs of obligation – transfer to consumers, or pay?
- Is it technically possible to have peak-load CCS only?
- Can a CCS-proof renewables policy be designed?

2.4 Session 1: Discussion 1

Brian Count asked if the EU ETS was not working to incentivise CCS why not stop it and replace it with something else. Ms Groenenberg replied that the EU ETS had dual objectives and was successful in other areas.

Paul Zakkour asked for more details of why DF1 was cancelled. Mr Chiaro replied that DF1 was cancelled because of timing with a decision still to be made by the UK Government on which CCS projects would be financed. He also said the DF2 and DF3 still need further finance and other types of support to make these projects feasible.

Mike Gibbins stated that an incentive system should not punish the new entrant as they bring new innovation where as the incumbent installations do not.

Ioannis Galanis from the European Commission asked if the EU's target of emissions reductions of 20% to 30% by 2020 would be sufficient to promote a ETS strong enough to give incentives for implementation of CCS technology. Ms Groenenberg stated that it would help but that it is difficult to answer definitively without further modeling work.

Mark Crowther said if the price of EUAs were higher then a number of new technologies would come into the market including CCS and microgeneration. At the moment the EU ETS EUA price does not drive CCS or any other high cost technologies. Trevor Sikorski answered this question from the floor saying that yes, if the price was higher it would encourage more abatement from many different technologies. He also said that the price is staying around 20 euro as the linking directive allowing CDM and JI credits enables access to cheaper emissions reductions which keeps the EUA price from rising.

Michael McKarney from HSBC asked Mr Chiaro what equity returns are required for investment in CCS. Mr Chiaro responded that this was a difficult question to answer,

equity investors will go where there is a good return but said that they would be looking for a similar return from CCS as they look for from comparable projects.

Leo Meyer said that governments cannot choose technologies but only make policies. If the EU ETS is linked with other regions then it could be more of an incentive and without that system it will be very unlikely that companies will invest in CCS.

Kjell Oren asked Dr Meyer what recommendations for policies were made for CCS by the IPCC. He said that the IPCC does not make policies, however there is no silver bullet but without CCS it would be difficult to achieve stabilization and that the whole portfolio of technologies are needed.

2.5 Results of Recent Innovation Forum on the Clean Carbon Economy Concerning CCS

Malcolm Wilson the Director of Centre for Studies in Energy and Environment at the University of Regina in Canada presented some results of the recent Kananaskis forum in Canada on Commercializing CCS as well as a North American perspective on financing CCS. The purpose of their forum was to bring together leaders from Western Canada and Western US including pipeline companies, utilities, oil companies, finance and insurance, coal mining and some technology suppliers.

The key goal of the forum was how we put together CCS projects and what role Government should play in commercializing those projects. In addition, there was a discussion on how to deal with the risks with CCS along the whole supply chain as well as the timing of building projects. A key point was made about the difficulty of financing a CCS project on EOR when the utility station will be operating for 40 plus years and the EOR would only have a 10 year lifespan.

An outcome was that EOR was defined as a transitional opportunity to learn by doing but not the long term solution with the key to large scale CO_2 reduction being CCS with saline aquifers. Other key major outcome is that this is the era of coal and it will play an increasingly more important role in energy supply in the near future. A challenge will be creating a harmonized regulatory regime although CO_2 is already being transferred across the Canada/USA boarder for use in EOR. It is apparent that each province or state will have different environmental regulations which need to be consistent. Public support has to be on board and politicians will not move forward without that support. Human capacity constraints are an issue there are not enough people in this area to build and operate the required plant.

In North America the drivers will be market forces with the likely development of a cap and trade system perhaps continent wide or a CO_2 tax which has not yet been entirely ruled out. Government does have a role but how much of a role has not been decided, for example will it be command and control or more use of the market. A number of models were discussed including BAT, financial incentives, or the garbage industry model where at each stage their needs to be some profit or return on investment. The Wheat board

approach is also an option: there is a government monopoly where they purchase of all the CO_2 produce and then market it out and sell it themselves as is currently done with Canadian wheat production. The Wheat Board approach would be very helpful in the setting up of a national pipeline infrastructure. Lastly, there is also the trading approach via an emissions trading system.

A result of the forum was that there is still a need to:

- Continue to drive down costs of all stages in the "carbon chain"
- Demonstrate CCS at commercial scale
- Establish performance guarantees
- Compensate early adopters – must have preferential dispatch
- Train people – this is an industry and university activity that must be coordinated
- Regulate issues such as pore space ownership, liability and the insurance rates, what are acceptable monitoring, measurement, verification techniques
- Establish a suitable insurance regime

The Forum also discussed the setting up of a North American Carbon Capture and Storage Association (CCSA) decision as well as a follow up forum in Colorado by the Energy Futures Network. To find out more about the EFN forum you can contact Doug Jones at dougjames@shaw.ca

2.6 The Otway Project in Australia and its current status

Peter Cook the Chief Executive of CO2CRC in Australia gave a detailed presentation on the Otway Project and addressed several issues including; how it is financed, what corporate structure is used, how liability and licensing issues are being addressed, how the project is insured and what are the implications for other Australian CCS Projects

His presentation covered the projects and potential projects in Australia which included:

- ZeroGen
- CSE Oxyfuels
- Fairview (CBM)
- Hazelwood PCC
- HRL IDGCC pre combustion project
- Monash CTL linked with storage
- Otway
- DF3 Kwinana
- Gorgon.

In total the projects are worth in excess of A$5 billion (A$1.2 = US1$) with A$500 million from the Government being used to fund the Low Emission Technology Development Fund. He also outlined the funding of coal in Australia which included:

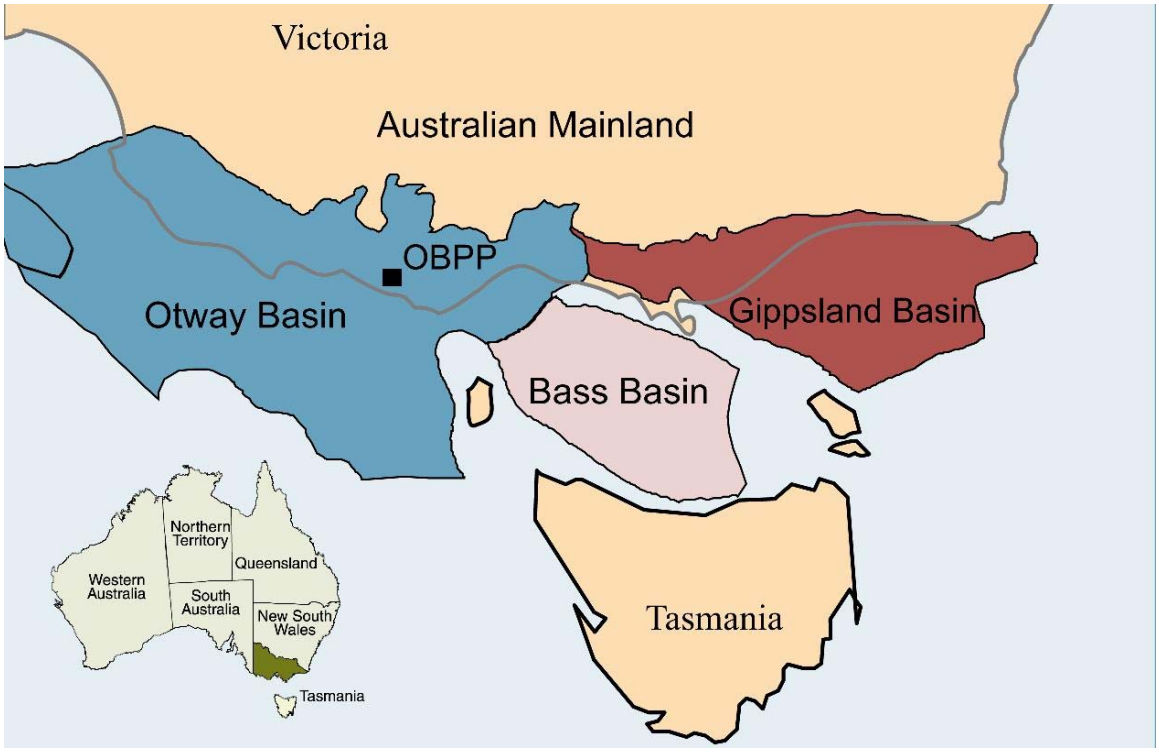
- Victorian Energy Technology & Innovation Strategy (ETIS)
  - A$ 161 million research funds for both brown coal and renewables projects

- Qld Clean Coal Fund
  - A$ 300 million government funding for low emission technologies from black coal, including CCS
- Western Australian Low Emission Energy Development Fund
  - A$36.5 million government funding
  - Separately, DF 3 announced by BP and Rio
- NSW Clean Energy Fund
  - A$20 million government funding, details still being developed

Coal21 Fund - A$1Bn over 10 years through a voluntary levy

A possible reason why there are so many CCS projects in Australia and significant government support is that, given their reluctance to ratify the Kyoto protocol, they are keen to demonstrate alternative, technology based solutions to climate change.

The Otway project involves the extraction of CO_2 (around 80% CO_2, 20% Natural gas) from a natural reservoir and reinjection in a nearby depleted gas field 2100m below the surface. In the first phase of the project the gas mix will be injected without treatment however in the second phase the natural gas component of the gas will be separated and used and only the CO_2 injected. Injection is scheduled to commence in the second half of 2007. During the pre-injection phase the project has encountered many of the issues that a commercial scale project would meet. This includes purchasing the oil tenements to the land in order to gain access to seismic data and physical access to the area, negotiating a pipeline route through region farm land, the review of a number of injection formations, as well as establishing an injection sequence amongst other issues.



Source: Dr. Peter Cook, CO2CRC, *Demonstrating CCS in Australia - The Otway Project*, London, May 31, 2007

The project is 75% government funded and 25% industry funded. Over the course of the project the cost have risen due mainly to increases in steel costs over the period and to a lesser extent, legal costs being far in excess of the plan. Rising costs had to be managed in particular for the government investors as they are not used to budgeting for rising costs. The project operations also had to be delayed due to a shortage in qualified people and equipment needed.

Currently the project has been insured until 10 years after the cessation of the injection. Insurance was difficult given the impossibility of a full quantitative risk assessment however 10 years may be adequate as the greatest risk of problems is considered to be during the injection phase. CO2CRC are still in the process of trying to resolve the long-term liability for the stored CO_2 with the local and federal governments as they are hesitant to take on total liability. This must be resolved before any CO_2 is injected however it is expected to be sorted in the next few months.

The resolution of legal, regulatory and licensing issues is a major deliverable for this project.

2.7 GHG Markets and CCS- Incentive, Impediment, Irrelevant?

Mark Trexler the Director of Ecosecurities Global Consulting Services presented on whether future carbon prices will make CCS a viable mitigation option, and what are the key factors going into answering this question?

CCS is seen as a key option but is it viable? CCS on a pulverized coal plant will cost $30-70/t$CO_2$, on a gasified coal plant will be $15-55/t$CO_2$ and a natural gas plant $40-90/t$CO_2$. There is a disconnect for many companies in the actual cost of CCS and what companies are looking at in their price forecast for the cost of CO_2 of around $8/t. The questions arise; are markets the best option to drive CCS, what will the price be in the future and how certain are those costs? GHG price anticipation is the key issue for any type of corporate strategy and for that matter Government policy. The demand for carbon credits is policy driven and this is also the case for the supply curve of credits as the decisions that influence technology will impact on price. This makes it a difficult commodity to trade and also to make long term investment decisions.

Mr Trexler illustrated by outlining a wide range of prices as outlined below:

- Chicago Climate Exchange: <$5/ton
- Current CER Prices: $5-15
- EU ETS Price Peak in 2005: $40
- Forecasted EU ETS Prices: $10-30
- Voluntary Environmental Branding: $5-10
- Macro-Economic CER Modeling for 2010: $1- 30
- 550 ppm Stabilization Modeling: $75-100

He made the point that there are a lot of factors influencing the price of CO_2 in the current market. For example; Russia has hundreds of million of tonnes of credits that if put into the market at one time, would crash the price of CO_2 to near zero. In terms of GHG markets and modeling market variables, there is no right answer and companies will inevitably come to different decisions. He outlined several scenarios

1. Policy collapses and the price of CO_2 remains under $10 a tonne.
2. Political status quo where the price of CO_2 will stay between $10-30.
3. Strict CO_2 mitigation policy with atmospheric stablisisation and a resultant CO_2 price of $75-100 per tonne.

Mr Trexler put the odds of Scenario 1 to be very low with the odds of Scenario 3 happening to be modest and the likelihood of Scenario 2 being quite high. Given the uncertainties of CCS and high investment costs it's important to understand whether CCS is able to compete with other mitigation technologies.

2.8 Session 1: Discussion 2

Dr Meyer asked Peter Cook asked about the proposal of an international CCS centre and whether the lessons learned at the Otway project storage site are unique to Australia or if they apply to other sites internationally. Dr Cook responded that all sites are different but there are a number of generic elements, eg, depleted oil and gas field, saline aquifer, etc. There is also the flexibility to do work with CO2CRC owning the land.

Jeff Chapman said if we relied on the EU ETS we would be waiting a long time for CCS projects to proceed as there is uncertainty after 2012 of the policy. In other areas of policy

a lot of investment is being made such as in the renewables obligation scheme. Mr Chapman also suggested that revenue could be raised through the UK auctioning 17 million tonnes of EUAs each year over five years which would generate around 2 billion euros that could be invested specifically into CCS. One response was that with renewables you can get more support than for CCS because renewables don't have the link to fossil fuels. A point was also made that CCS should be operated at base load.

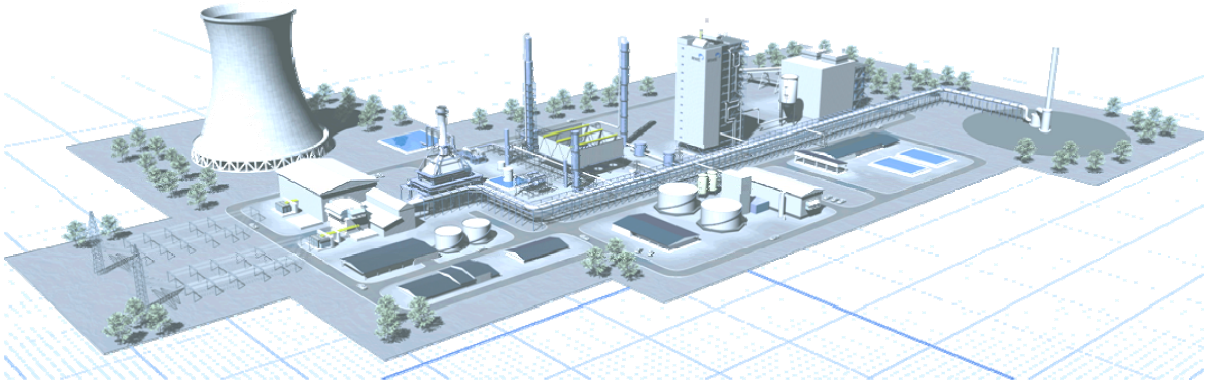
3.0 Afternoon Session: Industrial Perspectives on CCS and Experience

3.1 The Financial Aspects of Implementing an IGCC CCS Project in Germany

Hans-Wilhem Schiffer a Senior Manager at RWE Power AG in Essen outlined the key financial aspects from a utilities perspective in implementing an IGCC CCS project in Germany. RWE is undertaking two projects concerning CCS of which one is a zero-CO_2 450MW coal-fired power plant based on IGCC technology including CO_2 transport and storage with a target date for operation by 2014. In parallel, RWE is also going to develop technology for CO_2 scrubbing for future advanced coal-fired steam power plants and as a retrofit option for modern installations.

- RWE Power will focus on CO_2 scrubbing for lignite
- RWE npower will perform a feasibility study for a Clean Coal 1,000 MW steam power plant in Tilbury and carry out tests for CO_2 scrubbing in hard coal plants.

RWE IGCC CCS 450 MW Coal Fired Plant



Source: Dr. Hans-Wilhelm Schiffer, RWE Power AG, *The Financial Aspects of Implementing an IGCC CCS Project in Germany*, London, May 31, 2007

- Basic technology: IGCC
- El. capacity: 450MW gross, 360 MW net
- Net efficiency: 40%
- CO2 storage: 2.3Mt annually in gas deposits or deep saline formations
- Commissioning: 2014

RWE is prepared to bear the risk and financial burden of the demonstration plant. In order for it to work policymakers need to create a policy framework to ensure that further

plants are built. RWE has undertaken some scenario analyse out to 2030 using various assumptions including both a low and high price of oil and gas as well as CO_2 prices. The assumptions concerning costs and efficiency of new build coal-fired plants are as follows:

Investment costs in € million/MW

	Hard coal	Lignite
without CCS	1.20	1.35
with CCS	1.68	1.75

Efficiency after 2020 in %

	Hard coal	Lignite
without CCS	52	51
with CCS	44	43

An emissions reduction of 90 % was assumed for plants with CCS. The costs of transport and storage are based on an aggregate amount of €14/t CO2. RWE's conclusions are based on the above factors and also the net power output for Germany and in 2020 and 2030 are:

- Coal will remain an important pillar in the energy mix.
- Increase in efficiency and CCS are the decisive levers for securing the future of coal-based electricity generation.
- Technological solutions for CCS can be made available.
- Politicians have to create the legal framework for CO_2 transport and storage.
- RWE is willing to make the necessary investment using their own funds for a large-scale demonstration project.
- CCS can be made available at competitive conditions from 2020 onwards – depending on gas and CO_2 prices.
- Incentives to promote CCS are necessary, in particular appropriate rules as part of the ETS.

3.2 A Norwegian Perspective on Ongoing CCS projects

Michel Myhre-Nielsen is the Manager of CO_2 Value Chains at Statoil New Energy and gave a Norwegian perspective on ongoing CCS Projects including the Mongstad project. In Norway it is highly unlikely that any new gas fired power stations will be built without CCS. The Norwegian Prime Minister recently announced that by 2050 Norway will be climate neutral. Statoil is involved in the following projects; Sleipner, In Salah, Snohvit LNG, Halten CO_2 and Mongstad.

There is also a feasibility study on the Karsto CCS project with an estimated cost for CCS around €80-90/tCO_2. A model of the project can be seen below.

Source: Michel Myhre-Nielsen, Statoil New Energy, *A Norwegian Perspective on Ongoing CCS Projects*, London, May 31, 2007

Norway is unique as it already has a carbon tax of around €40/tCO_2 for offshore operations which CCS enables companies to avoid. In order to facilitate a roll out of more CCS projects Statoil has an incentive toolkit which includes:

- State direct investment
- Tax and depreciation
- Volume allowance EOR oil
- Credit for socio-economic benefits
- Gas-to-electricity pricing mechanisms
- Introduce/increase CO_2 tax

However, projects may still require direct subsidies, technology development or EOR. Statoil believes CCS is technically proven and the potential for CCS is high but it requires public support in order to be fully implemented. A key element to initiate projects is to identify or create the right financial mechanisms.

3.3 The SaskPower Project in Canada

Bob Stobbs is an executive director at SaskPower and in his presentation he outlined the many issues that SaskPower was dealing with in evaluating their proposed CCS project in Canada. In 2006 SaskPower assembled a team to investigate its options for a CCS project and in the end selected oxyfuel technology for a 300MW plant in Saskatchewan. The forecast capacity factor for the final plant will be 85% with lignite fields and a number of possible reservoirs nearby for sequestration. A significant driver for this project will be revenues generated through the use of CO_2 for EOR. A tonne of coal gives 0.8 MWh of electricity plus CO_2 to produce 2 to 10 barrels of oil using EOR,

depending on the reservoir. There has already been a lot of engineering work completed on this project including:

- 70 system design bases
- 32 process diagrams
- 23 Project Standards
- Single line diagrams, layout and arrangement drawings
- Full thermodynamic model (Gate cycle)
- Oxyfuel furnace CFD model (in production)

The work done so far equates to roughly 100,000 engineering man-hours.

The time line for the project if it proceeds will be:

- Air Fired Operation Date
  - March 1, 2012
- Oxyfuel In-Service Date
  - September 1, 2012

The operating costs for the project are:

- $26 million per year O&M cost
  - $18 million fixed cost
  - $3.80 variable cost/MWh
  - Life cycle capital costs also estimated
- Coal Requirements
  - 2.3 Mt per year
- Fuel Pricing
  - Fuel Supply has established coal price
  - Dragline pricing received

The actual cost of building the plant has increased over the year with construction costs increasing dramatically.

3.4 Session 2: Discussion 1

Dr Meyer asked Bob Stobbs if the common belief is that Oxyfuel is between research and demonstration phase and very expensive and whether this assumption is incorrect? Mr Stobbs responded that amine scrubbing and oxyfuels are similar in cost and development but the technology providers would give better guarantees with oxyfuels. The plant can also switch to air firing if there is a problem with the air separation unit or the CCS process.

Simon Wills asked about the risks of building CCS projects on the current EU ETS price and was interested in the slide on the potential price with GHG regulations. Mr Stobbs could not comment on the EU ETS but did comment on the new regulations in Canada that potentially could make building a new plant more economically effective.

Dominic Fitzpatrick asked Michel Myhre-Nielsen about long term liability for stored CO_2 and what the situation is in Norway. Mr Myhre-Nielsen said a decision was still to be made but his personal view was that it should be treated the same way as off shore oil and gas production and after the field is retired the license and all liability is returned to the government.

Michael Kearney from HSBC asked if RWE believed they would recover the cost of capital for their CCS project and how do they communicate it to the financial market. Hans said it is an R&D effort and does not require a return and because RWE is the highest CO_2 emitter in Europe they feel it is necessary to investigate the options to mitigate emissions including CCS. This investment is a hedge against a future rise in CO_2 prices and it is hoped that in the future the experience gainned in this project will be converted into a competitive advantage.

Peter Cook noted that most of the CCS projects in Norway are EOR or offshore oil and gas operations, like Sleipner. For the projects that don't fall into either of these categories they will have to deal with the OSPAR agreement, do Statoil see this impeding future projects. Michel said the Norwegian Government is working on OSPAR and its relation to CCS.

Harry Audus asked about linking sources and sinks together and whether the Norwegian government is considering a distribution network for CO_2. Michel said they are considering establishing an infrastructure for their own projects and possibly they could explore expanding it to other sources. Peter asked if RWE is considering a CO_2 distribution network in Germany as this could reduce prices if you could include other emitters. RWE is trying to find partners for a Co2 pipeline in Germany.

3.5 Building a CCS Project in the UK and Financial Issues

Brian Count the Chairman of Progressive Energy in the United Kingdom discussed the issues his company was facing in building a CCS Project in the UK.

CCS is beginning a pioneering journey with the next five years being critical to development. Over the next decade over 15GW of electrical capacity will need to be built in the UK with there likely to be no excess capacity. The EU ETS is firmly in place but there continuing uncertainty about long term policy and therefore price and price stability. However, in the UK CCS is now firmly on the policy agenda. The UK also has huge potential for CO_2 storage in the North Sea which is estimated to be able to store all the CO_2 emissions from 100GWe of coal plant over the life of the plant. Given the CCS opportunities that are present in the UK, it should be simple to implement CCS in this country in relation to most other places around the world.

Over the next decade in the UK most new plant is likely to be gas CCGT with some new coal fired supercritical plant without CCS. Unless long term CO_2 prices can be confidently assessed in excess of £20 per tonne there will be minimal impact on technology choices.

There are several technical risks that should be resolved once several plants have been built. To make IGCC with CO_2 capture comparable with other new entrant costs current estimates indicate that a CO_2 price in excess of £20 per tonne is required. This level of remuneration covers the capital and operational costs of CO_2 capture, transport and storage. Without such support the economic choice will be plant without CO_2 capture. Additional support will be needed to cover the first of a kind risk on construction and commissioning. In the long term with experience these risks can be eliminated from future decisions.

The model Progressive Energy is considering are normal new entrant risks taken by a utility with the power station financed by a utility on balance sheet. However, the Government needs to underwrite first of a kind risks sequestration and CO_2 disposal price risk.

The key conclusions from Brian Count's presentation were:

- The power station is most likely to be best funded by a utility on balance sheet with sufficient support from Government to cover first of a kind risk and cost of CO_2 capture and storage.
- The power station owner would likely require a contract for the transport of CO_2 by pipeline to, and storage in an offshore storage facility. These costs are covered with the support given to the power station owner to cover the costs of CCS
- If the offshore company is separate it may elect to build in more capacity to provide CO_2 transport and storage to others companies and projects. This additional cost would likely be equity funded. This could be re-financed with additional debt as additional CO_2 storage contracts are finalised.
- The entire structure is dependent on adequate support from Government to cover the risks over and above default new entry investment risks

3.6 Mersey & Dee Basins Carbon Capture Scheme

Mark Crowther outlined a study into the Mersey and Dee basins; a potential site for a collective CCS system given 20 million tonnes of CO_2 is emitted within 20 miles and only 50 miles from 1000Mt of storage capacity around Liverpool. The study analyzed the cost for CCS including separation, transport and storage. The overall cost was £3bn depending on which sites you include in the scheme. Insert slide

Harry Audus recapped on the afternoon presentations stating that there are three commercial CCS projects internationally all sequestering around 1 million tonnes of CO_2 a year. They include Sleipner, Weyburn and In-Salah. Snohvit, which is due to start operation very soon, will make this four. The cost of electricity for a pulverized coal plant excluding FGD would be 4.9p/kWh with FGD 5.4p/kWh and with the cost for CO_2 capture around 7.5p/kWh.

He summarized by saying that there appears to be two "funding gaps" for CCS:

1. The cost of CCS development

2. The additional cost for decarbonized electricity

3.7 Sessions 2: Discussion 2

A question was directed at Brian Count on whether he was saying that companies would build it if governments took the risk and how do you build the transport network. Mr Count said he believes that the government should take on market risk for the CCS part of the project. He also said he sees one source to sink pipeline being built initially with this being added to if other customers are looking to store CO_2. To share a pipeline however you need also to have regulation on the required quality of the CO_2.

Mike Gibbins asked why the Merseyside was chosen for the study as Humberside would seems to be a better location with more concentrated sources of CO_2. Merseyside was chosen as it has a good cross section of emitters and the pipeline required to the storage area is extremely short so would minimize costs. Mr Crowther also agreed that Humberside would also be a good location for a CCS study.

Mike Gibbins also asked why a power plant with CCS needed to be built on balance sheet? Mr Count suggested that a utility who could build a CCS plant on balance sheet would have an advantage over PPA as they would have more flexibility from their portfolio of plant and would generally have better access to capital.

Michael Kearney asked what premium would be needed on top of the capital expenditure? Brian Count said that if all other risks are dealt with then the normal 10-12% project return could be accepted to get the right risk-return balance.

Harry Scheurs explained how, the previous day, the Dutch Government asked companies to submit a tender to sequester 200,000 tonnes of CO_2 per annum over 10 years with a maximum of three projects. It is intended to have contracts by the end of the year with a fund of €60 million available. The CO_2 will all be produced in the Netherlands and must be stored in the Netherlands.

Dr Schiffer said RWE are against auctioning because it would create an incentive for gas fired power stations. They are also against it for security of supply reasons as the gas will come from Russia however he saw some advantages if the revenue from auctioning CO_2 credits is used to fund CCS demonstration projects.

4.0 Session 3: Banks, Insurance and Financing CCS Projects

4.1 Equity and venture capital investments in CCS and the current options

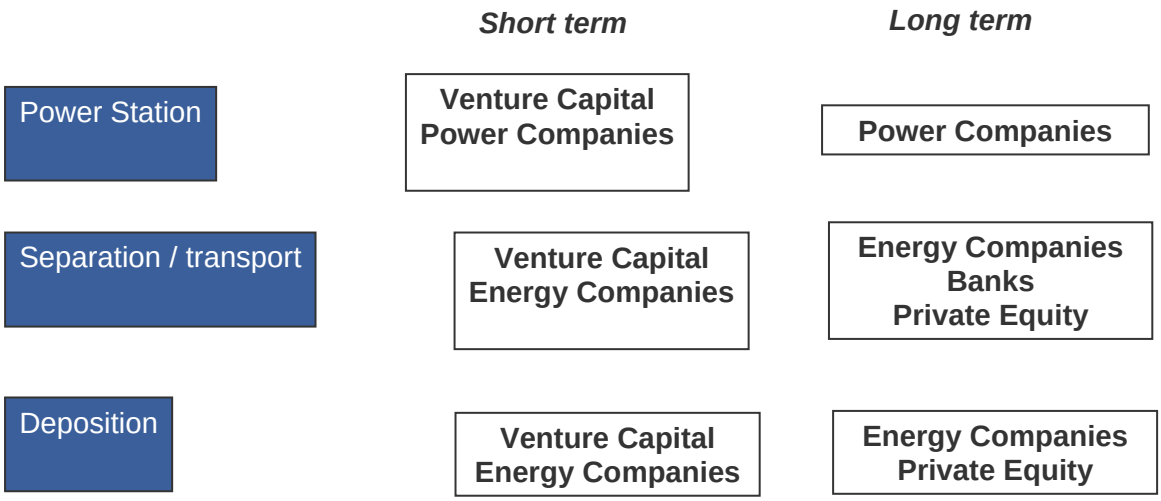
Anthony White the Managing Director of Market Development and Chairman of
Advisory at Climate Change Capital presented on equity and venture capital issues and what options were available for companies looking into CCS. Mr White discussed the carbon price that would make CCS economically viable which is around €20-30 per tonne of CO_2.

He illustrated using hypothetical projects, the revenues you may get from a project including the sale of carbon credits and the risks, including the carbon price over the last few years in the EU ETS. Anthony pointed out a Financial Times article he wrote on May 31st that discussed the need for a floor price for a CO_2. In order to finance a CCS project there are a number of options:

1. You could do it as an integrated project with the power station, separation/transport, and storage all owned by the one company.
2. You could have a value chain using separate companies to manage the power station, separation/transport and storage.

For the second option you need to resolve a number of issues around the price of CO_2, duration, and the credit ratings of the companies involved. It also opens up possible arguments between a power station trying to get rid of the CO_2 and an oil and gas field who may only want a portion and not pay a high price for the CO_2. Also, these projects are long term and you need to recognize and deal with the liability issues that may arise.

The participants who will pay for CCS projects could be from a venture capital organization in the short term but in the long term it would most likely return to the power companies. You also have to recognize that there are different options. Banks and private equity firms may become involved with separation/transport if there is a floor price for the CO_2 as this would make it easier for them to lend money with confidence of a sufficient return. Below is a slide he used to illustrate the role of key players over time.



Source: Anthony White, Climate Change Capital, *Equity and Venture Capital Investment in CCS*, London, May 31, 2007

4.2 Options for Managing Liability in CCS Projects

Matthew Elkington the Vice President of Marsh Risk Consulting Practice outlined the options for managing liability for CCS projects. For an insurance company, the risks associated with a CCS project are difficult to quantify because of their long term nature However, there is information available around EOR which could be used as a precedent.

Insurance companies perceive the risk around the capture and storage as a low, however with storage, the long term risk of a catastrophic event occurring as well as leakage and migration, in particular into drinking water are more of an issue. Also, if there is a leak and the project has carbon credits the question still remains whether these credits have to be repaid. The following questions needed to be answered for an insurance company to insure a CCS project:

- What are the size and likelihood of potential liabilities?
- What is the definition of CO_2?
- Who is liable and best placed to shoulder liability?
    - Operator/Developer/Owner
    - Credit benefactor
    - Government
    - All of the above?
- Who could be an injured party?
    - Property owners
    - Public
- How will MMV and remediation be undertaken? What levels are needed?
- What are the optimal approaches to long-term liability management?
    - Public/Private phasing

Long term liability is the biggest issue and the risks need to be quantified which will enable an insurance company to underwrite the costs. The best option put forward is private to public transfer of liability as it seems the most feasible solution but could take on several structures. Some examples are the US Price-Andersen Act which is a Government backed indemnity for the US nuclear industry. The system operates by an individual company putting aside a US$300 million fund with another fund of US$95.8 million contingency fund. The government has then agreed to cover any additional costs over and above these funds in the case of a major accident.

Another example is the US Superfund which an EPA administered fund created in the 1980s and 90s to clean up abandoned hazardous waste sites.

- The EPA administered fund was created via taxes on oil and chemical corporates to identify and clean up abandoned hazardous waste sites
    - This system can make current and past site owners/operators strictly and joint and severally liable for clean up, as well as any other party involved eg. The person who arranged the CO_2 transport to the storage site.
- Liable parties can use hybrid instruments to transfer risk e.g. stop loss, and self insurance to cap and manage their responsibilities
- CCS cost/benefit
    - US Superfund is flexible and responds to developments in market conditions
    - Allows use of hybrid instruments for optimal risk hedging and provides security (remediation fund) for orphan sites

- If the fund is too small – insufficient collection and poor solvency hedging
- Joint and several positions can be problematic which means if every member does not understand their responsibilities and something goes wrong it can result in a nasty surprise.

The final example is Private/Public Liability Transfer

This theoretical proposal is divided into three phases, the operational phase, the closure phase and the (agreed) post-closure phase.

During operational phase of injection, closure and (agreed) the post-closure period prior to transfer to government, the liable party must provide:

- Self insurance or insolvency proof financial guarantee for expected costs incurred during operational period
- Liability risk transfer for unexpected excess costs during operational phase
- Fund with excess layer for post-injection phase liability or full risk transfer e.g. environmental impairment insurance up to agreed hand over date
- Fund for post closure MMV up to or past agreed handover date

In the post closure stage an escrow fund could be put in place with an indemnity layer to cap the price. Environmental Impairment Liability (EIL) is normally not written for beyond 10 years, however, insurers are looking at extending the period up to 20-30 years. Lastly the Government handover could be based on time or a performance assessment. Private sector are likely to prefer a time based period and this needs to be decided up front with Government to understand the model and be prepared to take on the liability.

- Development of risk transfer will be contingent on many factors, including:
  - Creation of actuarial data and models
  - Ex ante and regulatory confirmation of:
    - Liable parties
    - CO_2 status
    - Cross-border treatment
    - CCS in GHG mechanisms
  - Full capacity estimates may ultimately only be available for certain project methodologies
- CCS cost/benefit
  - Long-term liability is transferred from private sector
  - Allows use of hybrid instruments for optimal risk hedging and caps liability
  - Flexible and responds to developments in market conditions
  - Risk transfer cost could remove economic feasibility of project
  - Negative public perception – government subsidy

In conclusion,

- Long-term nature of CCS liability poses a major challenge to its successful large-scale deployment.
- Multiple uncertainties and a lack of real actuarial data make risk management complex and underwriting risky, though analogous data is available.
- Existing models such as Price-Anderson and Superfund have elements of public/private liability management with potential application in CCS but none are ideal.
- Liability management model will most likely be determined on a case-by-case basis and require robust actuarial and contractual analysis combined with regulatory backing.
- The insurance community is committed to supporting companies and governments manage climate change risk but there needs to be more dialogue.

4.3 Policy Options for Incentivising Low Carbon Power Generation in Different Countries

Adam Whitmore the Director or Economic Consulting at Deloitte outlined the options for encouraging investment in CCS projects. His presentation covered the idea of a fiscal measure which puts a cap on CO_2 prices. However, CCS is likely to require incentives over and above the carbon price for many years and will involve several hundred billion dollars investment internationally. CCS deployment will need the above investment as an additional incentive on top of the CO_2 and will need 100s of Gigawatt installation to bring down costs. Contrary to what is often said, the cost of CCS will not come down with just a few demonstration plants. The cost of €30-40/tCO2, commonly quoted as being what is required for CCS to be economically viable does not include all the costs involved. Also contracting costs have increased and you often find there is appraisal optimism over the prices. If you use FDG as an example of new technology uptake, the cost was thought quite low but rose by a multiple of four until the FDG technology matured and the price did come down to the original estimates.

Ultimately the additional cost for funding CCS will have to come from the customers and taxpayers and finally also from shareholders. He outlined several options for CCS including capital grants, low cost capital, tax breaks, and low carbon obligation but each of these also raises different challenges. Feed in tariffs do work, Germany used feed in tariffs to support wind power and now has a quarter of the worlds onshore wind capacity, however, CCS plants are more complicated as they would have exposure to movements in fossil fuel costs. A guaranteed premium over the market price could be a good alternative for CCS instead of feed-in tariffs. Mr Whitmore's main conclusions were:

- There is wide consensus on the urgent need to reduce CO_2 emissions
- There is a range of policy instruments available that can be tailored to different national circumstances
- Trading schemes provide a powerful mechanism for incentivising reduction provided:
    - wide geographical and sectoral coverage

    - caps are tight, long term and credible
- A well-functioning inter-continental scheme still appears many years off
- Hybrid tax and trading schemes at national level appear to have significant potential to reinforce the incentives from wider reaching emissions trading scheme.
- Other schemes will be necessary to complement CO_2 pricing for new capital intensive technologies such as CCS
- The preferred support mechanisms will depend on policy objectives, technology stage, and market circumstances, with a possible role for:
    - feed in tariffs,
    - contracts guaranteeing a price premium over the market
    - well-designed quantity obligations

4.4 Session 3 Discussion 1:

The chair Milton Catelin opened the floor to questions. Peter Cook asked Matt about his proposed scheme for liability handover and said it was already being implemented in Australia for the Otway Basin pilot project. However, in the Australian experience the Government does not want to accept liability. In addition, if this happens for CCS then this would mean that other industries such as Genetically Modified Organisms (GMO) representatives would want to be given the same option. In the Otway project they currently only have 10 years of insurance. His question is, how do you get Governments to take on the liability? Matt responded that perhaps the World Bank or IFC could take on liability or that any unclaimed insurance money generated from the project could be transferred to the government as a "sweetener" if they accept liability. Harry Audus said that this is what happens with oil and gas fields when a company stops operating and Matt said that basically by default the government takes responsibility.

Mark Trexler said that of the US options we do not want to end up associating CCS with nuclear because of the difference in consequence of accidents and the problems they have with public acceptance. Assuming the US$30 tonne of CO_2 the engineering cost of CCS, what would be the premium required to cover the liability and any additional costs. Also what CO_2 price should companies factor in to their forward planning? The answer was that as it stands it is very hard to factor in any carbon costs beyond 2012.

Cameron Hepburn asked the views of the panel on the US proposal of a CO_2 tax and that his view was that any harmonized tax would be too low due to the inevitable concessions made during the negotiation process. Adam replied that yes it would be difficult to get an internationally harmonized tax and so emissions trading is the better option but both options will needs to be supplemented at a national level and other measures as he outlined in his presentation. Adam also pointed out that taxes don't necessarily change behavior if people are willing to just pay the additional money and also that what every system is decided it must involve China and India.

Hans-Joachim said it's not a good idea to associate nuclear with CCS and rather it's a better idea to compare the risk with CCS with natural gas pipelines and storage. Matt

stressed that the model he presented just as an example but carries with it some things that we can learn from and things we need to be aware of but not to use the model as a template for CCS.

4.5 Incentivizing CCS with Market Based Mechanisms

Jos Cozijnsen substituted for Gerhard Mulder the Vice President of the Commodities Derivatives Market at ABN AMRO and discussed how using market based mechanisms could assist in CCS projects. At the moment CCS is not explicitly allowed in the EU ETS but should be possible. It is expected that in the next phase the carbon price will be reasonably stable between €20-30 per tonne and allowances can now be banked in one phase for use in the next. He expects to see less volatility in the next phase of the EU ETS. There is still however concern that the allocation periods are too short and there is uncertainty around methodologies both of which have resulted in the first phase prices being quite volatile.

The current status of CCS in the EU ETS is mentioned in the UK and Netherlands National Allocation Plans Phase II although it is difficult to test the robustness of their inclusion until a project proceeds. The Government in the Netherlands has given an incentive for storage of CCS and EnergieNed announced, the previous day, that 5 new coal fired power stations will be prepared with CCS in mind as long as there is some government support. He argued that it is important to start CCS now to allow the benefits of CO_2 credits as soon as possible as early reductions would provide a multiplier bonus.

Several utilities have stated that any profits from the current free allocation system are being to invest in further mitigation measures. It also should be recongised that a coal fired plant can trade forward therefore a coal plant can sell future EAUs at the start of a project and can use that money for other options via the interest benefits and loan co-finance. Selling 5 years of EAU futures for a project that will store 3MtCO2/year at a CO_2 price of €23/tCO2 could produce revenue of €345 million upfront. However, whether a bank will pay for allowances after 2012 is a debatable question given the current uncertainty over post Kyoto 2012 measures.

Mr Cozijnsen concluded that:

- A quick solution from environmental markets such as the EU ETS and CDM/JI is unlikely and that the ETS market is currently not too well understood
  - More urgency is needed to turn political support into practical measures
  - A legitimate question is whether markets can play a role at all, and whether Governments should impose a command & control regime to push for CCS and that the problem is partly a power market problem
  - The climate problem is too serious to allow for thousands of new facilities without CCS to come on line
    - A more pragmatic approach is needed
  - The current ongoing research and experimental plants should provide some guidance as to the best way forward

4.6 Possible Regulatory Options for the UK Government to Enable CCS Projects

Jeff Chapman the Chief Executive for the Carbon Capture and Storage Association (CCSA) gave an overview of possible regulatory options for the UK Government to enable CCS projects. Jeff put forward an industrial viewpoint on where CCS is heading and his focus was the UK as an example that could be replicated to other countries.

There are several different business models including:

1. A company builds a power plant, a pipeline and accesses a storage site

2. Several companies that manage and own different stages including:
- PF or IGCC power generator with CCS
- Pipeline operator
- Storage site operator

3. Oxyfuel model:
- Air separation company
- PF power generator with CCS
- Pipeline operator
- Storage site operator

4. Hydrogen plant model:
- Gasifier hydrogen supplier with CCS
- Hydrogen power plant operator
- Pipeline operator
- Storage site operator

Who would regulate a CCS project as there are different areas and stages that DEFRA and DTI have remit over a CCS project. A CCS project is also covered by different regulations at the power station level, pipelines, health and safety, on-shore and off-shore, licensing phases including storage issues and finally long term liabilities. A key issue for industry in the UK is the Government taking responsibility of liability. It is important not to provide perverse incentives such as mandatory CCS after 2020 which could see a rash of companies building non-CCS plant in 2019.

4.7 Session 3: Discussion 2

Tim Dixon said that the CCS has not been decided at the UNFCCC level if it will be treated as a sink or as emissions reductions at the source. The EU ETS proposal that CCS is only an "opt-in" is sending the wrong message and the reason behind this decision is uncertainty over whether different storage sites should have generic guidelines or whether guidelines should be site specific and so this still needs to be addressed. Lastly, the EC is setting up a storage site verification unit for safety. UK would prefer each National government deal with safety issues over storage sites themselves.

Mike Gibbons from Powerfuel asked about Jeff's list of obstacles concerning CCS. His question was that people are working around the existing legislation to change it to fit in CCS and that CCS does not fit this so why not establish specific legislation concerning CCS only? Jeff said at Whitehall there is a sense of urgency to change the existing legislation.

Preston Chiaro asked about the concept of separating CCS from nuclear discussion. He pointed out that other people will make this comparison and there are parallels with nuclear as CCS will lock CO_2 in storage sites for thousands of years so this can't just be ignored. Jeff answered that leaving parallels with nuclear aside there are parallels with mineral extraction and Governments have coped with that issue. Jos said it's wrong to compare with nuclear because if explosion accident involving CO_2 it will not be the same with a nuclear accident and the resulting fallout. Harry said it would be good to put some numbers on the magnitude of the liability of a CCS accident.

Sanjeev Kumar from WWF said would like to get the civil society side to future discussions. He said storage is a critical issue for WWF and that they have some real concerns and would be looking for a guarantee on the viability of storage. WWF favours CCS because of the size of the problem and the need to include developing countries in the solution. He also would like to see demonstration projects outside EU and the key demonstration has to include storage. WWF also does not believe the carbon market is the driver for demonstration projects.

5.0 Conclusions

Preston Chiaro the Chairman thanked the speakers and the IEA CCC and IEA GHG R&D Programme for organizing the meeting. The Chair then stated it was important to recognize that CCS projects are different to what has been done before and thus present different risks. He outlined the scale of the issue as being huge and it was urgent to get solutions underway on an equivalent scale as soon as possible. There is a lack of CCS project history and risk profiles so we need to find new, novel ways to mitigate and manage any new risks that CCS presents. In addition, incentives are essential to get the projects in operation. In terms of options for consortium arrangements for CCS the answer to that is yes companies can work together to make large-scale CCS a reality and several models presented all have elements to assist.

In terms of financial derivatives there are options available today for most parts of the CCS cycle with the exception of storage which needs further investigation.

One of the objectives of the workshop was to decide if we should establish an international network on this topic. John Topper asked the audience about whether to establish a financial network and if they find it useful hearing the information from financial speakers. In addition, did the financial attendees find it interesting hearing technical information, case studies and the current status of CCS.

Mark Kenber from the Climate Group found both days very useful and that a number of the banks and financial members of his organization would be interested. WWF would like to see further financial discussions on this subject. Mark Walters from Morgan Stanley found the technical presentations very interesting. Harry Scheurs from SenterNovem said it would be most welcome to a follow up on the financial issues and also on policy because this is also a key for the progress of CCS. Brian Count said that he would have liked to see more policy presentations and perspectives.

Milton Catelin from the WCI point-of-view they felt it was interesting because of the variety of people involved considering CCS projects as well as financial people presenting on the issues. It would have been good to spend more time on financial aspects as well as on modeling. The use of the models was interesting and further work in this area is needed to assist people's understanding of the issue. The discussion on scale was important and the message is that it isn't incremental change we are talking about, but a revolutionary change that includes reliable renewables, safe nuclear as well as CCS projects. There are also the limitations of existing mechanisms such as the EU ETS to allow the scale discussed and possibly needed for CCS to be deployed. He also said it's important to have NGO involvement and further discussion.

Harry Audus said it would have been good to have more information on where the money can come from. It was clear that we need better information on what is happening with CCS and also the numbers around the potential long-term liability and we need to provide this information to allow investors to have certainty.

He also pointed out that CCS is often seen as competing for funds with other mitigation options.

The Expert meeting highlighted that CCS is still at a very early stage of development.

It is also important to note that while there has been considerable work and interest in CCS, policy and regulatory regimes are also very uncertain and CCS is largely unknown to policy analysts, planners, politicians and this is something that will need to be addressed. In particular, Governments will need to provide financial support for the first CCS projects.

The conference discussion provided the following points of note:

- Even with a price for carbon credits generated through CCS other financial incentives are needed to make CCS projects viable.
- CCS is not supported by a policy framework except in Norway and Holland.
- There is a perception that climate change and energy security supply issues will be drivers in the development and commercialization of CCS.
- More research is needed into the whole CCS value chain and to identify viable responses to deal with liability issues as well as undertaking projects using different technologies.

- If the required rapid large scale commercial deployment of CCS is going to happen, then the installation of significant GW capacity of CCS is needed as building demonstration plants alone is unlikely to bring costs down quickly enough.
- The financial sector is interested in CCS but needs to have more information on CCS and also the mechanisms available for financing the projects and what rate of return each generates.
- Liability is seen as an enormous issue which insurance companies do have several models for however there is no actual template available and there needs more work to be done on quantifying the actual liability in dollar terms to allow insurance companies a better means of assessing what underwriting is needed.

In conclusion, it was proposed that this event should be followed up by a second exploratory meeting in New York as it was also a financial hub. The general consensus from the attendees was that this is a good idea and should be organized for sometime in 2008.