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

Technical Study

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INTERNATIONAL ENERGY AGENCY

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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.

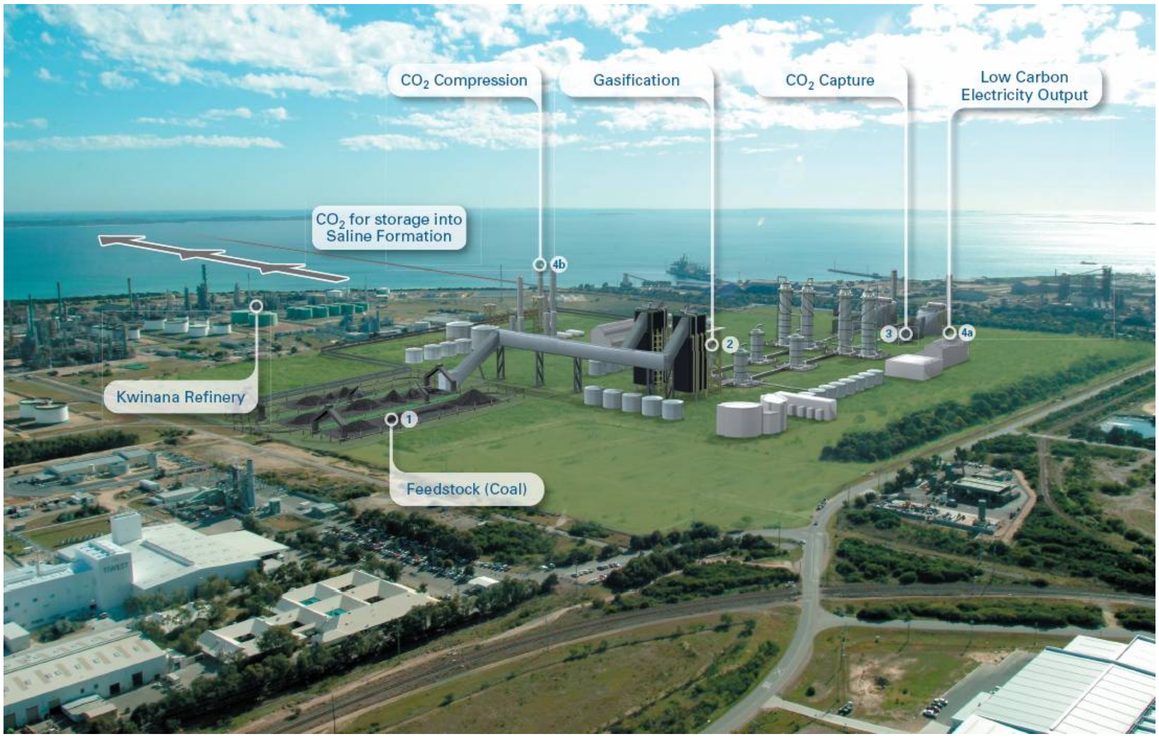
Preston Chiaro the Chairman of the meeting gave an opening address outlining the issues surrounding CCS including the growing contribution of CO_2 emissions from power stations as well as giving an overview of what companies were doing internationally in relation to CCS projects. His presentation outlined 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:

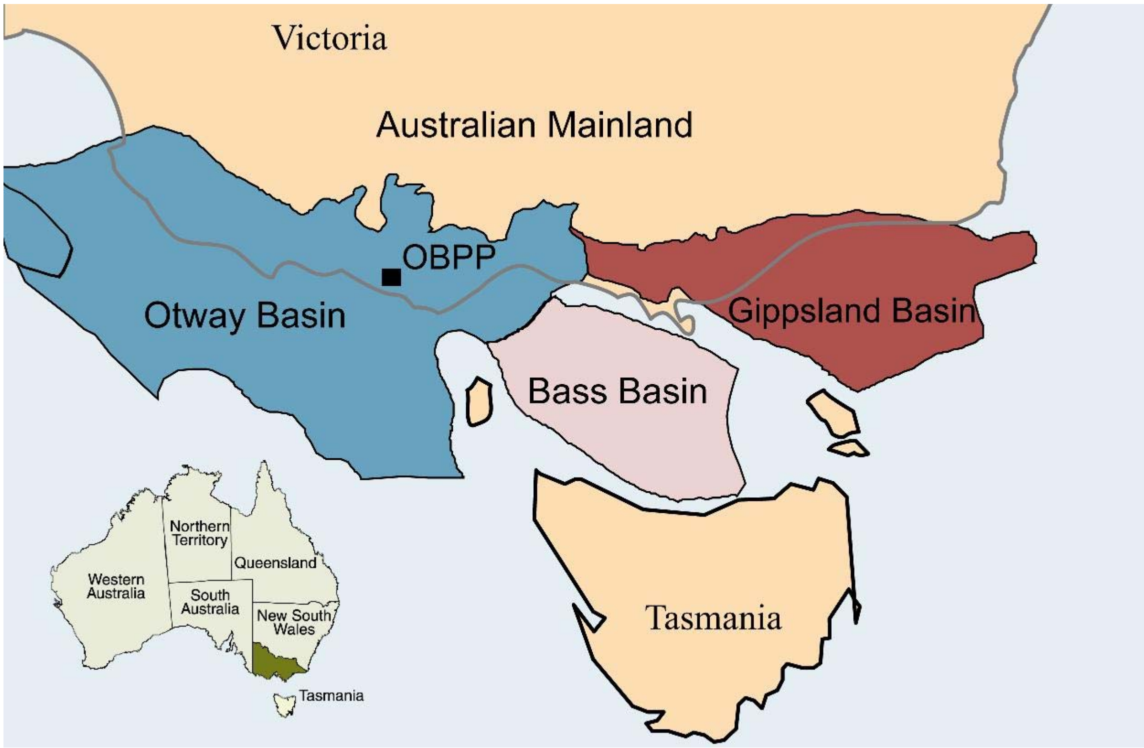
- Victorian Energy Technology & Innovation Strategy (ETIS)
  - A$ 161 million research funds for both brown coal and renewables projects

- 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/tCO_2, on a gasified coal plant will be \$15-55/tCO_2 and a natural gas plant \$40-90/tCO_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.

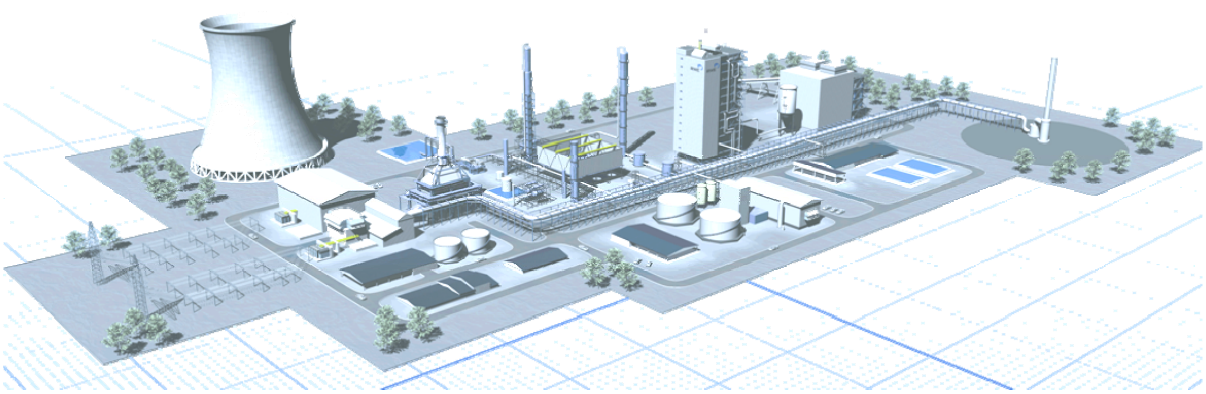
3.0 Afternoon Session: Industrial Perspectives on CCS and Experience

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

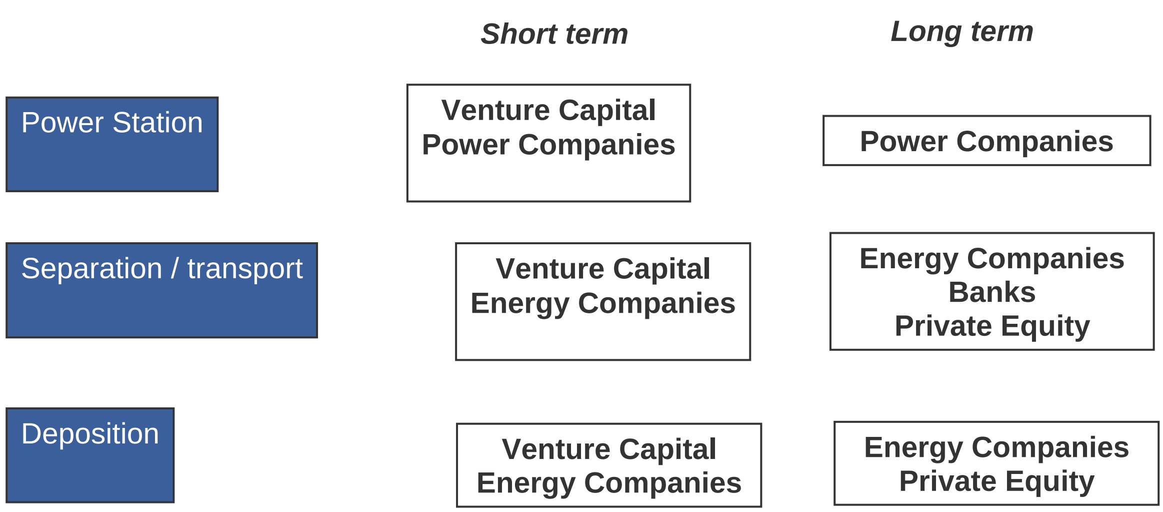
Anthony White the Managing Director of Market Development and Chairman of Advisory at Climate Change Capital presented on equity and venture capital issues and what options were available for companies looking into CCS. Mr White discussed the carbon price that would make CCS economically viable which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

Houses of parliament, London, England

EXPERT MEETING ON FINANCING CARBON CAPTURE AND STORAGE PROJECTS

31st May – 1st June 2007

Rembrandt Hotel, 11 Thurloe Place, London, England

Organised by

IEA Greenhouse Gas R&D Programme
and IEA Clean Coal Centre

Sponsored by

Rio Tinto and World Coal Institute

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World Coal Institute

IEA CLEAN COAL CENTRE

IEA GREENHOUSE GAS R&D PROGRAMME

31st May 2007 Day 1

Session 1: Opening Session: The status of CCS

08.00 Registration Desk opens

09.00 Welcome by John Topper, Managing Director of the Operating Agent for the IEA GHG R&D Programme and IEA Clean Coal Centre

09.05 Opening Address: Preston Chiaro, Chairman of the World Coal Institute and Chief Executive of Energy for Rio Tinto: Issues surrounding CCS including current financial Incentives and government regulations for CCS Projects internationally.

09.30 Leo Meyer, Head of the Technical Support Unit for the Intergovernmental Panel on Climate Change (IPCC) WG III (Mitigation): The Role of CCS as a Mitigation Option within the IPCC Fourth Assessment on Climate Change Report

09.50 Heleen Groenenberg, ECN, The Netherlands: Options for Incentivizing CCS: the ETS vs. Additional Policy Instruments.

10.10 Discussion Group made up of speakers and Chaired by Preston Chiaro

10.30 Morning Tea/Coffee

10.50 Malcolm Wilson, Director of Centre for Studies in Energy and Environment, University of Regina, Canada: Results of Recent Innovation Forum on the Clean Carbon Economy concerning CCS

11.10 Peter Cook, Chief Executive, CO2CRC: : The Otway Project; 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

11.30 Mark Trexler, Director, Ecosecurities: Global Consulting Services: Will future carbon prices make CCS a viable mitigation option, and what are the key factors going into answering this question?

11.50 Panel Discussion by speakers and Chaired by Preston Chiaro

12.15 Lunch sponsored by the World Coal Institute

Session 2: Industrial Perspectives on CCS and Experience

13.30 Hans-Wilhem Schiffer, Senior Manager Energy Economics, RWE Power AG, Essen: The Financial Aspects of Implementing an IGCC CCS Project in Germany

14.00 Michel Myhre-Nielsen, Manager CO2 Value Chains, Statoil New Energy: A Norwegian Perspective on Ongoing CCS Projects including the Mongstad project

14.30 Bob Stobbs, Executive Director, SaskPower: The SaskPower Project

15.00 Panel Discussion by Speakers and Chaired by Harry Audus

15.30 Afternoon Coffee/Tea Break

16.00 Brian Count, Chairman, Progressive Energy united Kingdom: Building a CCS Project in the UK and the financial issues

16.30 Seb Walhain, Fortis, The Netherlands: Financing CCS Projects from A Banks Perspective, betting on long term carbon constraints in the face of short term uncertainty.

17.00 Panel Discussion by Speakers and Chaired by Harry Audus

Close Day 1

19.00 Reception and Dinner Hosted by Rio Tinto

1st June 2007 Day 2

Session 3: Banks, Insurance and financing CCS projects

09.00 Opening of Day Two by Chairman: Milton Catelin, Chief Executive of the World Coal Institute

09.05 Anthony White, Managing Director of Market Development and Chairman of Advisory, Climate Change Capital: Equity and venture capital investment in CCS, what are the current options?

09.25 Matt Elkington, Vice President, Marsh Risk Consulting Practice: Options for managing liability in CCS projects.

09.50 Adam Whitmore, Director, Economic Consulting, Deloitte: Policy options for incentivising low carbon power generation in different jurisdictions

10.20 Panel Discussion made up of speakers and Chaired by Milton Catelin

10.40 Morning Tea/Coffee

11.00 Gerhard Mulder, Vice President Commodities Derivatives Market, ABN AMRO: Incentivizing CCS through market based mechanisms.

11.30 Jeff Chapman, Chief Executive for the Carbon Capture and Storage Association (CCSA): Possible Regulatory Options for the UK Government to Enable CCS Projects

12.00 Discussion, wrap up and next steps led by Chairman: Preston Chiaro

12.30 Lunch sponsored by the World Coal Institute and close of workshop

Workshop on Financing Carbon Capture and Storage Projects

31 May – 1 June

Rembrandt Hotel, London

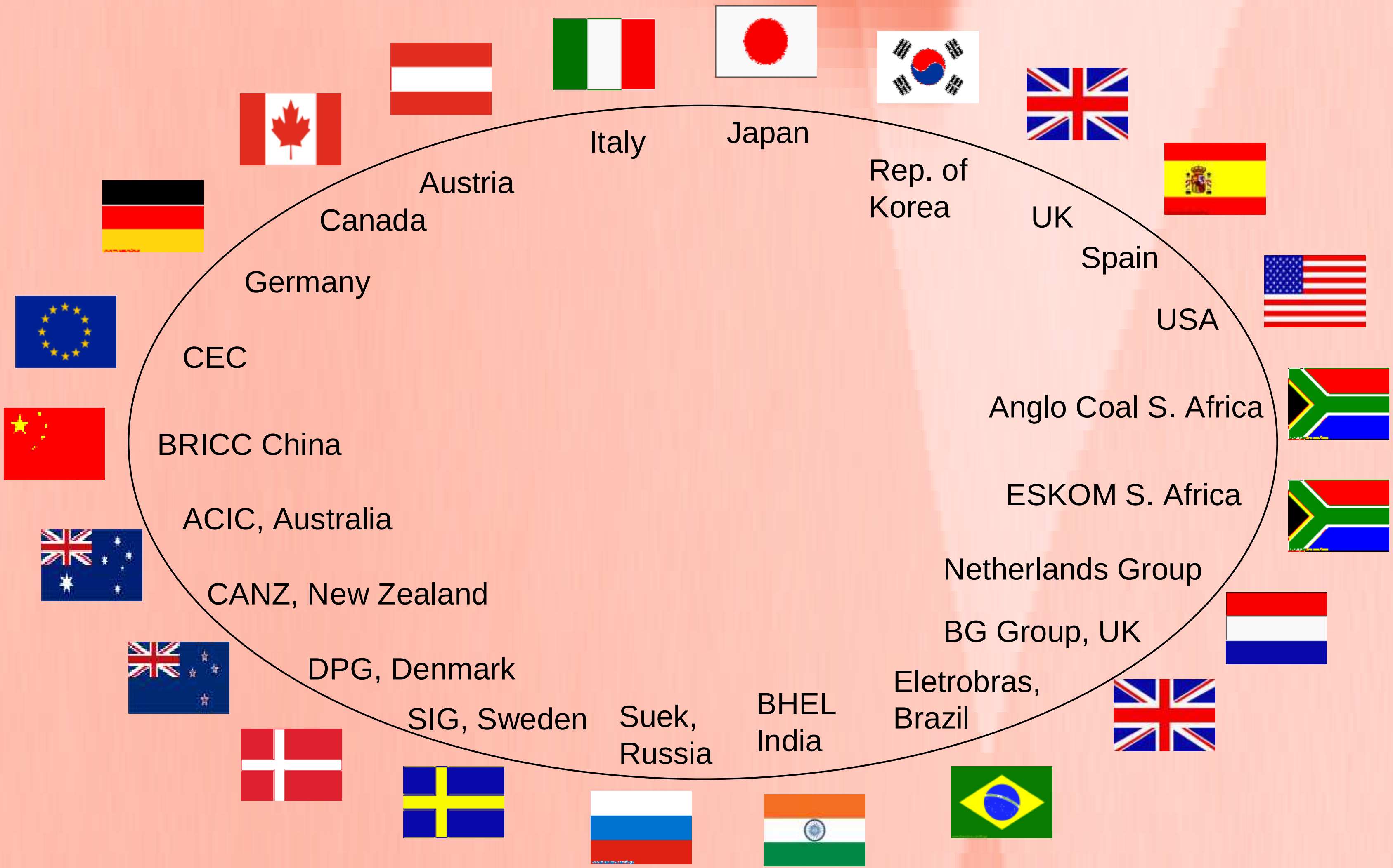
www.co2captureandstorage.info/networks.htm

Sponsored by

World Coal Institute

and Rio Tinto plc

MEMBERS



Schlumberger are completing process of joining

Current Membership

Carbon Capture and Storage Projects and Financing

Preston Chiaro

Chairman, World Coal Institute

Chief Executive Energy, Rio Tinto

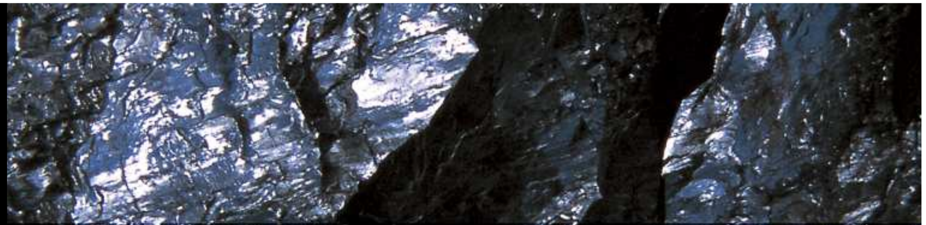
Carbon Capture and Storage Expert Meeting on Finance,

May 31-June 1 2007, London

What is the pathway to finance CCS?

Introduction

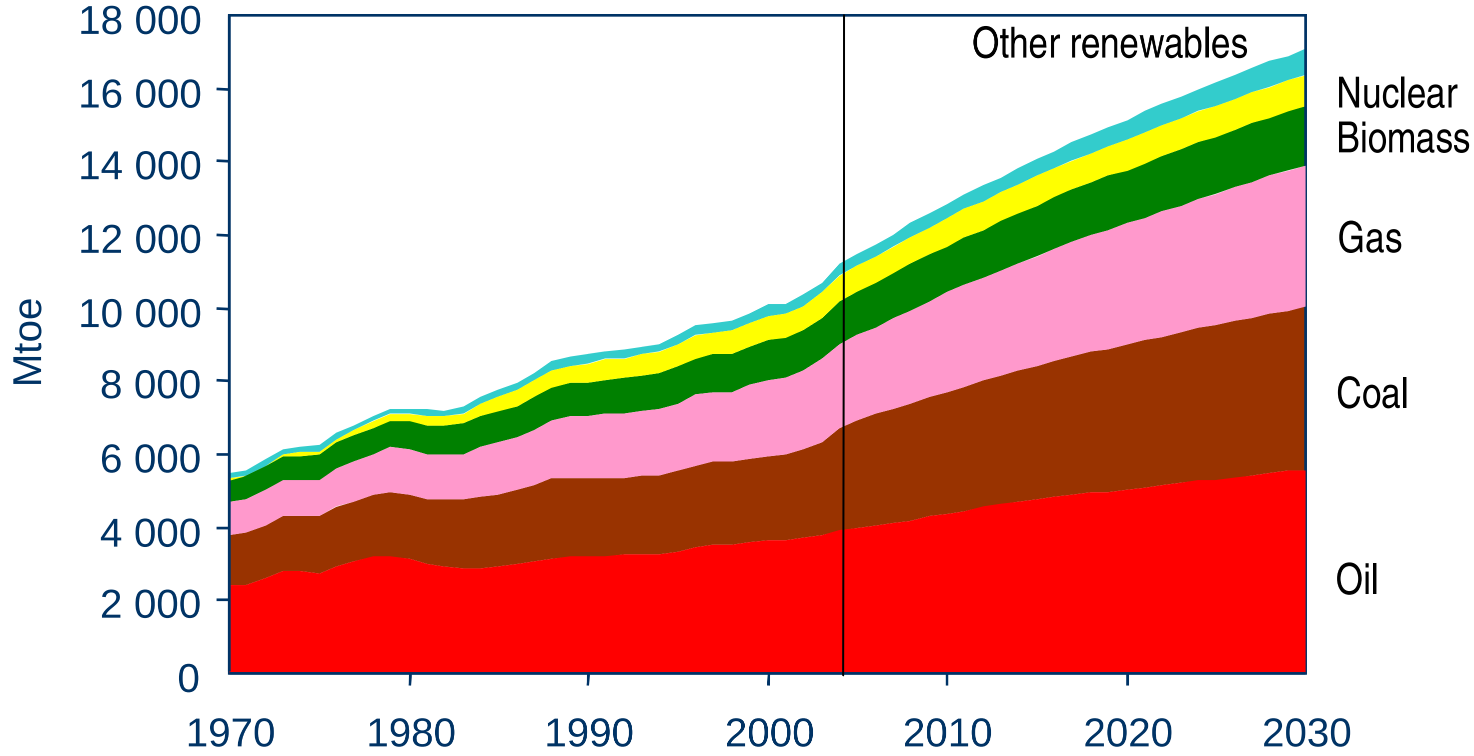
- How do we finance CCS Projects?
- Why is CCS such a key technology?
- How much will be invested in the energy sector?
- Where are the proposed projects?
- How big is the challenge?



Future Scenarios and the Role of Coal

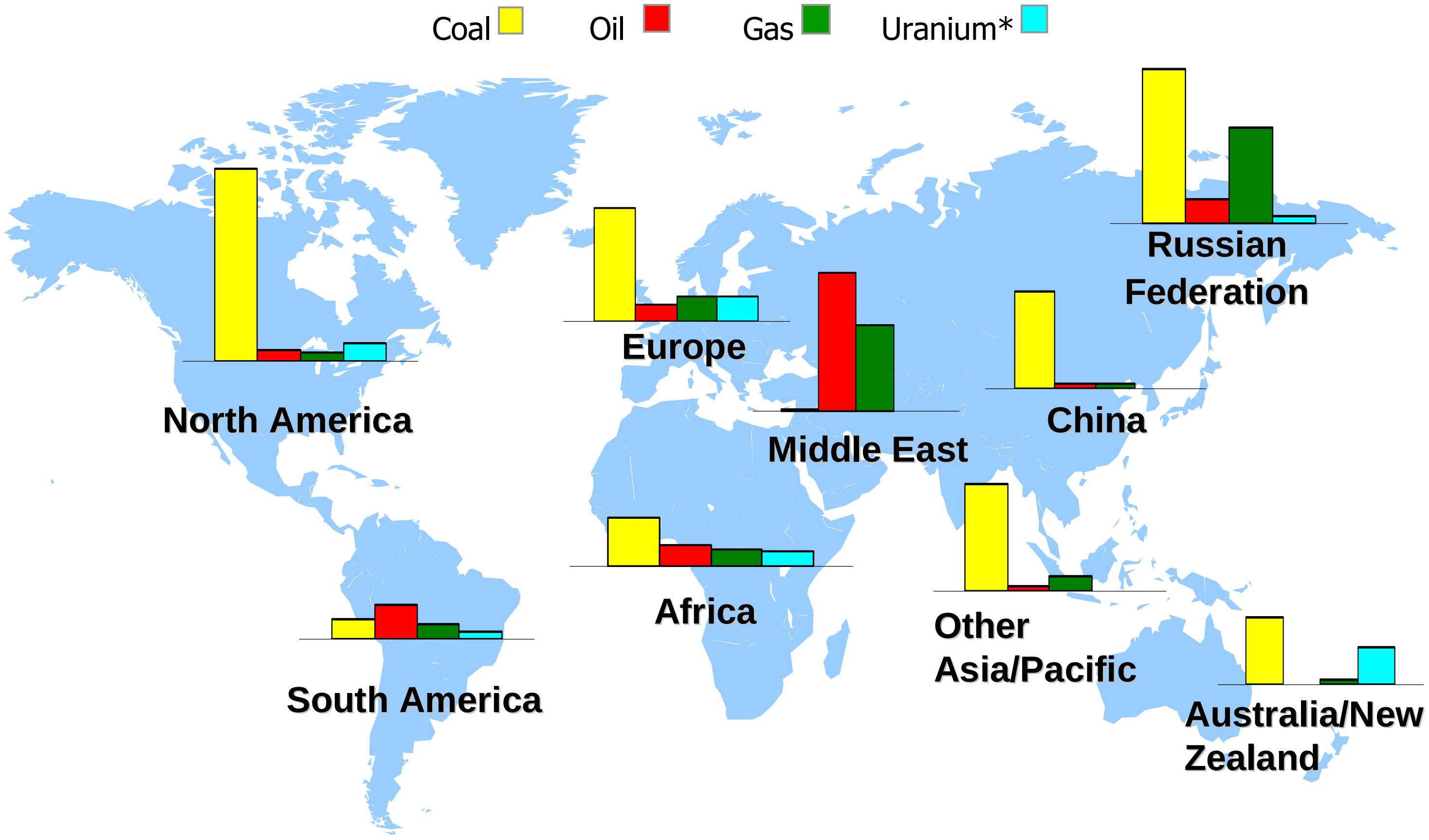
- What will be the energy demand?
- How will it be met?
- How much coal is left?
- Where is it?
- What are the implications for CO_2 emissions?

WEO 2006 Reference Scenario: World Primary Energy Demand



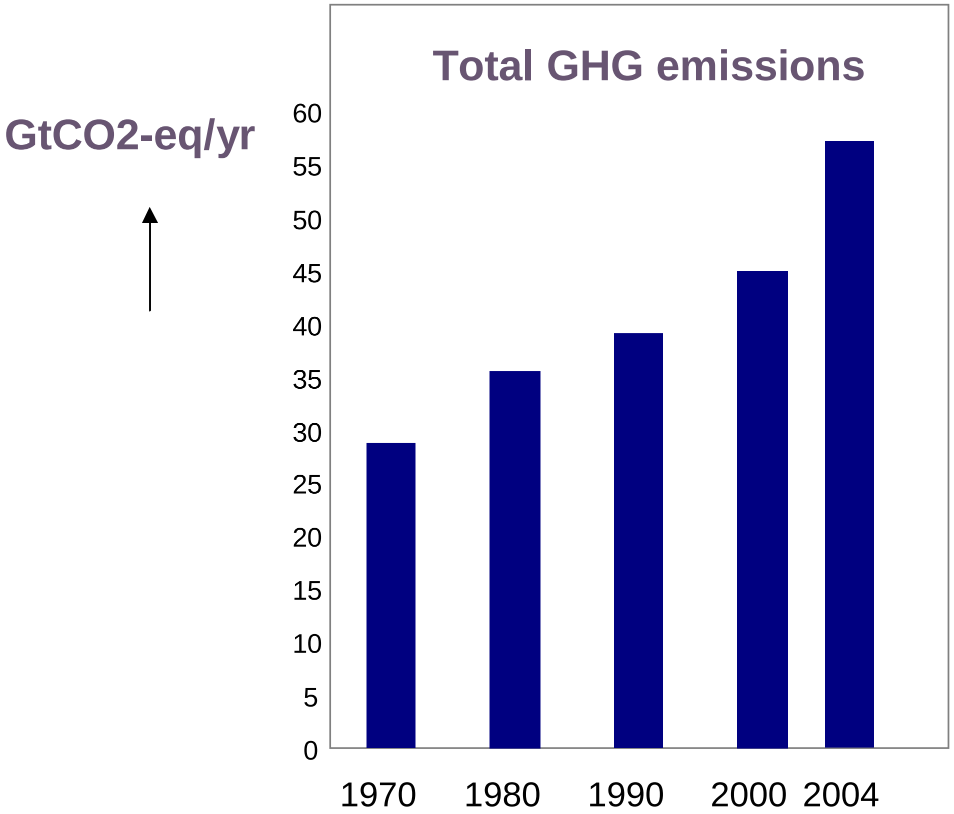
Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms

How much energy is left in the world?



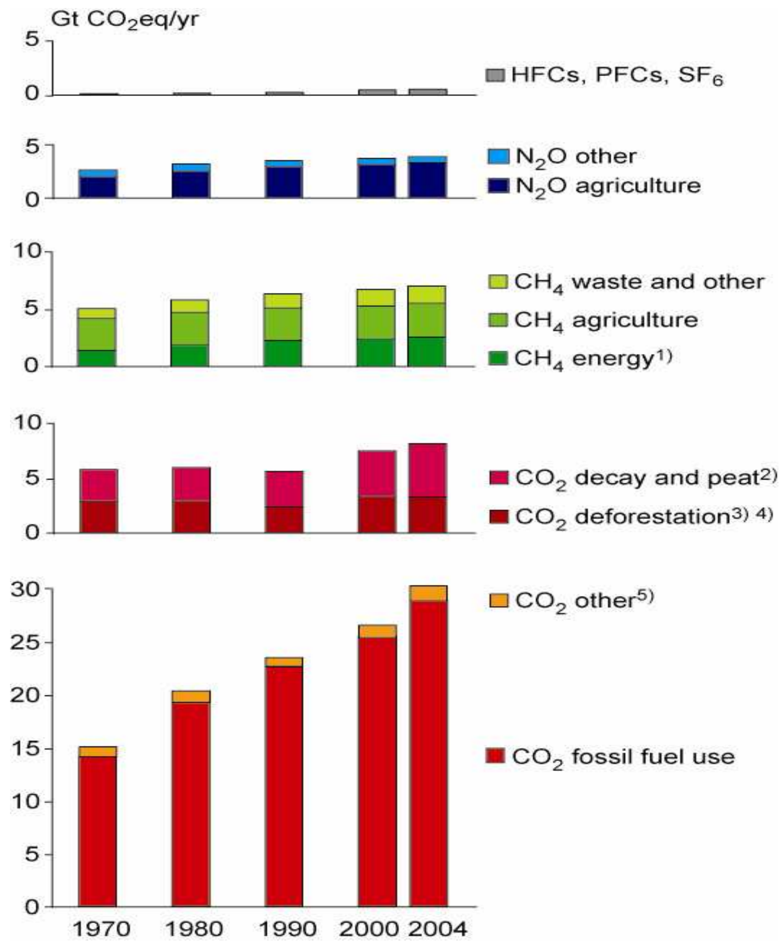
Sources: BP Statistical Review 2005; WEC Survey of Energy Resources 2001; Reasonably Assured Sources plus inferred resources to US$80/kg U 1/1/03 from OECD NEA & IAEA Uranium 2003; Resources, Production & Demand updated 2005; *energy equivalence of uranium assumed to be ~20,000 times that of coal

IPCC WG III in 2007 estimated between 1970 and 2004 global GHG emissions increased by 70 %

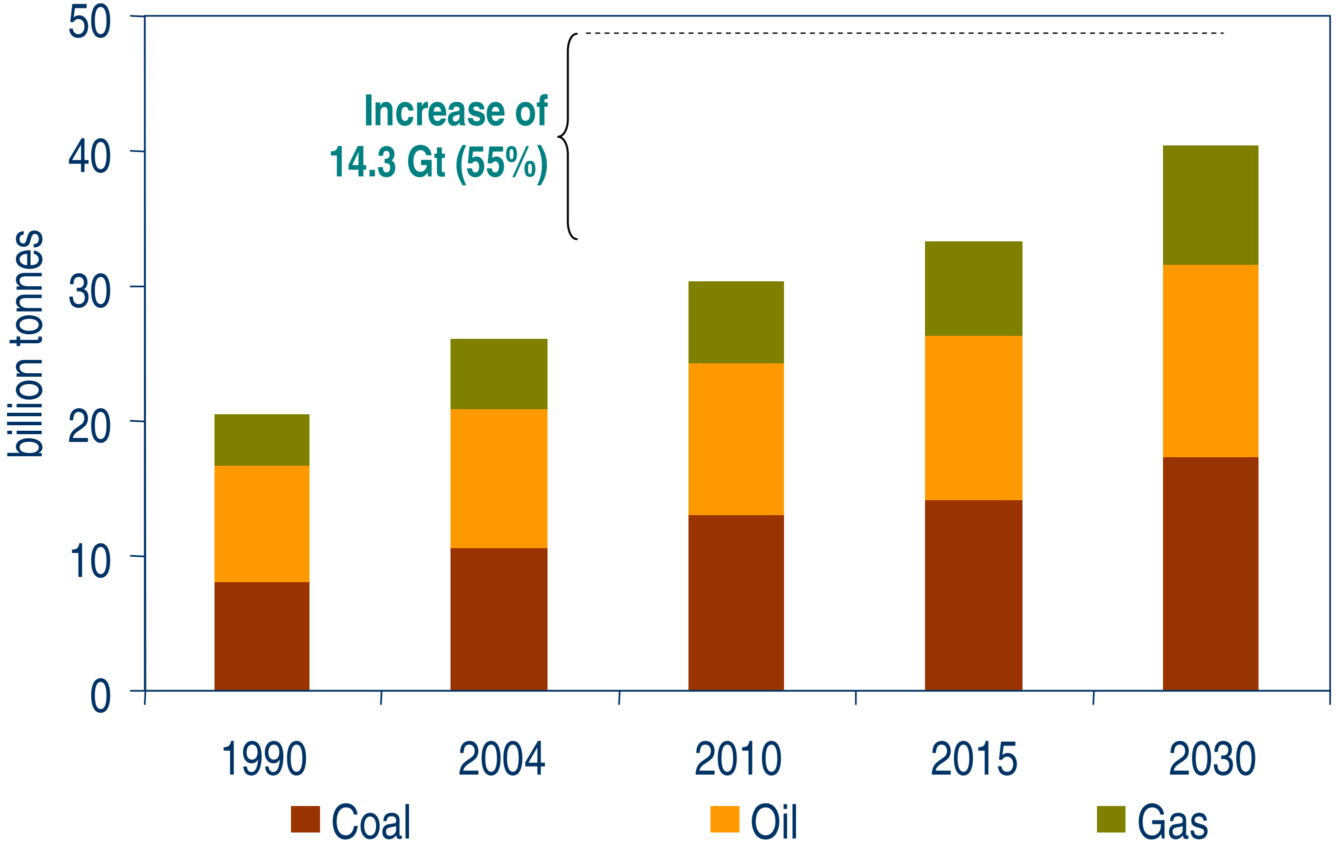


Carbon dioxide is the largest contributor

- IPCC Special Report on Emission Scenarios estimates a range of 25 - 90 % increase of GHG emissions in 2030 relative to 2000



WEO 2006
Energy-Related CO_2 Emissions by Fuel



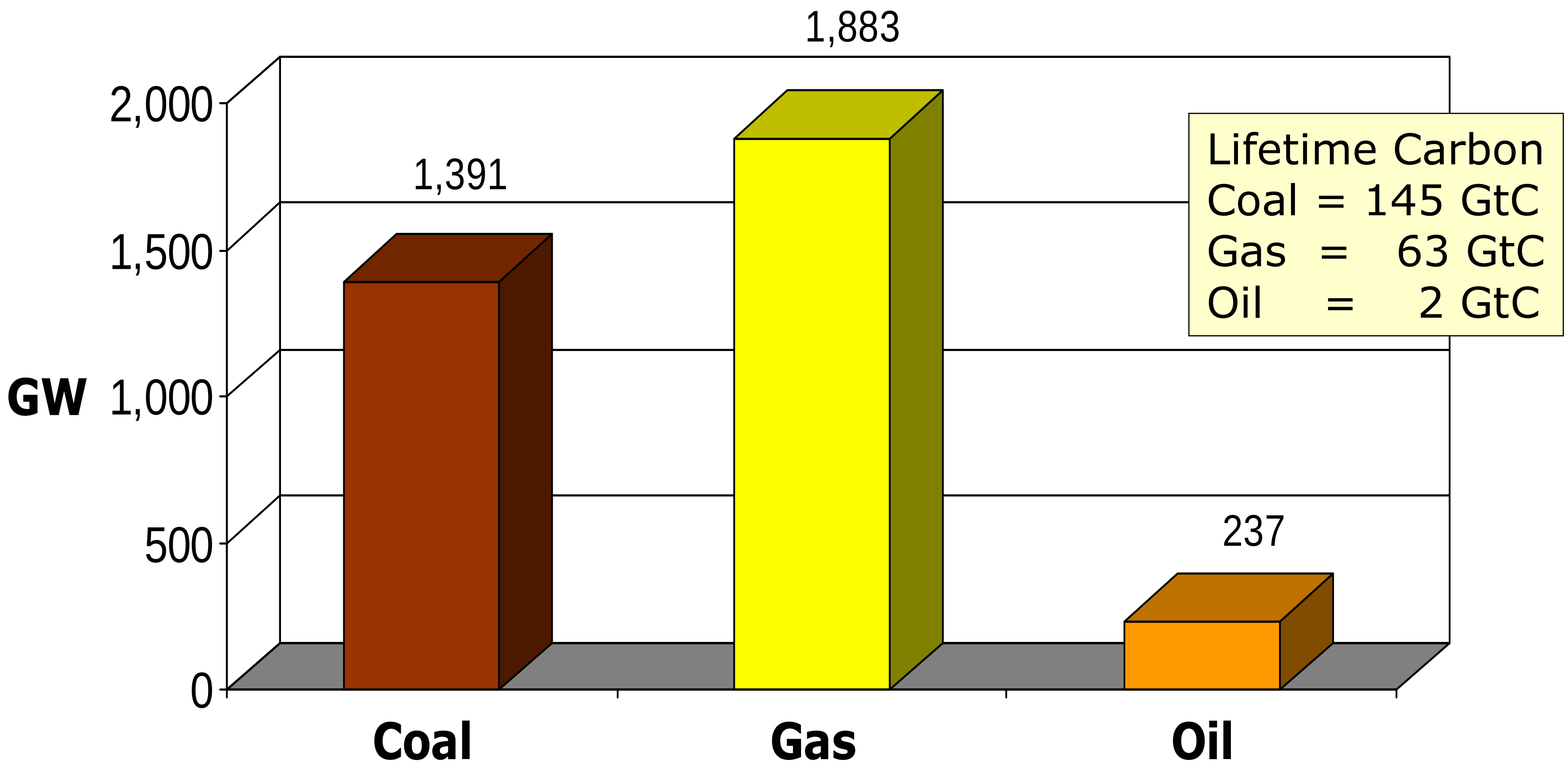
Half of the projected increase in emissions comes from new power stations

Need to Act now to avoid Carbon Lock-in

New and replacement fossil fuel power generation capacity (GW)

	2010	2020	2030
World	520	967	1205
OECD	160	309	363
Developing Countries	343	587	750
Transition Economies	16	72	90
European Union (25)	39	105	132
North America	83	141	171
China	162	210	260
India	24	66	97
Russia	5	27	34

Carbon Lock-in - New Fossil Units 2003-2030



Using CCT and CCS

Table 1. **Regional scenario results**

$MtCO_2$/yr reduction in 2030	SPCC low 30%	SPCC high 100%	IGCC low 20%	IGCC high 60%	CCS low 10%	CCS high 50%
China	193	645	129	387	247	1233
India	58	193	39	116	74	370
Indonesia	26	88	18	53	34	168
US+Canada	154	513	103	308	237	1187
EU-25	143	475	95	285	220	1100
OECD Asia	45	149	30	90	69	345
Australia	12	41	8	25	19	95
total	631	2104	421	1262	899	4497

Proposed Integrated CCS Projects

Some Of The Proposed Zero Emission Power Plants In The European Union

Date Announced	Companies Involved	Technology Options	Plant Capacity	CO2 Avoided per year Million Tonnes	Estimated Cost	Place and Date of start of Operation
May 2005	VATTENFALL	Thermal Oxyfuel Pilot Coal Power Plant with CO_2 capture	30 MW		40 million €	Germany 2008
March 2006	STATOIL and SHELL	Natural Gas Power Plant a) Capture and transport of CO_2 for offshore injection b) Enhanced oil recovery	860 MW	2.5	1 - 1.5 billion $	Norway 2010-2011
March 2006	RWE	IGCC Power Plant-, CO_2 capture and storage	450 MW		1 billion €	Germany 2014
May 2006	SIEMENS	IGGC (Polygasification process + CCS + polygeneration)	1000 MW		1.7 billion €	Germany 2011
Sept 2006?	GE/ POLISH UTILITY	IGCC Power Plant-, CO_2 capture and storage	1000 MW		?	Poland

hydrogen energy

bp

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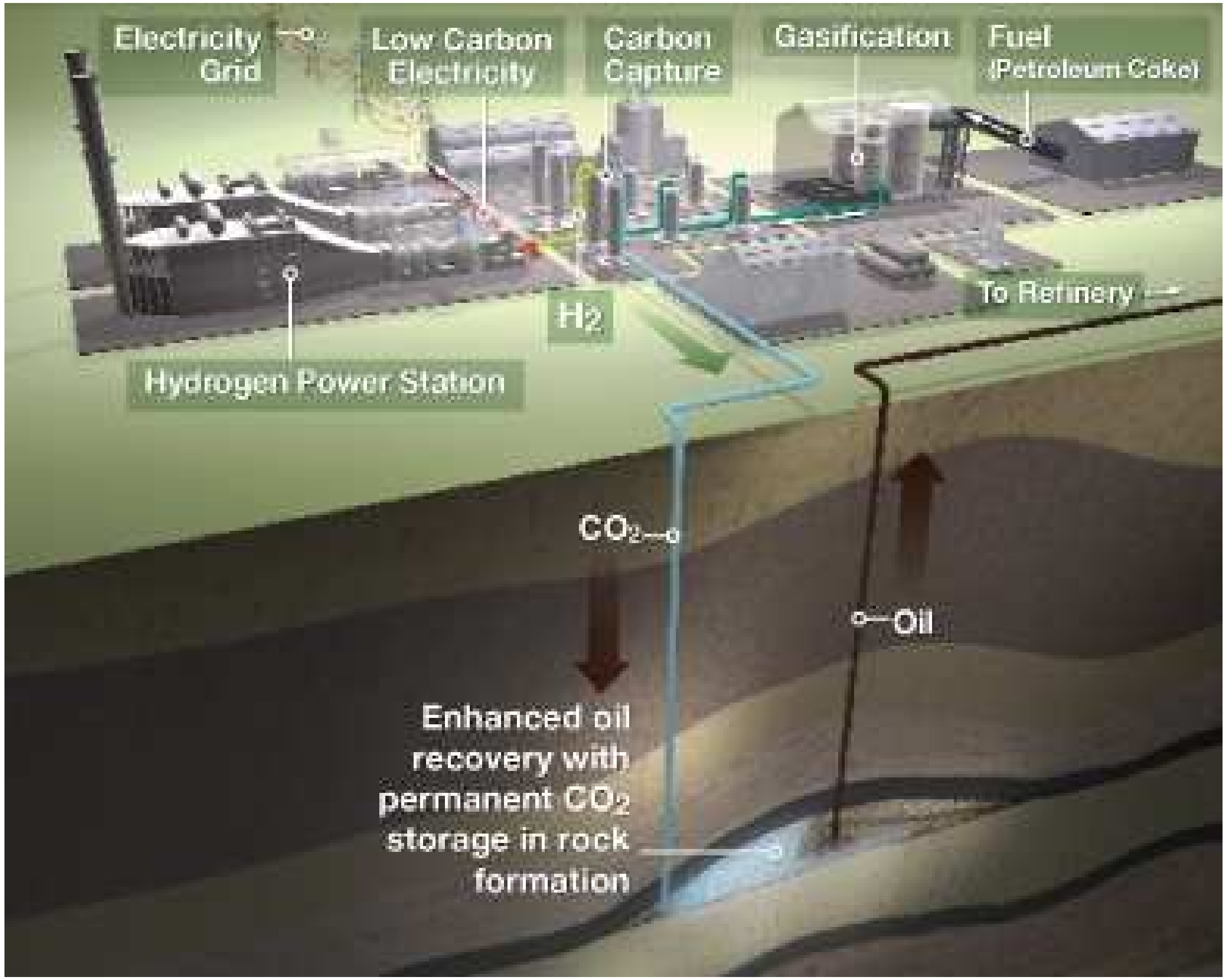
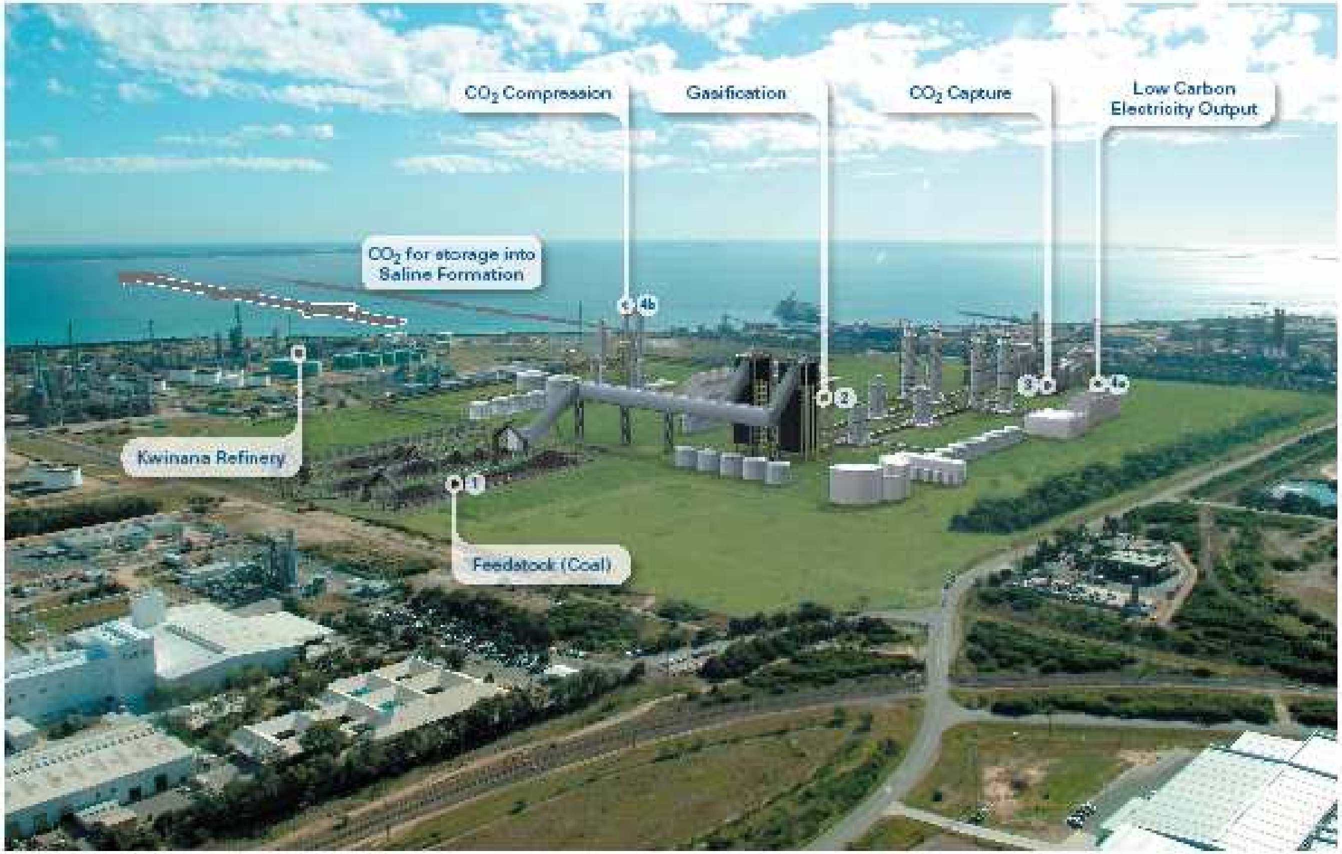
a joint venture

DF2 - Carson Hydrogen Power Project



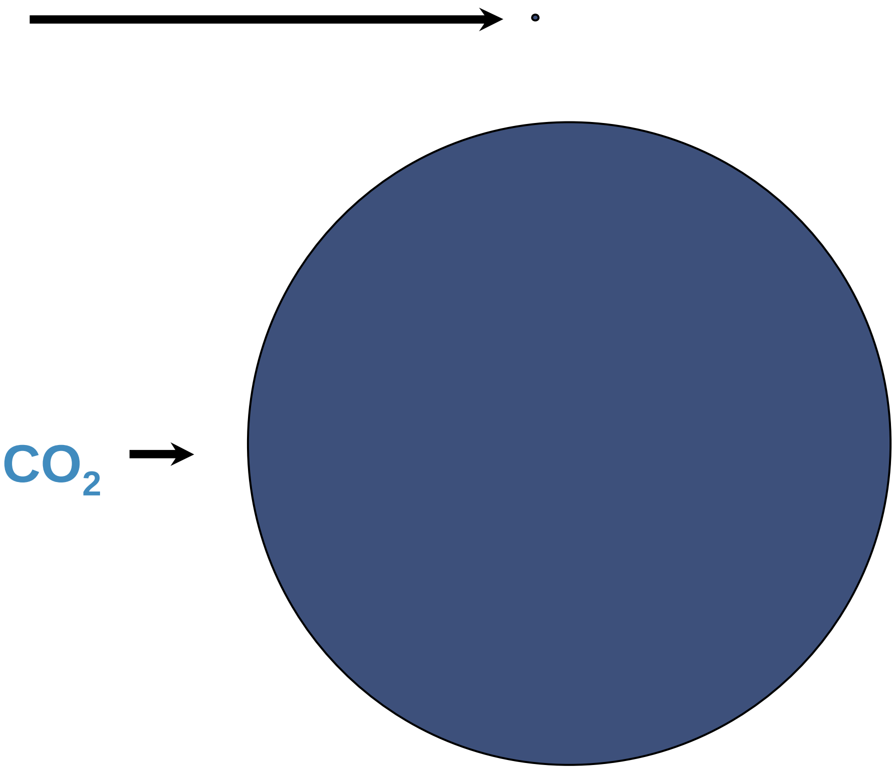
DF3 - Kwinana Hydrogen Power Project



Size matters!

Cumulative globally sequestered CO_2

Cumulative global need to sequester CO_2



Feed and emissions for a 1,000MW utility

CCS Commercialization

- Too few large scale demonstrations to accelerate deployment of CCS technologies
- This approach could result in risk of project failure
- High profile failures concerning CCS projects will result in a reluctance to invest in the deployment of CCS technologies
- What is the path forward to rapid commercialisation of CCS?

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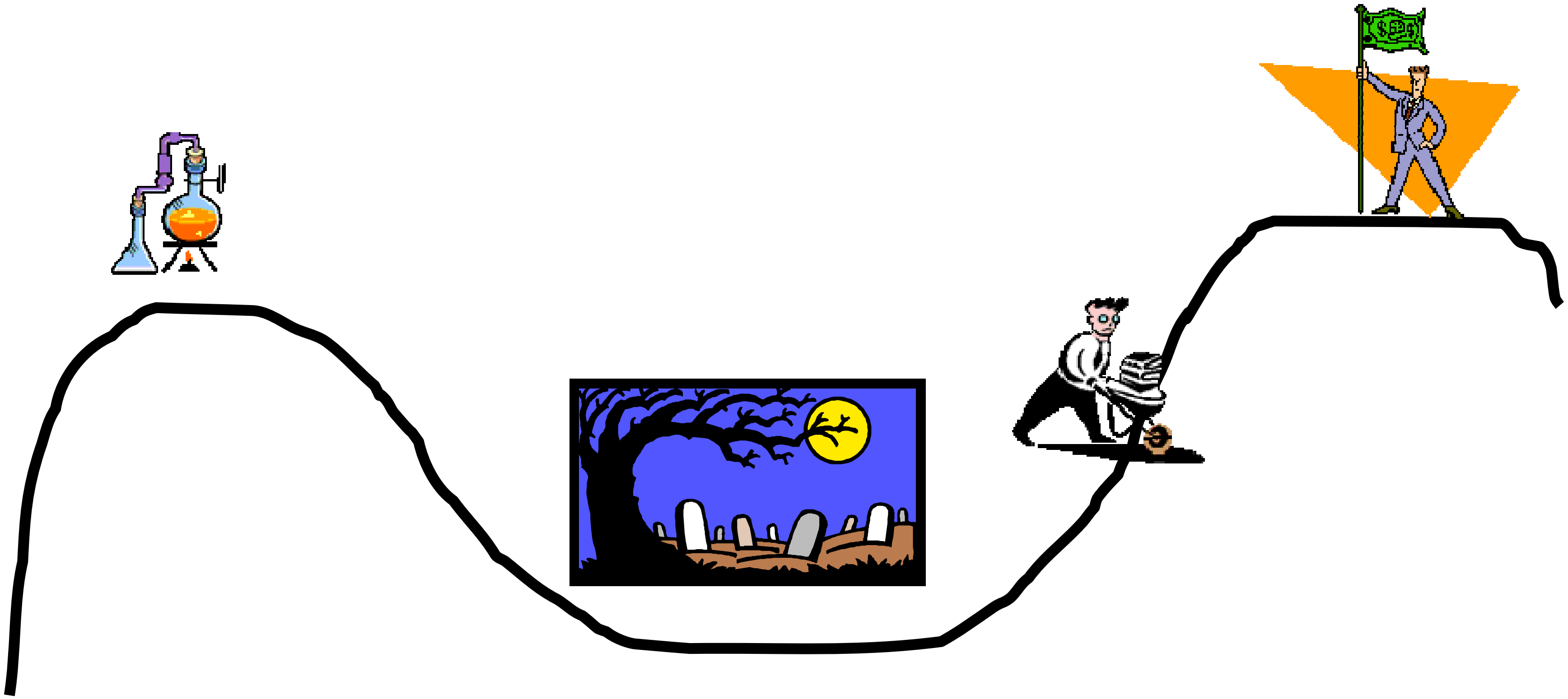
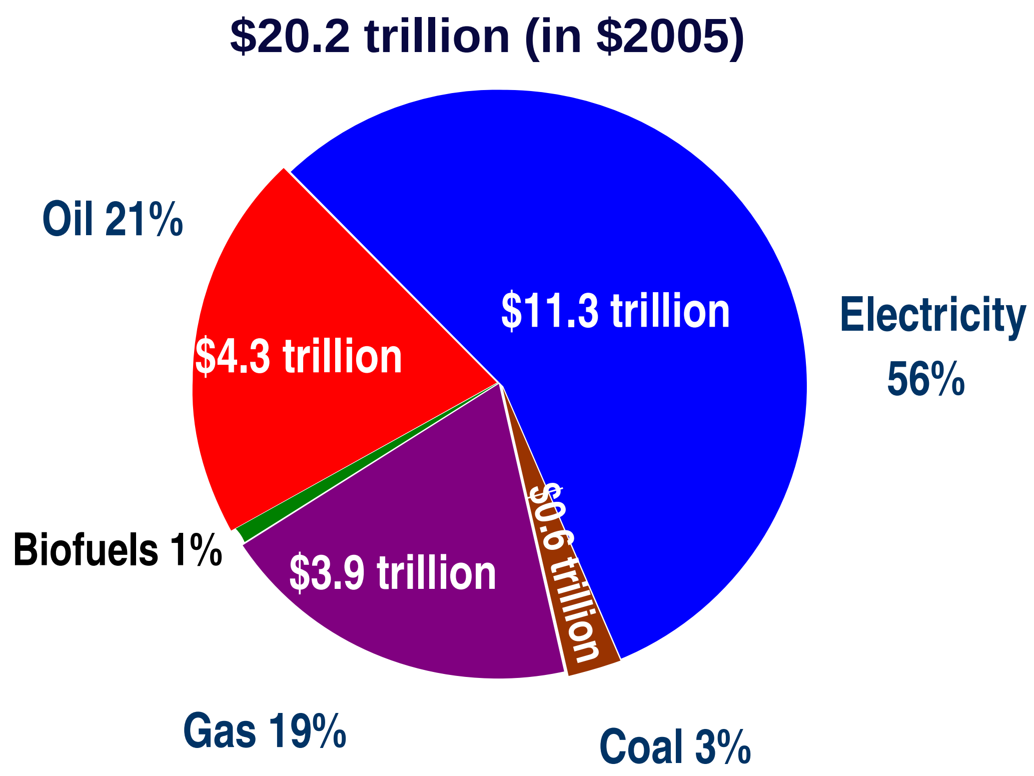
How can CCS avoid the “Valley of Death”?



Basic research → **Commercialisation**

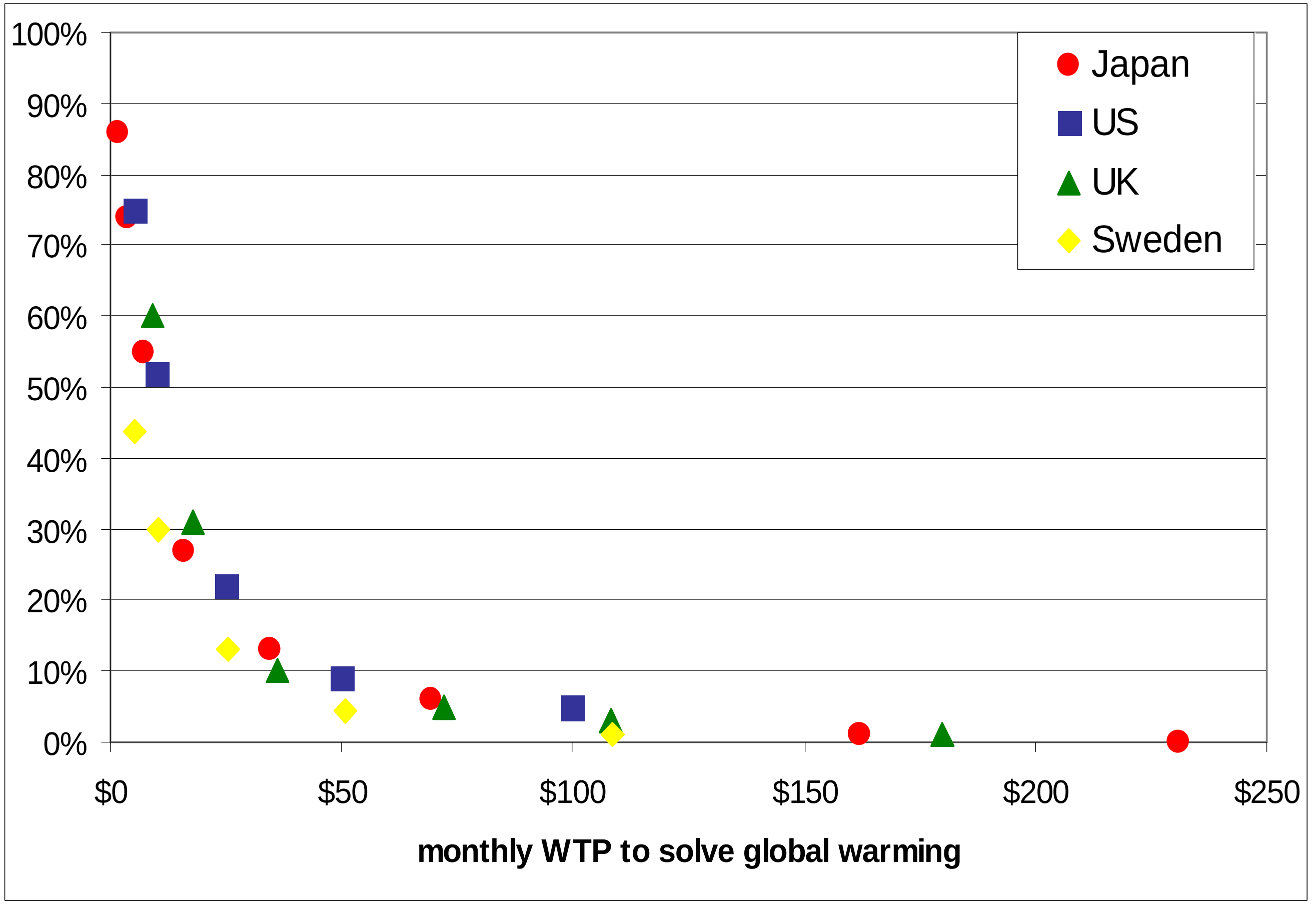
How much will it cost?

IEA WEO 2006 Reference Scenario: Cumulative Investment, 2005-2030



Investment needs exceed $20 trillion – $3 trillion more than previously projected, mainly because of higher unit costs

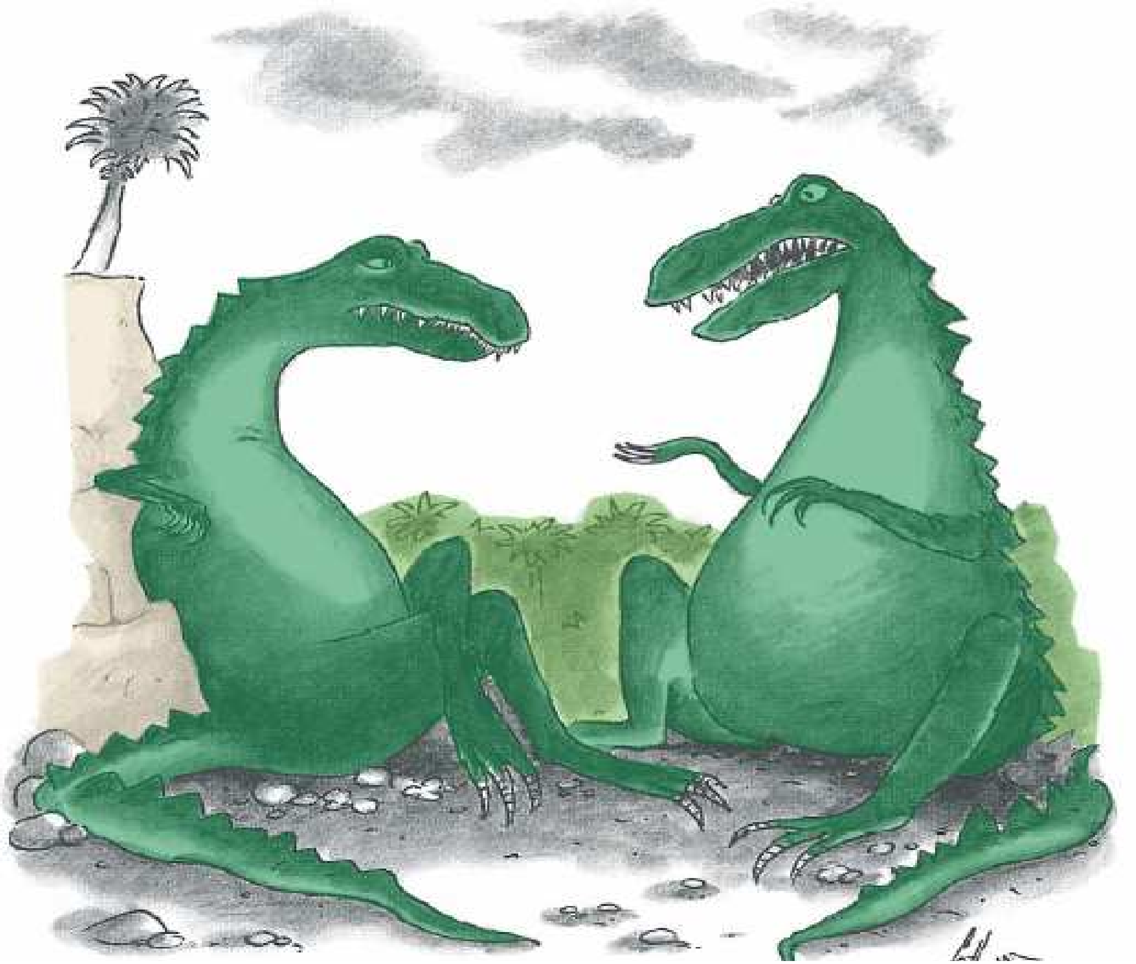
Are people willing to pay the price?



Source: David Reiner, University of Cambridge & MIT

The Expert Meeting

- The Status of CCS
- Industrial Perspectives on CCS and their experience
- Banks, Insurance and financing CCS



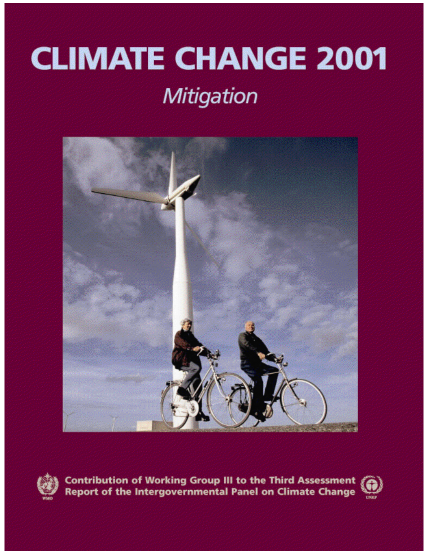
"All I'm saying is **NOW** is the time to develop the technology to deflect an asteroid"

CCS in the IPCC Fourth Assessment

Expert meeting on Financing CCS projects
IEA GHG R&D Programme
London, 31 May 2007

Dr. Leo Meyer, IPCC Working Group III

About IPCC



- Founded 1988 by UNEP and WMO
- No research, no monitoring, no recommendations
- Preferably peer-reviewed literature
- Authors academic, industrial and NGO
- Reviews by Experts *and* Governments
- Policy relevant, but NOT policy prescriptive
- Summary for policymakers: government approval
- Fourth Assessment cycle 2003-2008

Key issues addressed in this presentation

The IPCC Special Report on CCS (2005)

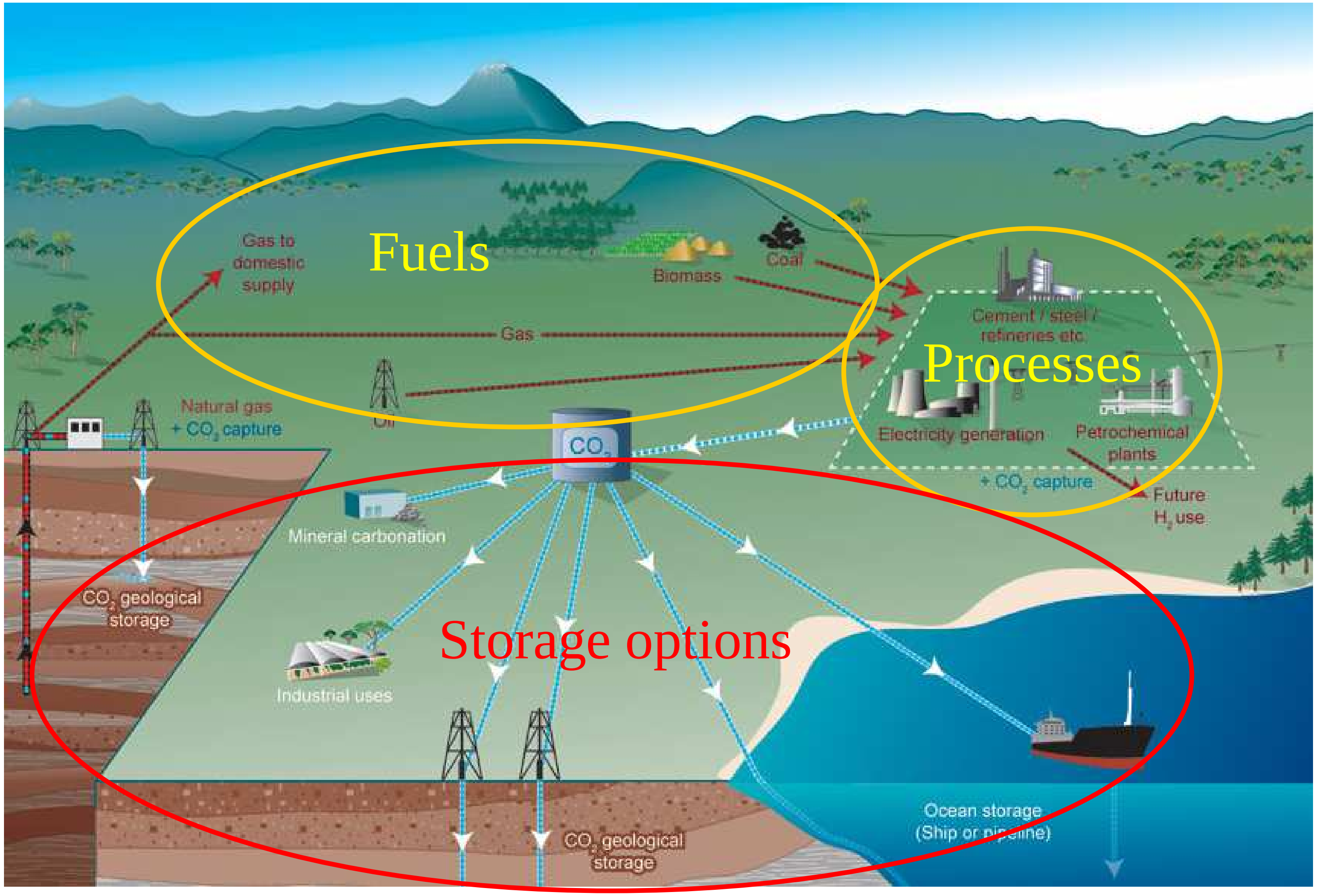
- What is CO_2 capture and storage?
- Sources, Capture, transport
- Geological storage, Ocean storage, mineral carbonation
- Maturity of the technologies
- Cost and potential
- Health, safety and environment risks

The IPCC WG III AR4: mitigation of Climate change (2007)

- CCS : transient or expansion;
- CCS readiness of power plants
- New cost and potential estimate in 2030 ; LT potential

‘*take home’ messages*

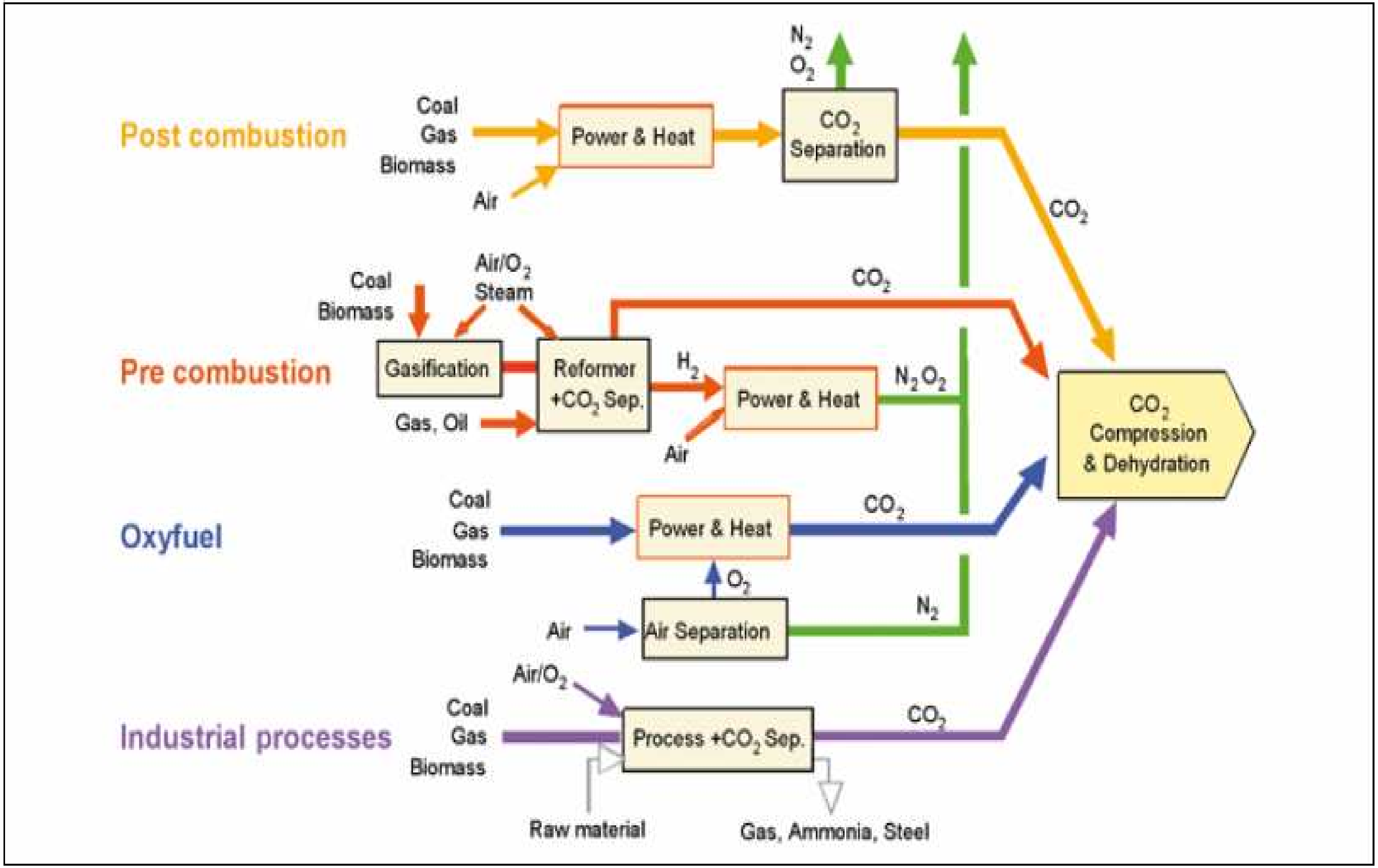
CO_2 capture and storage system



Global large stationary CO_2 sources with emissions of more than 0.1 $MtCO_2$/year

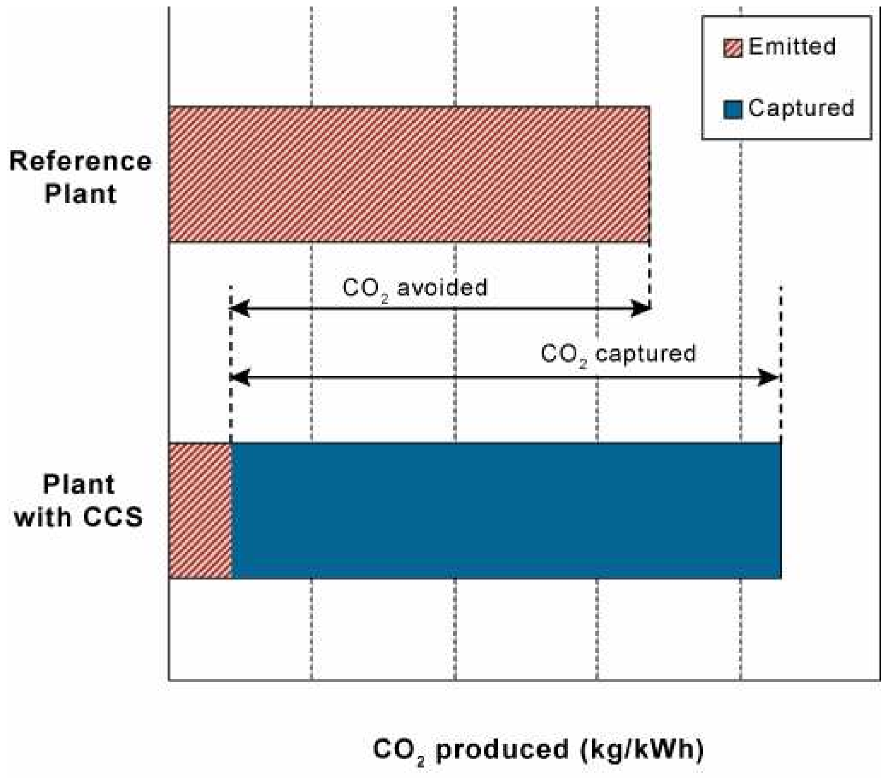
Process	No. of sources	Emissions ($MtCO_2$/yr)
Fossil Fuels		
Power (coal, gas, oil and others)	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	N/A	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

Overview of CO_2 capture systems



Capture and transport energy requirements

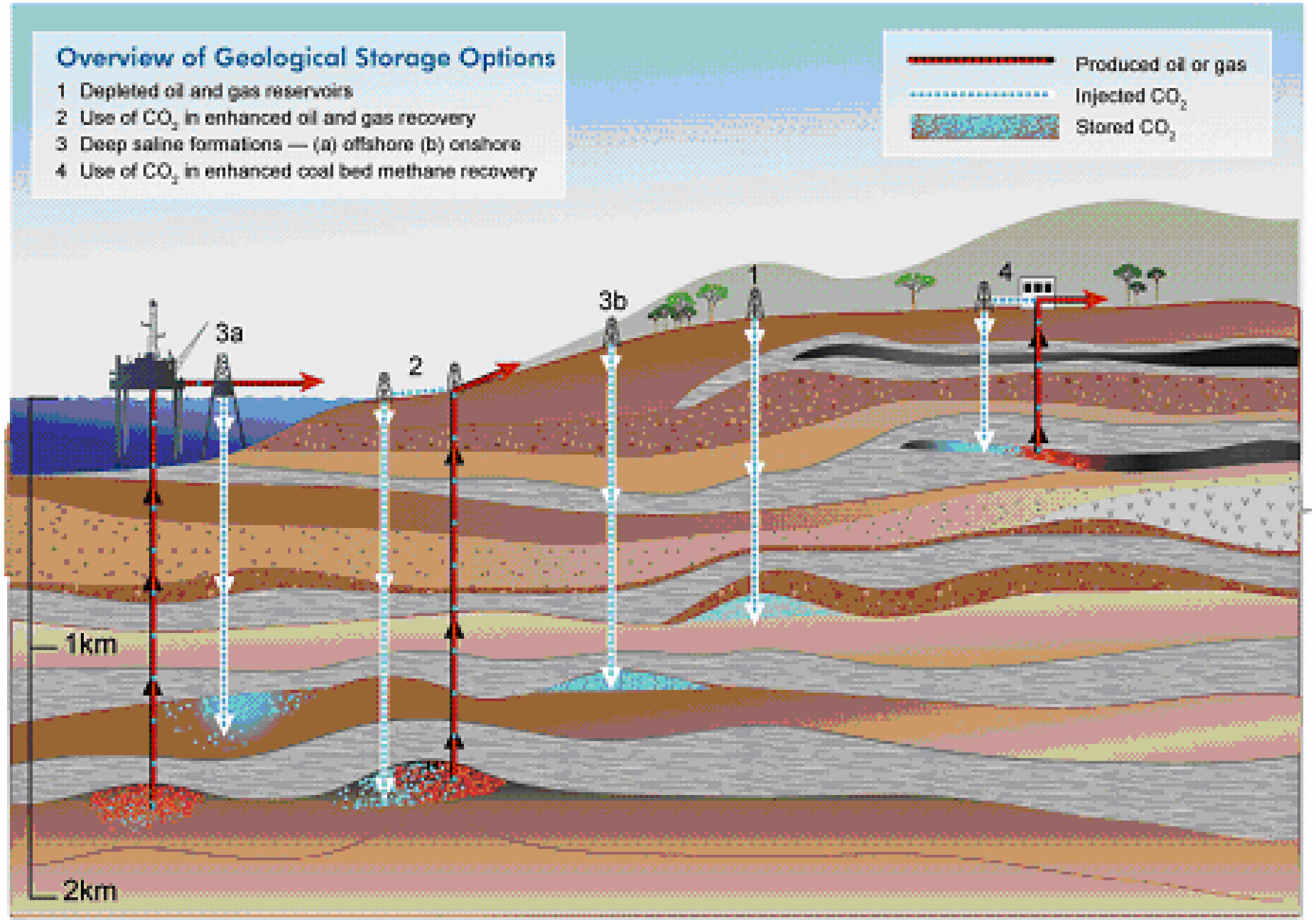
- Additional energy use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO_2 reduction: 80 - 90%
- Assuming safe storage



Capture energy requirements

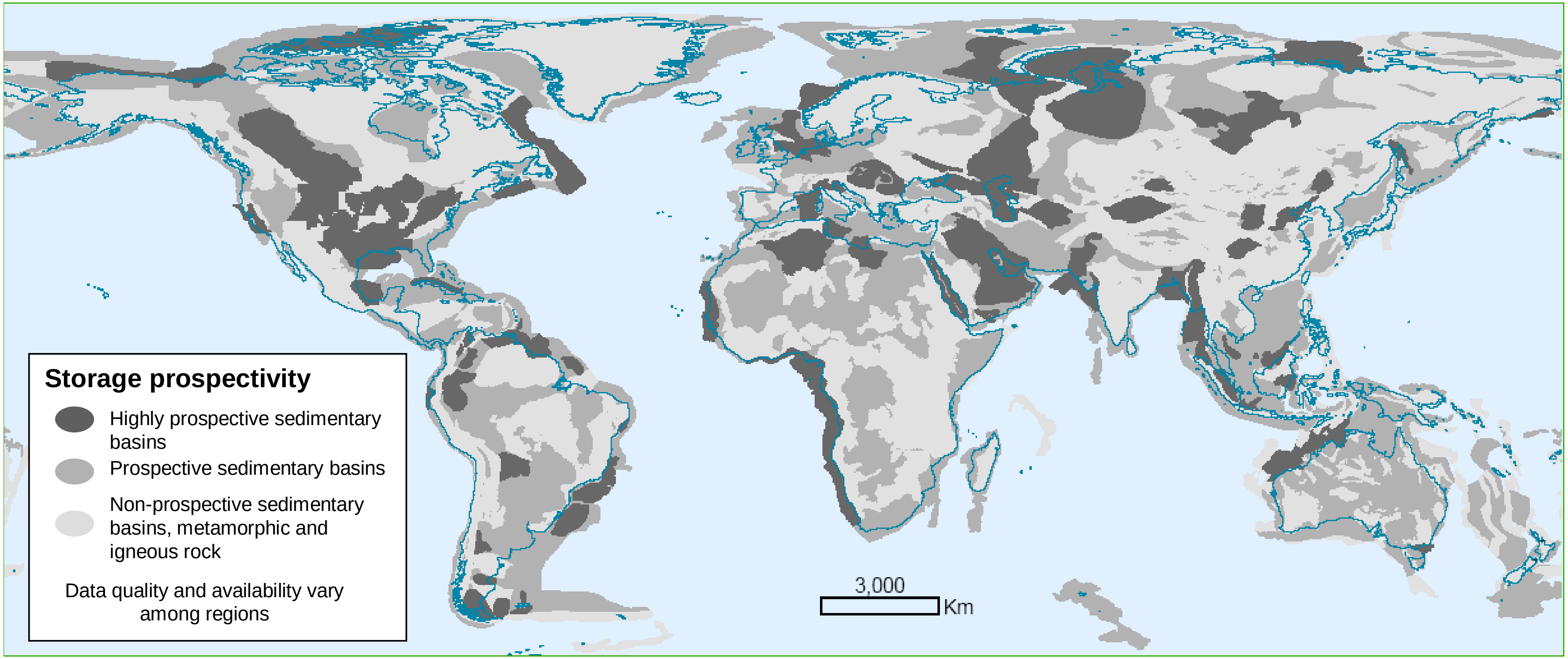
Power plant (new)	**Thermal eff. without capture (LHV), %**	**Thermal eff. with capture (LHV), %**	**Increased primary energy use / output electricity %**
Pulverized Coal	41- 45	30 - 35	24 - 40
NGCC	55 - 58	47 - 50	11 - 22
IGCC	38 - 47	31 - 40	14 - 25

Geological storage



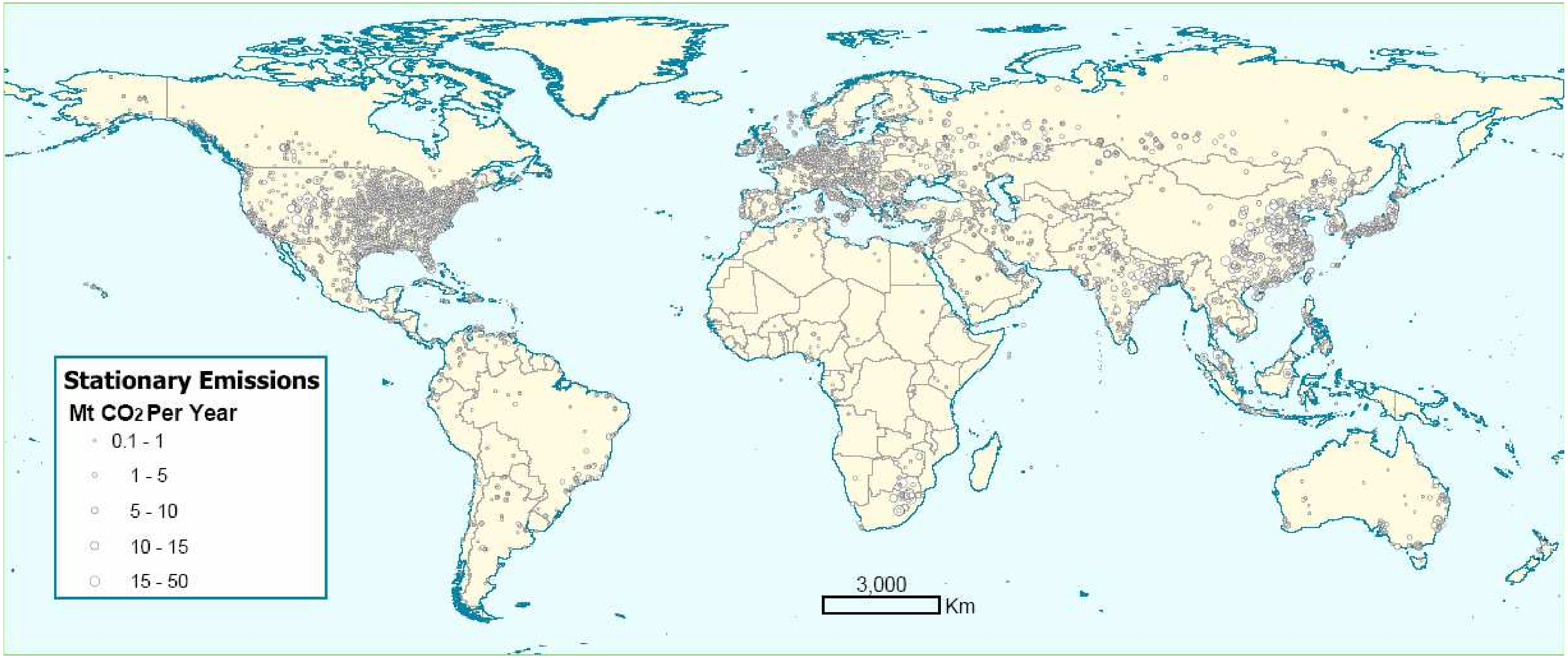
Planned and current locations of geological storage

Geographical relationship between sources and storage opportunities



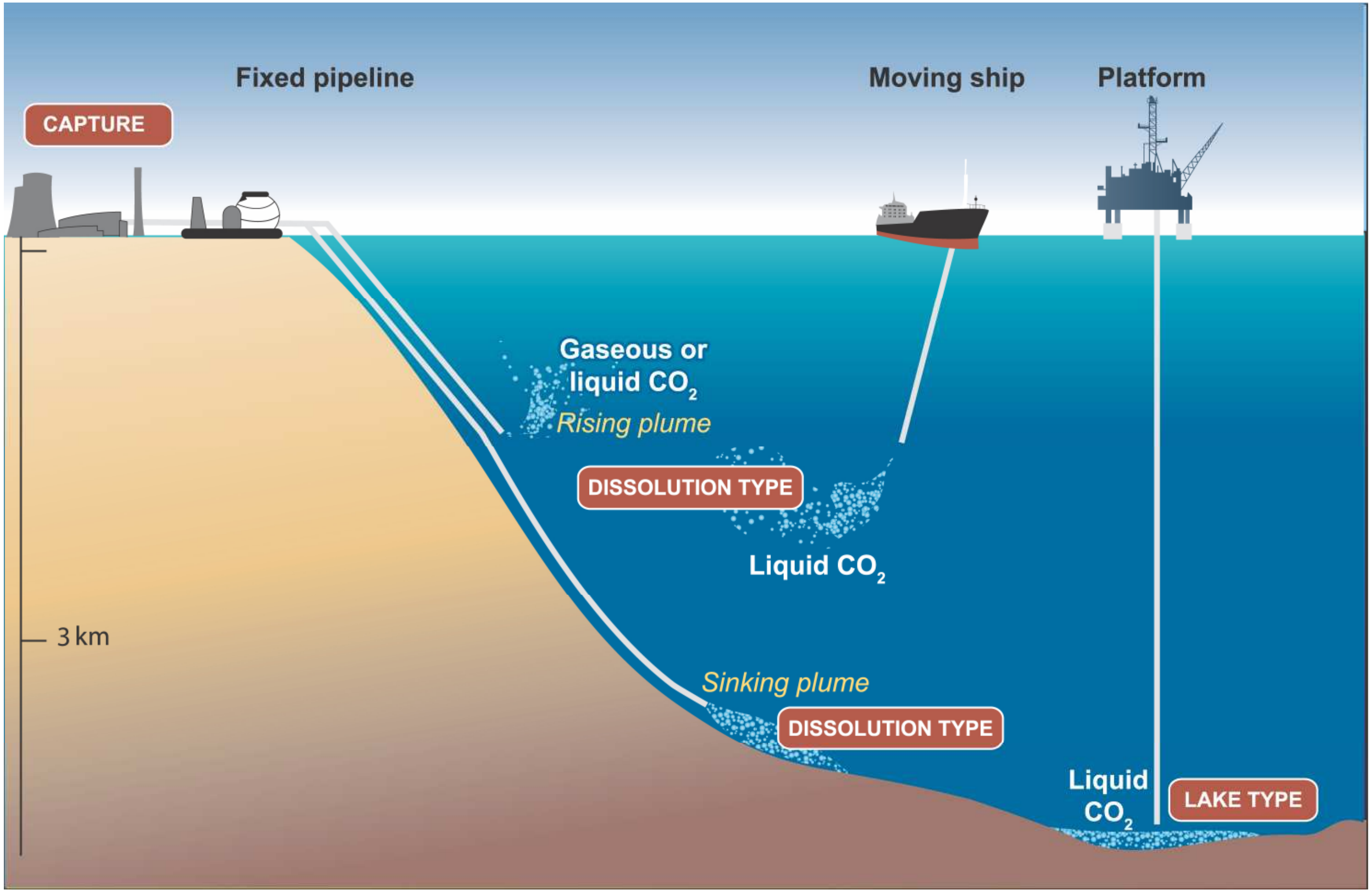
Prospective areas in sedimentary basins where suitable saline formations, oil or gas fields, or coal beds may be found. Locations for storage in coal beds are only partly included. Prospectivity is a qualitative assessment of the likelihood that a suitable storage location is present in a given area based on the available information. This figure should be taken as a guide only, because it is based on partial data, the quality of which may vary from region to region, and which may change over time and with new information (Courtesy of Geoscience Australia).

Geographical relationship between sources and storage opportunities

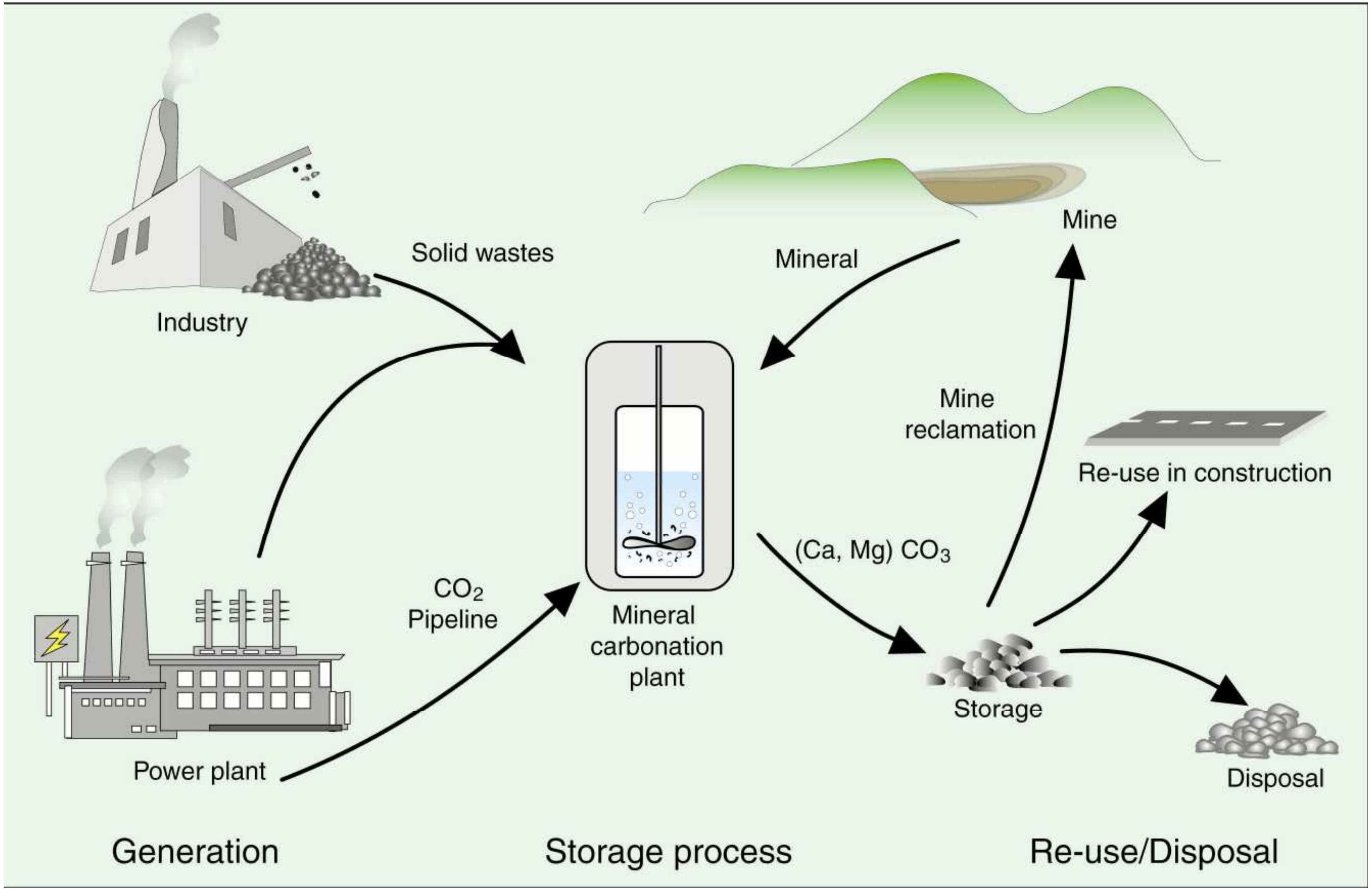


Global distribution of large stationary sources of CO_2 (Based on a compilation of publicly available information on global emission sources, IEA GHG 2002)

Ocean storage



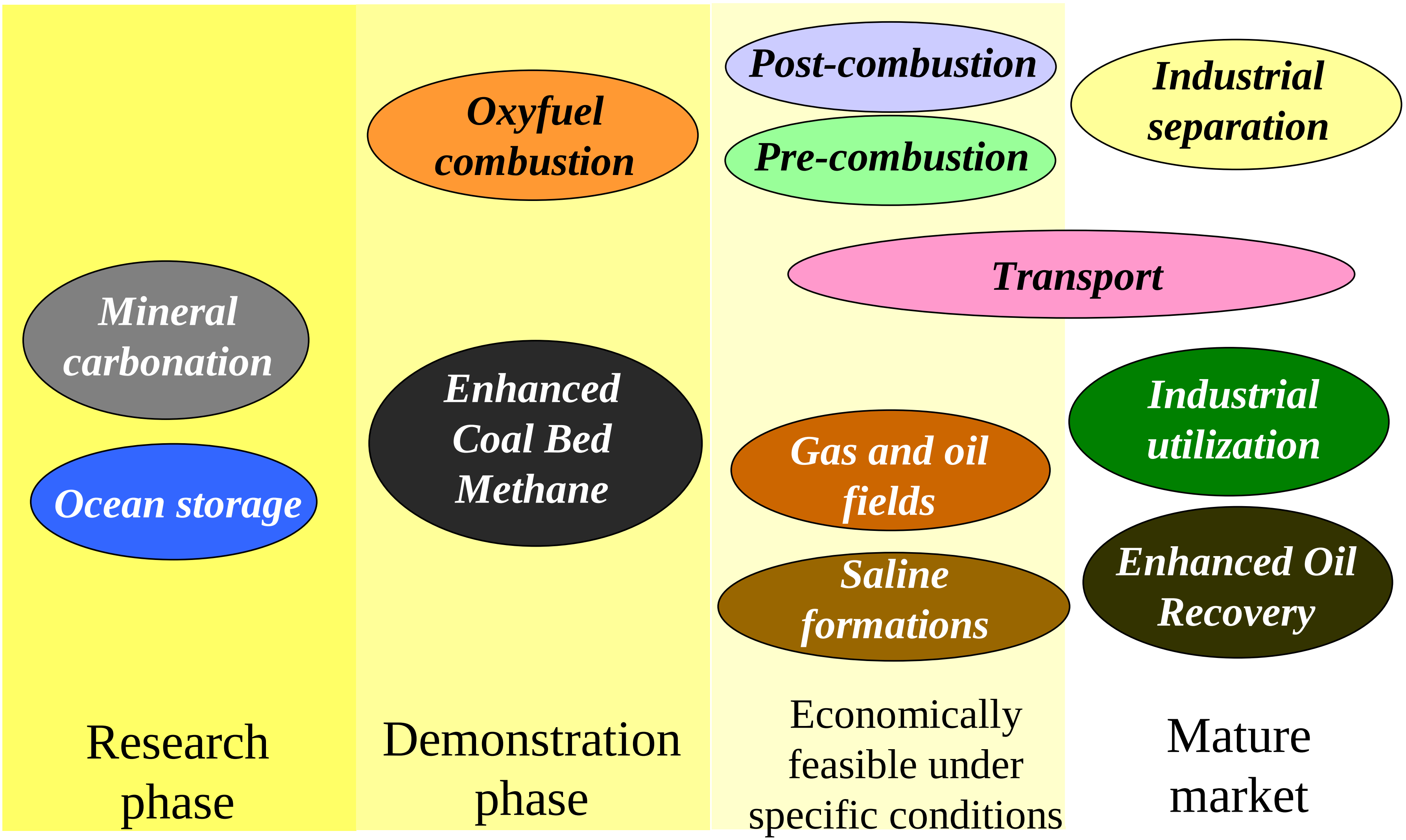
Mineral carbonation



Maturity of CCS technology

- Research phase means that the basic science is understood, but the technology is currently in the stage of conceptual design or testing at the laboratory or bench scale, and has not been demonstrated in a pilot plant.
- Demonstration phase means that the technology has been built and operated at the scale of a pilot plant, but further development is required before the technology is ready for the design and construction of a full-scale system.
- Economically feasible under specific conditions means that the technology is well understood and used in selected commercial applications, such as in case of a favourable tax regime or a niche market, processing at least 0.1 $MtCO_2$/yr , with few (less than 5) replications of the technology.
- Mature market means that the technology is now in operation with multiple replications of the commercial-scale technology worldwide.

Maturity of CCS technology



Costs

Two ways of expressing costs:

- Additional electricity costs
  - Energy policymaking community
- CO_2 avoidance costs
  - Climate policymaking community

Different outcomes:

0.01 - 0.05 US$/kWh

20* - 270 US$/t$CO_2$ avoided

(with EOR: 0*– 240 US$/t$CO_2$ avoided)

* low-end: capture-ready, low transport cost, revenues from storage: 360 MtCO_2/yr

CCS component costs

CCS component	Cost range
Capture from a power plant	15 - 75 US$/t$CO_2$ net captured
Capture from gas processing or ammonia production	5 - 55 US$/t$CO_2$ net captured
Capture from other industrial sources	25 - 115 US$/t$CO_2$ net captured
Transportation	1 - 8 US$/t$CO_2$ transported per 250km
Geological storage	0.5 - 8 US$/t$CO_2$ injected
Ocean storage	5 - 30 US$/t$CO_2$ injected
Mineral carbonation	50 - 100 US$/t$CO_2$ net mineralized

Economic potential

- Cost reduction of climate change stabilisation: 30% or more
- Most scenario studies: role of CCS increases over the course of the century
- Substantial application above CO_2 price of 25-30 US$/t$CO_2$
- 15 to 55% of the cumulative mitigation effort worldwide until 2100
- 220 - 2,200 GtCO_2 cumulatively up to 2100, depending on the baseline scenario, stabilisation level (450 - 750 ppmv), cost assumptions

Storage potential

- Geological storage: likely at least about 2,000 $GtCO_2$ in geological formations

"Likely" is a probability between 66 and 90%.

- Ocean storage: on the order of thousands of $GtCO_2$, depending on environmental constraints
- Mineral carbonation: can currently not be determined
- Industrial uses: Not much net reduction of CO_2 emissions

Health, safety, environment risks

- **In general**: lack of real data, so comparison with current operations
- **CO_2 pipelines**: similar to or lower than those posed by hydrocarbon pipelines
- **Geological storage**:
  - appropriate site selection, a monitoring program to detect problems, a regulatory system, remediation methods to stop or control CO_2 releases if they arise:
  - comparable to risks of current activities (natural gas storage, EOR, disposal of acid gas)

Health, safety, environment risks

- **Ocean storage**:
  - pH change
  - Mortality of ocean organisms
  - Ecosystem consequences
  - Chronic effects unknown
- **Mineral carbonation**:
  - Mining and disposal of resulting products
  - Some of it may be re-used

CCS in the Fourth Assessment Report of IPCC WG 3 2007 (1)

- IPCC 2005: expansion towards 2100
- IEA 2006: CCS is ‘transitional’, peaking at 2050 and declining thereafter
- CCS and biomass could return CO2 conc below 450 ppm

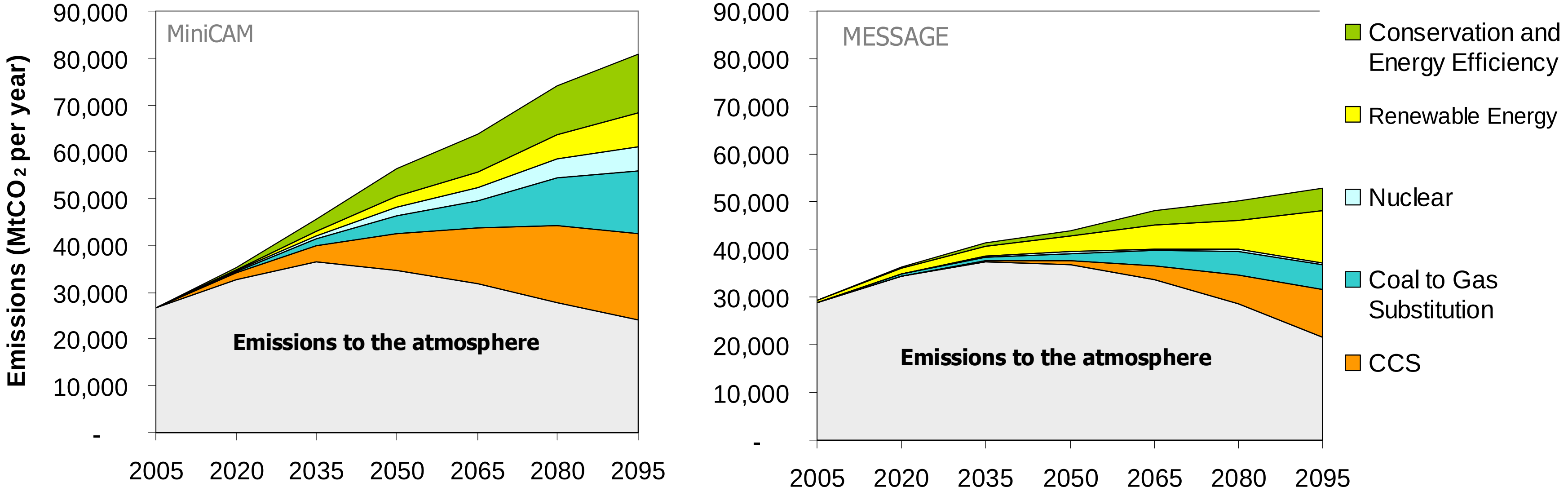
CCS in the Fourth Assessment Report of IPCC WG 3 2007 (2)

- ‘Make power plants CCS-ready if rapid deployment desired‘
- Significant pre-capital investments not justified
- Detailed reports not yet published

CCS in the Fourth Assessment Report of IPCC WG 3 2007 (3)

Global potential reduction and costs for CCS in 2030				
Power plants with CCS	Share %	Avoided emissions (GtCO2/y)	Costs US$/ tCO2	Costs (US ct/kWh)
Coal	6	0.49 (3%)	22-42	2-4
Gas	6	0.22 (1%)	43-79	1.3-2.4

Long term economic potential



‘Take home messages’

1. Potential 15 -55 % of mitigation effort to 2100 , but no silver bullet - portfolio needed to address climate change
2. Reduce overall mitigation costs (30%) by increasing flexibility in achieving greenhouse gas emission reductions
3. Energy requirements still considerable (10-40 %)
4. No substantive deployment unless CO_2 market price over 25-30 USD/tonne CO_2 to offset costs
5. Risks comparable to current industrial activities, but more experience needed

THANK YOU FOR YOUR ATTENTION!

More information:

www.ipcc.ch

Reports published by
Cambridge University Press
Order at www.cambridge.org

ECN

Energy research Centre of the Netherlands

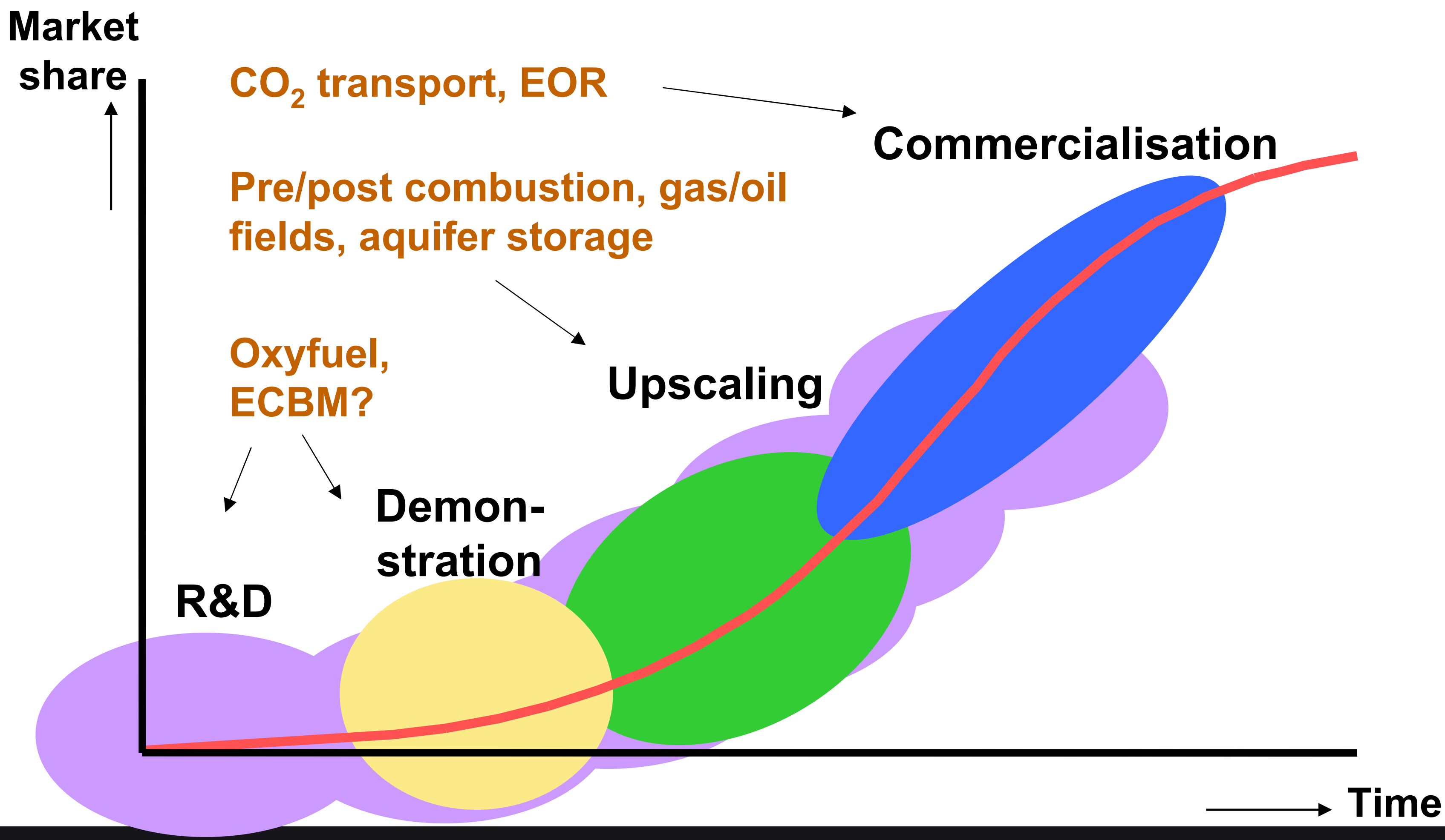
Incentivising CCS in the EU

Heleen Groenenberg & Heleen de Coninck

IEA Expert Meeting 'Financing CCS projects' 31st May 2007

www.ecn.nl

Appropriate policy for innovation phase?



ECN

EU Emissions Trading Scheme

- Cost-effective instrument, if strong incentive given
- However, if EUA prices remain low:
  - Preference for low-cost abatement options
  - Innovation market failure
  - ETS unlikely to lead to CCS deployment

→ Need for complementary policies

ECN

Complementary policies

- Public financial support (most likely MS level)
  - Investment support
  - Feed-in subsidies
  - CO_2 price guarantee
- Low-carbon portfolio standard with tradable certificates (most likely EU level)
- CCS obligation (EU level)
- (Public-private partnerships)

Investment support

- Early demonstrations, pipeline network
- Most likely MS level, any sector
- Environmentally effective
- Reduction of financial uncertainty for operator
- Government has influence on investment decisions
- Possibly high costs
- Poor incentive for further innovation or cost reduction

ECN

Feed-in subsidies

- Widely applied to promote renewables towards commercialisation
- Most likely MS level, usually power sector
- Environmentally effective
- Reduction of financial uncertainty for operator
- Poor incentive for further innovation or cost reduction
- Risk of overshooting target and high costs

CO_2 price guarantee

- Buy CCS-generated EUAs at fixed price (high enough to set of CCS)
- Most likely MS level, any sector
- Environmentally effective
- Reduction of financial and CO_2 market uncertainty for operator
- Poor incentive for further innovation or cost reduction

Low-carbon portfolio standard

- Source minimum % of power from specified sources
- May be combined with tradable certificates
- Applied for renewables in some MS and US States
- EU level, power sector
- Environmentally effective if target is strong
- Incentive for further innovation and cost reduction
- Risk for operator (technological, financial, and availability of storage)
- Complex and administratively challenging

ECN

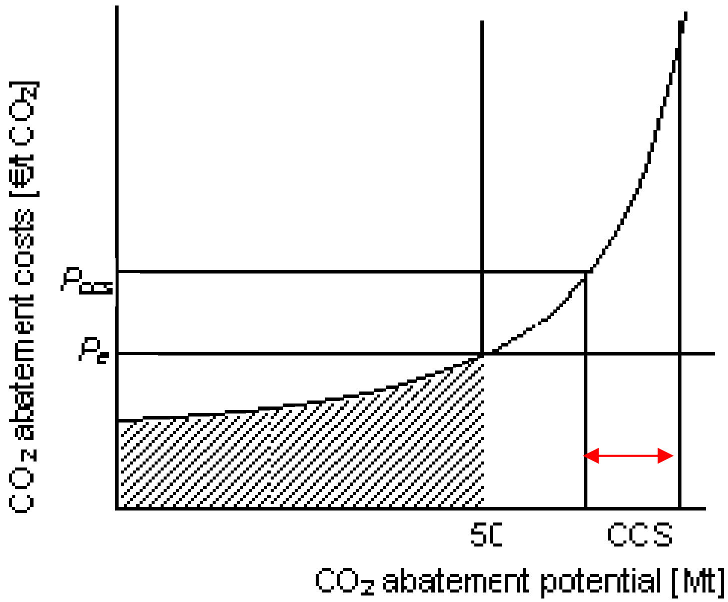
CCS obligation (2020 →)

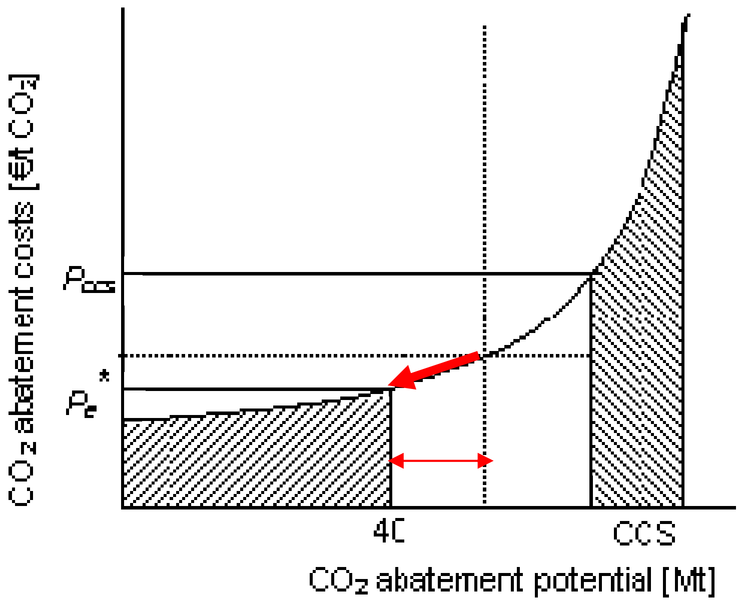
- Also e.g. retrofit (2020-2040), capture ready (2012→)
- Targeted sector: power and/or other point sources
- EU level, any sector (but likely power sector)
- Environmentally effective
- Strong incentive for further innovation and cost reduction
- Easy to monitor and determine compliance
- Risk for operator (technological, financial availability of storage)

Public private partnerships

- Not enabling full CCS,
- Potentially useful for realising pipeline infrastructure
  - if there are efficiency gains on supra-MS scale
  - if it is beyond interest individual industries or projects
- Possible analogues to Trans-European Energy Networks

Interaction
additional incentives ↔ ETS





Interaction additional incentives ↔ ETS (ctd)

- MS incentives small scope; less market impact
- *Any* additional instrument will reduce demand for EUAs and lower CO_2 market price *unless* cap is lowered accordingly

→ *Lower cap in MS*

→ *New entrants: no allowances*

Other interactions

Renewable energy:

Diversion of resources + attention

→ *% renewables contingent on CCS implemented*

Innovation:

Cost reduction discouraged

→ *Portfolio standard, obligation*

Electricity market:

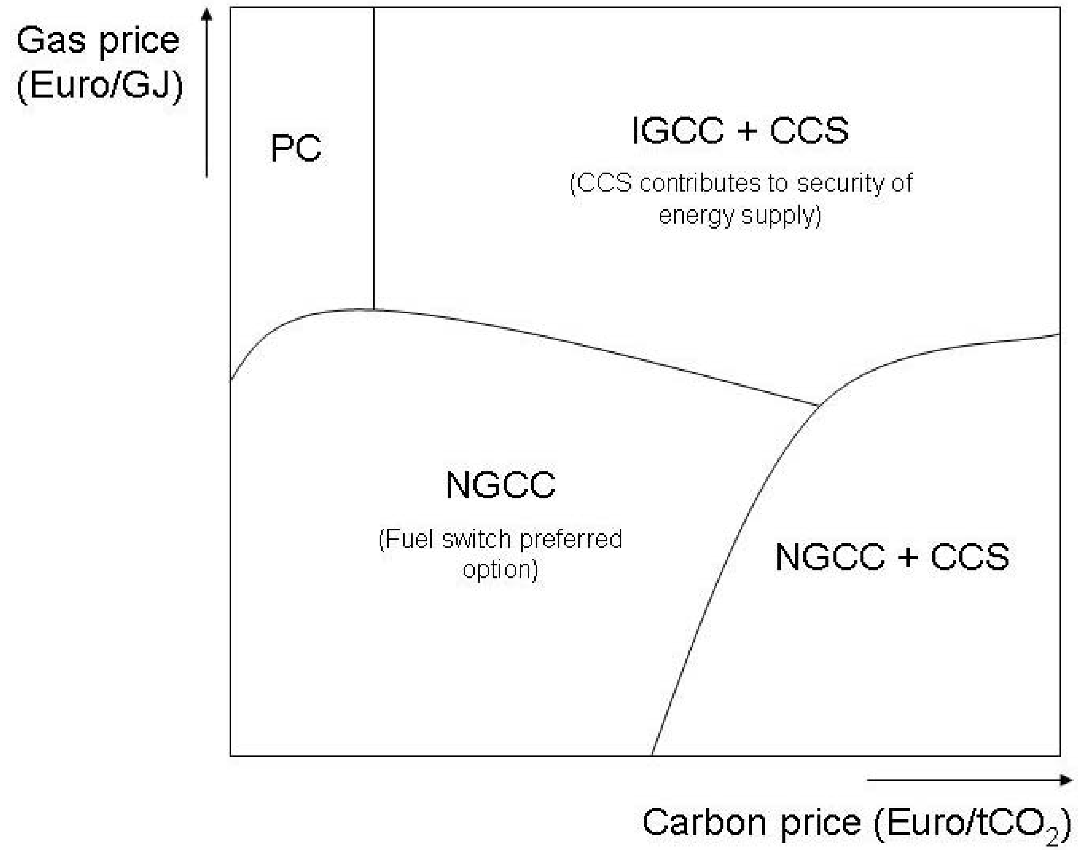
Technical reasons for placing CCS as baseload option,

however O&M cost lead to higher electricity price

Security of energy supply:

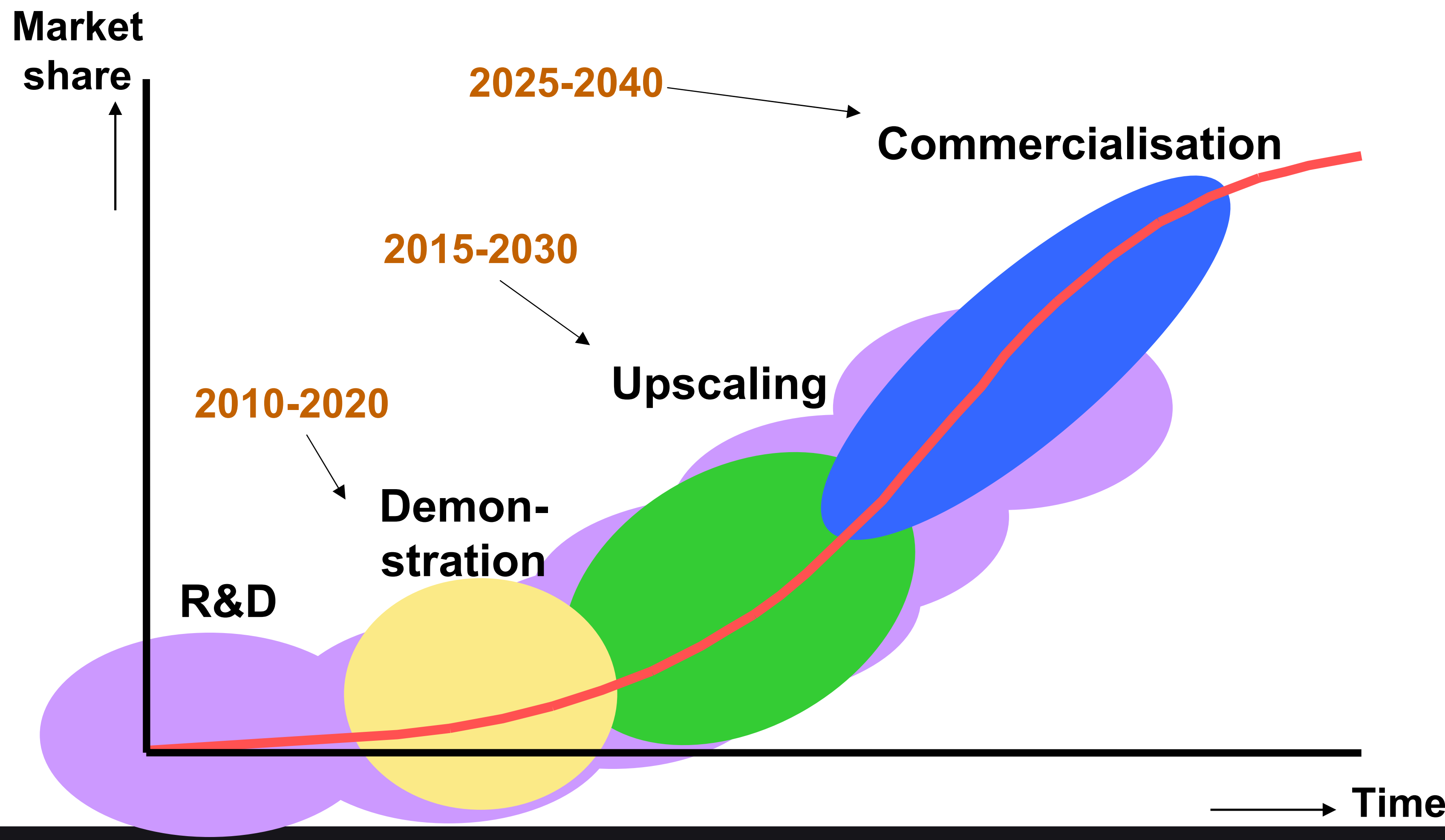
CCS only contributes if gas prices spur a shift to coal, and CO_2 prices are high enough for CCS

Impact CCS → security of supply



(Damen 2007)

Timing of policies



Timing of policies

	Demonstration 2010-2020	Up-scaling 2015-2030	Commercialisation 2025-2040
ETS (weak)	Yes	Yes	Yes
ETS (strong)	Yes	Yes	Yes
Investment support	Yes	No	No
Feed-in subsidy	Yes	Yes	No
CO_2 price guarantee	Yes	Yes	No
Portfolio + certificates	No	Yes	Yes
Obligation	No	Yes	Yes

Multi-criteria analysis

	Effectiveness	Risk + cost burden	Consistency	Feasibility (NGO view)
ETS (weak)	-	0	+	+
ETS (strong)	+	+	+	+/-
Investment support	+	-	0	-
Feed-in subsidy	+	-	0	-
CO_2 price guarantee	+	-	0	-
Portfolio + certificates	+	+	0/-	+/-
Obligation	+	+	0/-	+

Conclusions

- ETS cost-effective incentive for CO_2 reduction, however market failures and low prices may hinder CCS deployment
- Additional incentives needed to advance large-scale CCS deployment
- MS policies may tend to divert resources from renewables, place financial risk with national governments and do not provide incentives for innovation
- EU-wide structural policies preferable, possibly complemented by MS policies in demonstration phase
- Revision of State Aid rules required
- Interaction with ETS requires cap adjustment

Thank you

Heleen Groenenberg: groenenberg@ecn.nl
Heleen de Coninck: deconinck@ecn.nl

Kananaskis, Alberta Meeting

Malcolm Wilson
University of Regina
Canada

Purpose

- Intent to bring together industry leaders from western Canada and western US
- Limited government involvement
- Evaluate the potential to deliver commercial demonstration facilities for capture and storage
- Determine role of government and industry.

In attendance

- Senior industry representatives from:
  - Pipeline companies
  - Utilities
  - Oil companies
  - Finance and insurance
  - Coal miners
  - Technology suppliers
- Also present CCSA and IEA Greenhouse Gas R&D Programme

Major outcomes - opportunities

- This is the “era” of coal
- EOR is an opportunity not a solution
- Industry can take leadership
- The opportunity crosses political boundaries and sector boundaries

Major outcomes - challenges

- Harmonised regulatory regimes
- Public support (the public must empower government and be willing to pick up the cost)
- Human capacity constraints
- There is a cost

Approaches

- Market forces will drive the development:
  - Cap and trade unlikely
  - Emissions trading of some form, perhaps continent wide
  - Taxation not ruled out yet
- Role for government, but unclear as to how invasive
- Learn from the garbage industry

Discussion points

- The “stick” approach – BAT, other regulation etc
- The “carrot” – financial incentives
- The garbage industry model
- The “Wheat Board” model
- The trading approach

Still a need to:

- Continue to drive down costs of all stages in the "carbon chain"
- Demonstrate at commercial scale
- Performance guarantees
- Compensate early adopters – must have preferential dispatch
- Train people
- Regulatory issues – pore space ownership, liability etc
- Acceptable MMV
- Insurance

Some definite outcomes

- Commitment to another forum – in Colorado – under Energy Futures Network
  - Contact Doug James dougjames@shaw.ca 403.681.1163
- Creation of a North American CCSA chapter
  - Contact Malcolm Wilson malcolm.wilson@uregina.ca 306 337 2287/2296

In addition

- Several sub-groupings occurred as a result of the meeting – for example
- A Montana – Saskatchewan initiative was proposed
  - Development of a modular PC unit for test on a Montana or Saskatchewan coal unit
  - Major saline aquifer test in Montana
  - 1000 tonne per day commercial test
  - Best available technology

Contact

- Malcolm Wilson
  - University of Regina
  - 001-306-337-2287/2296
  - Malcolm.wilson@uregina.ca
- Harry Audus
  - IEA Greenhouse Gas R&D Programme
  - www.ieagreen.org.uk
- Copies of Kananaskis report available from above or electronically

Demonstrating CCS in Australia
- The CO2CRC Otway Project -

Dr Peter Cook

Chief Executive

Cooperative Research Centre for

Greenhouse Gas Technologies (CO2CRC)

INTERNATIONAL ENERGY AGENCY

London, England,

31 May 2007

The CO2CRC Otway Project, Victoria, Australia

1 CO2CRC and the national setting for CCS
2 The concept of the Otway project
3 The site
4 Land access
5 Site characterization and due diligence
6 Corporate structure
7 Costs and funding
8 Legal, regulatory and licensing issues
9.Monitoring and verification
10. Risk, insurance and liability
11 Where to from here?

1. CO2CRC

CRC Australia
Australian Government Geoscience Australia
CSIRO
Shell
bp
Chevron
xstrata coal
RIO TINTO

THE UNIVERSITY OF ADELAIDE AUSTRALIA
THE UNIVERSITY OF MELBOURNE
Schlumberger
bhpbilliton
NZ RESOURCE CONSORTIUM

MONASH University
SOLID ENERGY Coals of New Zealand
ANGLO AMERICAN
Origin energy

UNSW
Curtin University of Technology
WOODSIDE AUSTRALIAN ENERGY
NSW DEPARTMENT OF PRIMARY INDUSTRIES
Victoria The Place To Be

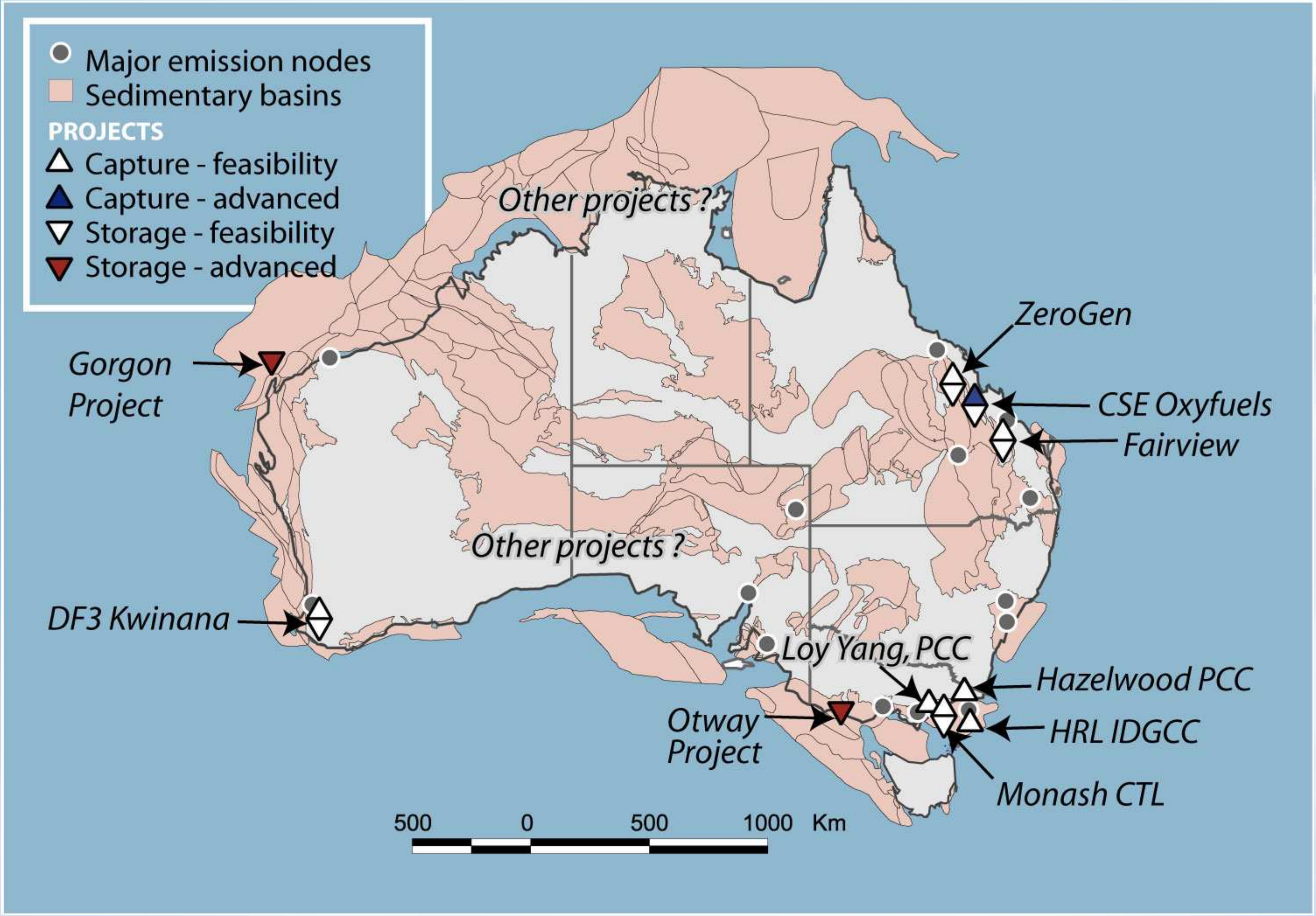
FOUNDATION FOR RESEARCH SCIENCE & TECHNOLOGY
ACARP Australian Coal Association Research Program
ConocoPhillips
STANWELL CORPORATION LIMITED

Supporting participants: Australian Greenhouse Office | Australian National University |
| CANSYD | Meiji University | The Process Group | University of Queensland |

www.co2crc.com.au

CO2CRC

1.The national setting: Projects and potential projects in Australia involving capture and/or storage of carbon dioxide



CO2CRC

Low Emissions Technology Demonstration Fund (LETDF)

LETDF established by the Australian Government to support industry-led large scale demonstration of low emissions technologies. Total expenditure approx A$3 B (500M Govt)

Projects currently funded under LETDF include:

- **A$ 445M ($75M Govt) Fairview Coal Seam Gas Power Station with PCC and ECBM**
- **A$370M ($50M Govt) Hazelwood Power Station Lignite Drying with PCC**
- **A$750M ($100M Govt) HRL Integrated Drying Gasification Combined Cycle Power Station with pre comb capture**
- **A$1B? ($60M Govt) Gorgon LNG Project with CCS**
- **A$180M ($50M Govt) CS Energy's Callide A Oxy-fuel Power Station with CCS**
- **A solar Power plant**

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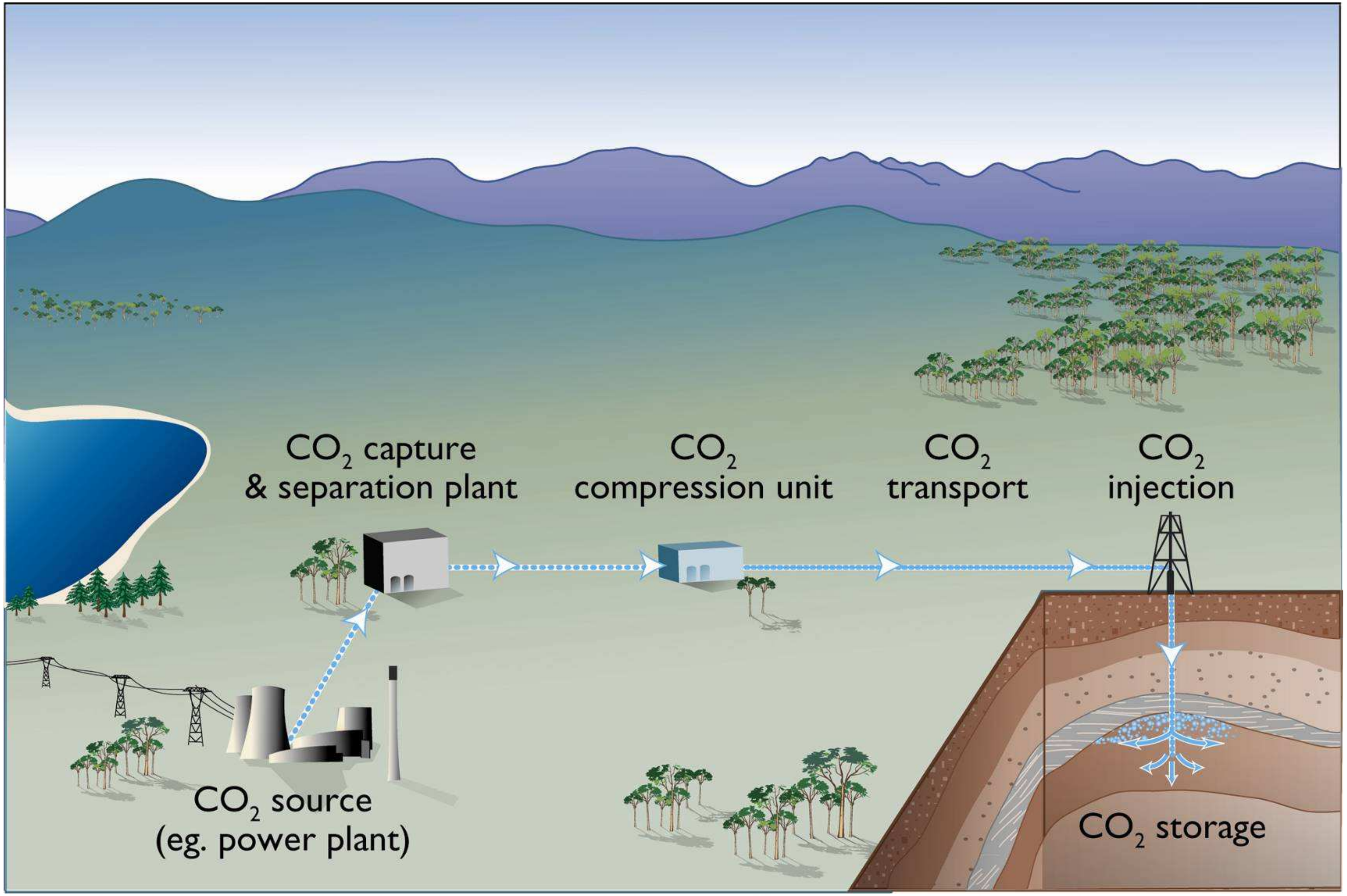
Major Australian RD&D Initiatives

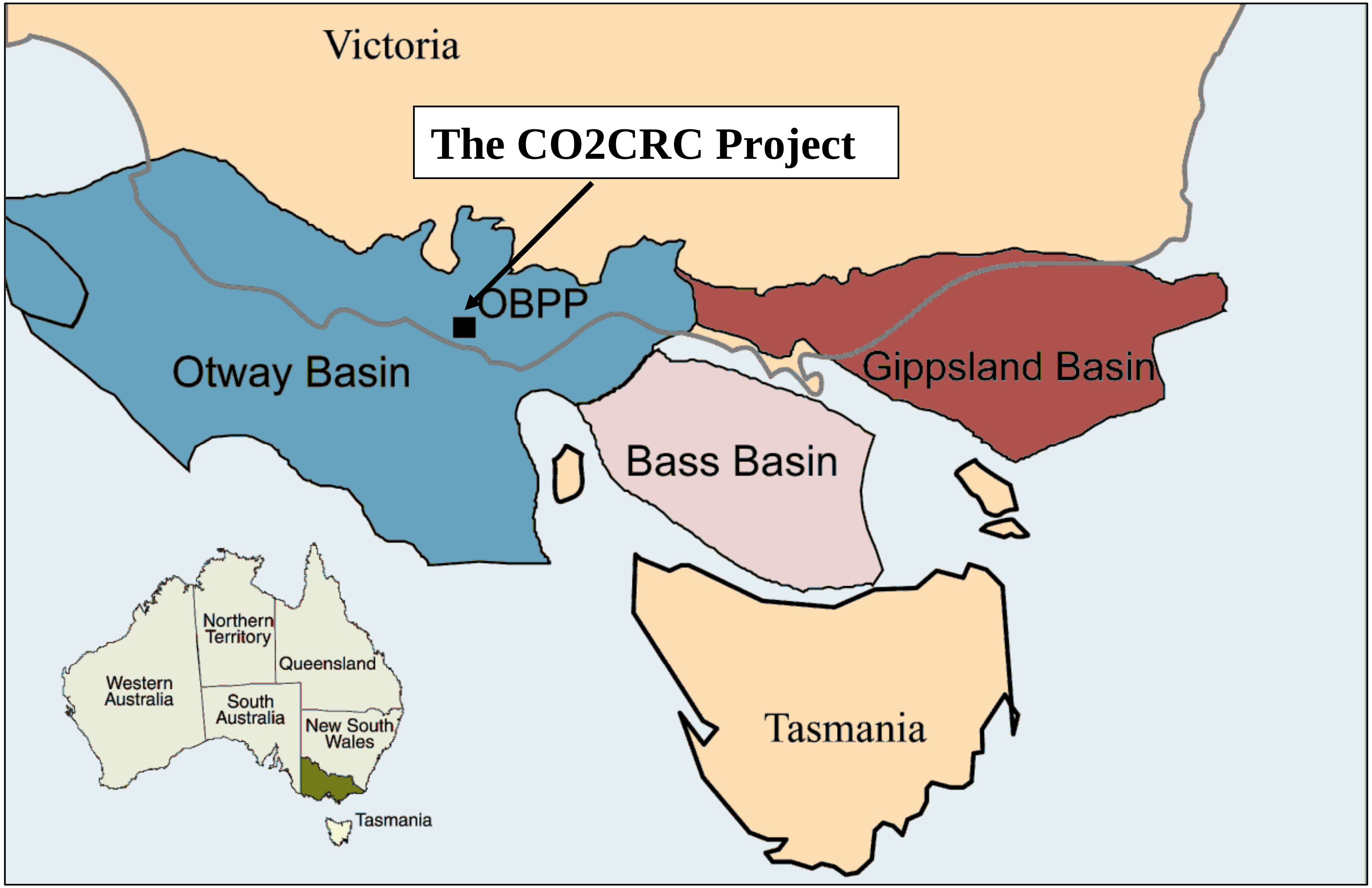
- Victorian Energy Technology & Innovation Strategy (ETIS)
  - A$ 161 million research funds for both brown coal and renewables projects
- Qld Clean Coal Fund
  - A$ 300 million government funding for low emission technologies from black coal, including CCS
- Western Australian Low Emission Energy Development 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$1B over 10 years through a voluntary levy

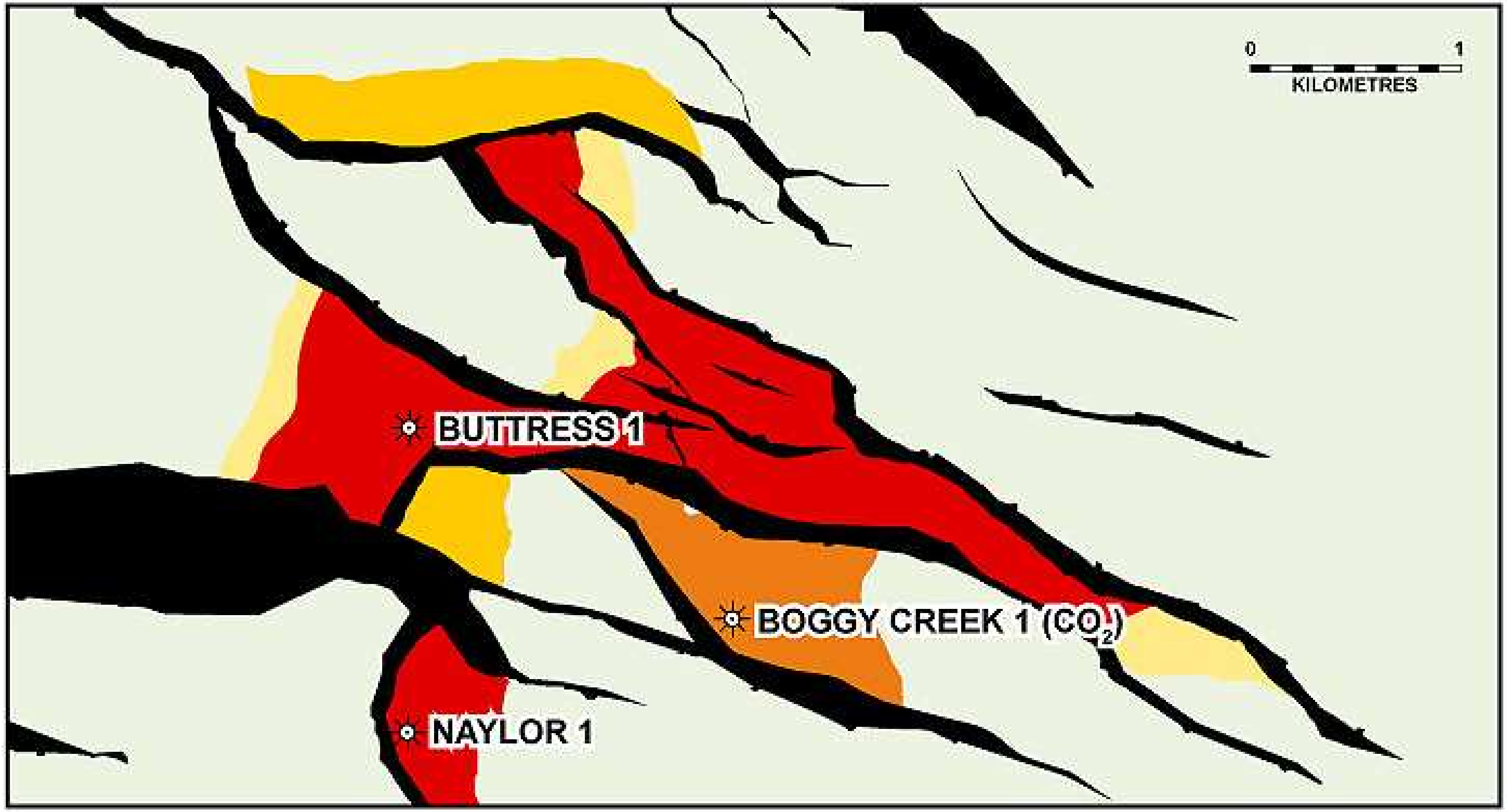
2. The Concept:
Demonstrating the Carbon Capture, Transport & Storage Chain



3. The Site


Victoria
The CO2CRC Project
OBPP
Otway Basin
Gippsland Basin
Bass Basin
Tasmania
Northern Territory
Queensland
Western Australia
South Australia
New South Wales
Tasmania

The site is in an oil and gas producing area, with lots of small fields and compartmentisation by sealing faults



CO2CRC

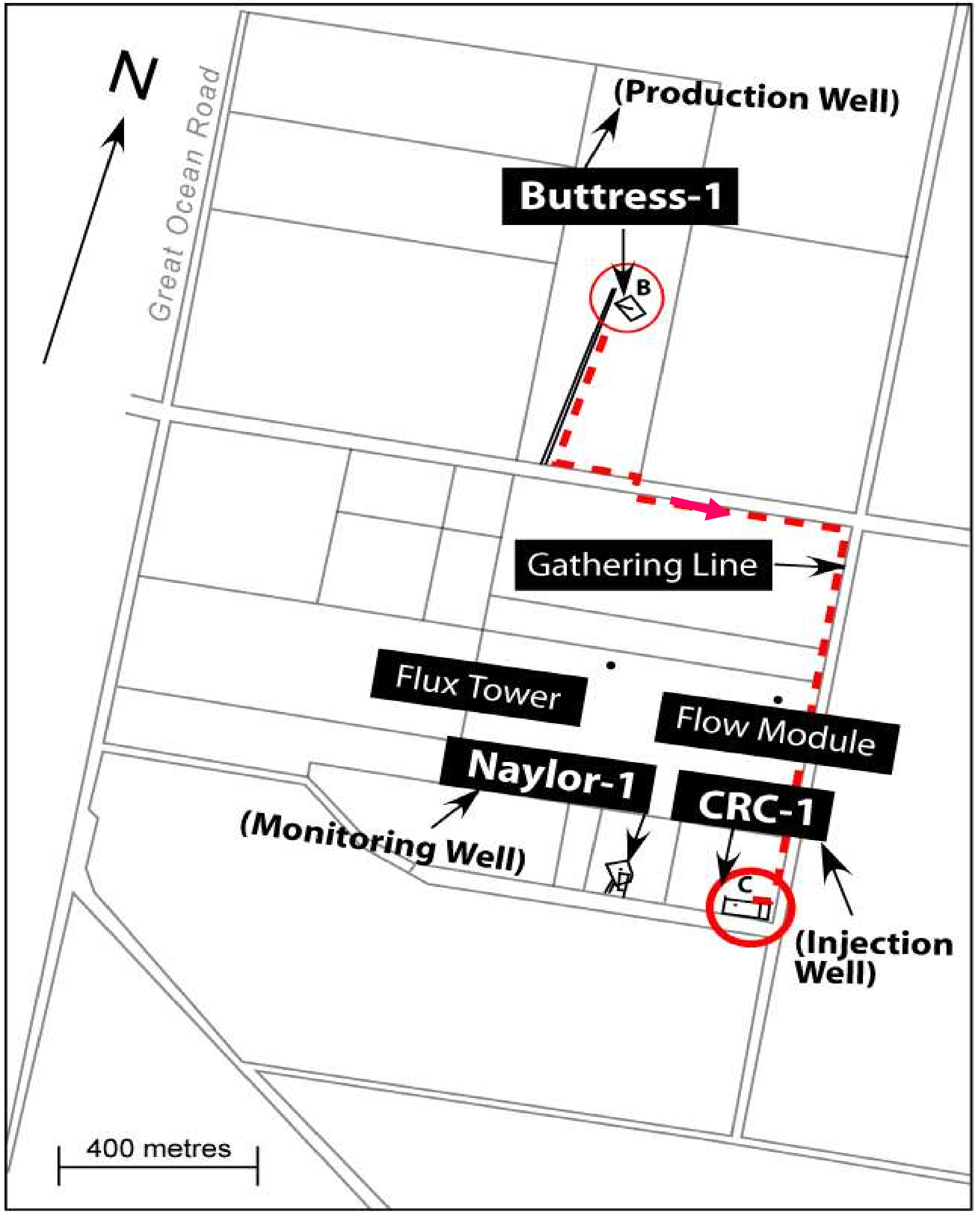
Perhaps the only research project anywhere with its own dedicated source of CO_2 - from the Buttress Well

CO2CRC

Testing the CO_2 source was a significant issue

Buttress produces 80% molar carbon dioxide and 20% methane, with reserves of approx 250,000 tonnes

4. Accessing the land

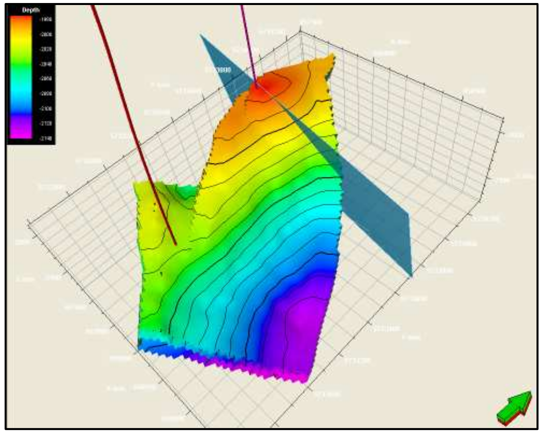


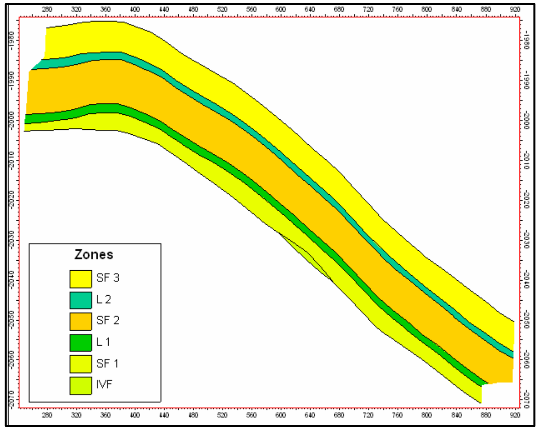
Accessing the facilities for the CO2CRC Otway Project, Victoria.

Access to the site and the subsurface was through purchase of the petroleum tenements, negotiations, and through declaration of a "project of state significance"

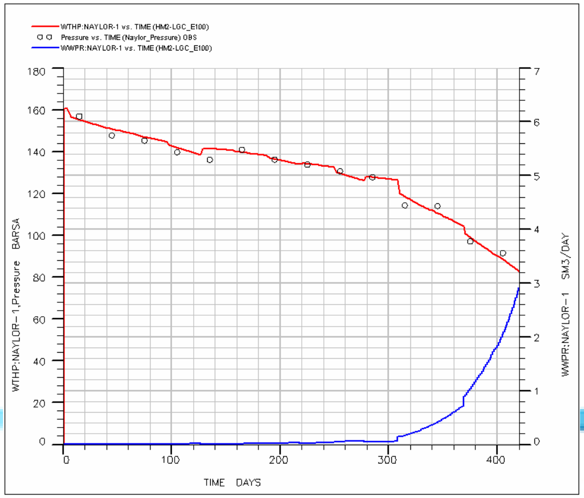
5. Site Characterisation and due diligence

- Rigorous multi-disciplinary approach based on established oil field processes validated through peer reviews.





- Build detailed reservoir model using current state of the art modelling packages. Availability of seismic data was crucial

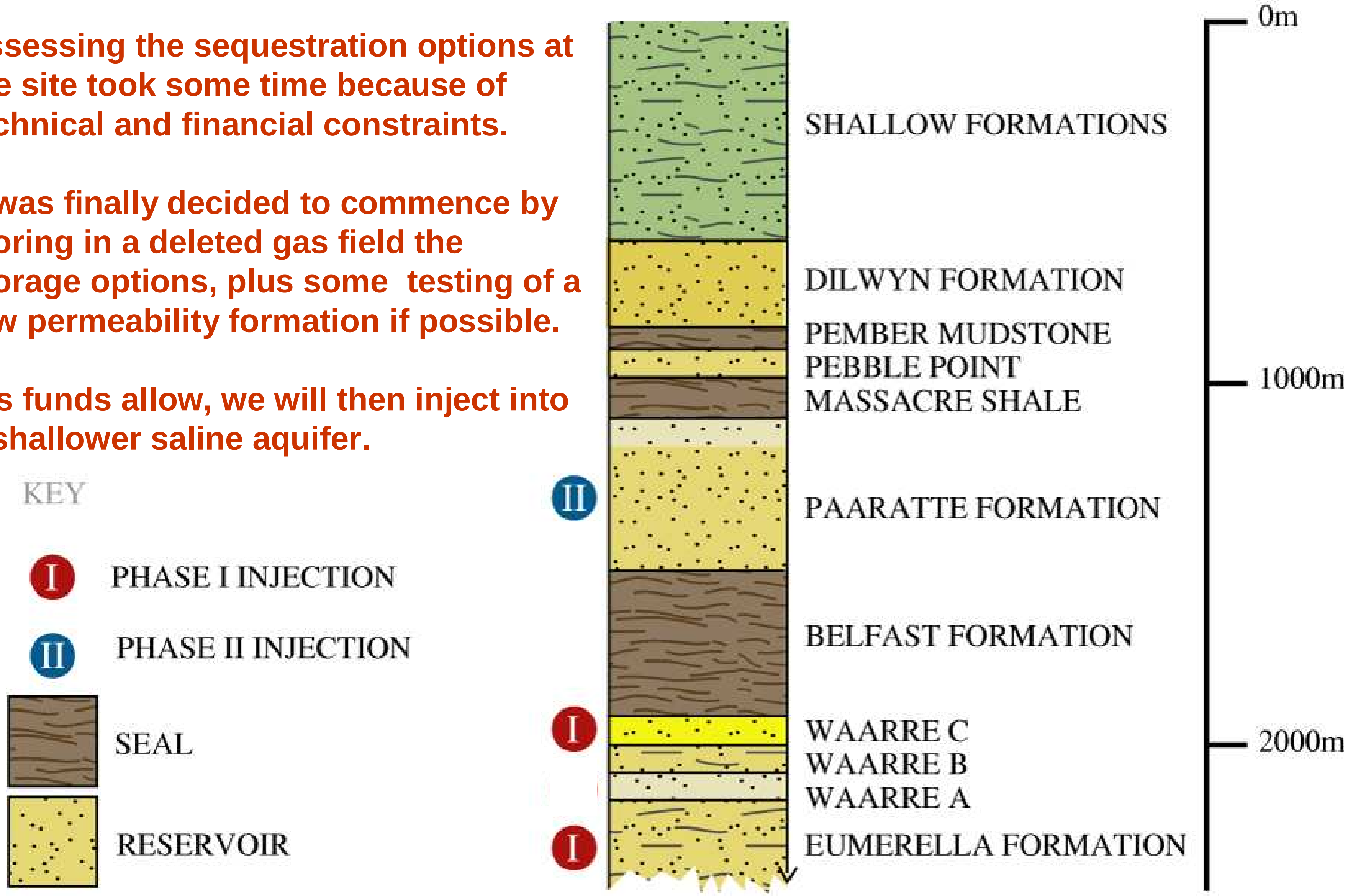


- History match with actual production data to validate model.

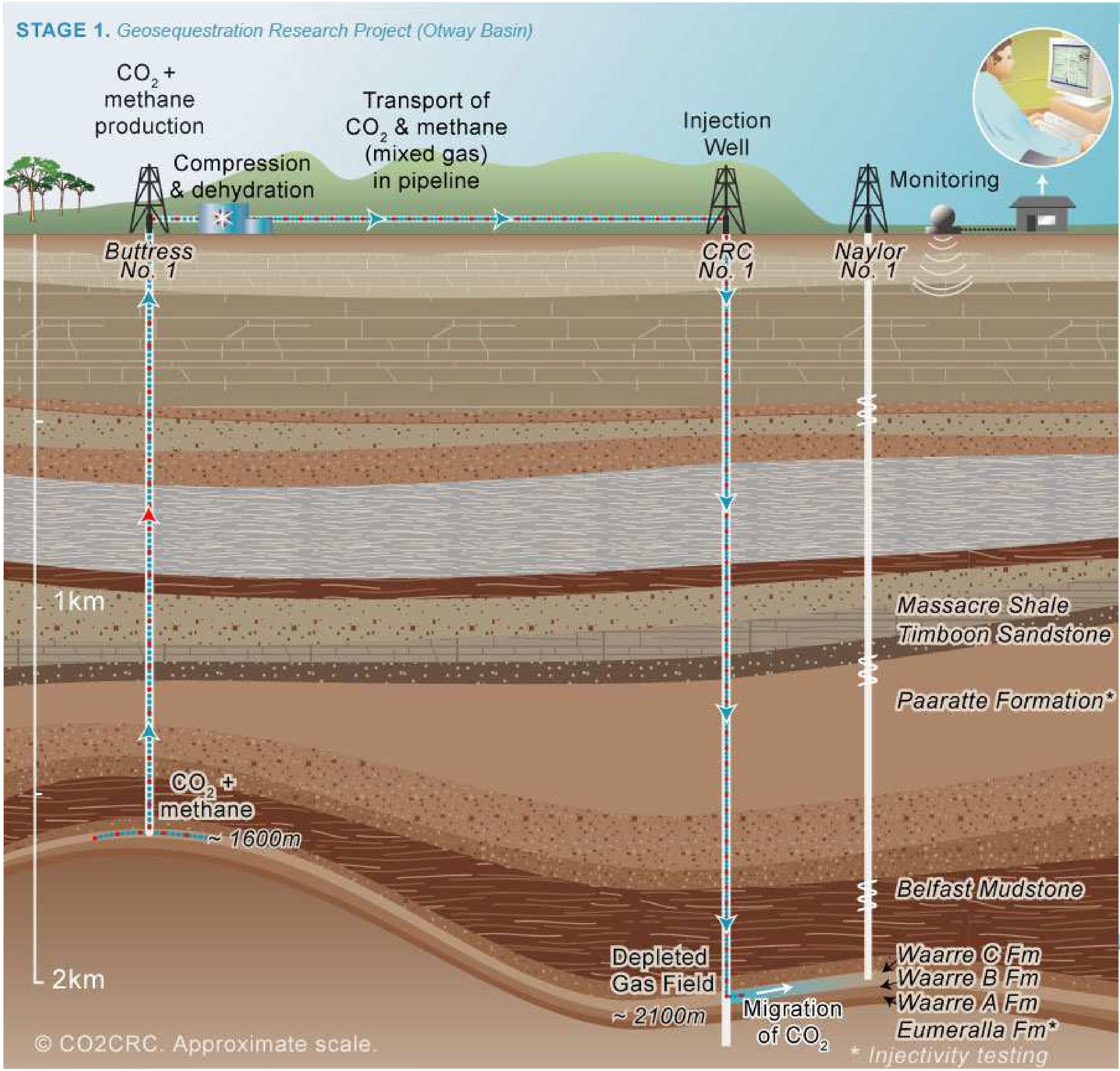
Assessing the sequestration options at the site took some time because of technical and financial constraints.

It was finally decided to commence by storing in a deleted gas field the storage options, plus some testing of a low permeability formation if possible.

As funds allow, we will then inject into a shallower saline aquifer.



CO2CRC



CO2CRC Geosequestration Research Project (Otway Basin)

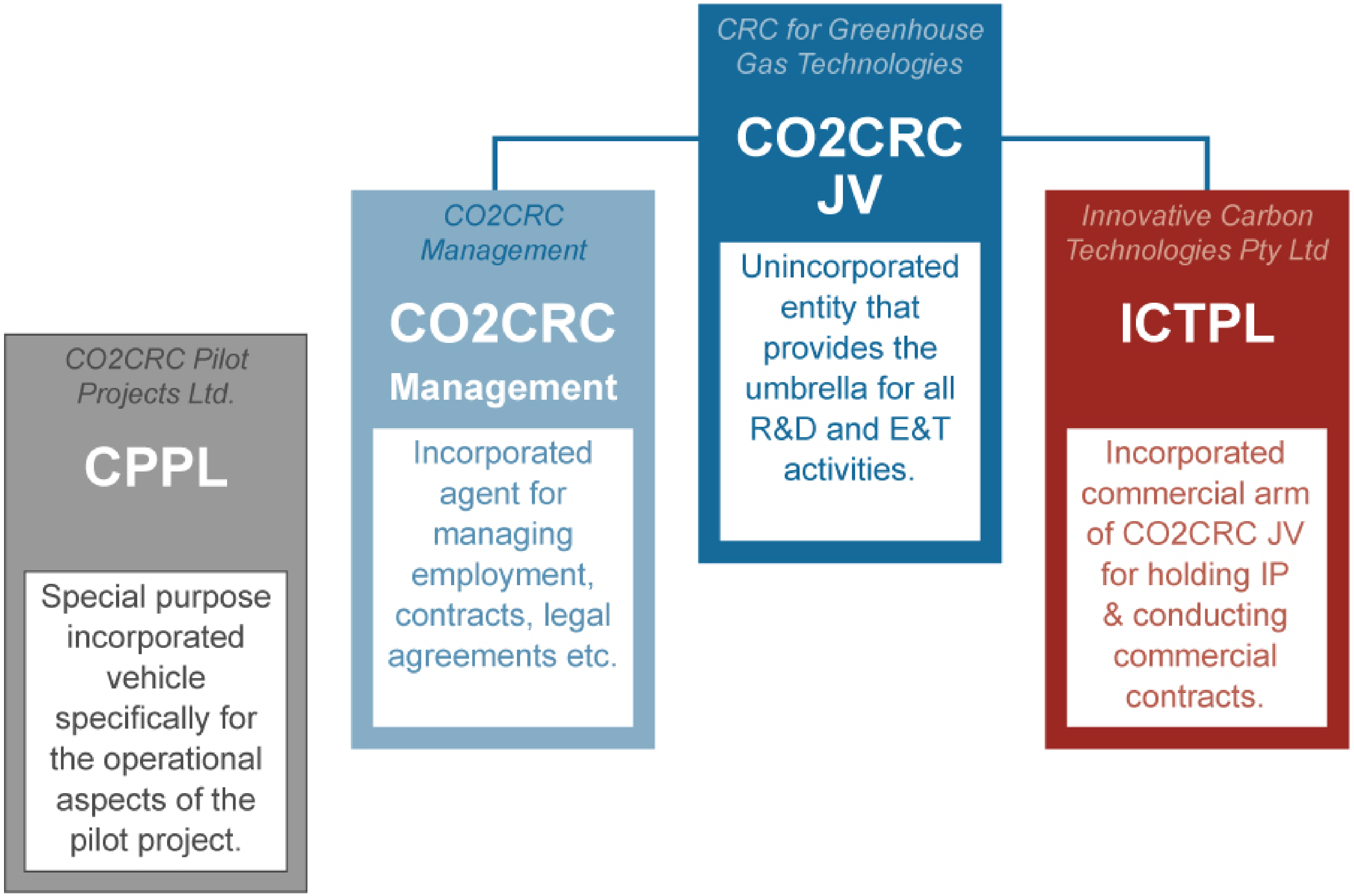
Stage 1

This involves:

- **Production of CO_2 rich gas**
- **Compression**
- **Injection into Waarre Fm**
- **M&V**

CO2CRC

6. Corporate structure



CO2CRC

CO2CRC JV and related entities

CRC for Greenhouse Gas Technologies

CO2CRC JV

Unincorporated entity that provides the umbrella for all R&D and E&T activities.

CO2CRC Management

CO2CRC Management

Incorporated agent for managing employment, contracts, legal agreements etc.

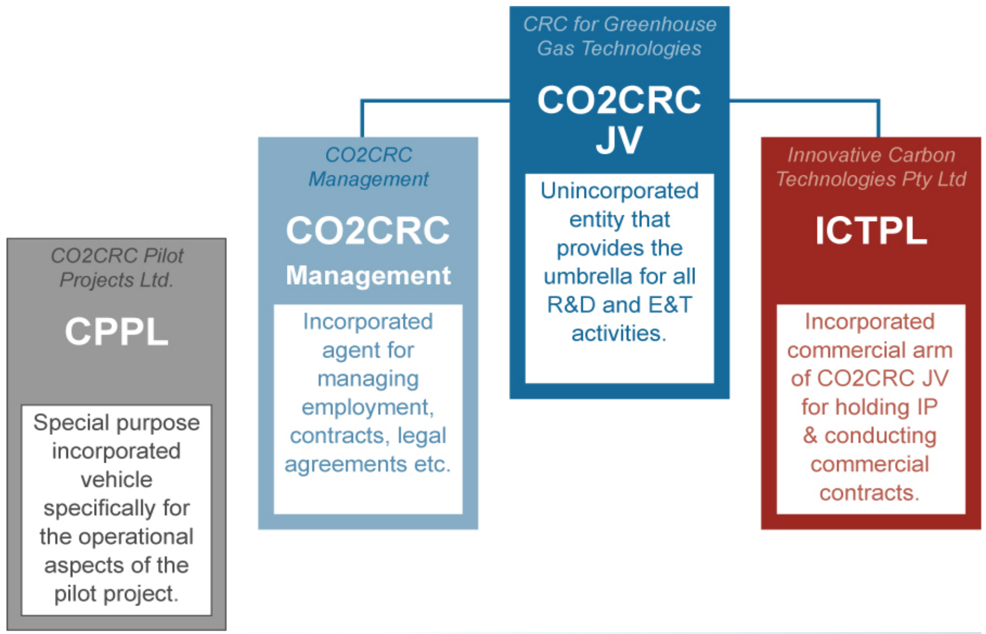
Innovative Carbon Technologies Pty Ltd

ICTPL

Incorporated commercial arm of CO2CRC JV for holding IP & conducting commercial contracts.

CO2CRC Pilot Project Ltd (Operating Company)

Shell, bp, Chevron, xstrata coal, RIO TINTO, Schlumberger, bhpbilliton, SOLID ENERGY Coals of New Zealand, WOODSIDE, ANGLO AMERICAN



7. Costs and funding

- *Management:*
  - *Operations:* **CO2CRC Pilot Project Ltd (CPPL)**
  - *Research:* **CO2CRC Joint Venture (JV)**
  - *Contracts:* **CO2CRC Management Pty Ltd (CMPL)**
  - *IP:* **Innovative Carbon Technologies Pty Ltd (ICTPL)**
- *Cost:* **$A 30M plus (Govt funds: $A 20M; Industry: $A 7M; CO2CRC: $A 3M) + $A 20-30 (Stage 2); the structure of some Government funding posed challenges for a "real world" project, but Government funding crucial to the project.**
- **Rising costs and non availability of gear and people during the course of the project was of great concern and led to significant project reconfiguration and delays**
- **Funding Partners:CO2CRC, Governments, industry, SMEs, research providers (additional in kind); DoE/LBNL (approx $2 M); ARC (in kind);**
- *International:* **CSLF-endorsed project. IEA peer reviewed**

Funders

Current Members of CO2CRC Pilot Project Ltd

Other Financial Supporters

8. Legal, regulatory and licensing issues

- **A legal regulatory and licensing regime does not exist for CCS – work in progress in Australia onshore and offshore**
- **Petroleum, environmental, water, planning, R&D regulations all impact on the project**
- **We work closely with supportive state authorities but inevitably progress is slow, which adds to the cost**
- **Legal costs have been far in excess of estimates**
- **But our identification of legal and regulatory impediments is seen by industry as a very important outcome from the project**

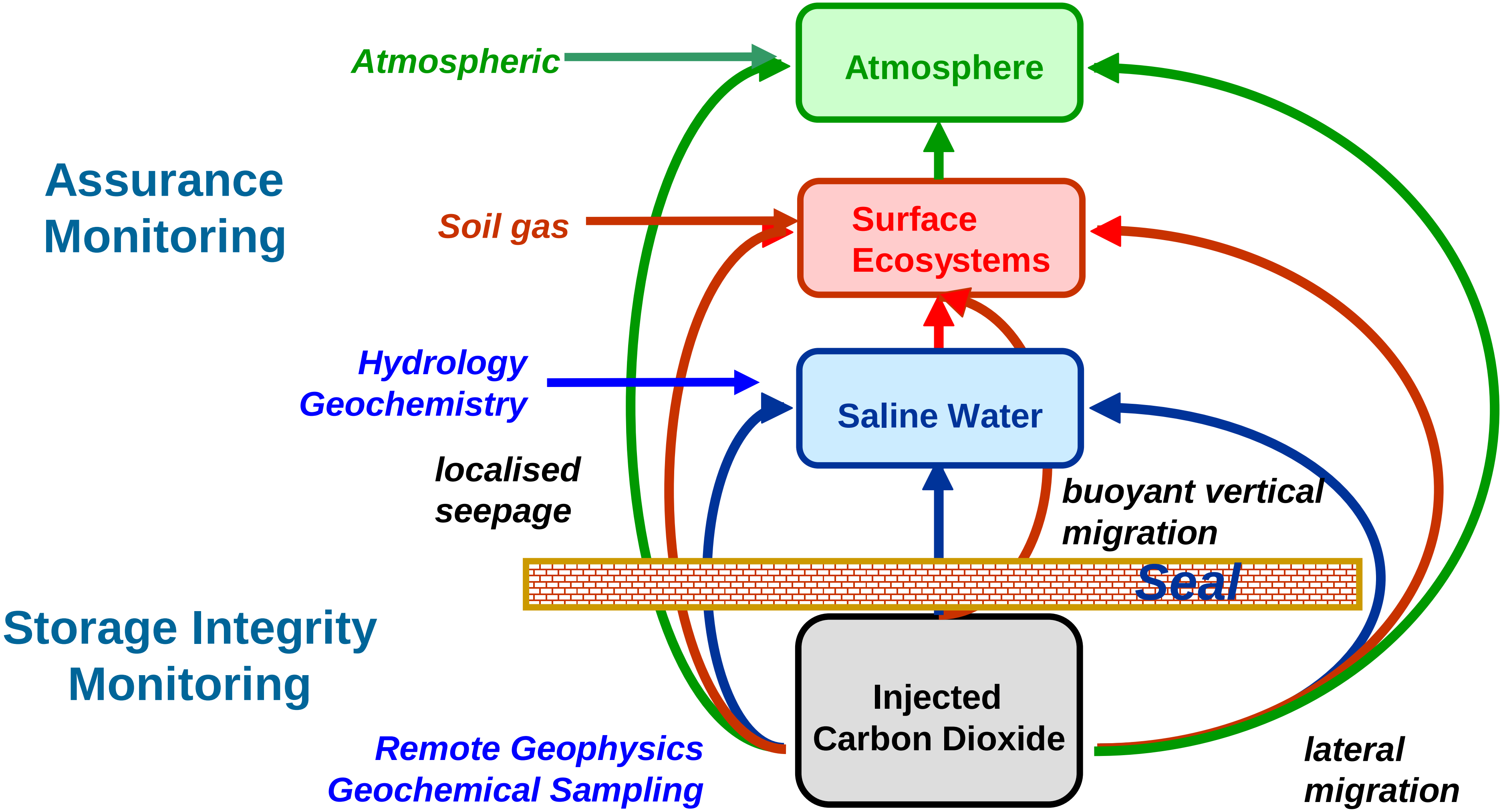
CO2CRC

Regulatory and licensing issues addressed as part of the Otway Project

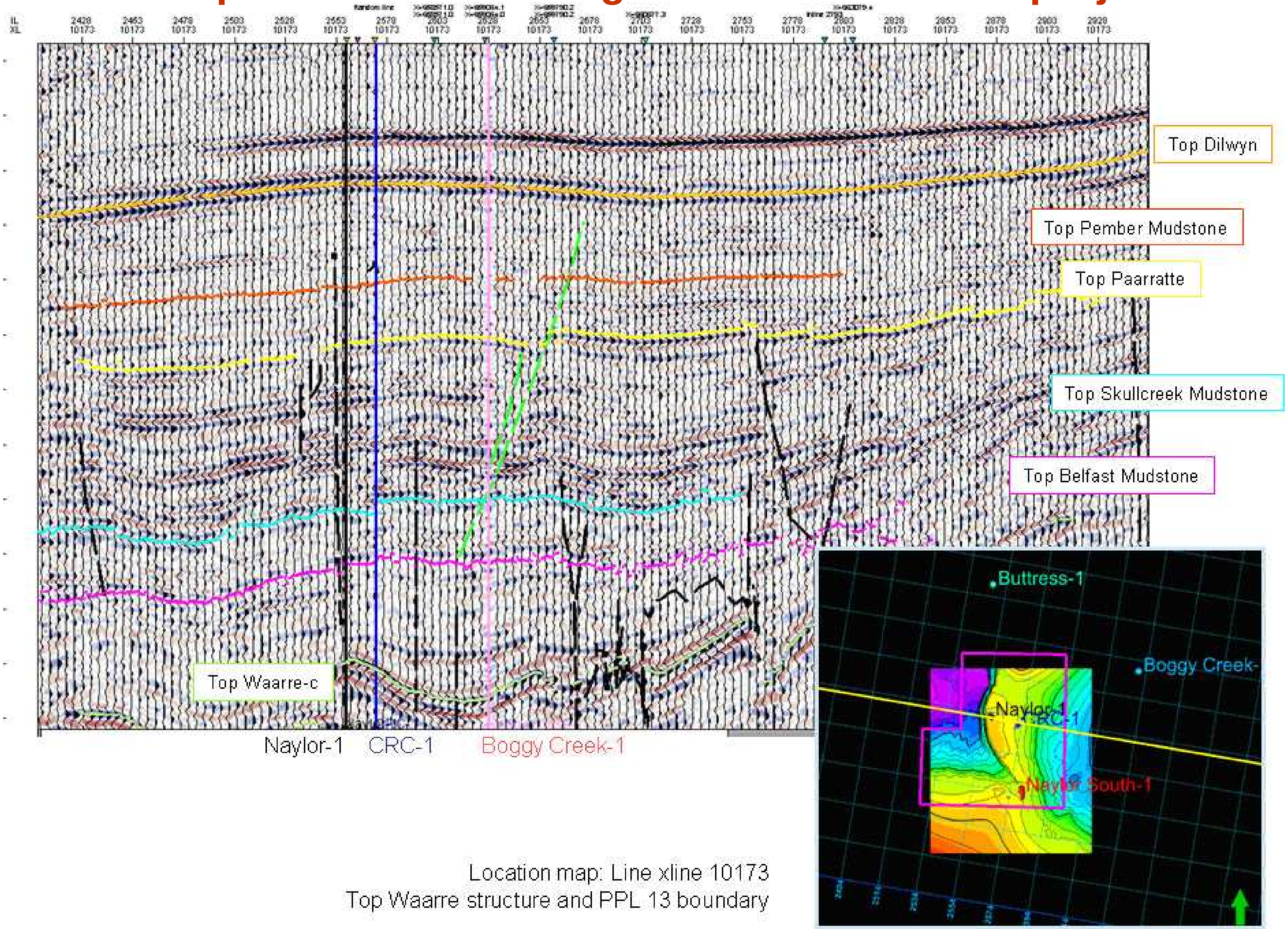
Activity	Approvals/Permits *(Regulator)*	Application Process
Drilling injection well	Drilling License *(DPI)*	Well drilled under exploration license.
Storage of CO_2	Storage Approvals *(EPA, DPI, SRW, LA)*; Biodiversity Act (EA)	- Environment Protection Act 1970: RD&D Approval
Production of CO_2 (Buttress) Injection of CO_2 (Naylor)	Production Plan Disposal approval, storage plan (*SRW, DPI)*	- Petroleum Act - Water Act - Compensation agreement, consent to land access
Transport processing of CO_2, (1) compressor, (2) gathering line, (3) other facilities (shed, etc.)	Planning approval, gathering line approval (*DSE, DPI, LA)*	- Petroleum Act 2000 (DPI) - Ministerial Amendment request of the Planning & Environment Act - Exemption of Pipeline Act - Cultural Heritage Act - Compensation agreement, consent to land access
Monitoring activities: (1) Atmospheric, (2) Water wells, (3) Down-hole Monitoring	Planning approval, compensation agreement (*DSE*), access rights (*DSE, LA)*	- Ministerial Amendment request of the Planning & Environment Act 1987 (*LA/DSE*) - Consent to use water bores - Compensation agreement, consent to land access

SRW: Southern Rural Water **DSE**: Dept. of Sustainability & Environment **LA:** Local Authority (Moyne Shire)
EPA: Environment Protection Authority **DPI:** Victorian Dept. of Primary Industries **EA**;Envir Australia

9. Monitoring and Verification is a key part of the project



Seismic profiling will be one of the sub surface monitoring methods It requires access throughout the time of the project.



Location map: Line xline 10173
Top Waarre structure and PPL 13 boundary

Atmospheric monitoring requires access & "permanent" facilities

Flux Tower

- To detect, attribute and quantify CO2 emissions to the atmosphere
- Measurements of CO_2 concentration (continuous)
- Measurements of other gases and isotopes (including tracers)
- Measurements of CO_2 fluxes
- Interpretation with transport and dispersion models
- Integration with subsurface work - soil, hydro, geochemistry….

Lo-Flo*

CO2CRC

International comparison of scope of monitoring

	Geological Data Availability		Baseline data	Reservoir Geochem	Geo-physics	Ground water monitoring		Soil Gas	Atmos	Contain-ment Risk Ass. prior to project start
	Regional	Reservoir				Hydrology	Geochem			
West Texas	✓	Largely confidential		very limited	limited					
Alberta Basin	✓	limited		very limited						
Sleipner	✓	limited	limited		✓					
Weyburn	✓	Largely confidential	✓	✓	✓			limited		
Frio	✓	✓	✓	✓	✓	limited	limited	limited		
Japanese	✓	✓	✓		✓					

International comparison of scope of monitoring

	Geological Data Availability		Baseline data	Reservoir Geochem	Geo-physics	Ground water monitoring		Soil Gas	Atmos	Contain-ment Risk Ass. prior to project start
	Regional	Reservoir				Hydrology	Geochem			
West Texas	✓	Largely confidential		very limited	limited					
Alberta Basin	✓	limited		very limited						
Sleipner	✓	limited	limited		✓					
Weyburn	✓	Largely confidential	✓	✓	✓			limited		
Frio	✓	✓	✓	✓	✓	limited	limited	limited		
Japanese	✓	✓	✓		✓					
CO2CRC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

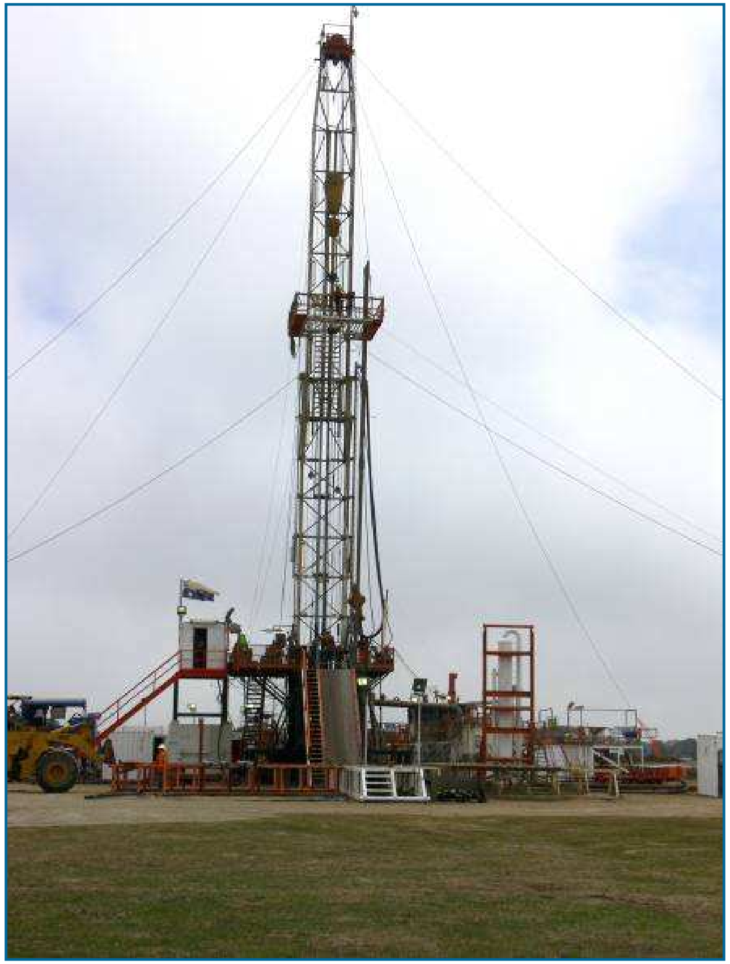
Monitoring and verification reassures the community and the regulators

It validates the models

It also provides the basis for being able to surrender the tenements at the conclusion of the project

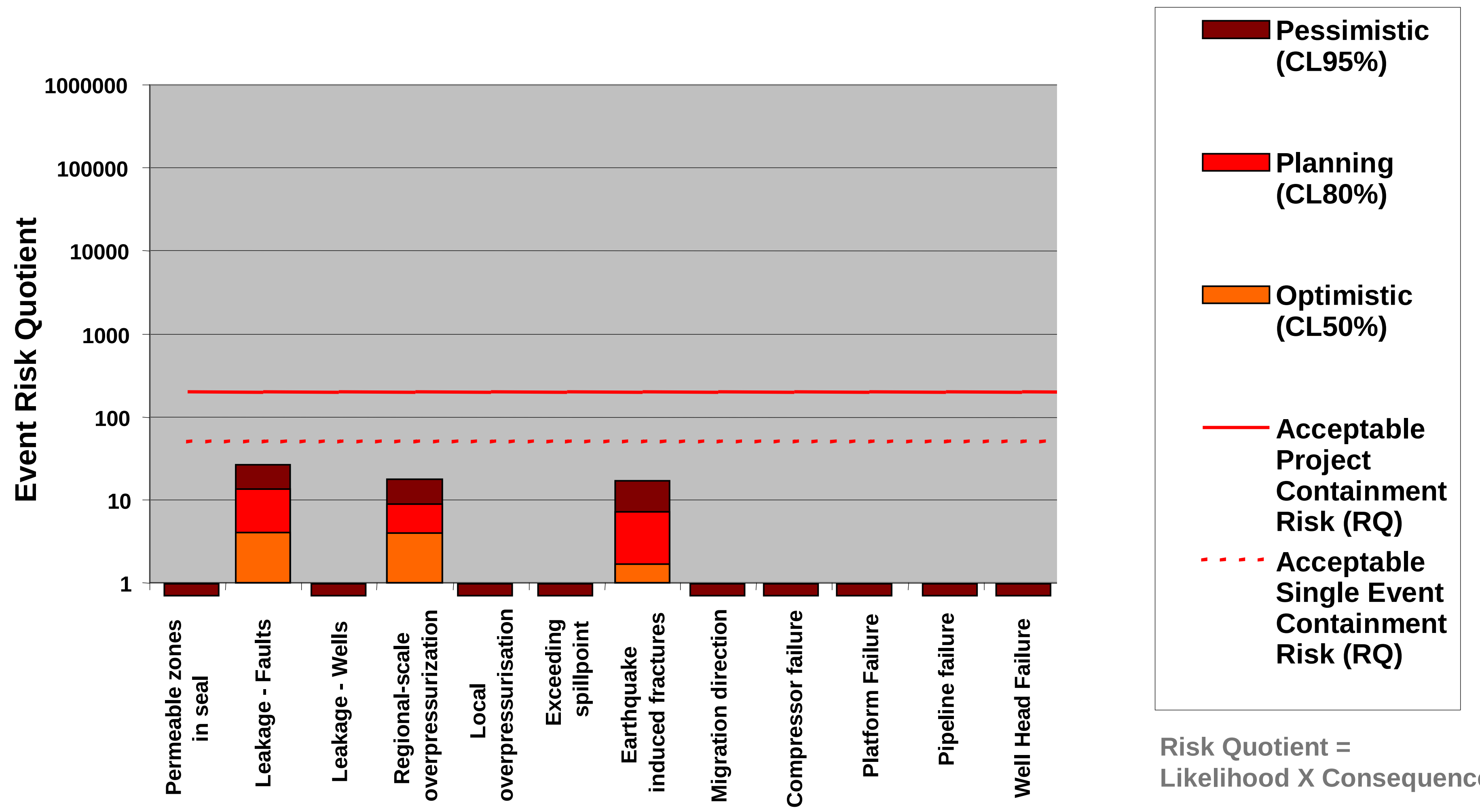
And it may be crucial to any deal regarding liability

10. Risk, insurance and liability



- A challenge to provide quantified risk assessment
- Risk is seen as very low, with greatest risk in the operational phase.
- The risk of the project not proceeding because of community opposition was a concern, which is why we put a lot of effort into community consultation.
- Operational risk is covered by insurance but any claim above the cap is covered by CO2CRC Pilot Project Ltd
- Insurance to 10 years after operations cease

CO2CRC Otway Project Risk Assessment demonstrates low risk



Risk Quotient = Likelihood X Consequence

CL= Confidence Limit

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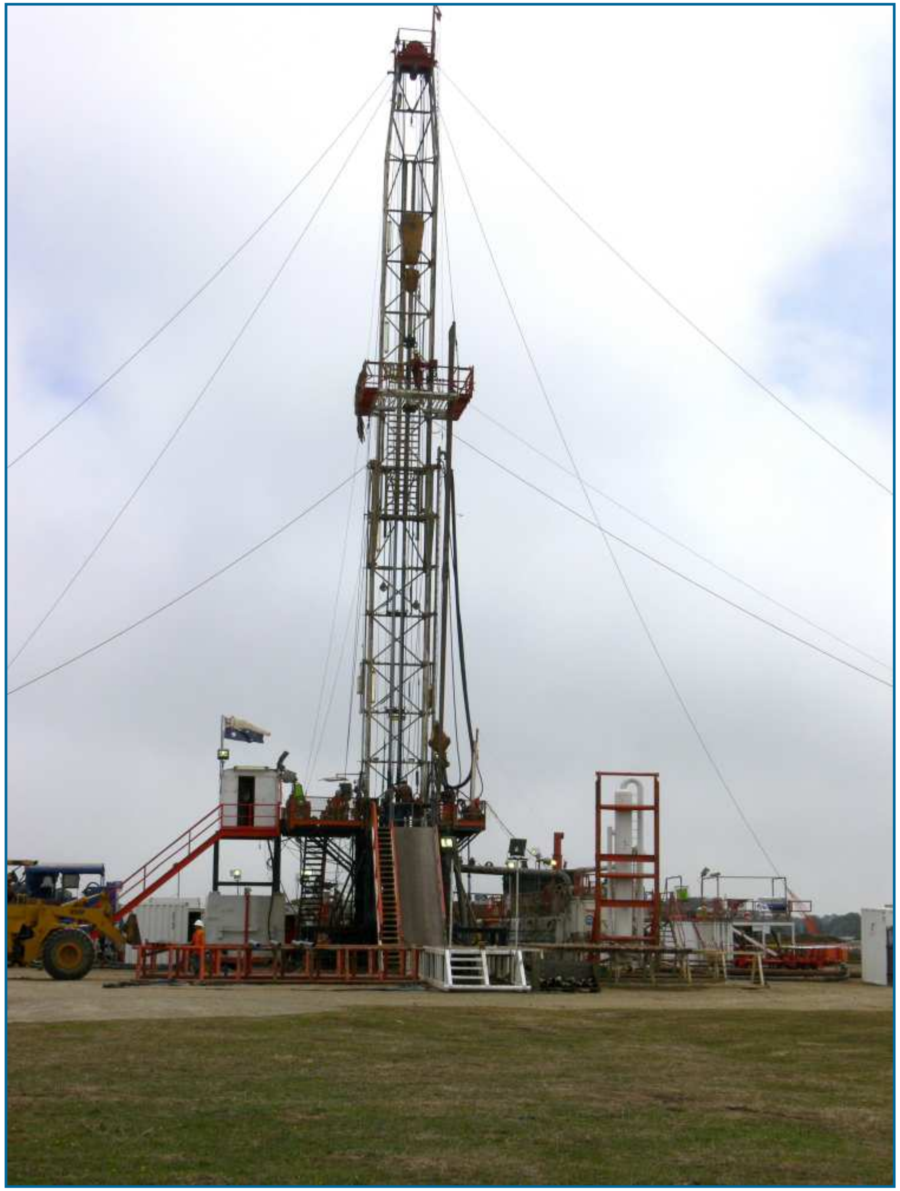
Long term liability

- This has still to be resolved and discussions are underway with the state of Victoria
- Until agreement is reached, we will not be able to commence injection
- So it is a potential show-stopper – but one that will be resolved in the next couple of months!



11. Where to from here?

- **Sort out long term liability!**
- **Commence injection (Sept-Oct 2007)**
- **Successfully complete Stage 1**
- **Raise more funding for Stage 2 (injection into a saline aquifer)**
- **Establish an international geosequestration test centre**

I thank the following for their support and contribution to the Project

Tim Besley & the Board of CO2CRC Joint Venture
Mal Lees & the Board of CO2CRC Pilot Project Ltd
Sandeep Sharma (Project Manager)
Thomas Berly (Government Liaison)
The many CO2CRC researchers and their associates in other institutions
LBNL, DoE, CSLF, ARC,IEA,
and other international collaborators and peer reviewers
The Australian Greenhouse Office, AusIndustry, the Victorian Government & regulators
Company sponsors and participants

Victorian coastline

CO2CRC

Otway Basin, Victoria

GHG Markets and CCS – Incentive, Impediment, Irrelevant?

Dr. Mark C. Trexler
Managing Director, EcoSecurities Global Consulting Services Group

London, May 30, 2007

ECO SECURITIES

Originate → Implement → Commercialise

EcoSecurities guides projects through this process

ACTIVITY	REPORT	RESPONSIBLE
Project Identification	PIN	PP
Project Formulation	PDD	PP
National Approval	Host Country Approval	DNA
Submission of PDD & Host Country Approval to Validator		PP
Validation	Validation Report	DOE-A
Submission of PDD & Validation Report to CDM-EB		DOE-A
Registration		CDM-EB
Monitoring	Monitoring Report	PP
Submission of Monitoring Report to DOE-B		PP
Verification/Certification	Verification Report Certification Report	DOE-B
Submission of request for CERs		DOE-B
Issuance of CERs	CERs	CDM-EB

EcoSecurities' successful track record::

- 12 methodologies approved
- 76 projects validated
- 55 projects registered
- 283 projects financed
- 166 projects under construction or operating
- 156 million CERs expected

PIN=Project Idea Note, PDD=Project Design Document, PP=Project Participant, DNA=Designated National Authority, DOE=Designated National Authority

ECO SECURITIES

Inform → Support → Implement

- First Mitigation Deals in U.S. and Globally
- Leaders in Project, PDD, and Methodology Development
- Won First GHG Regulatory Proceeding
- Designed a Major GHG Early Action Crediting Program for U.S.
- Took First Company Climate-Neutral
- Completed First Major GHG Offset Portfolio
- Supported First Utility-Based GHG Business Unit
- Developed First GHG Market Supply-Demand Model
- Point Carbon - Best CDM Project Developer 2006
- Envtl Finance – Best GHG Advisory Firm 2001 - 2006

ECO SECURITIES

A Local Presence in a Global Market

Table of Contents

Table of Contents

Portraying CCS as a Key Option

> But in What Context is CCS Being Viewed?
  - Based on current market value of EOR CO2 ($15/ton)?
  - Based on simple cost of injection of almost pure CO2 ($8-10/ton)?
  - Based on current costs of capture through storage?
    - Pulverized coal: $30-70
    - Gasified coal: $15-55
    - Natural gas: $40-90

> Do the Economics and Characteristics of CCS Fit Into Policy and Market Forecasts, and Realities of Financial Decisionmaking?

Portraying CCS as a Key Option

- Is There a Disconnect?
  - Companies and sectors pushing CCS are sometimes those least likely to be building aggressive CO2 economics in their planning
  - Companies and sectors pushing CCS are often those most aggressively pushing market mechanisms as key solution
- GHG Market Mechanisms Can be a Key Technology Driver
  - But not necessarily a near-term outcome
- But Will They for CCS?
  - What will CO2 reductions be worth? And how certain?
  - What will CCS cost as a mitigation option? And how discounted?
  - Does CCS Fit?
- Are We Assuming a Convergence of Economics?
- Or Are We Assuming Technology Mandates, or Complementary Policies?

Table of Contents

2. Forecasting GHG Markets

ECO SECURITIES

GHG Price Anticipation is Indeed Key!

Can Society Afford Emissions Targets?

Should Companies Buy Credits Today?

Should Utilities be Building IGCC Plants?

Should Projects be Selling Credits Today?

What's the Right Oil Sands Technology?

What's Plausible for Post-2012 Targets?

Will GHG Prices Promote New Technologies?

Should EU Power Plants be Fuel Switching?

Carbon Credit Price Forecasting

> While a Supply and Demand Approach Makes Sense…
  - Demand is (obviously) largely a function of policy decisions
  - But (much less obviously) so is supply
    - What is a “credit”?
    - How are “credits” quantified?

> This Makes the GHG Commodity a Very Different One
  - Price forecasting almost meaningless outside of the accompanying policy context
  - Makes it hard to think of as predictable commodity
  - Makes it hard to interpret simple targets
  - Potentially quite susceptible to market feedback effects

Examples of Price Anticipation

> A Wide Variety of "Price Signals"
  - 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

> This Range Spans Immateriality to a Falling Sky, and a Strong Technology Driver to an Irrelevant Financial Factor

Where's Our Crystal Ball?

- > Unfortunately, There Isn't One
- > This Range of Estimates isn't "Wrong"
- > It Reflects "Apples & Oranges" Scenarios
  - – Involving policy, market, and other variables
- > Where Does That Leave Us?

ECO SECURITIES

GHG Market Forecasting Variables

- > Context Variables
  - – Science, media, public opinion, policy
- > Technology Variables
  - – Costs, R&D spending, deployment support, mandates
- > Demand Variables
  - – Growth, fossil prices, targets, U.S. role, policies and measures
- > Supply Variables
  - – What counts, how counted, rules, behavior, psychology, hot air

GHG Market Modeling Variables

Supply Variables

- The annual rate at which projects can be validated
- The stringency of additionality rules
- When methodologies are approved for different sectors
- What regions of the world supply can come from
- When host countries are ready to approve projects
- Sector-specific technical and practical potentials, based on the latest studies and expert insight
- Sector-specific deployment rates, based on expert insight
- Sector-specific economic analysis

Demand Variables

- Global emissions growth
- Stringency of the EU ETS
- Whether, when, and the severity future targets are set
- United States participation
- How much hot air will come into the market
- The proportion of demand met through credits

ECO SECURITIES

Coalmine Methane Summary

Datapoint Name	Methane Reductions From Coal Mining
Sector	Methane
Region	Global

NOT USED

Technical Potential (1000 Tons CO2e)	345,000
Percentage Likely to Be Available	85%

Lowest Cost	$0.50
Highest Cost	$15.25
Cost Distribution	Low
Transaction Cost	$1.50

Lowest Additionality	1
Highest Additionality	5
Additionality Distribution	High
Additionality/Cost Correlation	20%

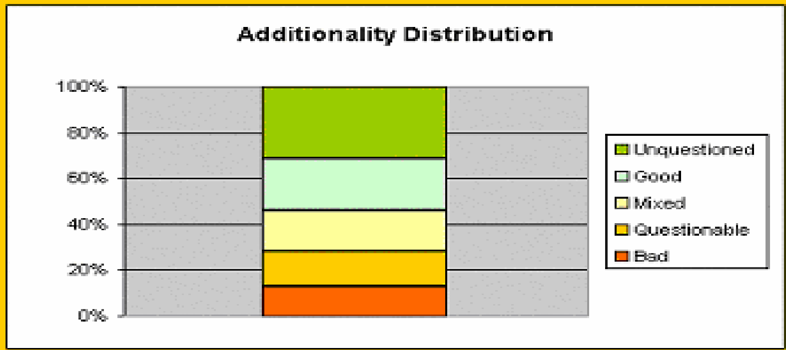
% Realized Potential	85%
Total Realized Tons (000s)	293,250
Available Cost Range	$2.00 - $16.75

* using additionality screen of '1 or above' - set on Price v. Quantity tab

Select Standard Datapoint to Retrieve:
Methane Reductions From Coal Mining

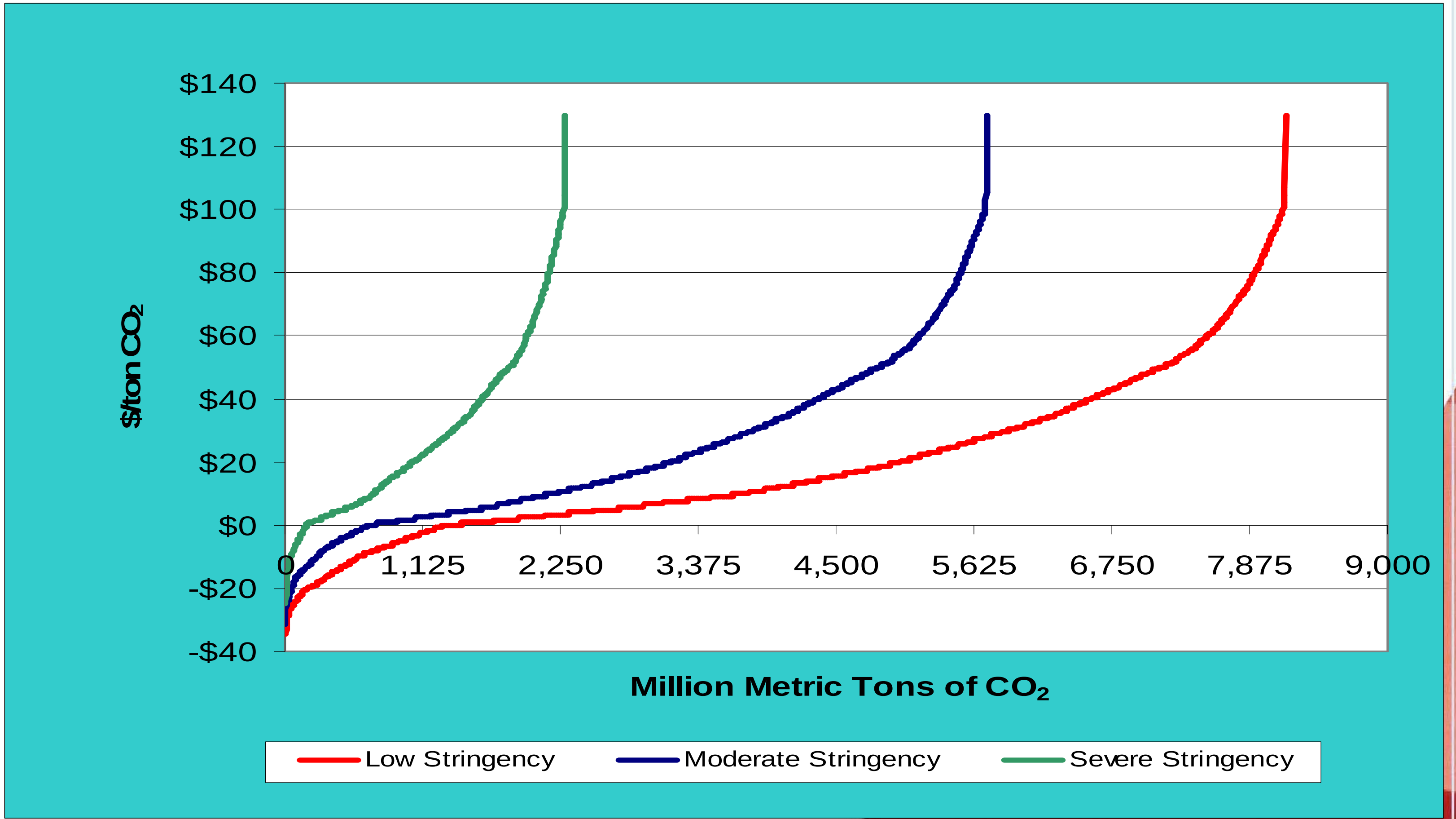
Get Datapoint | Save to Database | Return to Supply Curve

Average: $7.03



Create New

2010 GHG MAC Curve



Scenario 1 – Policy "Collapse"

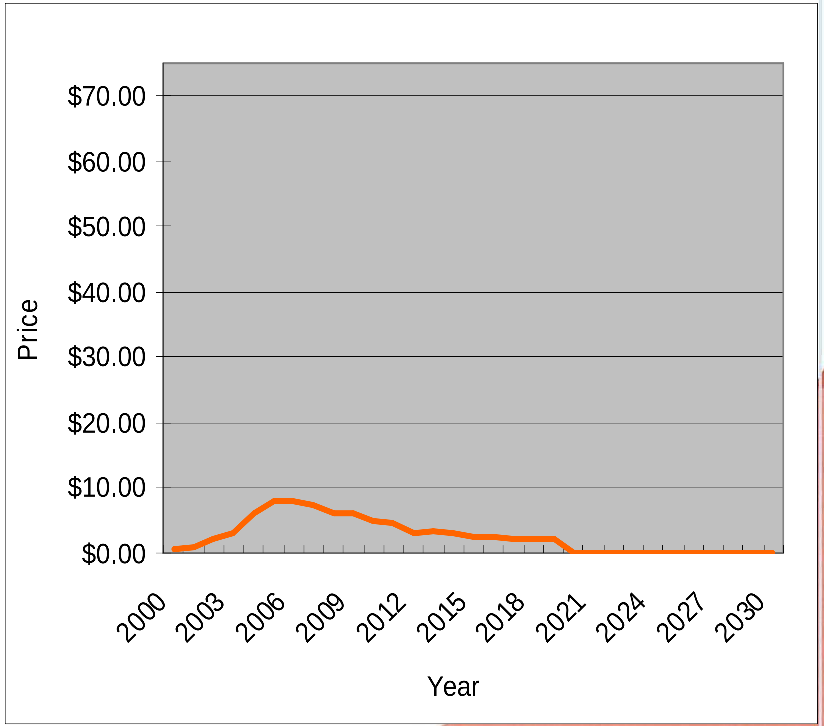
> Major Political and Economic Challenges

> Could Challenges Lead to Collapse of Int'l and Domestic Policy Momentum?

- Absent a scientific reversal, hard to see
- Broad public support for action on this issue

> The Odds: Low

> Note: Scenario Subject to Sudden Reversal



Scenario 2 – Political Status Quo

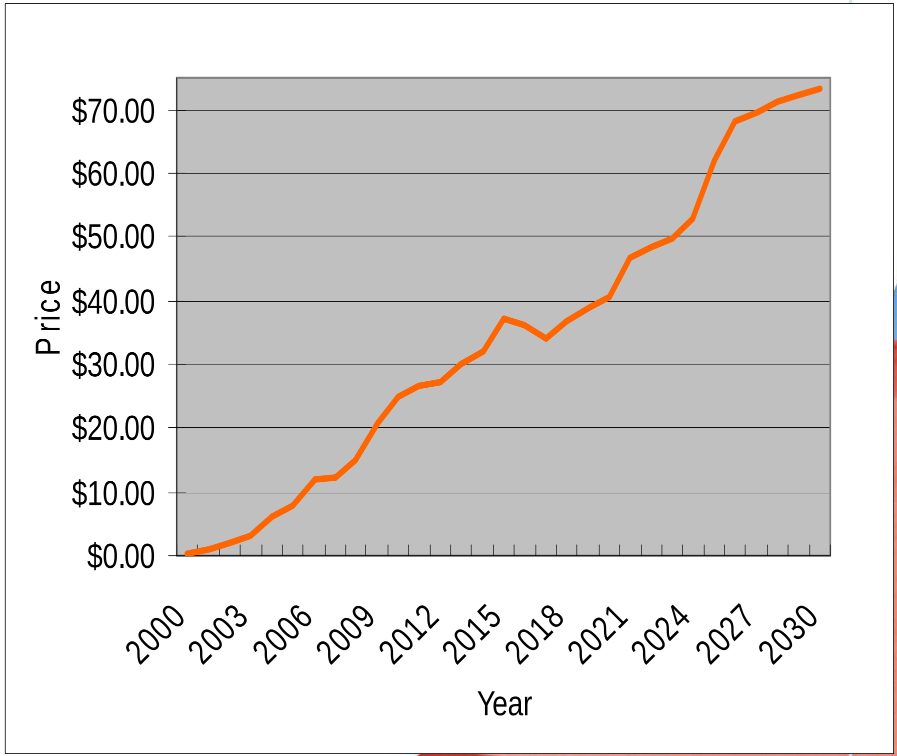
- Issue is Here to Stay
  - Numerous policies and measures pursued
- Will Affect Many Sectors in Material Ways
  - Range of Cost Estimates: $5-30/ton CO_2
- But Policy Unable to Achieve CO_2 Stabilization
- The Odds: High
- Note: Scenario Subject to Sudden Reversal

Scenario 3 – Atmospheric Stabilization

> Political Will Exists to Tackle
  – Aggressive emissions reductions
  – Aggressive technology development
  – Aggressive reliance on GHG markets

> Would Significantly Affect Economics
  – Stanford Modeling Forum: $75-100/ton CO_2

> The Odds: Modest



Will The Pieces Fall Into Place?

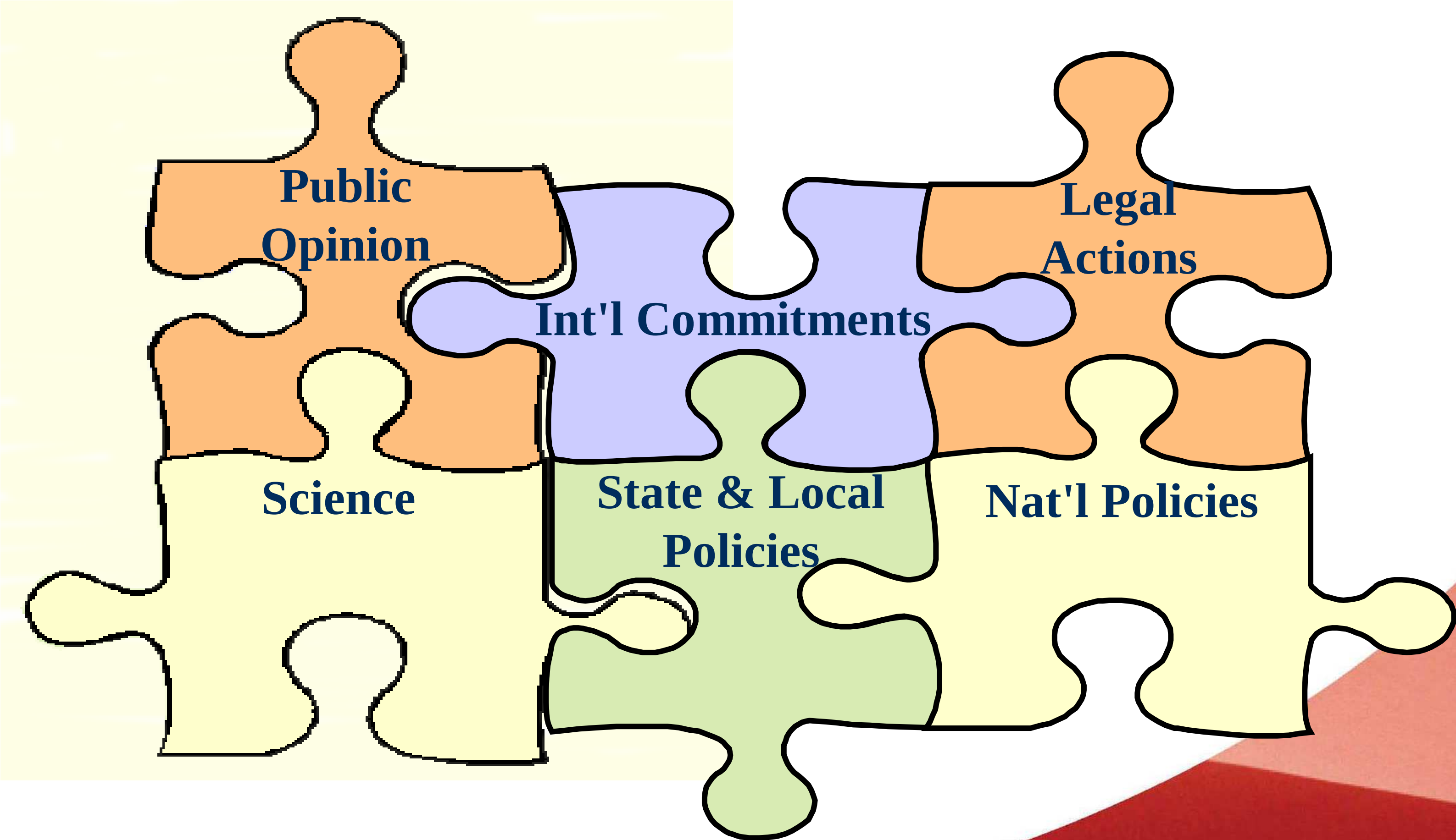


Table of Contents

3. How Does CCS Fit?

How to Think About CCS

- A Key Factor in GHG Market Demand?
  - Are we assuming simple CCS mandates?
- A Key Factor in GHG Market Supply?
  - Are we assuming CCS is part of the larger supply curve, and will compete in those markets?
- Is CCS Susceptible to GHG Market Uncertainties?
  - Timing, risks, capital commitments?
  - Risk of feedbacks: CCS mandates = lower CO2 prices = larger gap
- Is CCS Competing With Other "Disruptive" Mitigation Technologies
  - Technologies like ocean fertilization?
- And if Price Signal Isn't Sufficient, Should We Push Complementary Measures, or Push for a Higher Price Signal?

ECO SECURITIES

Will GHG Markets be Pivotal?

Case	2020 Estimate, CO_2 Value	CO_2 Driver for IGCC and Capture	Promote IGCC?
Political Status Quo	\$10-30	~\$38-42	Unlikely in this timeframe
Aggressive Policy	\$25-50	~\$38-42	Likely with aggressive policy

ECO SECURITIES

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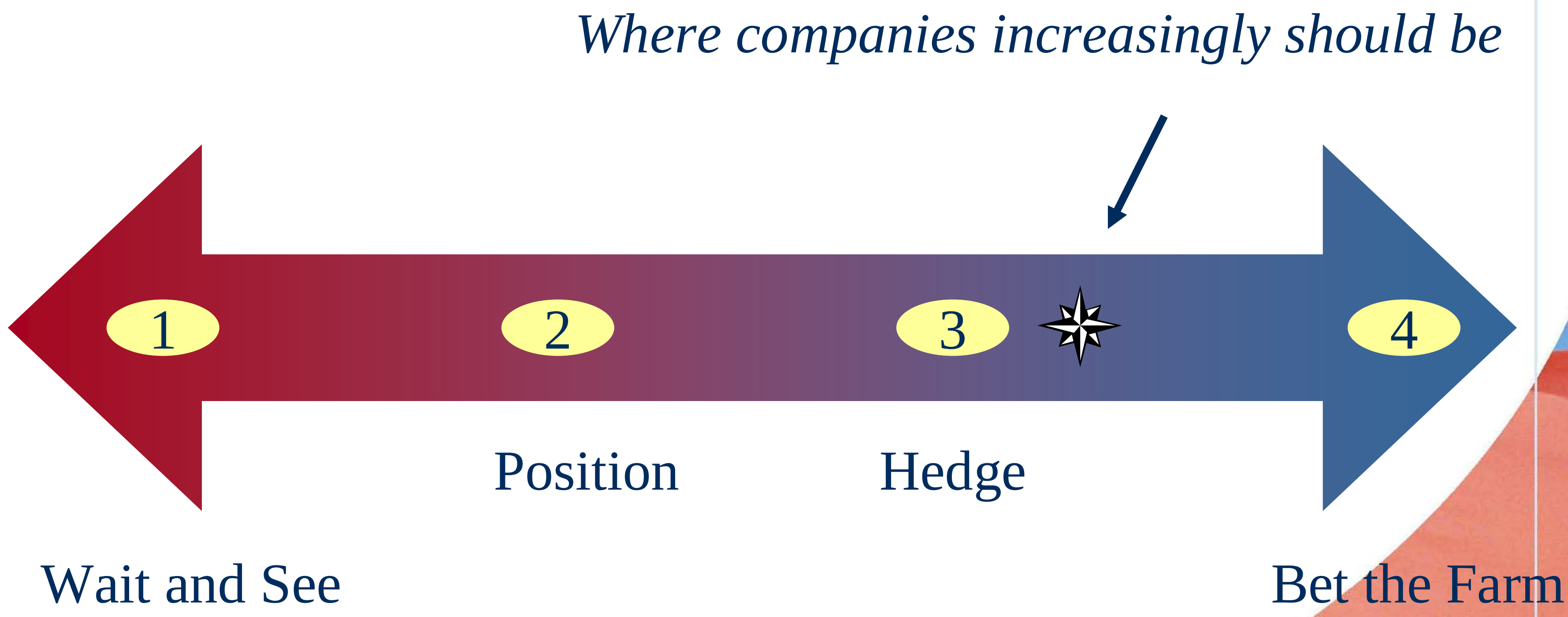
4. The Point? Being Positioned

Structuring a Strategy for Advantage



Structuring a Strategy for Advantage

> You Can't Get There Without A View of Future GHG Prices

ECO SECURITIES

Structuring a Strategy for Advantage

So When and If We Resolve the Technical Issues, How Should We Be Anticipating CCS's Role in Future Markets and Business Decisions?

For More Information

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RWE Power

RWE

The Financial Aspects of Implementing an IGCC CCS Project in Germany

Paper presented at the Expert Meeting on Financing Carbon Capture and Storage Projects

Organised by IEA Greenhouse Gas R & D Programme
and IEA Clean Coal Centre

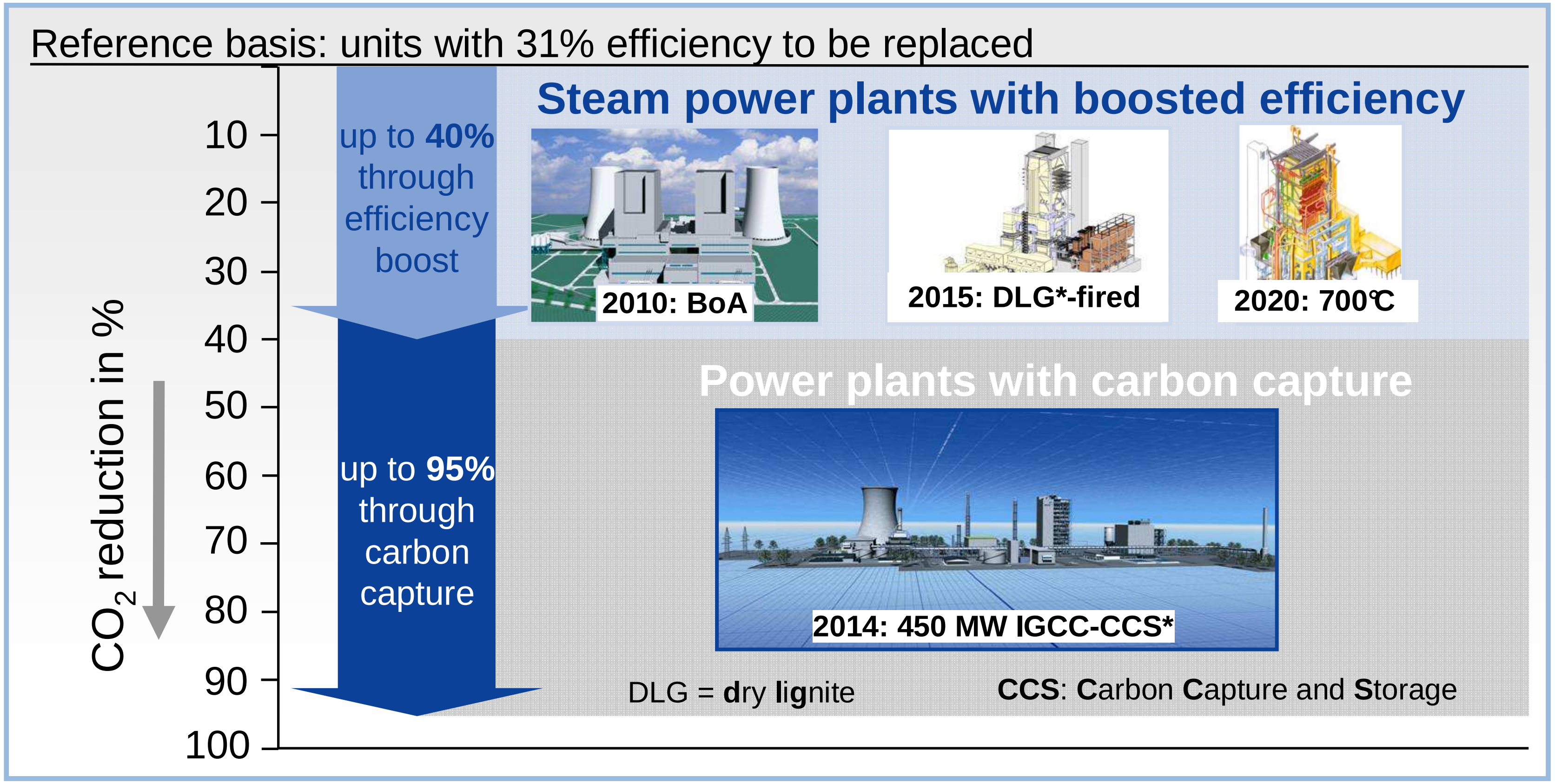
May 31, 2007, London

Dr. Hans-Wilhelm Schiffer
Senior Manager, Energy Economics
RWE Power AG, Essen

Structure

- Potential for the reduction of CO_2 emissions via efficiency improvements and CCS
- RWE's decision on CCS
- RWE project of a zero-CO_2 450 MW power plant (IGCC-CCS)
- Timetable of RWE's IGCC CCS project
- CO_2 scrubbing as a retrofit option for steam power plants
- Financial aspects of implementing CCS
- New scenario study concerning the development of the German energy market by 2030 (scenario design)
- Assumption for CCS in the scenario study
- Results concerning CO_2 prices, energy mix in power generation and CCS share
- Conclusion

Zero-CO_2 coal-fired power plants can slash carbon emissions further



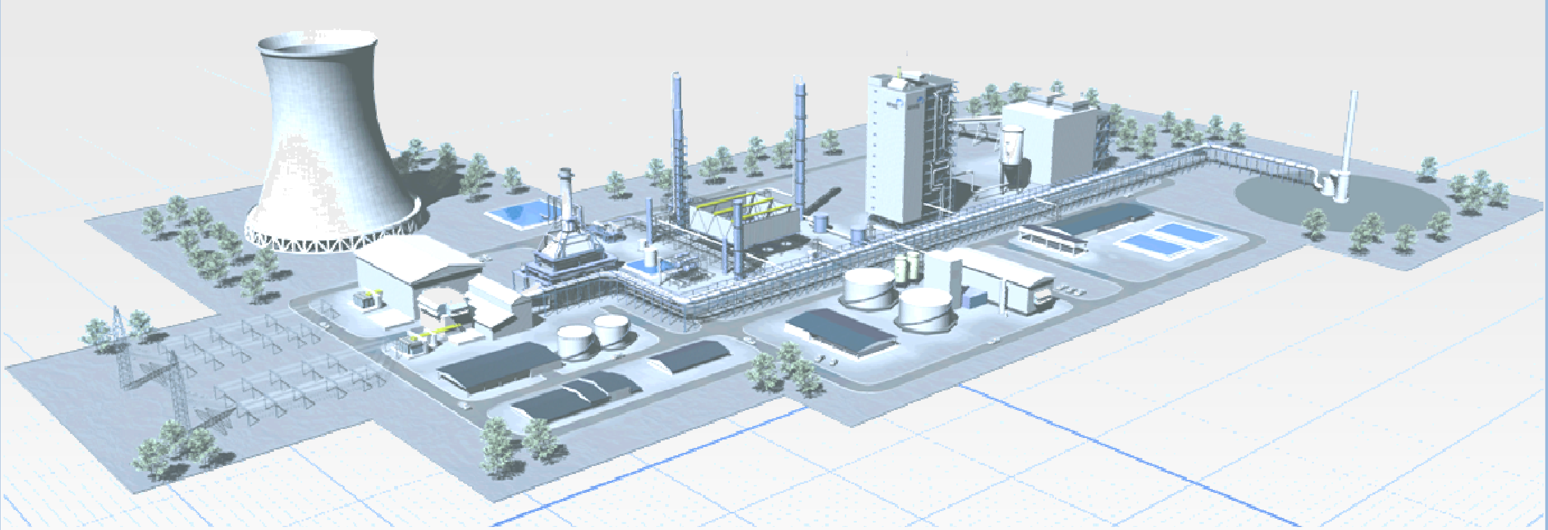
Efficiency boost also required for zero-CO_2 power plant: The higher the efficiency the less carbon must be captured and stored

Horizon 3: RWE's decisions on CCS

1. RWE Power develops and builds a **zero-CO_2 450 MW coal-fired power plant** based on IGCC technology incl. CO_2 transport and storage; start of operation is planned for 2014.

2. In parallel, RWE will develop the technology of **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's project of a zero-CO_2 450 MW power plant with carbon storage (IGCC-CCS)

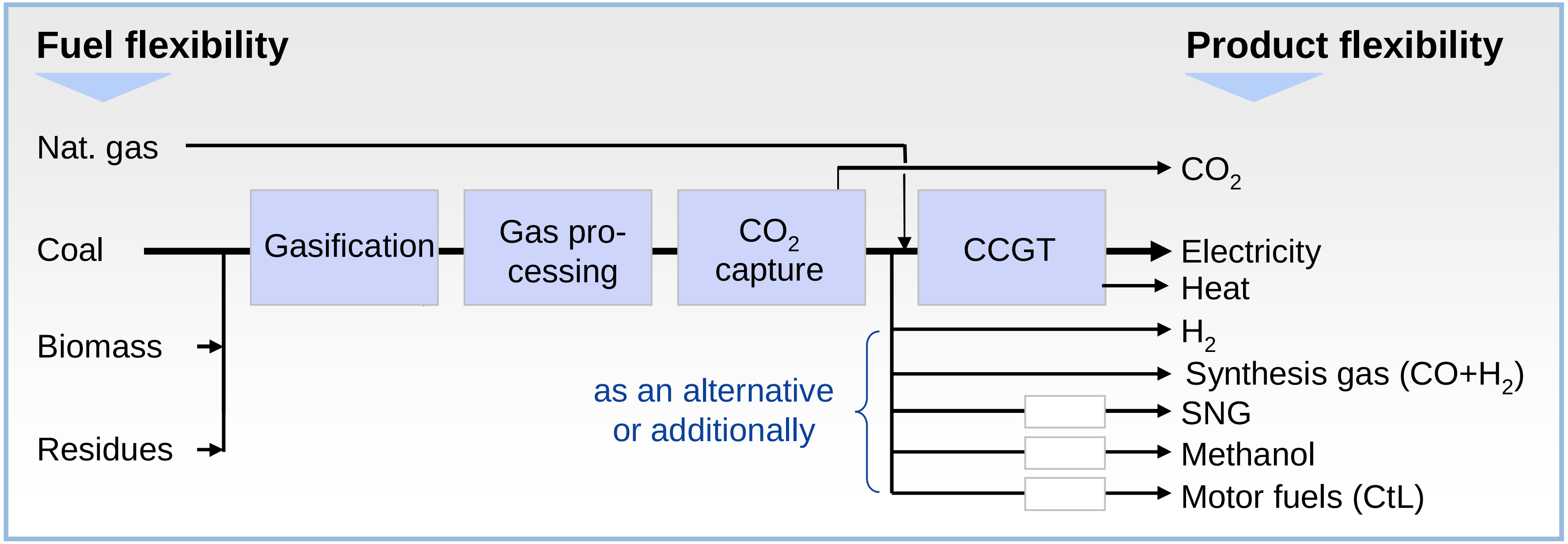


- Basic technology: IGCC
- El. capacity: 450 MW_{gross}, 360 MW_{net}
- Net efficiency: 40 %
- CO_2 storage: 2.3 mill. t/a in gas deposits or deep saline formations
- Commissioning: 2014

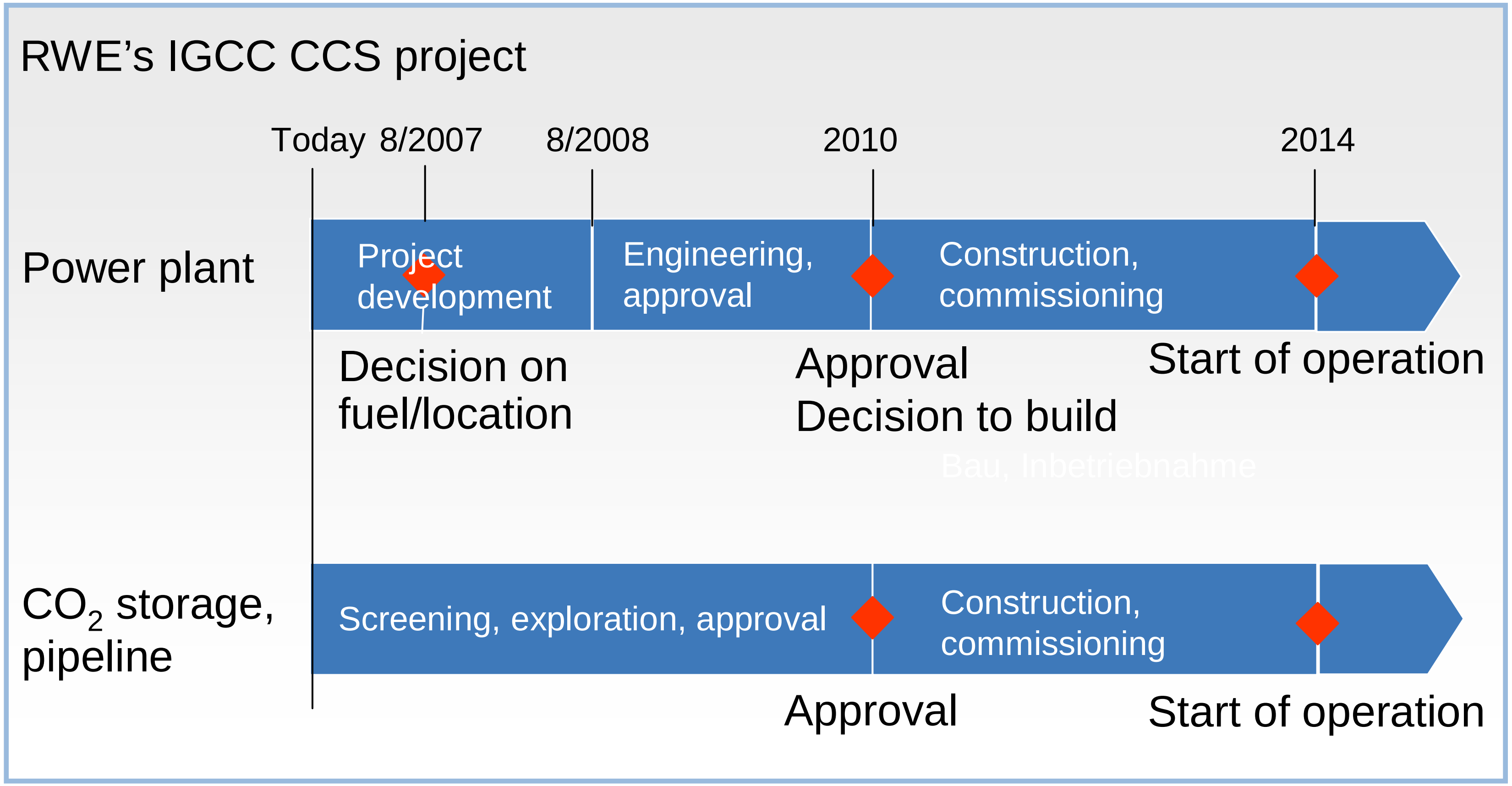
RWE Power has inhouse power plant and gasification know-how and RWE Dea has basic CO_2 storage know-how.

IGCC is particularly attractive for the zero-CO_2 power plant and, at the same time, offers the key to other coal-derived products

- All process steps are commercially available
- Technical and economic figures are robust
- Power plant can also be operated efficiently without carbon capture
- IGCC offers additional potential for emission reduction
- High fuel and product flexibility



The timetable of RWE's IGCC-CCS project is ambitious and requires support by the overall environment



The development of the CO_2 storage site must be step by step and on several levels

Phase 1 2008	Phase 2 2010	Phase 3 2014
Screening: ■ Screening of potential reservoirs ■ Evaluation and feasibility study for 2 – 3 sites	**Exploration:** ■ Exploration (3D seismics) ■ Selection of storage site ■ Approvals	**Construction:** ■ Drilling of wells and construction of storage facility ■ Surface installations

The following tasks must be tackled in parallel:

- Development of standards for the evaluation of CO_2 storage sites and their long-term tightness
- Creation of underlying legal and regulatory conditions
  - Legal norm must be defined
  - Regulatory frameworks below the law level must be created
- Reaching public acceptance

⇒ Joint tasks of companies, policy-makers and authorities

Parallel RWE programme on the development of CO_2 scrubbing for steam power plants

This opens up the retrofit option

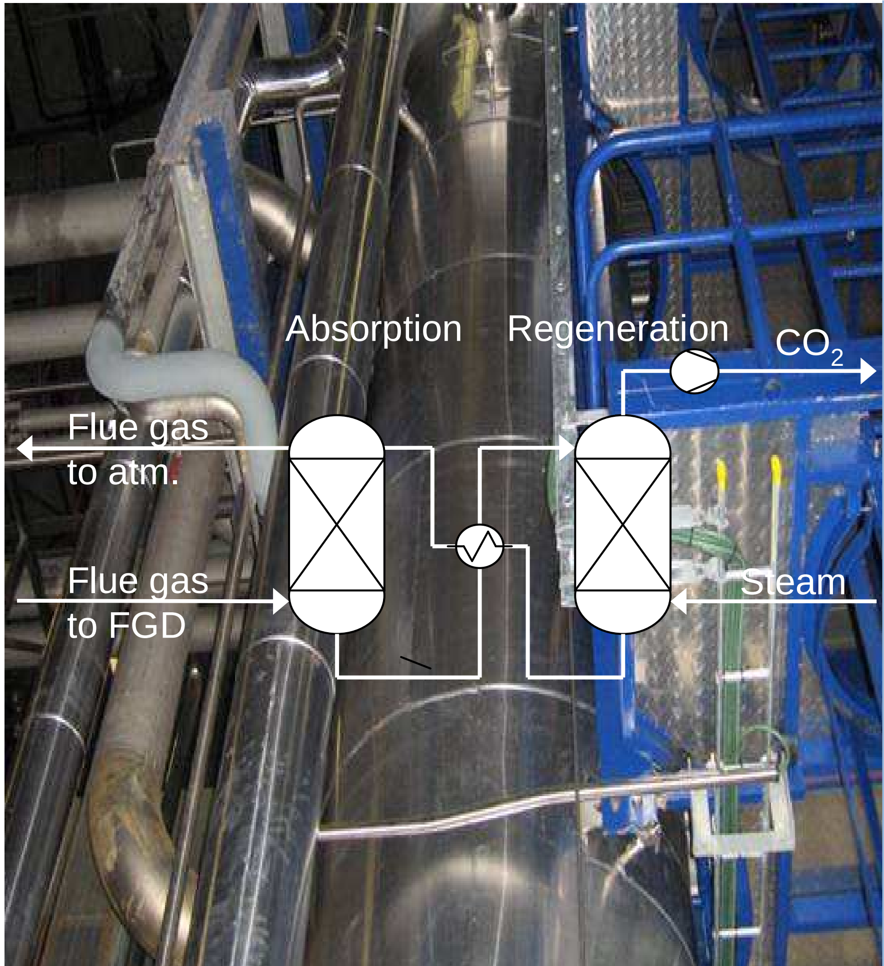
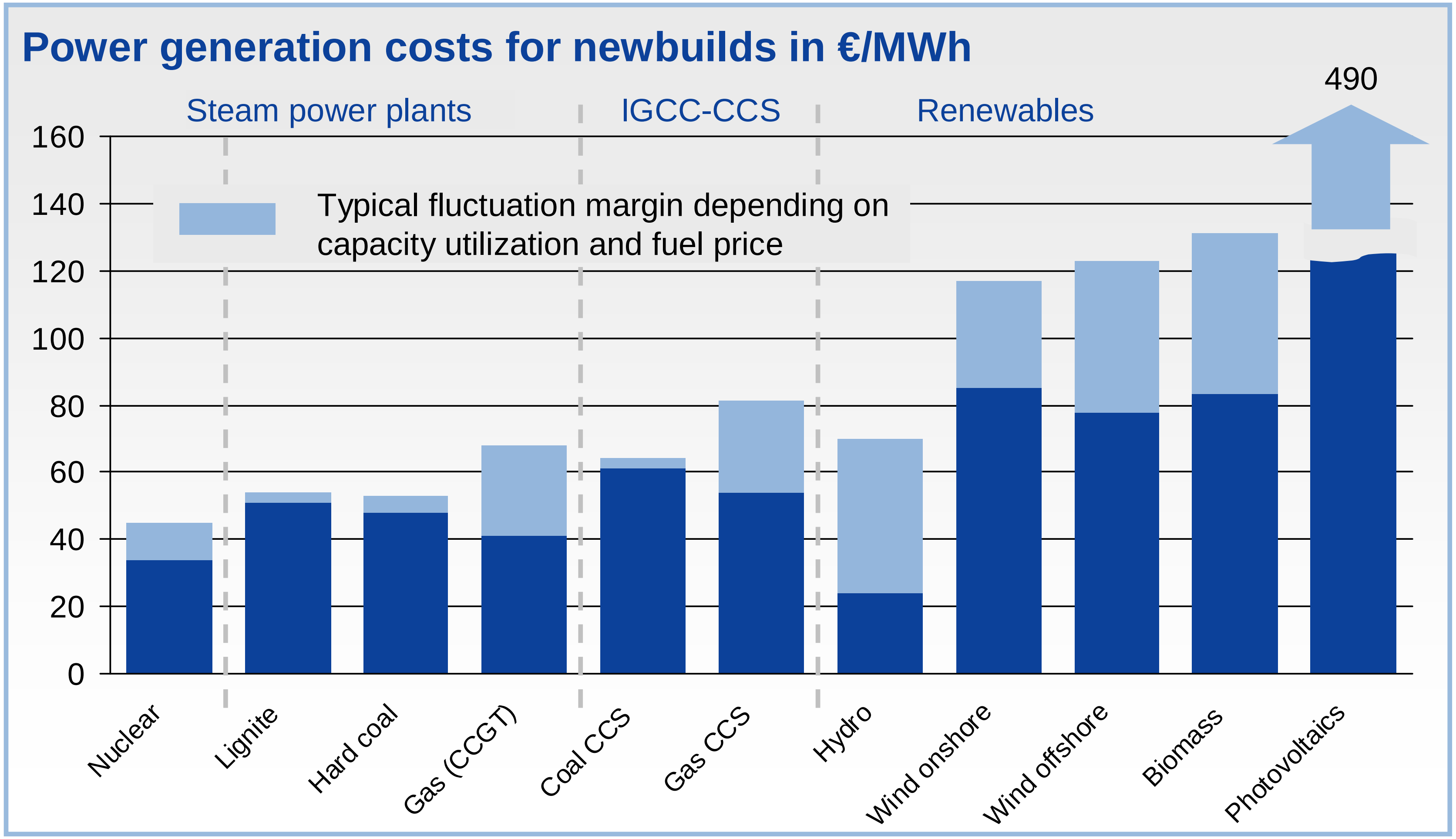


Photo: CO_2 pilot scrubbing plant, Esbjerg power plant

- RWE involvement:
  First pilot plant for HC in operation at the Esbjerg power plant (DK) as part of the EU CASTOR project
- RWE developments:
  - RWE Power for lignite:
    - until 2008: pilot project
    - from 2009: demonstration plant
  - RWE npower for hard coal:
  - Pilot test plant
  - Study for 1,000 MW Tilbury plant with CO_2 scrubbing
- Currently formation of partnerships with plant makers and chemical industry
- Budget: ~ €90 million

Comparison of power generation costs for various technologies



Source: VGB (German Technical Association of Large Power Plant Operators), supplemented by CO_2 allowances costs of €20/t and plants with carbon capture

Scenario design in the EWI/EEFA study

Scenario 1: Consideration of the stipulations made by the European Council in March 2007 with regard to the reduction of greenhouse gas emissions in the EU-27 (- 20 % by 2020 over 1990) with unchanged energy policy conditions in Germany

Scenario 2: Equal consideration of supply security, economic efficiency and environmental compatibility/backing of market mechanisms (no restrictions for nuclear energy use, EU-wide harmonized funding model for renewable energies, free allocation of CO_2 certificates based on fuel-specific benchmarks)

Scenario 2a: Like Scenario 2, but 100 % auctioning of CO_2 emission allowances after 2012

Scenario 3: Priority on environmental protection and nuclear phase-out (100 % auctioning of CO_2 certificates after 2012 – as in Scenario 2a)

Overview of policy scenarios (1)

	Scenario 2	Scenario 2/2a	Scenario 3
GHG reduction[1)]			
EU 2010 2020 2030	- 8 % - 20 % - 25 %	- 8 % - 20 % - 25 %	- 8 % - 30 % - 40 %
DE 2010 2020 2030	- 21 % - 25 % - 30 %	- 21 % - 25 % - 30 %	- 21 % - 40 % - 50 %
NAP	Unchanged NAP II after 2012		100 % auctioning after 2012
JI/CDM[2)]	max. 50 % of each reduction (stipulated by EU Commission)		

1) over 1990
2) optionally: over base year, 2004 or forecast, if appropriate
Source: EWI/EEFA, "*Energiewirtschaftliches Gesamtkonzept 2030*" (Overall Energy Policy Concept), 23/05/2007

Overview of policy scenarios (2)

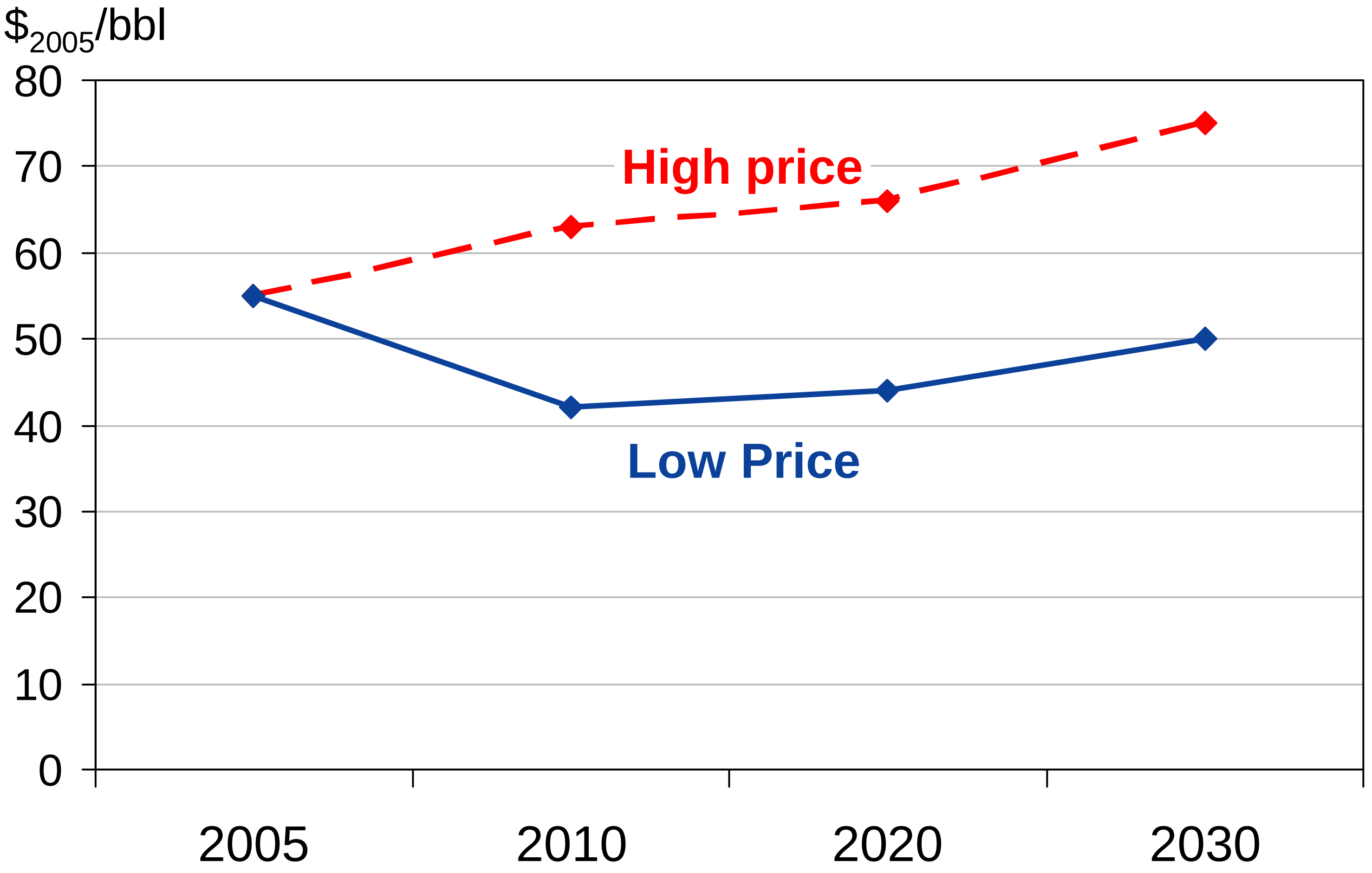
Renewable energies targets[1)]	Unchanged Renewable Energies Act	Market economy integration model of the EU	Forcing Renewable Energies Act
EU 2010 2020 2030	17 % 22 % 27 %	17 % 22 % 27 %	22 % 30 % 35 %
DE 2010 2020 2030	13 % 20 % 26 %	13 % Market result Market result	15 % 25 % 35 %
CHP	Unchanged CHP Moder-nization Act	Production discontinued	Ratio: Doubling of CHP power generation by 2030
Nuclear energy	Phase-out	No restrictions	Phase-out

1) Share in gross power consumption

Source: EWI/EEFA, "*Energiewirtschaftliches Gesamtkonzept 2030*" (Overall Energy Policy Concept), 23/05/2007

Crude oil price

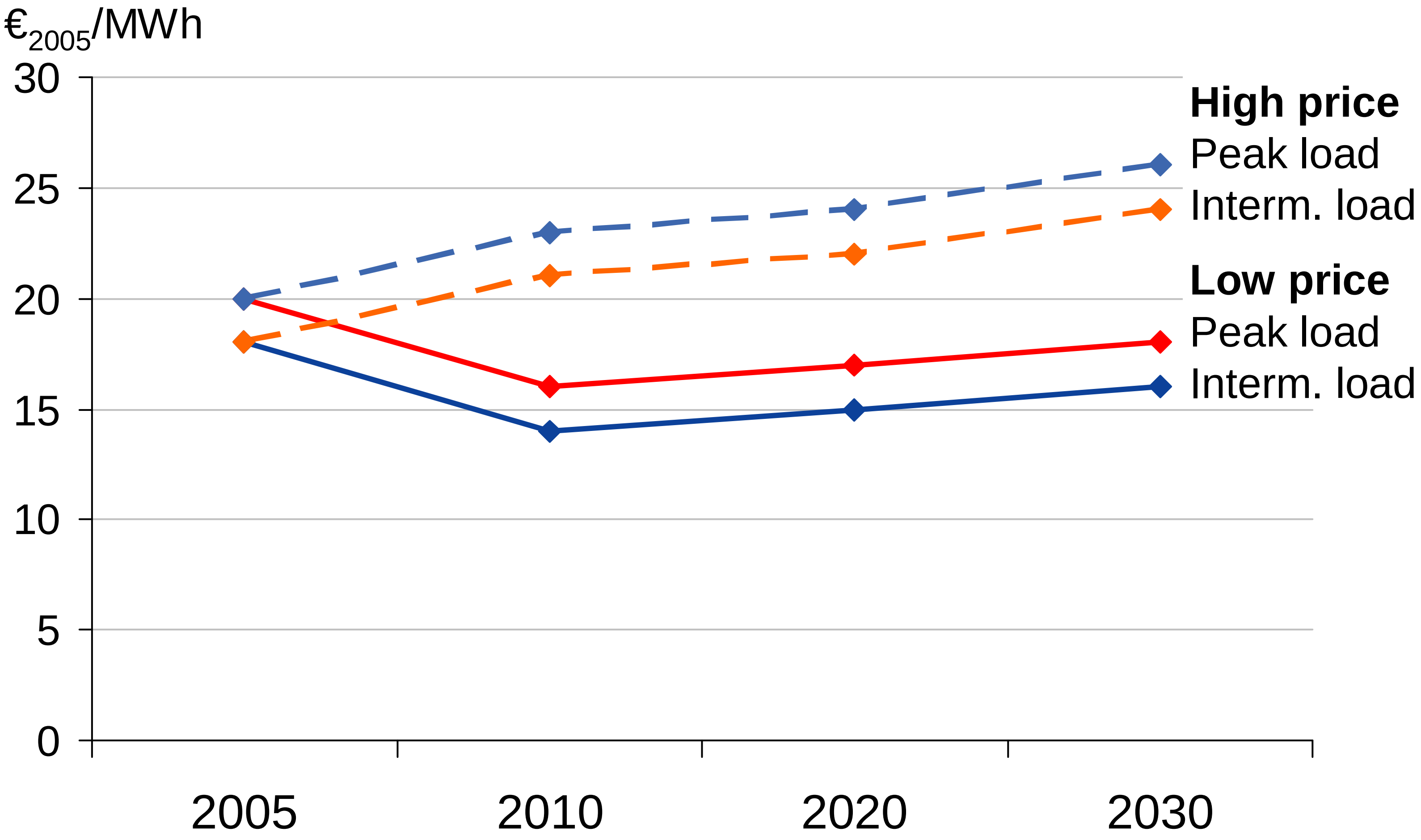
High-price and low-price path



Source: EWI/EEFA, *"Energiewirtschaftliches Gesamtkonzept 2030"*, (Overall Energy Policy Concept), 23/05/2007

Gas prices free power plant

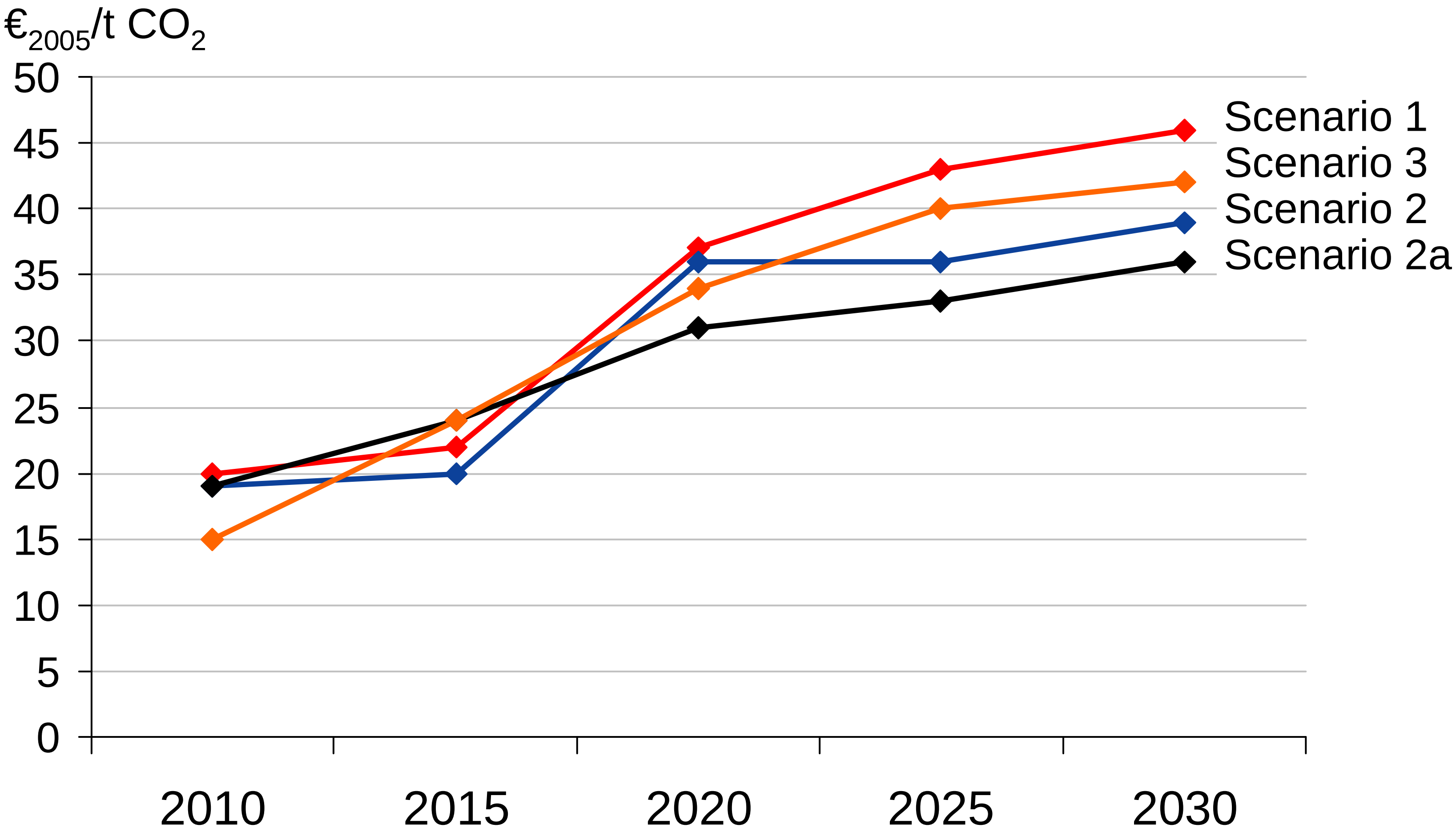
Low and high price, intermediate and peak load



Source: EWI/EEFA, *"Energiewirtschaftliches Gesamtkonzept 2030"*, (Overall Energy Policy Concept), 23/05/2007

Real CO_2 prices in scenarios

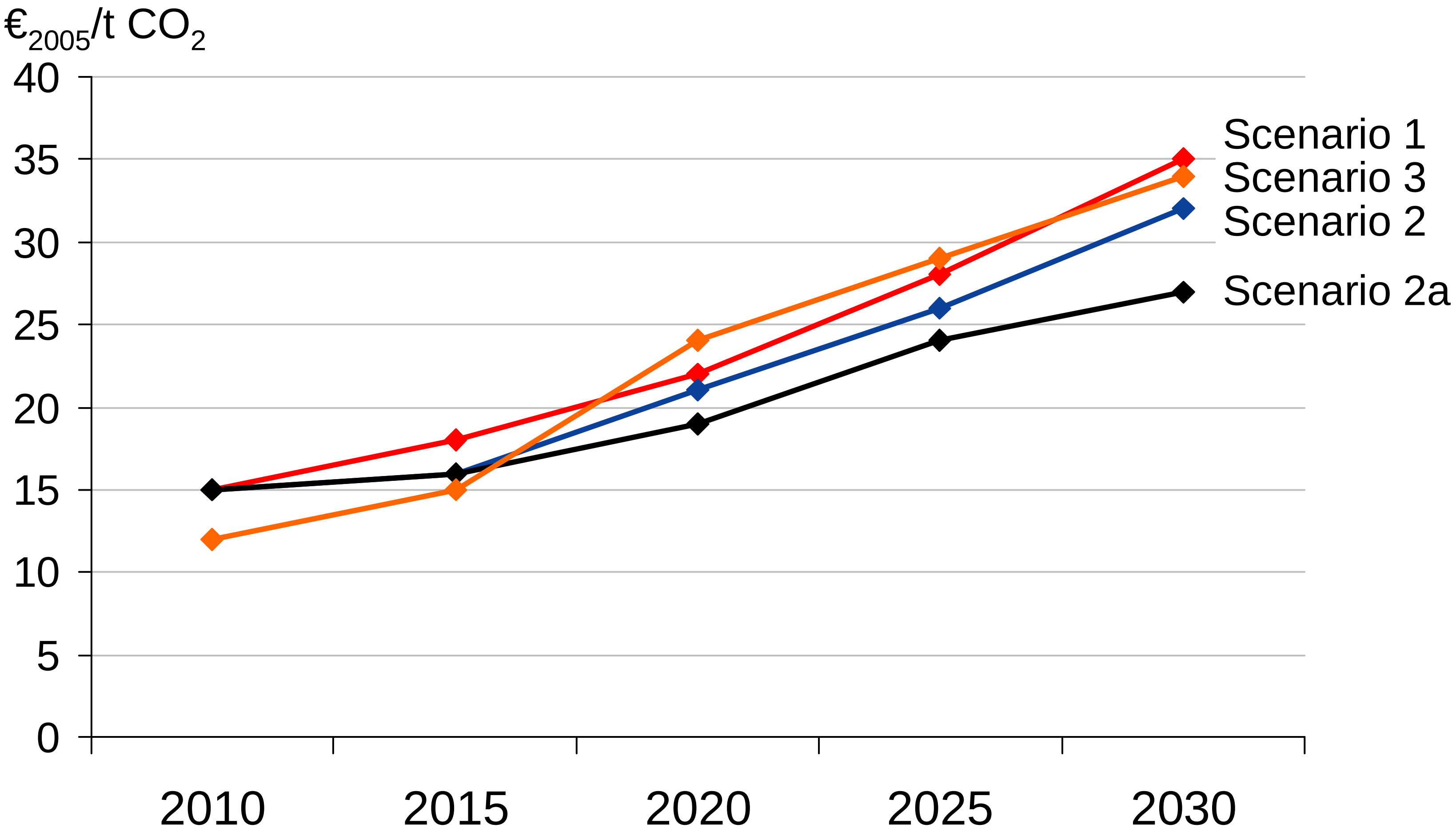
Price basis 2005, high price



Source: EWI/EEFA, *"Energiewirtschaftliches Gesamtkonzept 2030"*, (Overall Energy Policy Concept), 23/05/2007

Real CO_2 prices in scenarios

Price basis 2005, low price



Source: EWI/EEFA, *"Energiewirtschaftliches Gesamtkonzept 2030"*, (Overall Energy Policy Concept), 23/05/2007

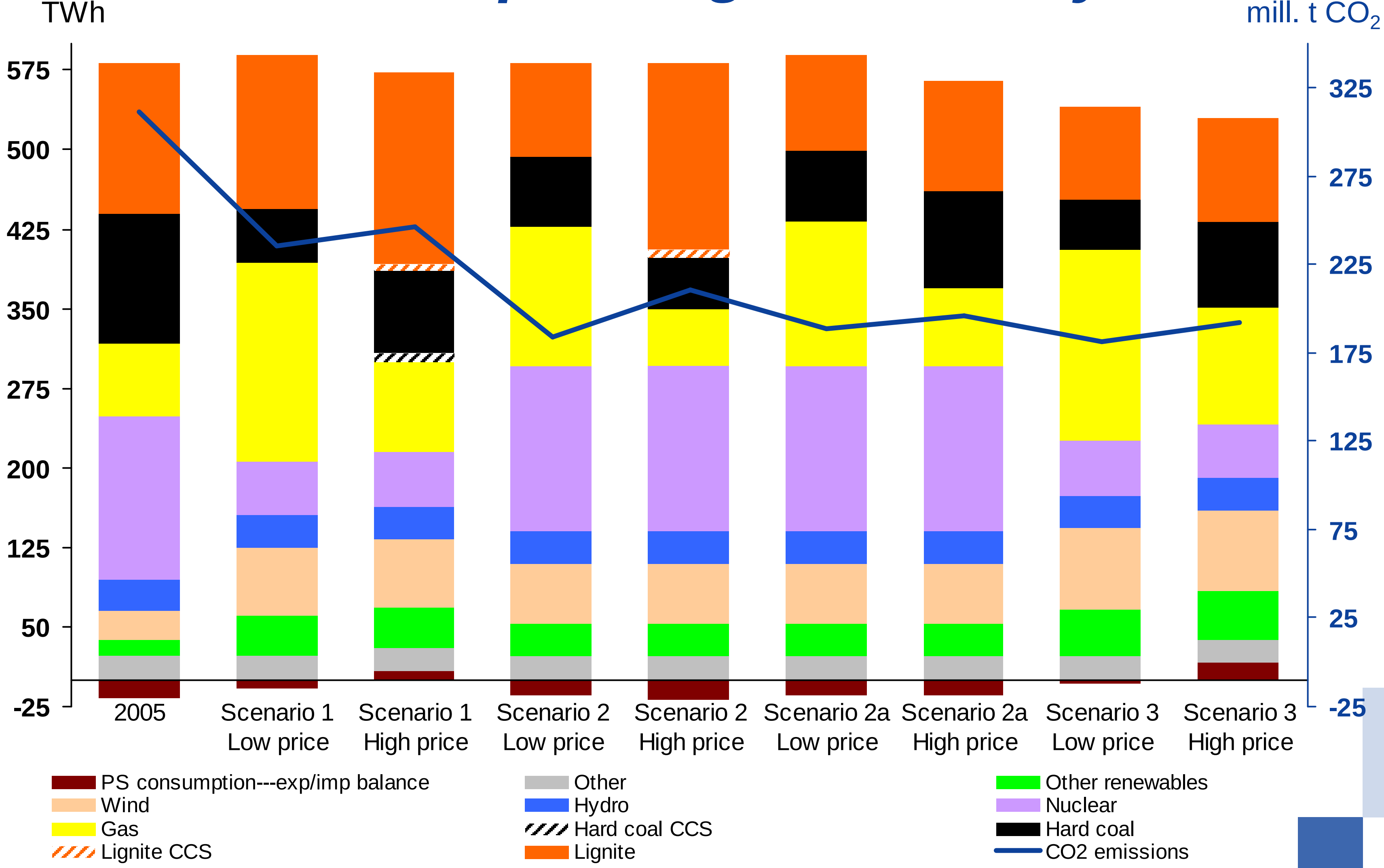
Assumptions concerning costs and efficiency of newbuild coal-fired plants

	Hard coal	Lignite
Investment costs in € mill./MW_{el}		
without CCS	1.20	1.35
with CCS	1.68	1.75
Efficiency after 2020 in %		
without CCS	52	51
with CCS	44	43

An emission reduction of 90 % was assumed for plants with CCS. The costs of transport and storage are based on an aggregate amount of €14/t CO_2.

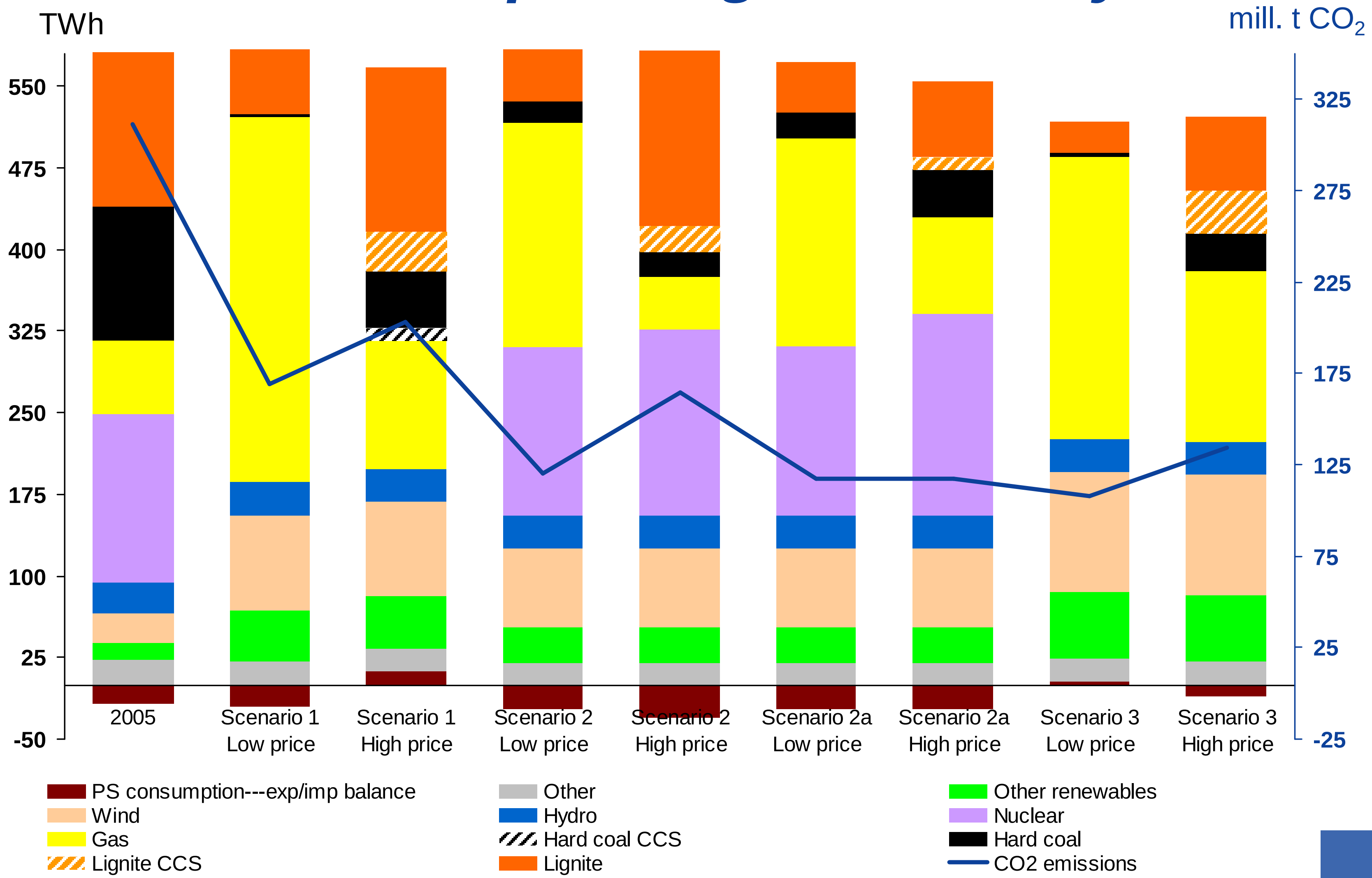
Source: EWI/EEFA "Energiewirtschaftliches Gesamtkonzept 2030" (Overall Economic Energy Policy Concept), 23/05/2007

Net power output in Germany/CO_2 emissions from power generation, year 2020



Source: EWI/EEFA study: “Energiewirtschaftliches Gesamtkonzept 2030“ - overview of scenarios - status: 23/05/07

Net power output in Germany/CO_2 emissions from power generation, year 2030

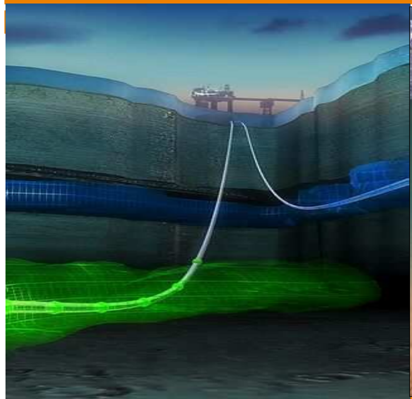


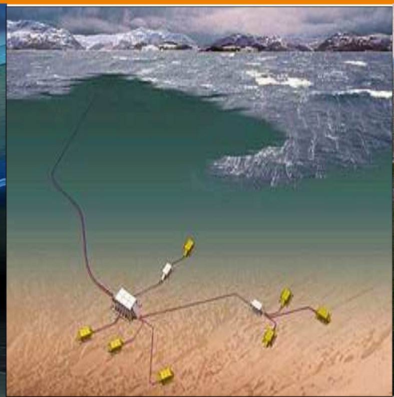
Source: EWI/EEFA study: “Energiewirtschaftliches Gesamtkonzept 2030“ - overview of scenarios - status: 23/05/07

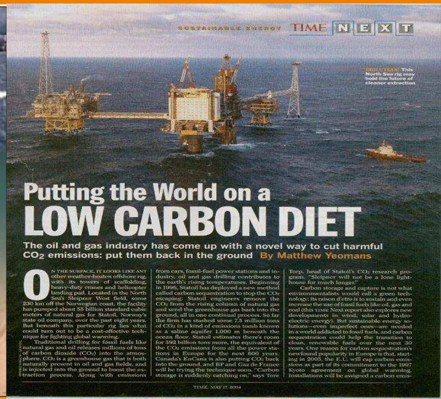
Main findings:

- 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 own funds for their 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.

A Norwegian Perspective on Ongoing CCS Projects







SUSTAINABLE ENERGY TIME NEXT

This North Sea rig may hold the future of cleaner extraction

Putting the World on a LOW CARBON DIET

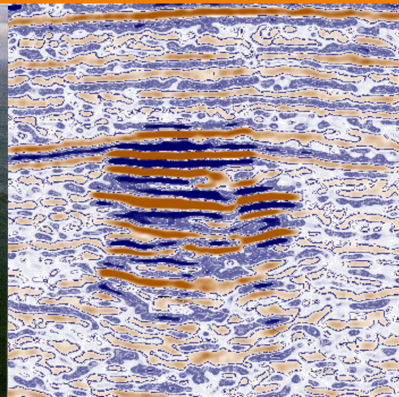
The oil and gas industry has come up with a novel way to cut harmful CO_2 emissions: put them back in the ground By Matthew Yeomans

ON THE SURFACE, IT LOOKS LIKE ANY other weather-beaten offshore rig, with its towers of scaffolding, heavy-duty cranes and helicopter landing pad. Located in the North Sea's Sleipner West field, some 230 km off the Norwegian coast, the facility has pumped about 55 billion standard cubic meters of natural gas for Statoil, Norway's state oil company, over the past eight years. But beneath this particular rig lies what could turn out to be a cost-effective technique for fighting global warming.

Traditional drilling for fossil fuels like natural gas and oil releases millions of tons of carbon dioxide (CO_2) into the atmosphere. CO_2 is a greenhouse gas that is both naturally present in oil and gas fields, and is injected into the ground to boost the extraction process. Along with emissions from cars, fossil-fuel power stations and industry, oil and gas drilling contributes to the earth's rising temperatures. Beginning in 1996, Statoil has deployed a new method called carbon sequestration to stop the CO_2 escaping: Statoil engineers remove the CO_2 from the rising column of natural gas and send the greenhouse gas back into the ground, all in one continual process. So far the firm has stashed some 7.5 million tons of CO_2 in a kind of emissions tomb known as a saline aquifer 1,000 m beneath the ocean floor. Statoil estimates there's room for 392 billion tons more, the equivalent of the CO_2 emissions from all the power stations in Europe for the next 600 years. Canada's EnCana is also putting CO_2 back into the ground, and BP and Gaz de France will be trying the technique soon. "Carbon storage is suddenly catching on," says Tore Torp, head of Statoil's CO_2 research program. "Sleipner will not be a lone lighthouse for much longer."

Carbon storage and capture is not what environmentalists would call a green technology; its raison d'etre is to sustain and even increase the use of fossil fuels like oil, gas and coal (this TIME Next report also explores new developments in wind, solar and hydroelectric energy). But sustainable energy solutions—even imperfect ones—are needed in a world addicted to fossil fuels, and carbon sequestration could help the transition to clean, renewable fuels over the next 30 years. One reason for carbon sequestration's newfound popularity in Europe is that, starting in 2005, the E.U. will cap carbon emissions as part of its commitment to the 1997 Kyoto agreement on global warming. Installations will be assigned a carbon emis-

TIME, MAY 17, 2004

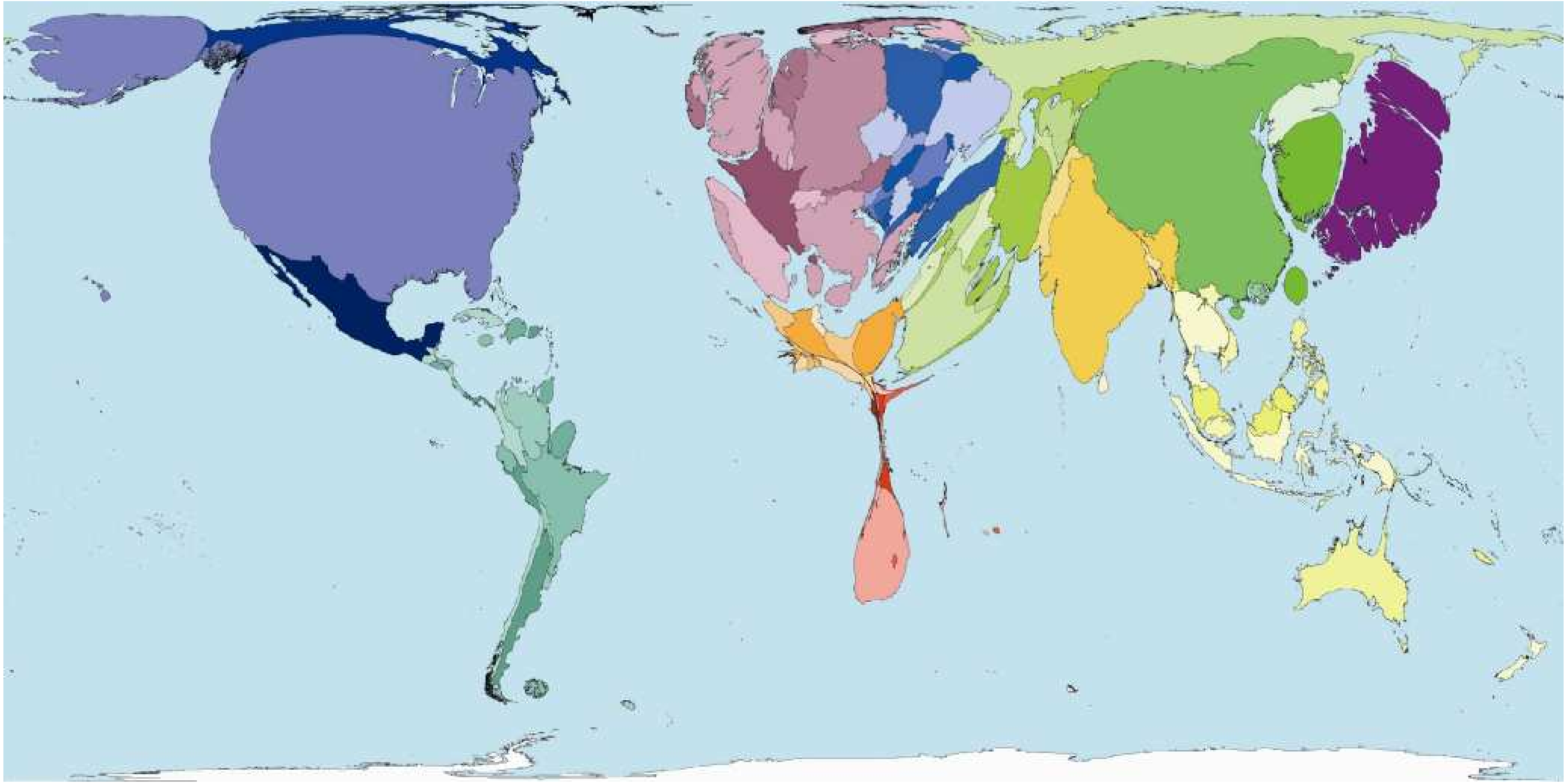


Michel Myhre-Nielsen
BD Manager CO2
Statoil New Energy

IEA GHG – Expert meeting on financing CCS projects
London 31 May – 1 June 2007

CO2-emissions by country

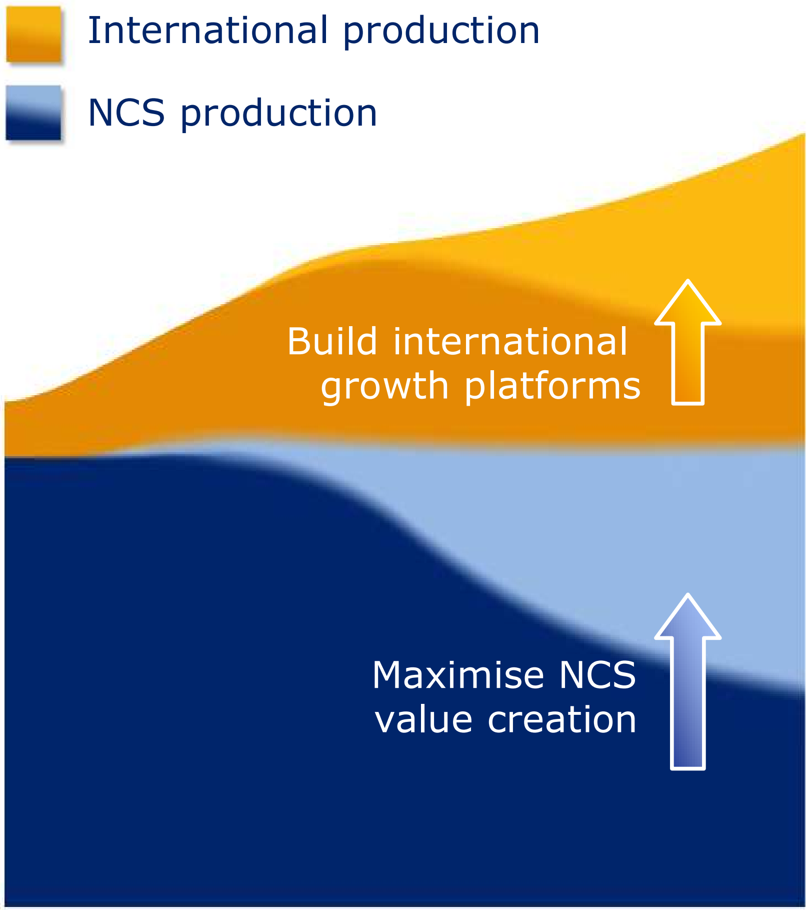
Maps are re-sized to reflect emissions in each country

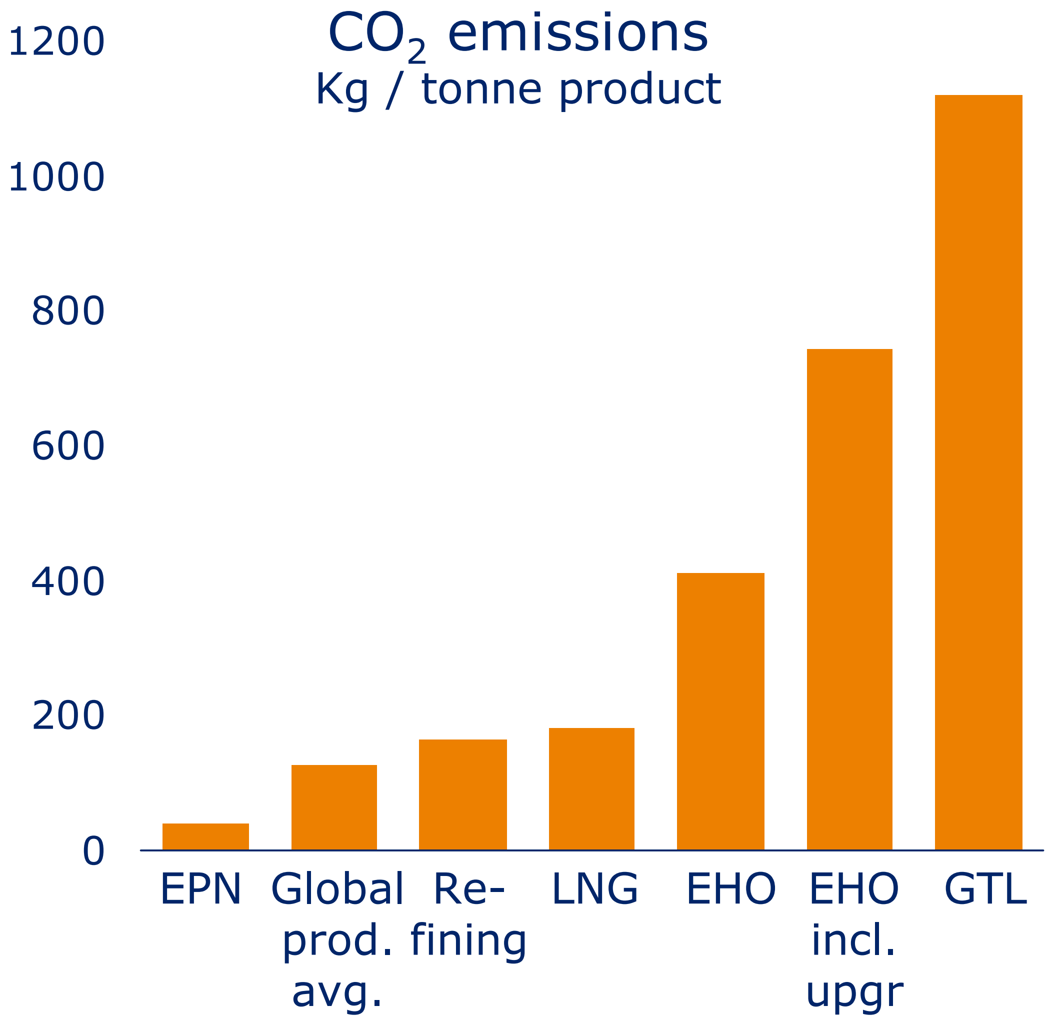


Source: www.worldmapper.org

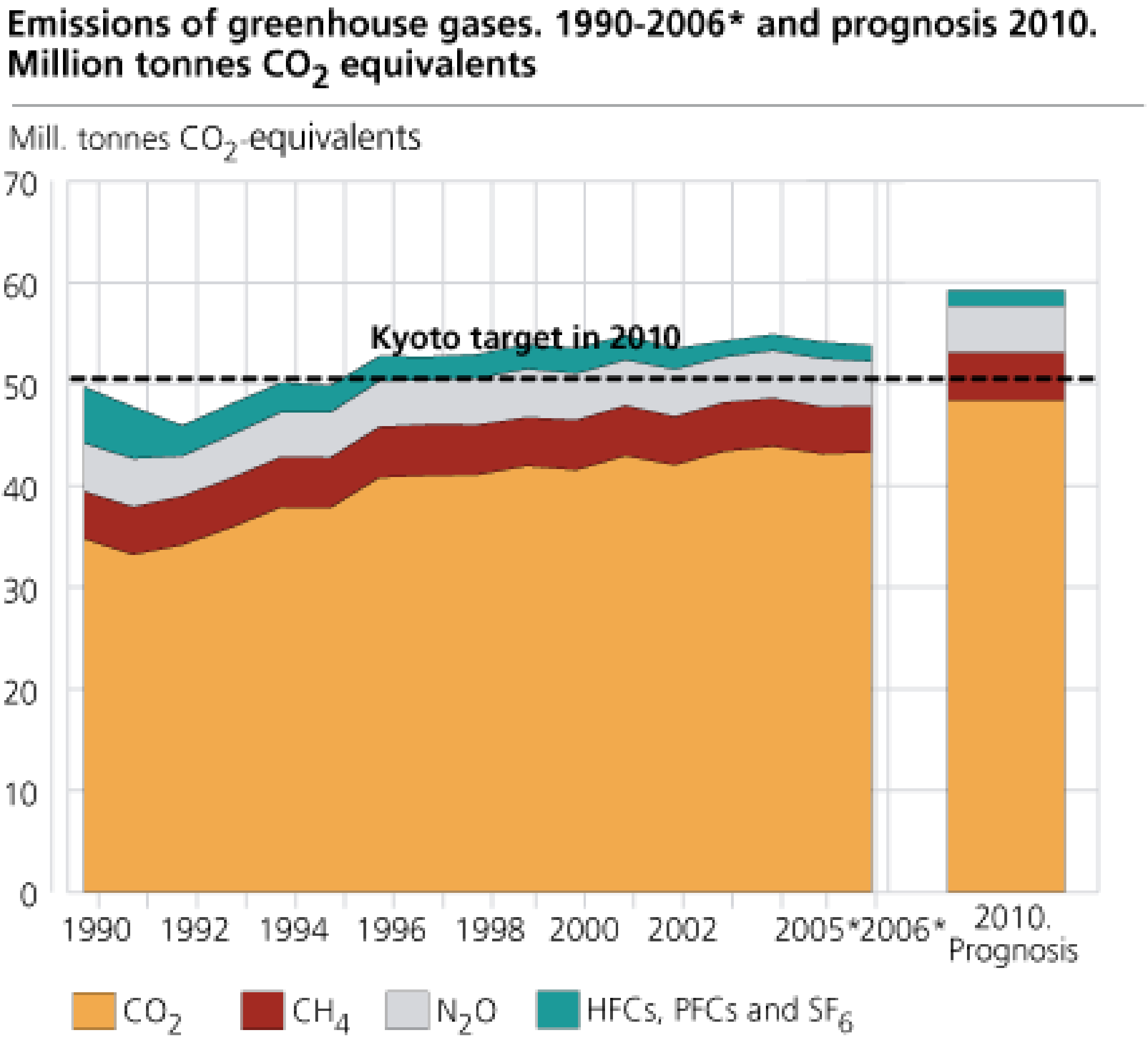
Statoil's climate challenge

Increasing and more CO2 intensive production





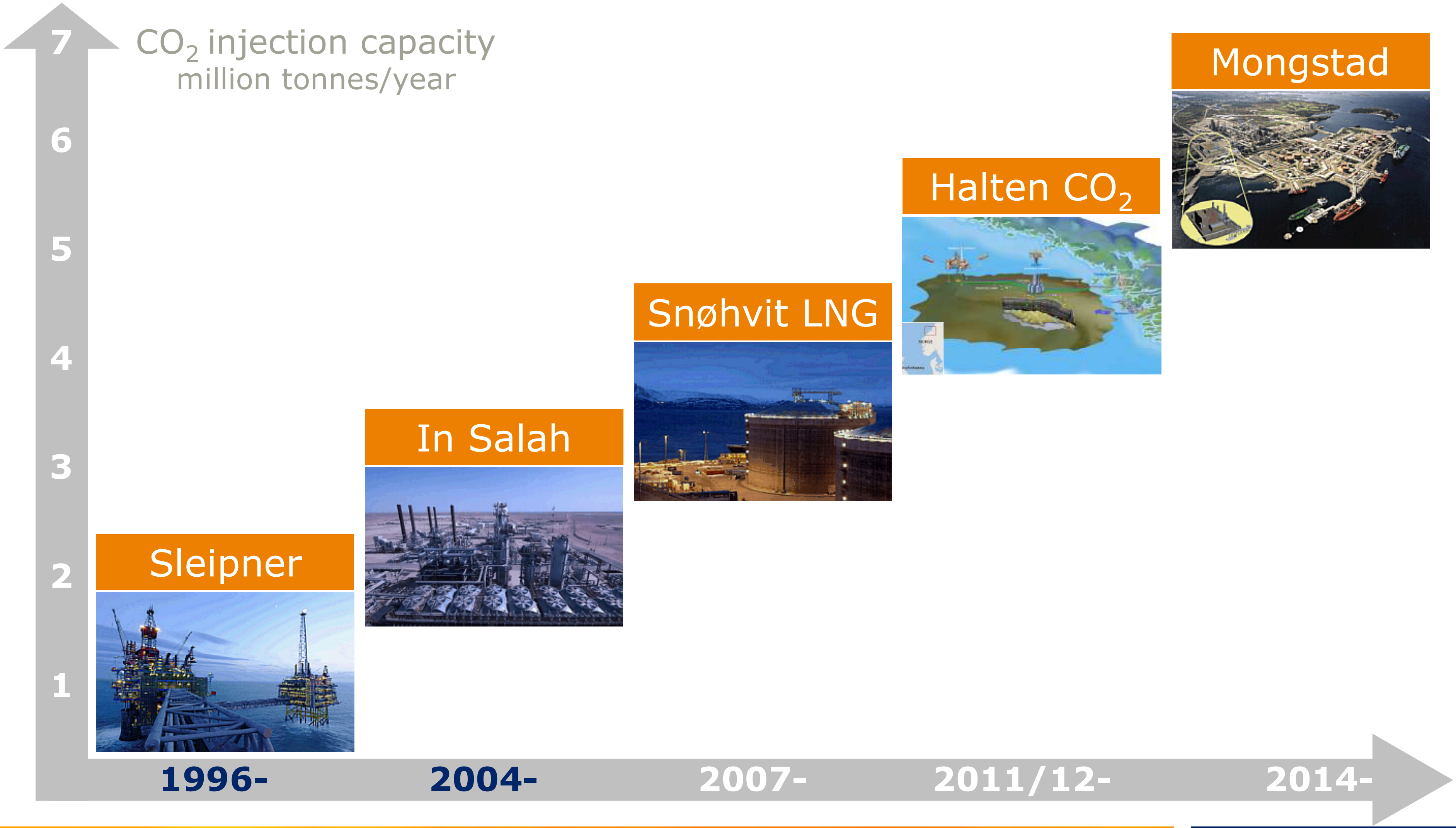
....and Norway's climate gas challenge



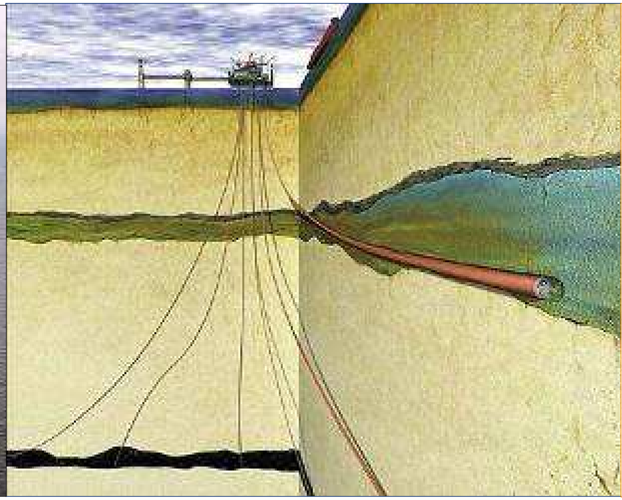
Source: Historical data: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority; Prognosis: Report No. 1 (2006-2007) to the Storting: The National Budget 2007.

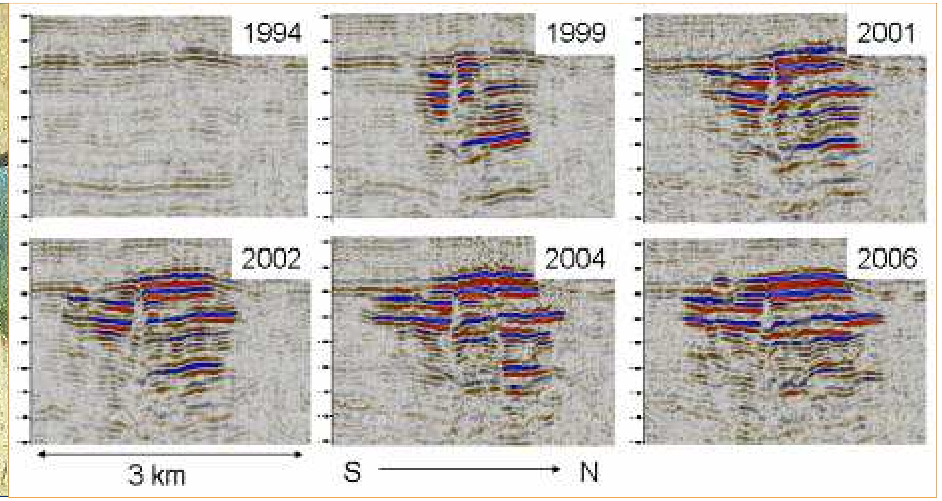
Statoil's CO_2 projects

An industrial approach to climate change



The Sleipner experience – our starting point





- Started in 1996 (10 year anniversary in October 2006)
- Statoil with license partners (Exxon, Total, Hydro)
- Source: CO2 from natural gas (removed to reach sales gas spec of 2.5%)
- Separating and injecting approx. 1 mill. tons CO2 annually
- Storing in saline aquifer above natural gas reservoir
- **Driver:** CO2-tax (340 NOK/ton – 40€/ton)
- Learning and confidence building through a series of large EU-wide R&D programmes – especially on storage monitoring

In Salah and Snøhvit LNG – taking the next CCS steps

- Started in 2004
- BP with Sonatrach & Statoil
- Source: CO2 from natural gas (feed to LNG plant)
- Separating and injecting 1,2 mill. tons CO2 annually
- Injection into reservoir aquifer
- **Driver:** BP internal quota system?

- Starts in late 2007
- Statoil with license partners
- Source: CO2 from natural gas (feed to LNG plant)
- Separating, piping and injecting 0,7 mill. tons CO2 annually
- Injection below reservoir
- **Driver:** CO2 tax

The Halten CO2 project

- Starts 2011/2012 if sanctioned
- Statoil/Shell JV
- Source: CO2 from gas power plant
- Separating, transporting and injecting/EOR up to 2,5 mill. tons CO2 annually
- Injection into producing oil reservoir
- **Driver:** EOR and electrification

- Current results shows challenging economics and additional incentives are necessary

Mongstad CO2 test centre and full scale capture project

Capture test centre

- Starts late 2010
- Statoil, partners and authorities
- Source: CO2 from gas power plant and refinery cracker gas
- Separating, transporting and storing 0,1 mill. tons CO2 annually
- Transportation and injection site not yet identified
- **Driver:** Technology development, qualification and cost reduction. Authorities to bear cost of transport and storage.

Full scale capture

- Starts 2014
- Statoil on behalf of authorities
- Source: CO2 from gas power plant and refinery cracker gas
- Separating, transporting and storing up to 2,5 mill. tons CO2 annually
- Injection site not yet identified
- **Driver:** Fully covered CCS cost by authorities

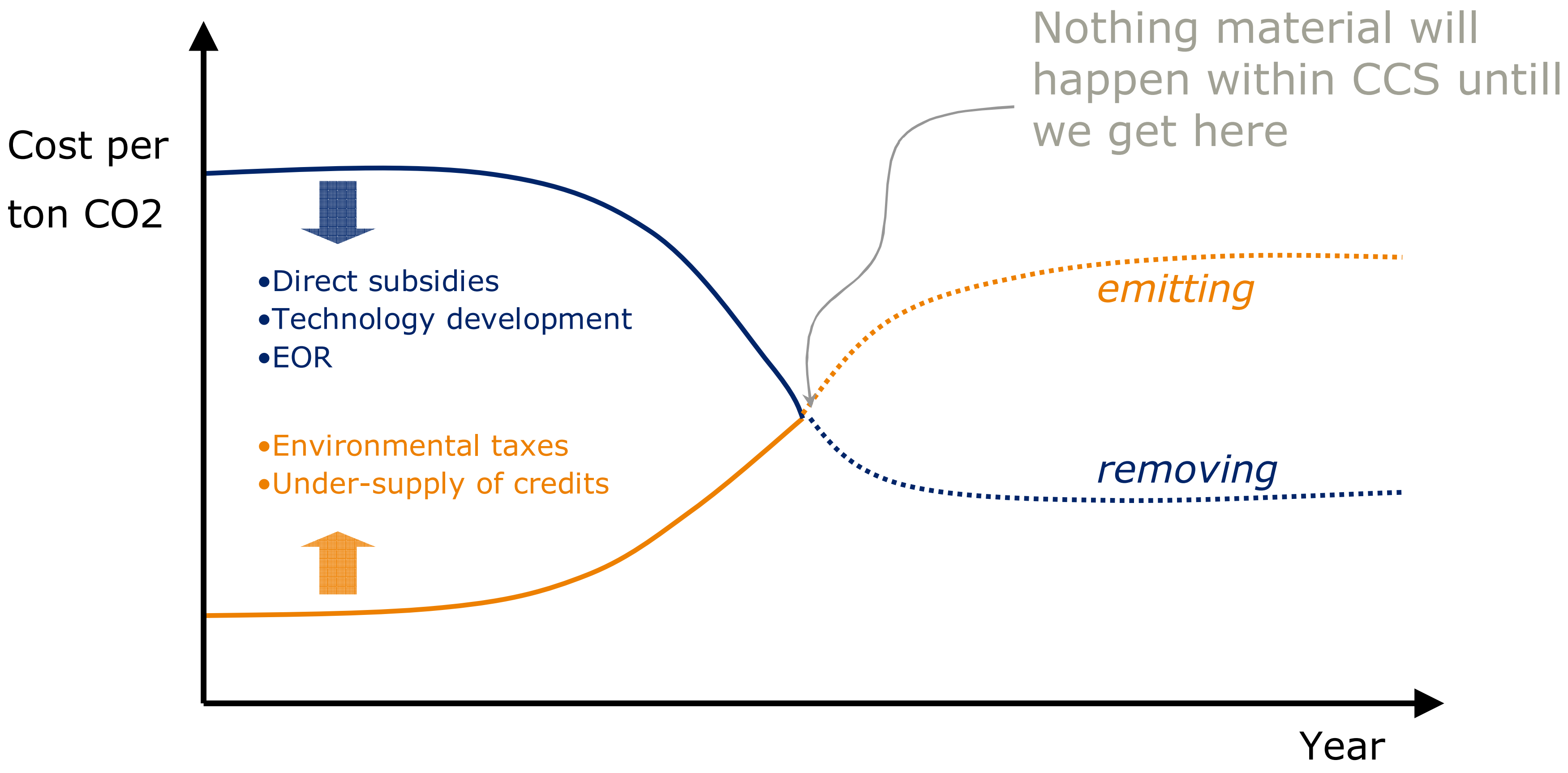
The Kårstø CCS project

- Starts 2011/2012 if sanctioned
- Authorities through project dev. group
- Source: CO2 from gas power plant
- Separating, transporting and injecting 1,0 mill. tons CO2 annually
- Injection site not yet identified – Sleipner/Utsira studied
- **Driver:** Environment (environmental politics)

- Feasibility report available for public: http://www.nve.no/FileArchive/447/NVE%20Report%202-07.pdf

What does it take?

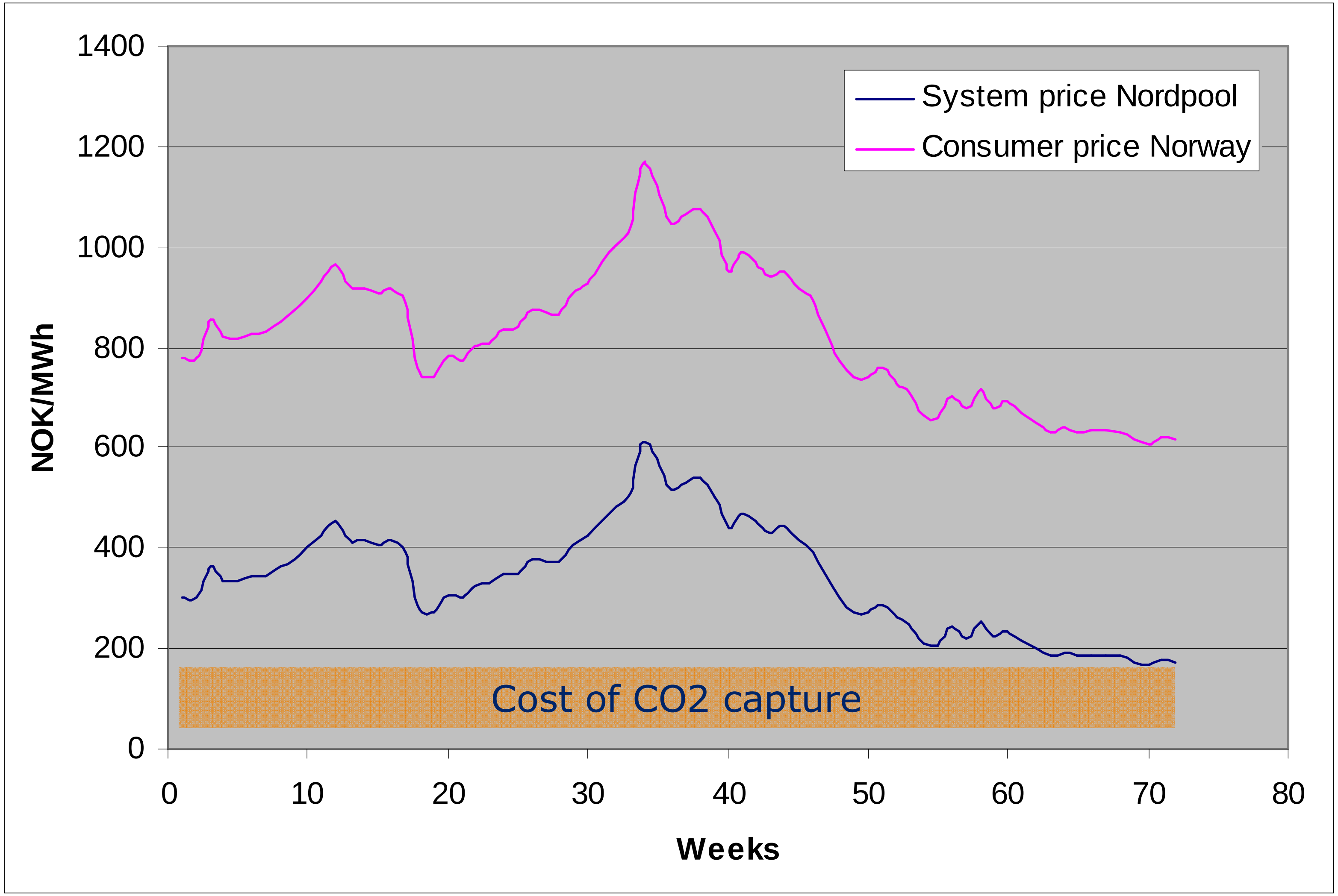
Simple economic rules will decide speed and volume of CCS roll-out



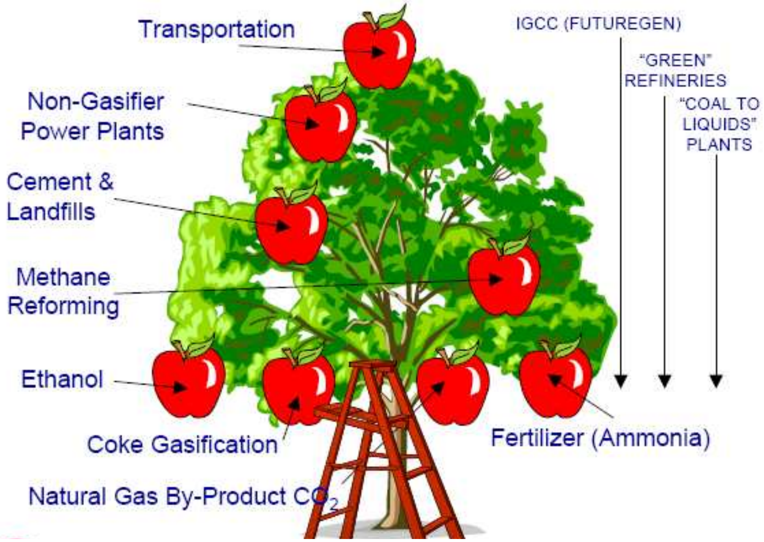
Incentive toolkit

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

CO2 capture cost/kWh vs. electricity price

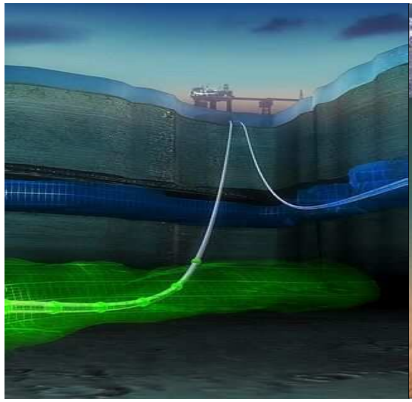
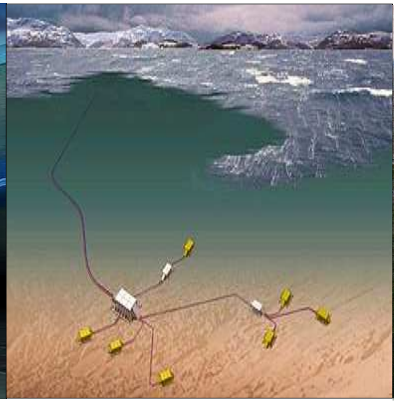
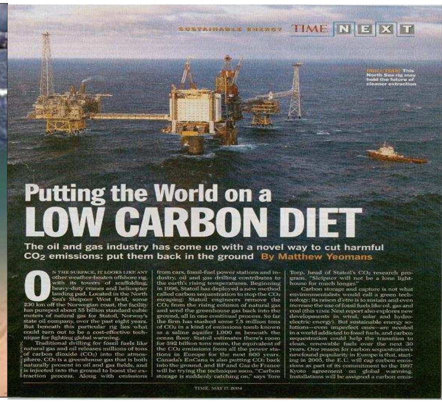


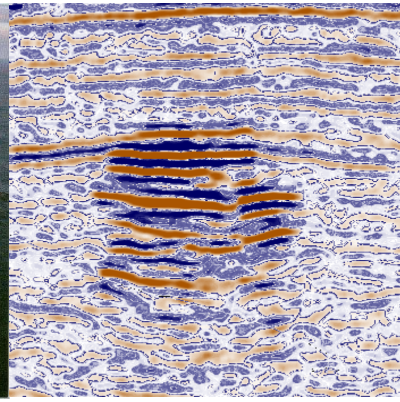
How to begin the CCS industry



- Sort out the regulations
    - —Int’l conventions
    - —Local tax regimes
    - —Authority involvement
- O&G companies are keys in developing CCS
    - —Obvious similarities to natural gas infrastructure development
    - —No lack of money
- Pick the low-hanging fruits first
- Public acceptance

Summary and conclusions

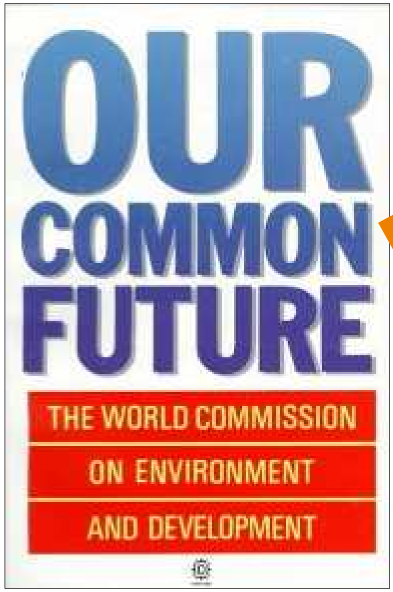







- CCS technically proven
- Enormous potential – public acceptance necessary
- Value chain approach (EOR) can support pioneering projects
- Financial mechanisms key to initiate projects
- Key element in meeting the global climate challenge

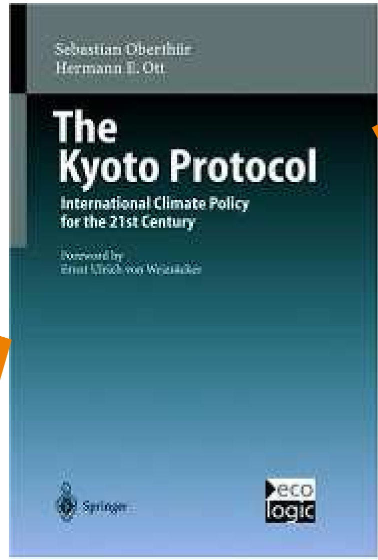
Thanks for the attention!

20 Year Anniversary for Our Common Future



"The Brundtland Report", 1987

Norway's Prime Minister Gro Harlem Brundtland in Rio in 1992*

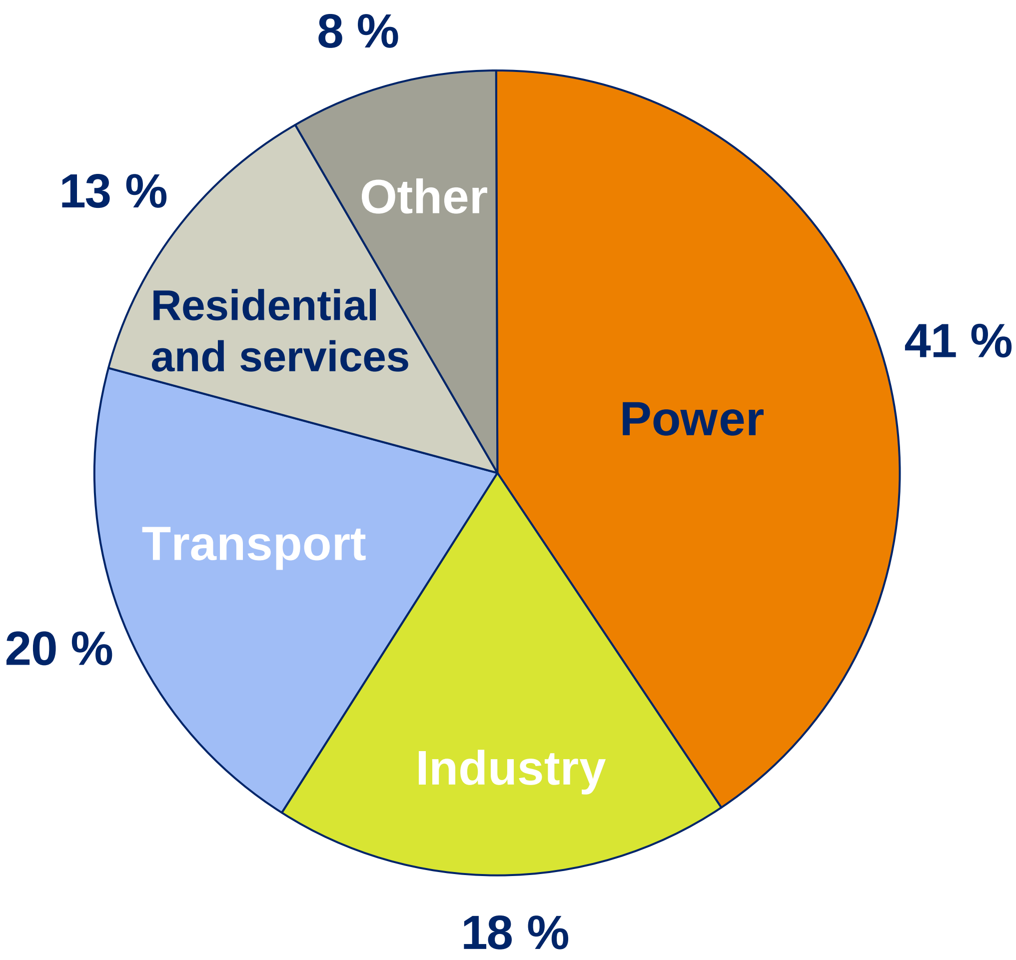


The Kyoto Protocol, 1997

The Kyoto Protocol ratified, 2005

*** Gro Harlem Brundtland introduced a CO2-tax of about 45 US$/ton in Norway in 1992**

World energy-related CO2-emissions by sector 2004



Announced projects are not sanctioned before developers see an economic driver in realising them

Other large CCS-projects internationally*

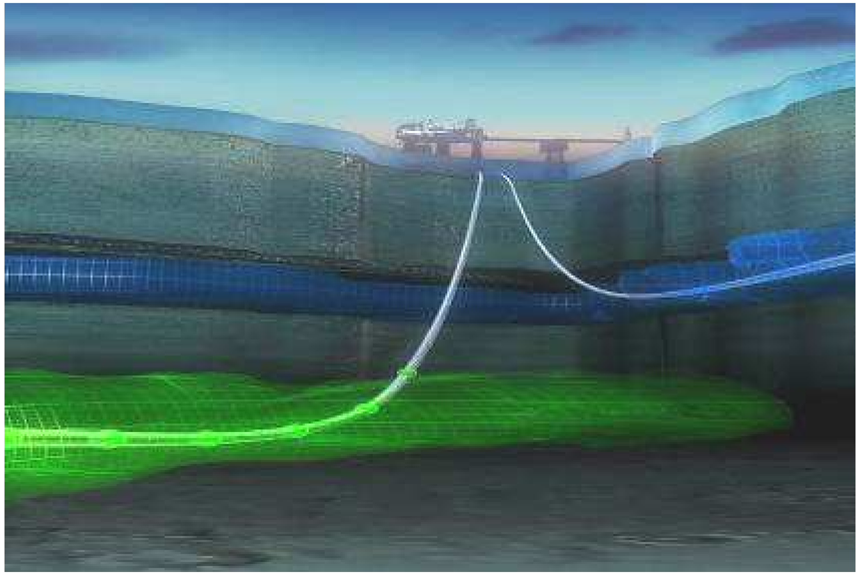
Power plants with CO2-capture:

Proposed full-scale projects

15 projects

CO2-storage projects:

Commercial and demonstration



7 projects

The Clean Coal Advantage

Expert Meeting on Financing CCS Projects

London, England

May 31, 2007

Bob Stobbs, P. Eng.
SaskPower

Contributors:

Max Ball and Doug Daverne, SaskPower

David Cameron and Alan Farmer, Neill & Gunter

Kevin McCauley, Babcock & Wilcox

David Beacon and Dennis Williams, SNC-Lavalin

Bill Castor, Air Liquide

Editing: Randa Elder, SaskPower

Presentation Overview

- Background
- The Opportunity
- The Engineering
- The Project as Proposed

History Lesson

Fall 2005:

- **Canada tables GHG regulations**
- **Canada requests proposals for GHG initiatives**
- **SaskPower engaged in option studies (internally and with others)**

2006 - January

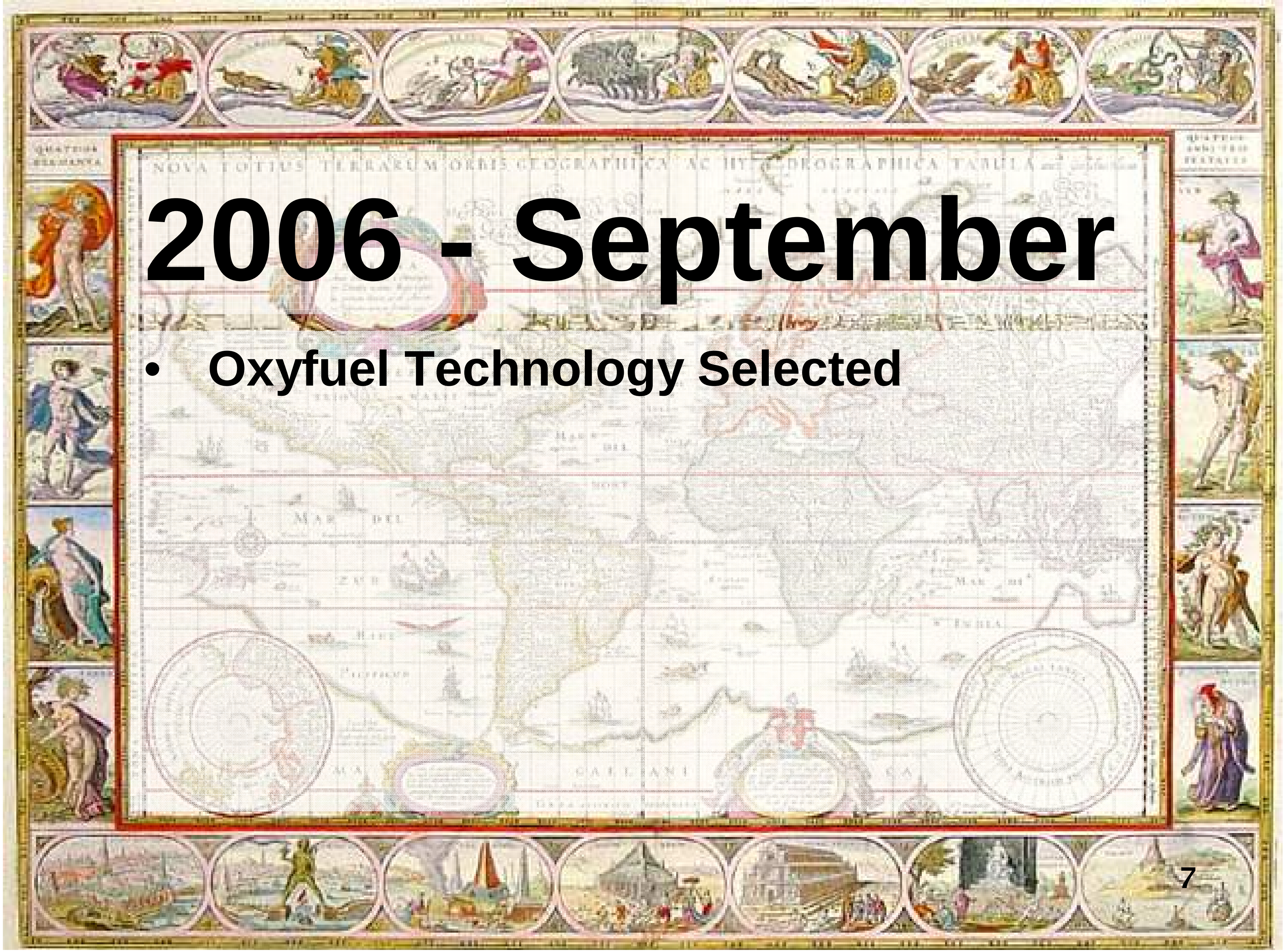
- **SaskPower Assembles Clean Coal Team to prepare Commercial Proposal to be evaluated against other supply options**
- **Coal Exploration rigs into the field (-30C)**

2006 - February

- **Engineering Resources and Manufacturers Engaged**
- **EOR Operators Contacted**
- **Project Office Opened**

2006 - September

- Oxyfuel Technology Selected



2006 - November

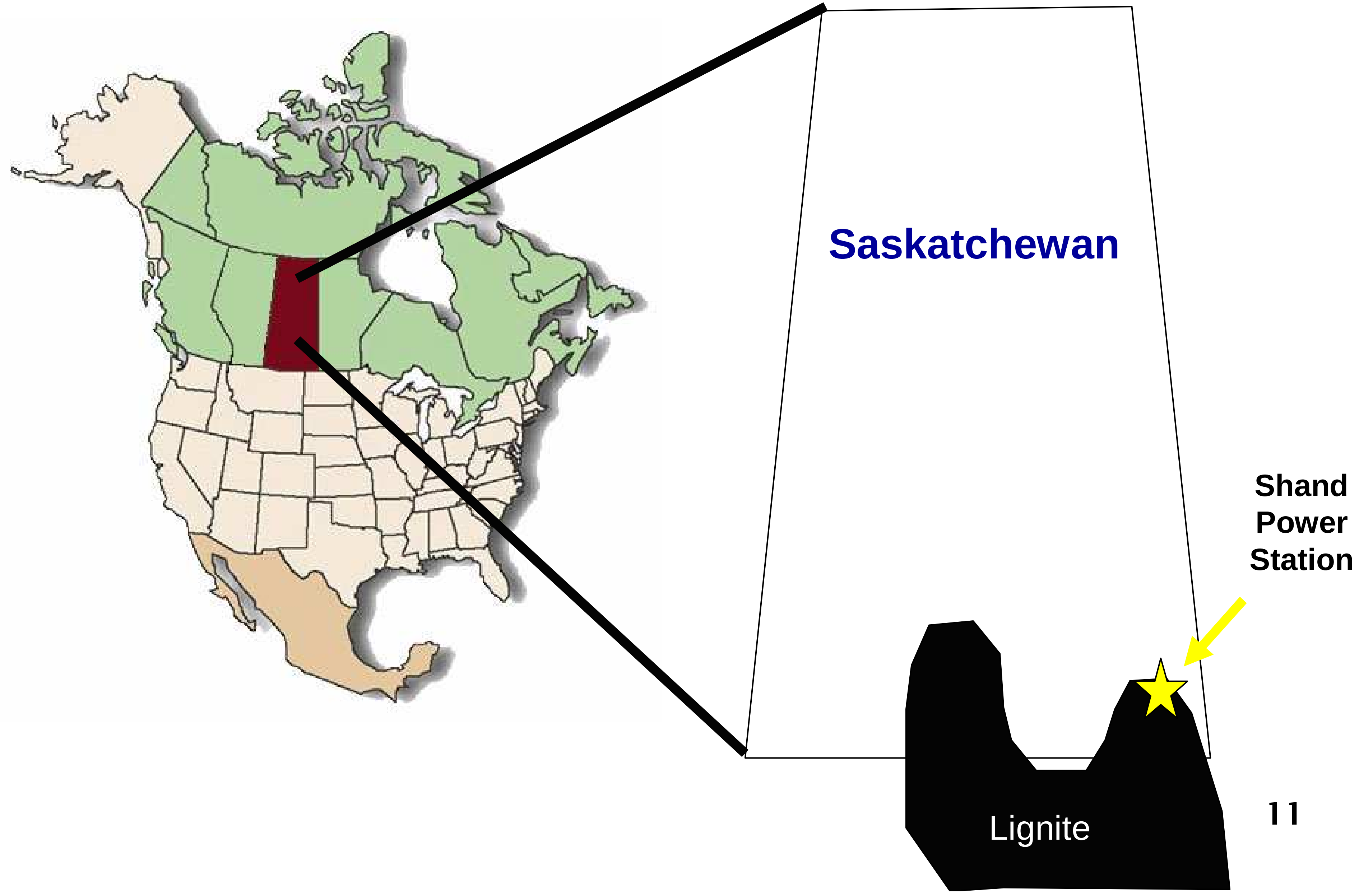
- **Coal Negotiations Completed**
- **Site Selected**

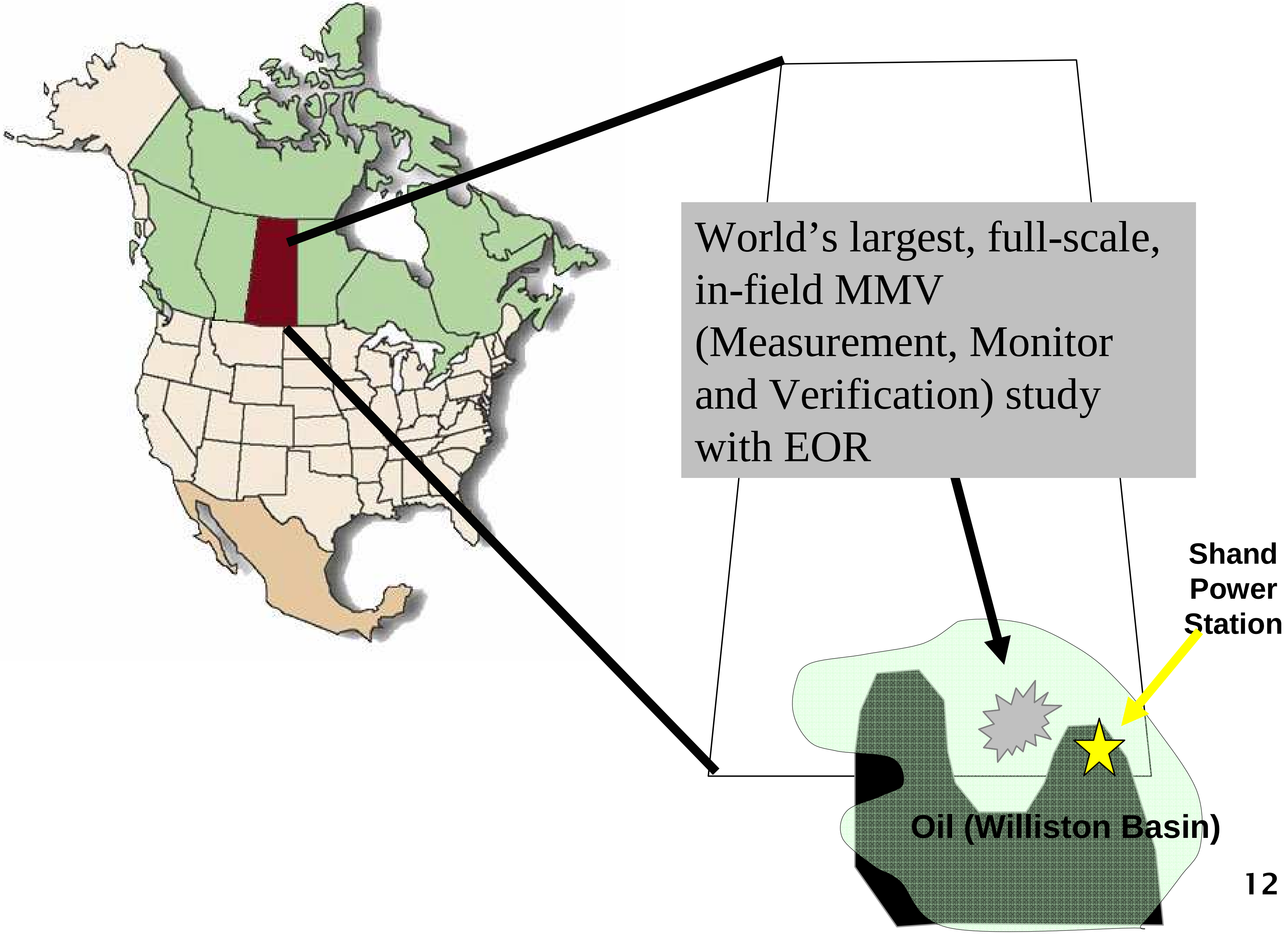
2007 - April

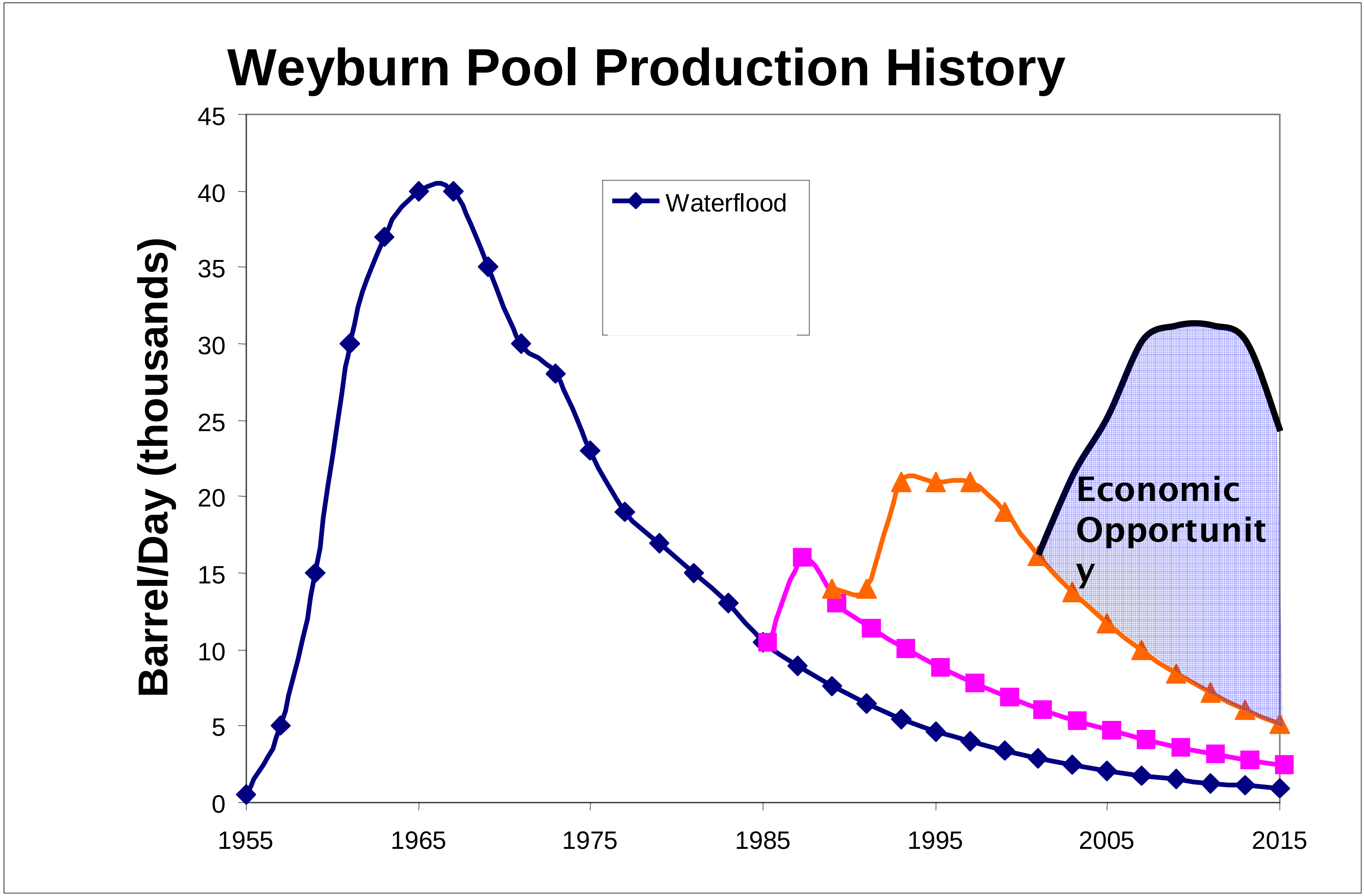
- Technical Proposal to SaskPower
- Project Guidelines for EIA Received
- Application for Water License Submitted

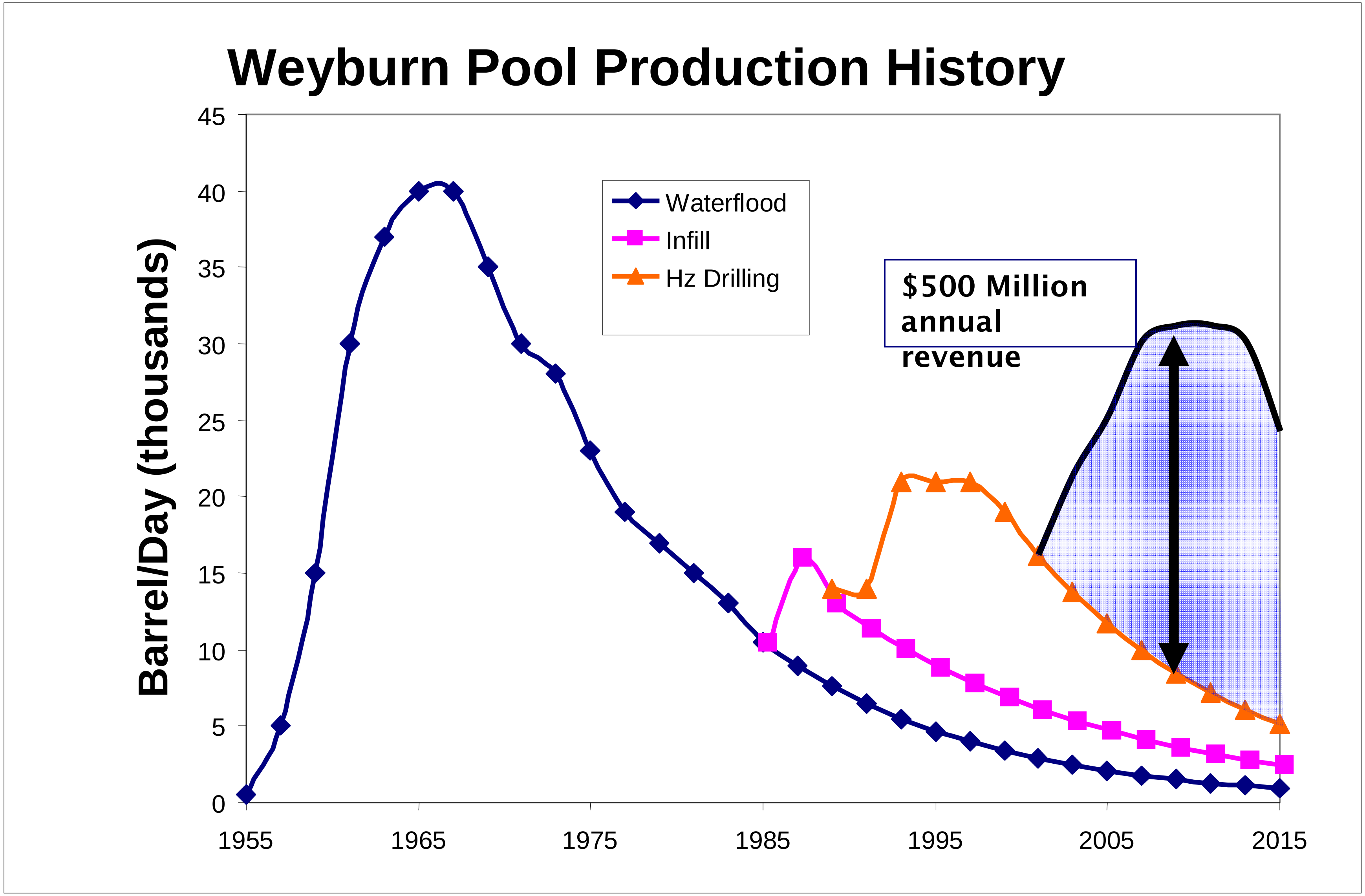
Presentation Overview

- Background
- **The Opportunity**
- The Engineering
- The Project as Proposed


Saskatchewan
Shand
Power
Station
Lignite

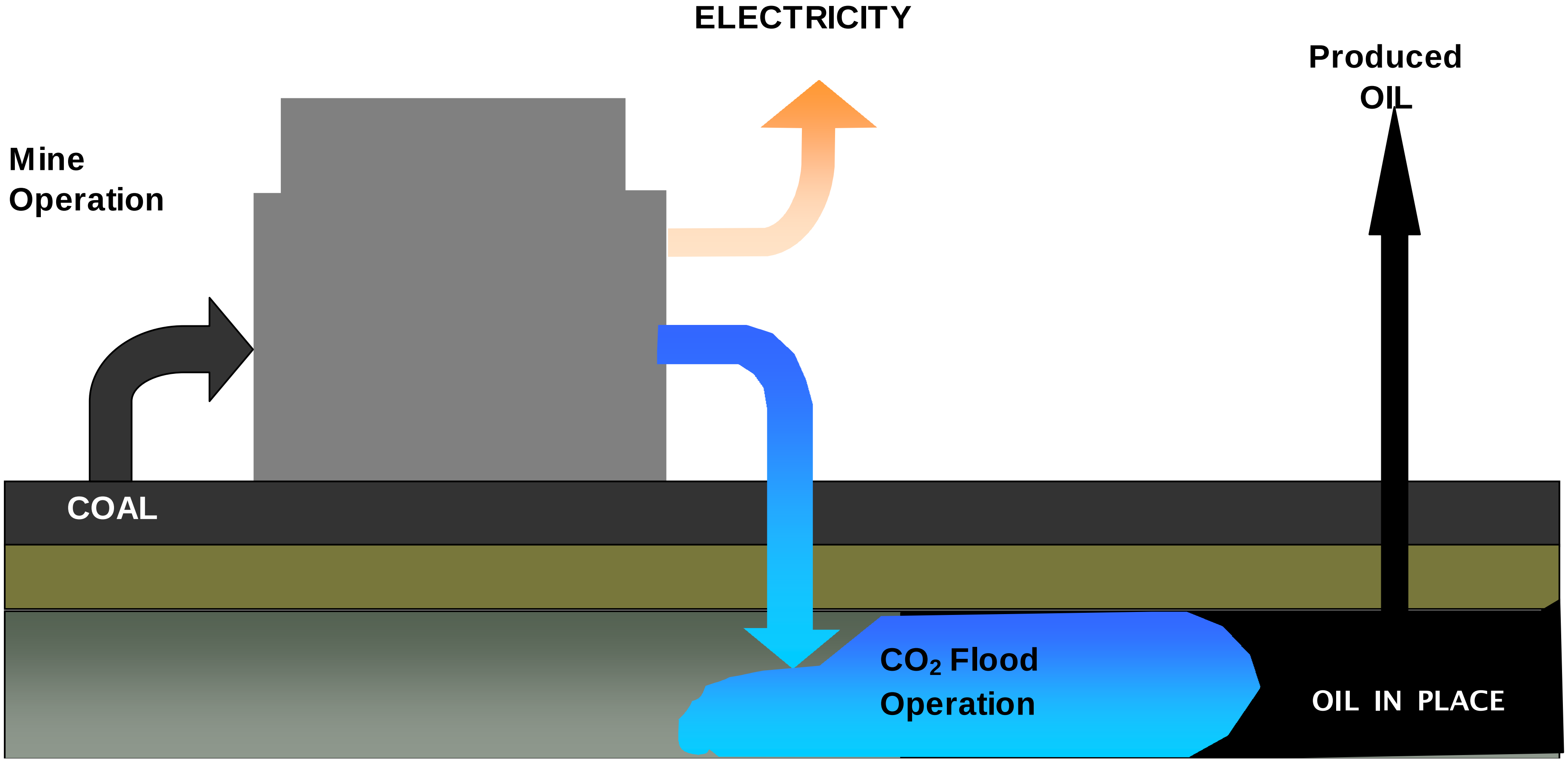

World's largest, full-scale, in-field MMV (Measurement, Monitor and Verification) study with EOR
Shand Power Station
Oil (Williston Basin)


Weyburn Pool Production History
Barrel/Day (thousands)
Waterflood
Economic Opportunit y
0
5
10
15
20
25
30
35
40
45
1955
1965
1975
1985
1995
2005
2015


Weyburn Pool Production History
Barrel/Day (thousands)
45
40
35
30
25
20
15
10
5
0
1955
1965
1975
1985
1995
2005
2015
Waterflood
Infill
Hz Drilling
$500 Million annual revenue

Overall COAL to OIL Process

1 Tonne Coal ➔ Produces ➔ **0.8 MWh** + **2 to 10 barrels Oil**



Net Emissions Impact

Near Zero emissions electricity plus:

1 Barrel Weyburn Crude: Equivalent to 1.0 GHG unit

Offsets

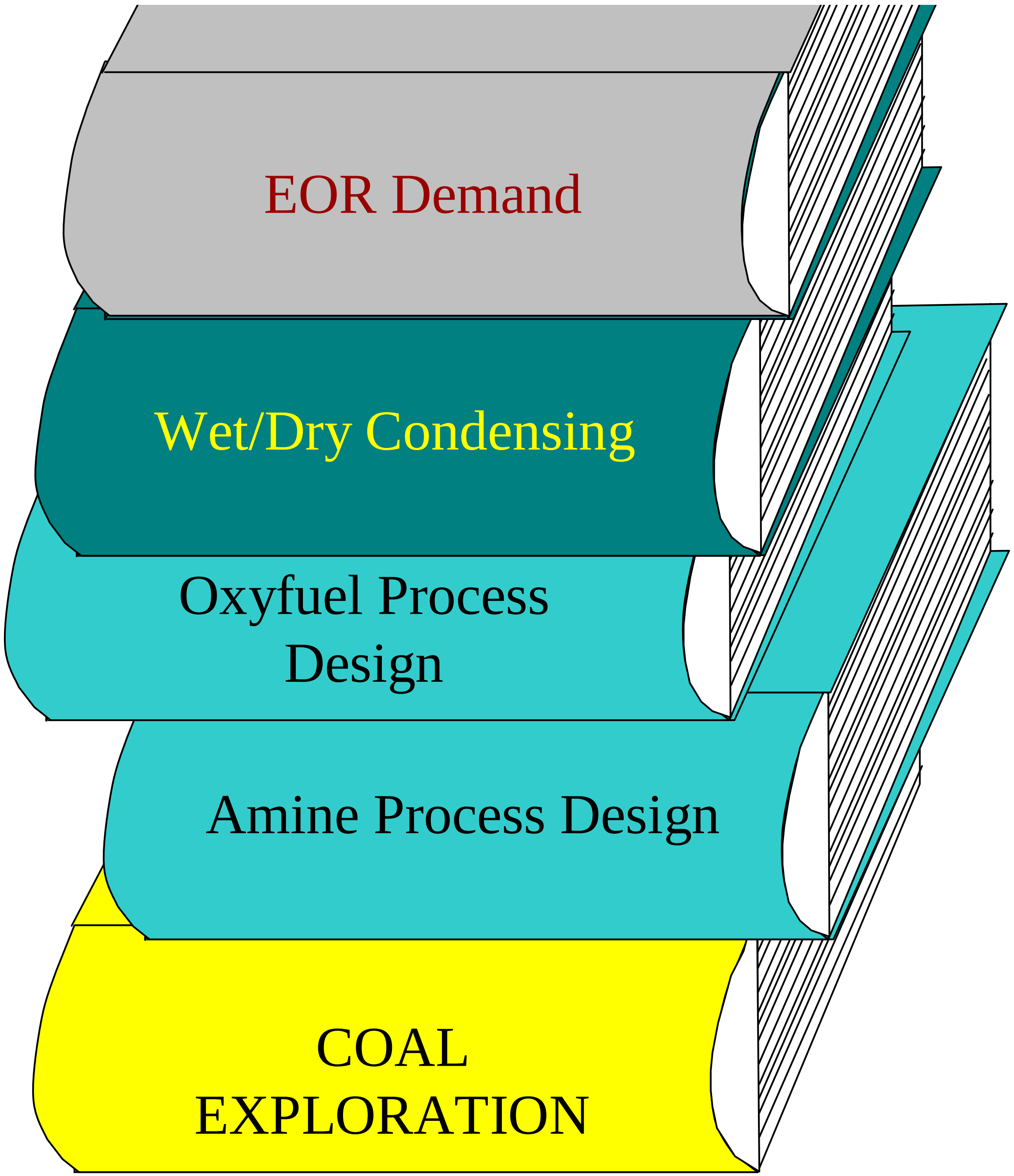
1.3 to 1.4 GHG equivalents Middle East Oil

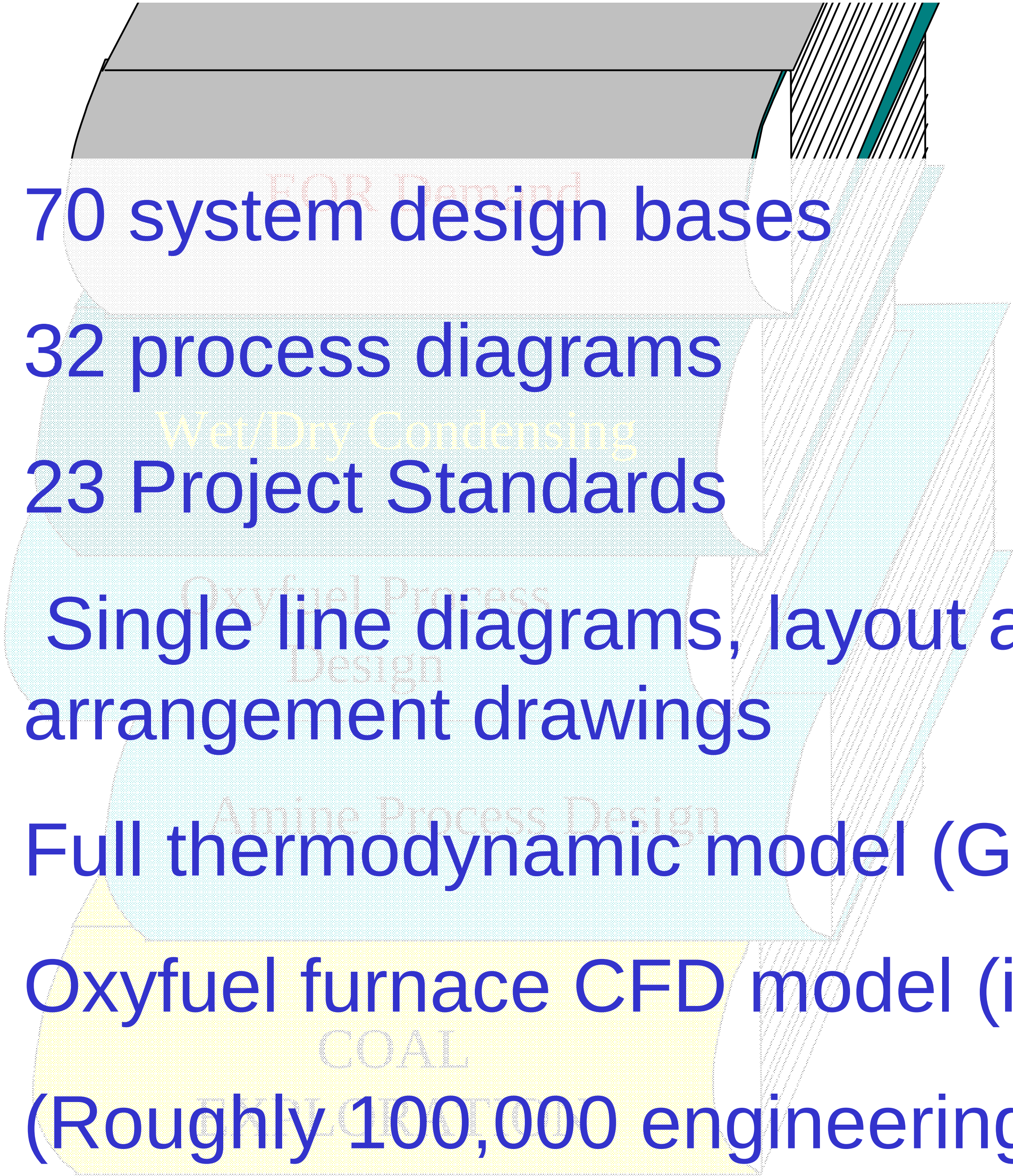
or

1.9 GHG equivalents Alberta Oil Sands

Presentation Overview

- Background
- The Opportunity
- **The Engineering**
- The Project as Proposed

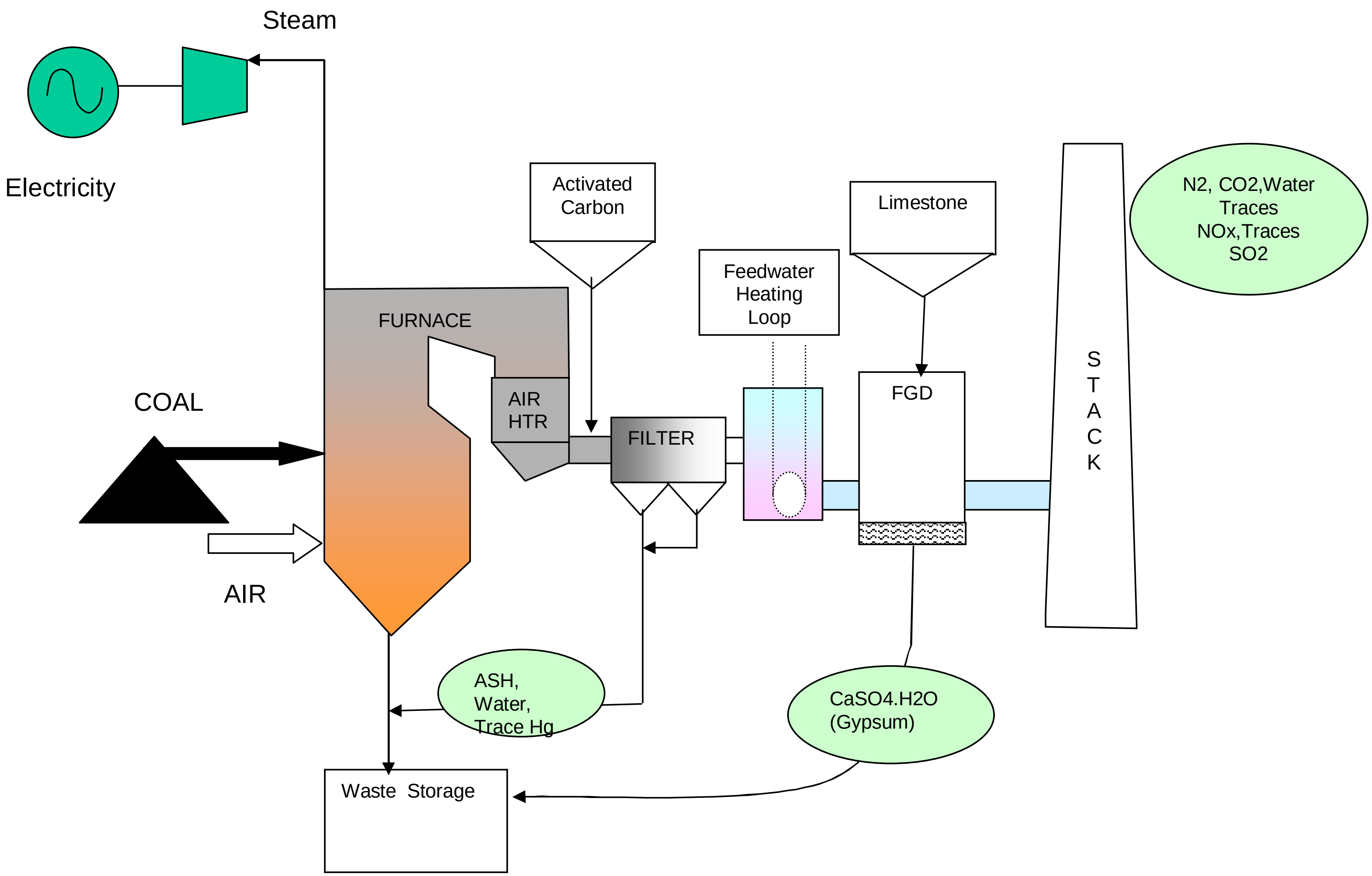

EOR Demand
Wet/Dry Condensing
Oxyfuel Process Design
Amine Process Design
COAL EXPLORATION



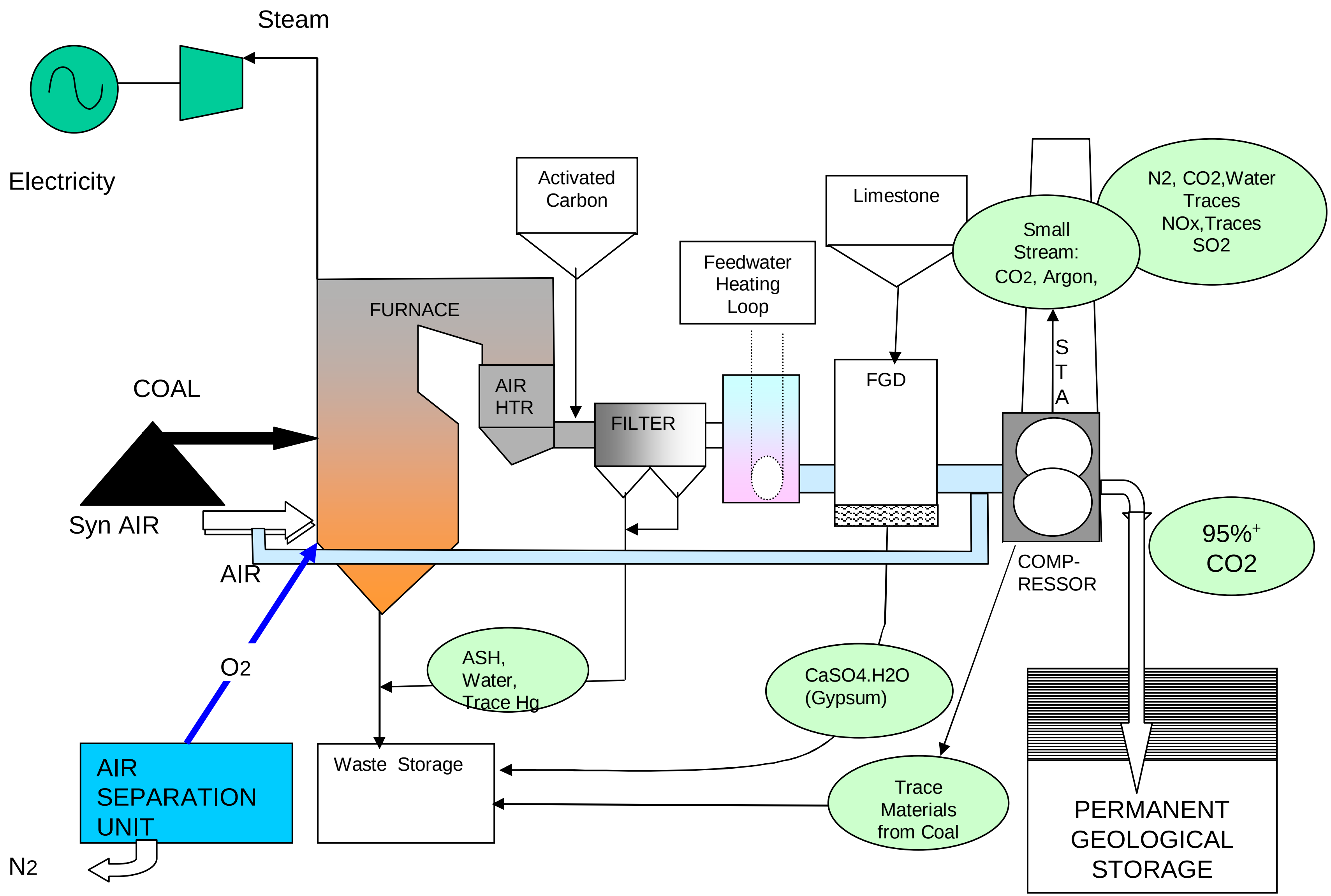
- 70 system design bases
- 32 process diagrams
- 23 Project Standards
- Single line diagrams, layout and arrangement drawings
- Full thermodynamic model (Gate cycle)
- Oxyfuel furnace CFD model (in production)
- (Roughly 100,000 engineering man-hours)

Engineered Deliverables

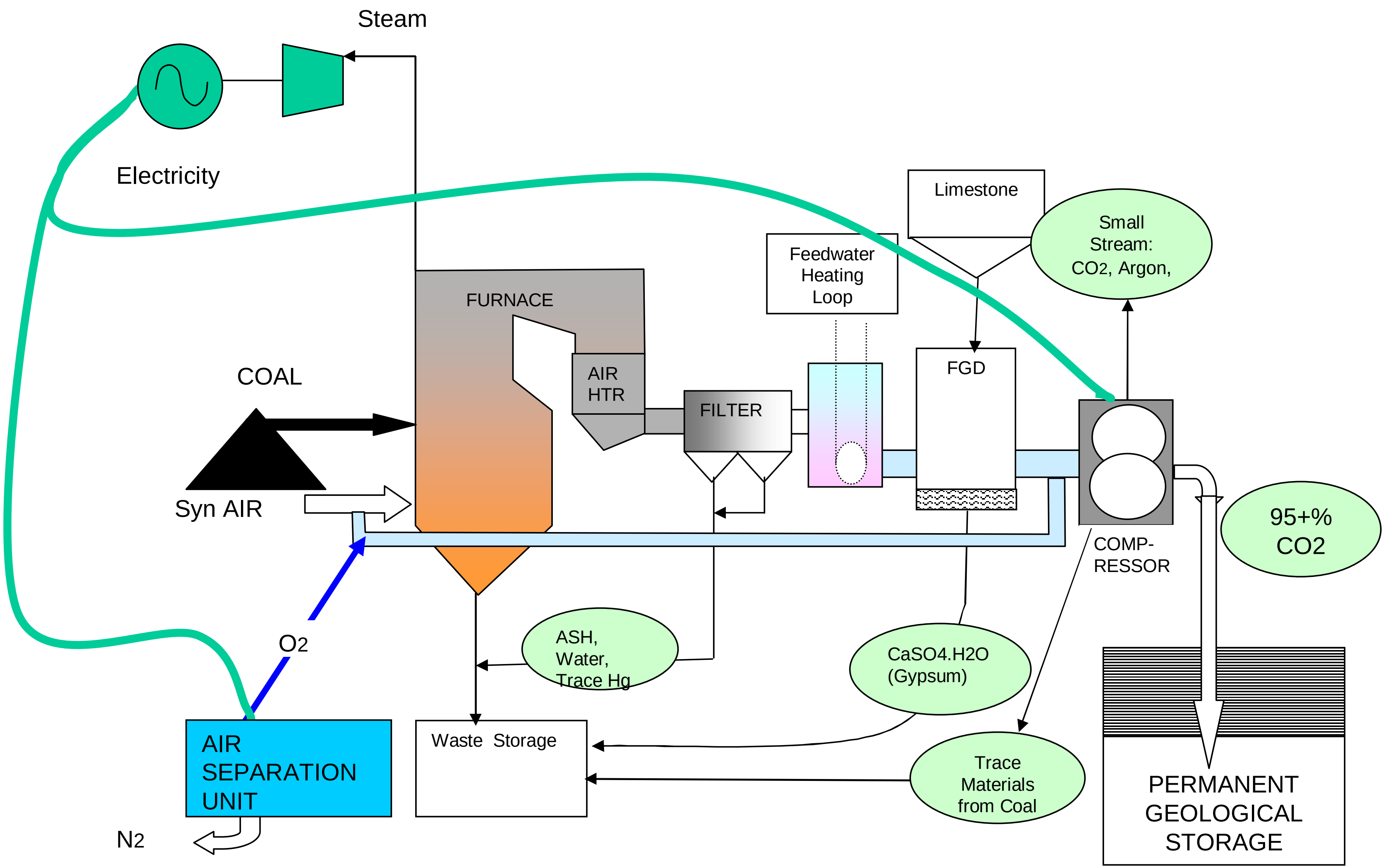
- Detailed plant design (two sites) for amine and oxyfuel with cost/performance comparison
- Detailed Oxyfuel design:
  - Full and part load
  - Air fired start up
  - Range of fuel characteristics
  - Range of ambient conditions
  - Work with available water resources
- Project Integrated Construction Schedule
- Hazop Analyses
- Structured Risk Analyses



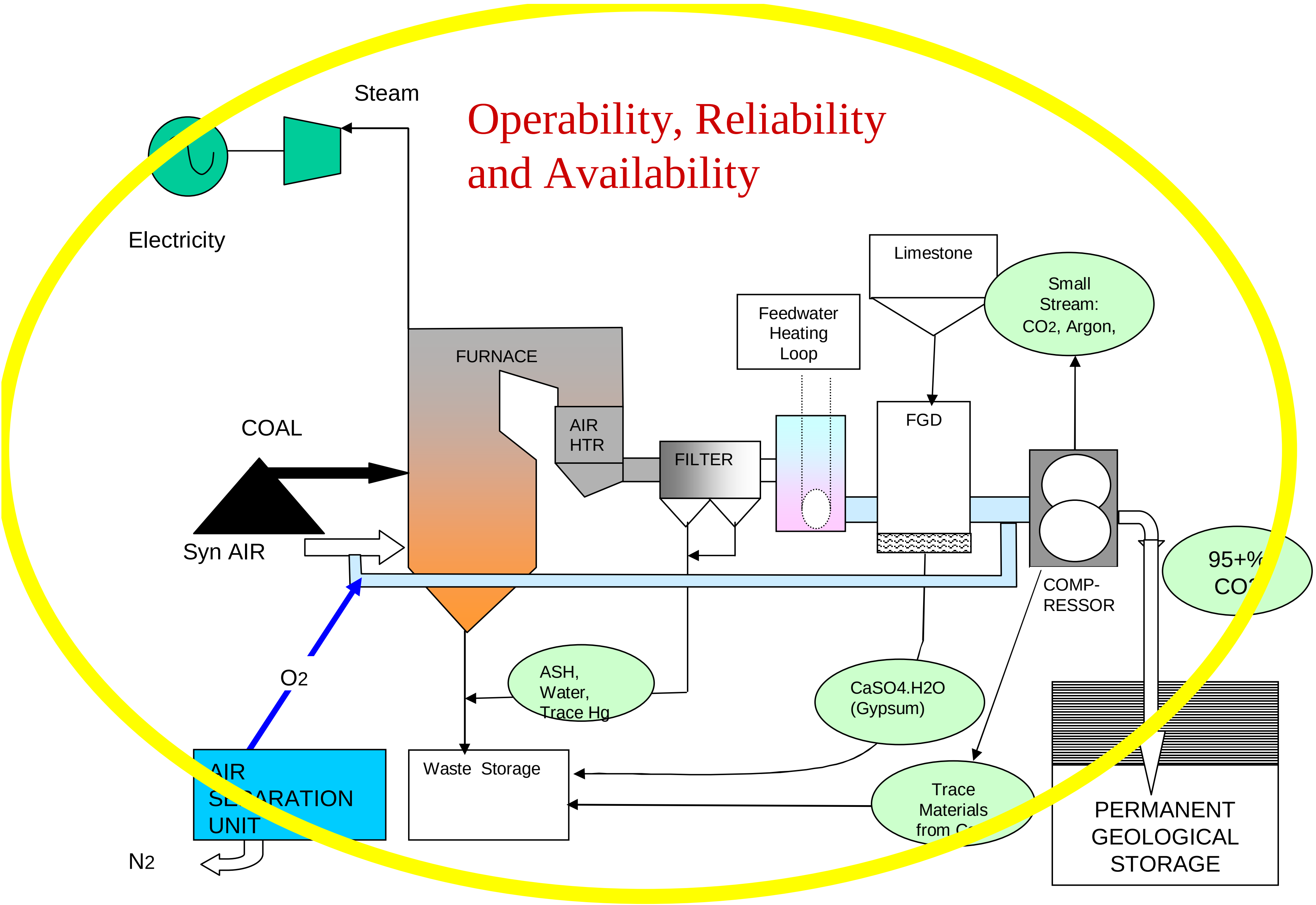
COMPLIANT COAL UNIT



SaskPower Oxyfuel Process



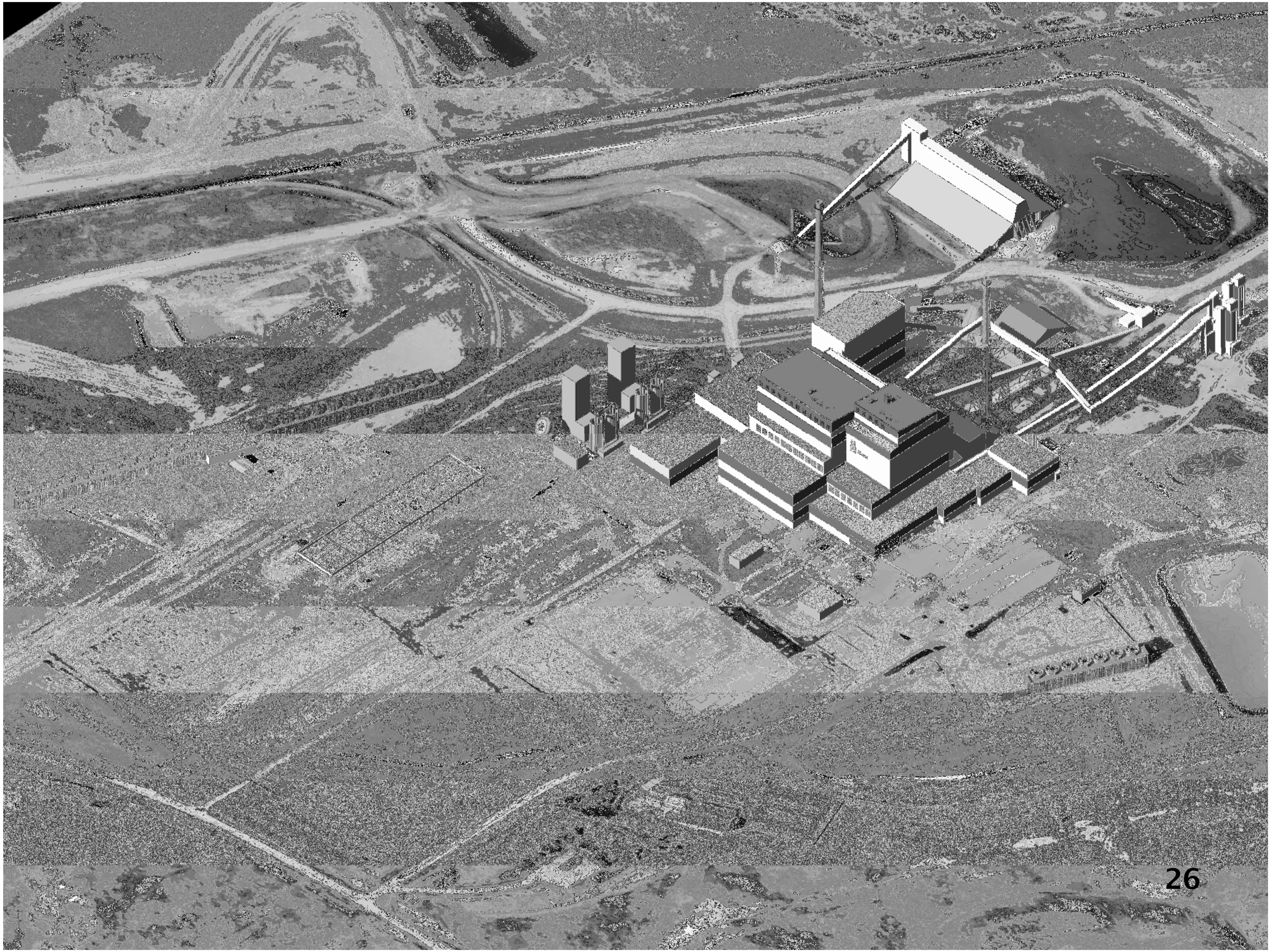
SaskPower Oxyfuel Process

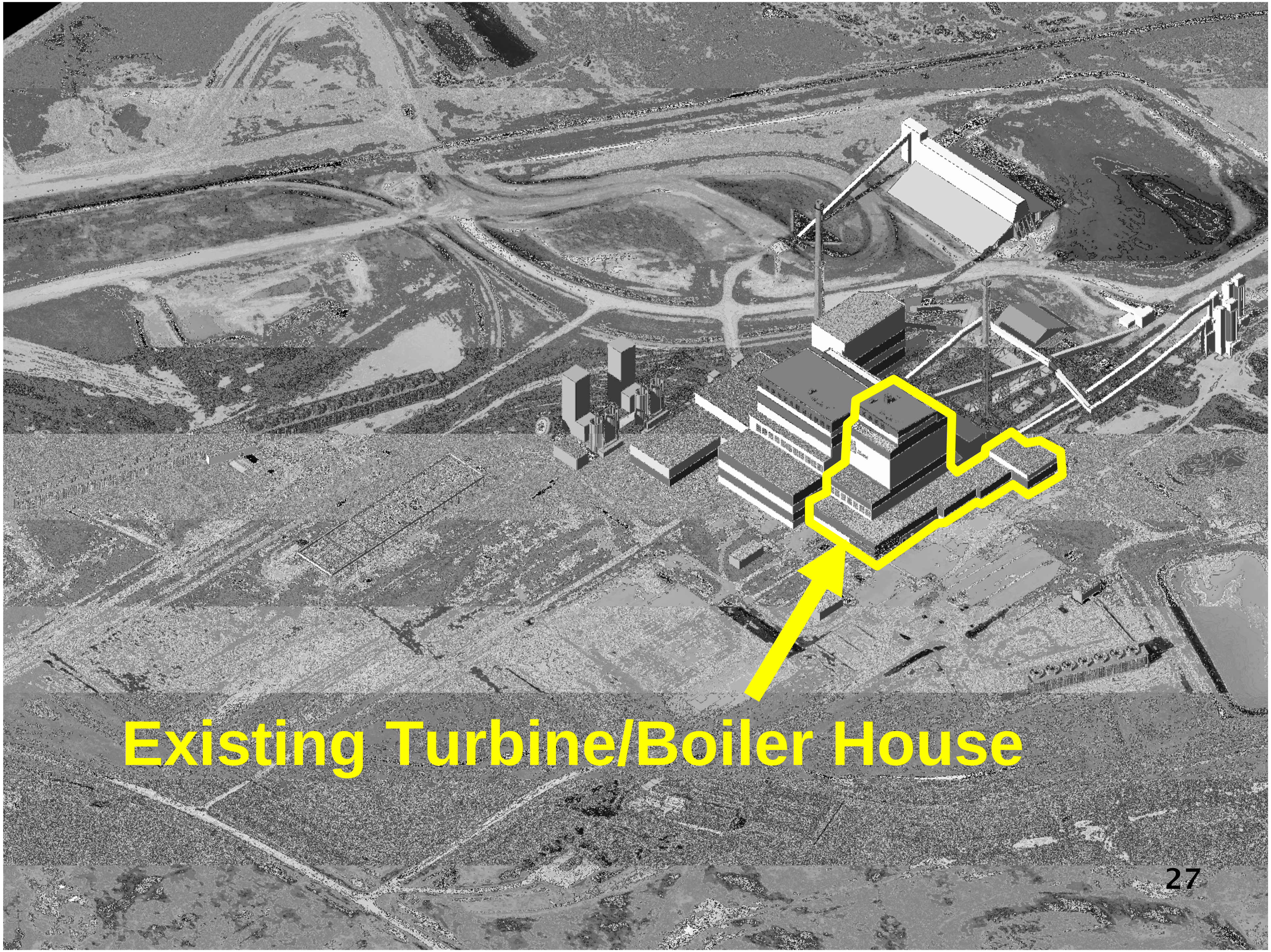


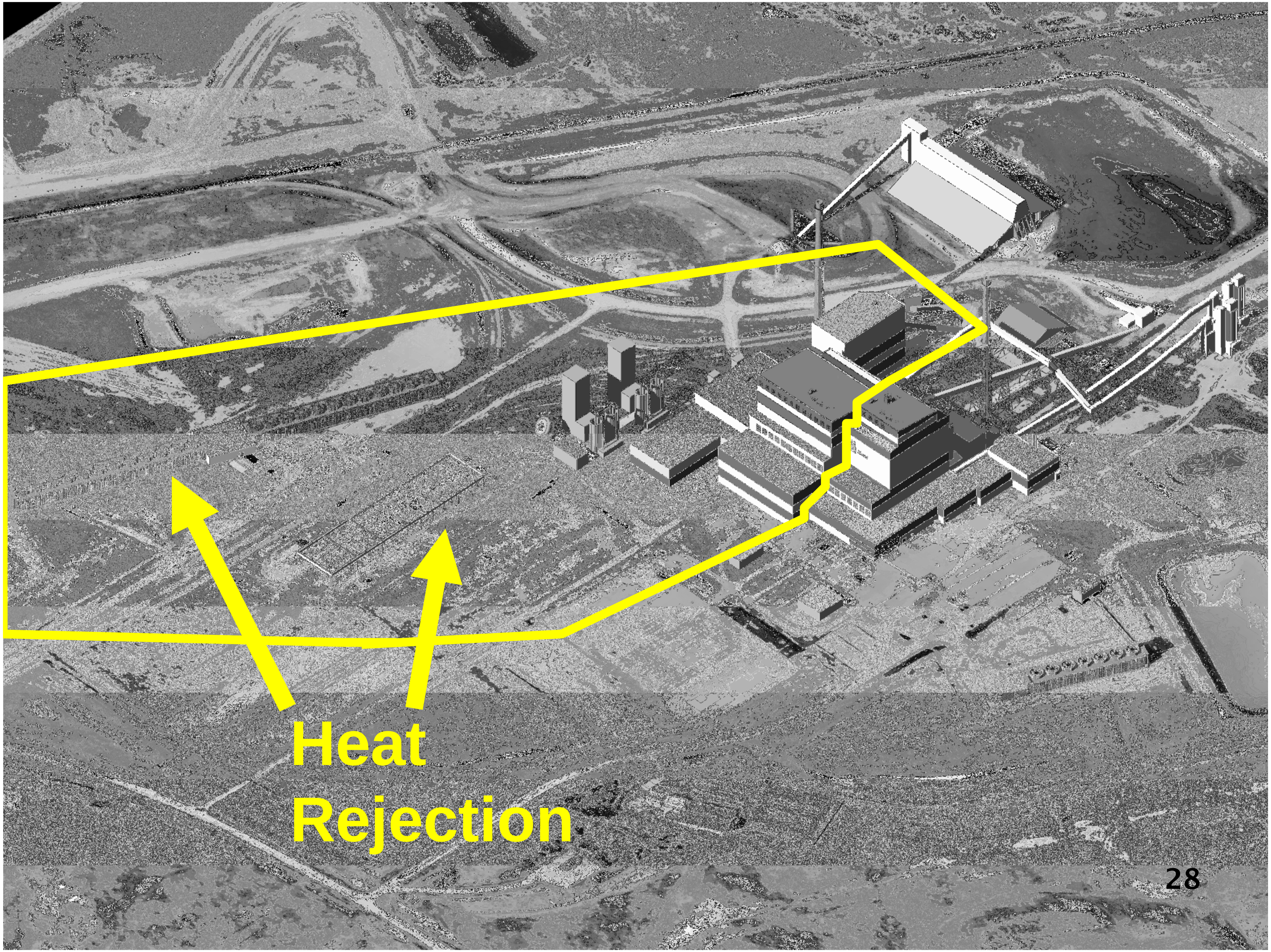
SaskPower Oxyfuel Process

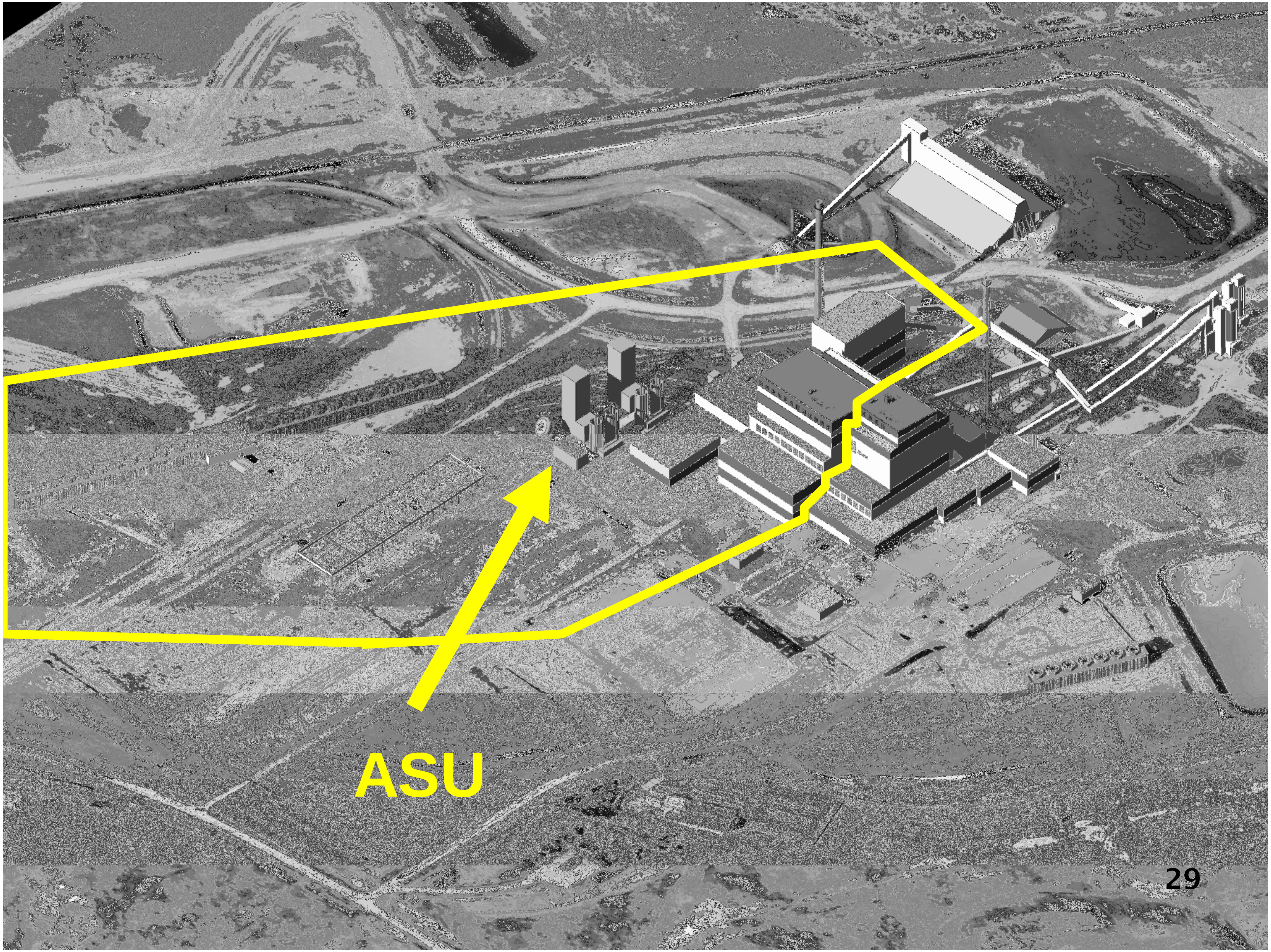
Presentation Overview

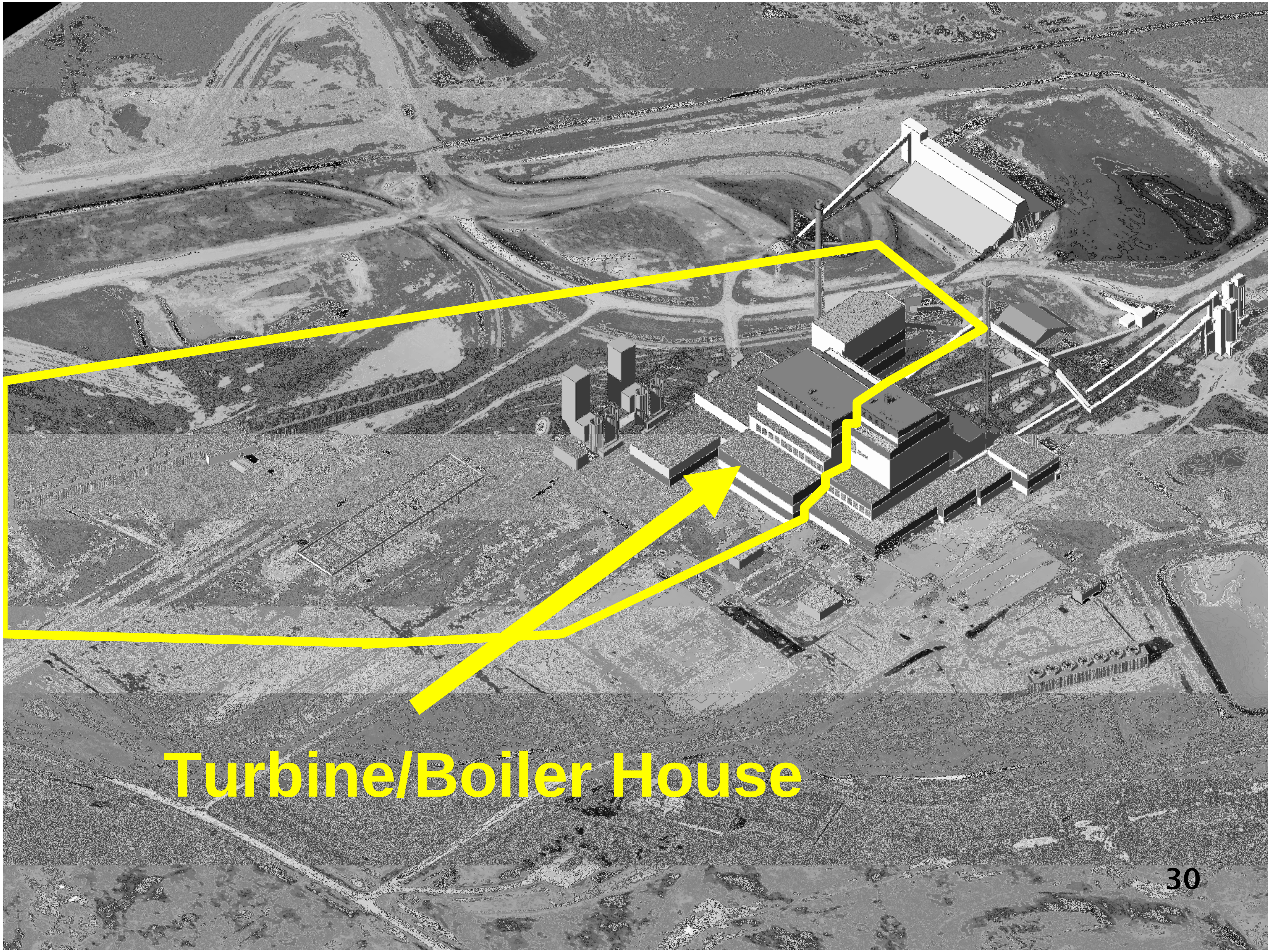
- Background
- The Opportunity
- The Engineering
- **The Project as Proposed**

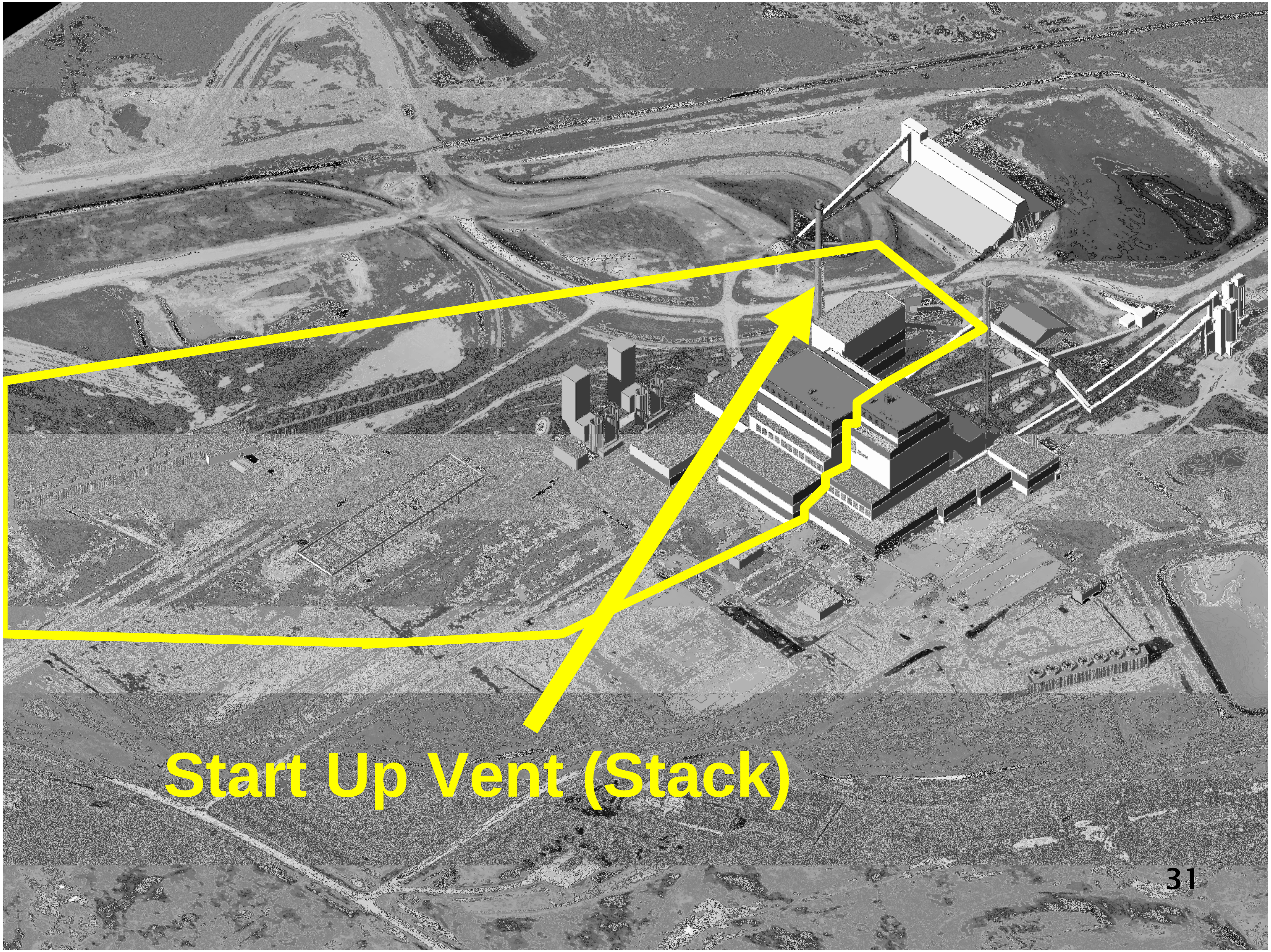


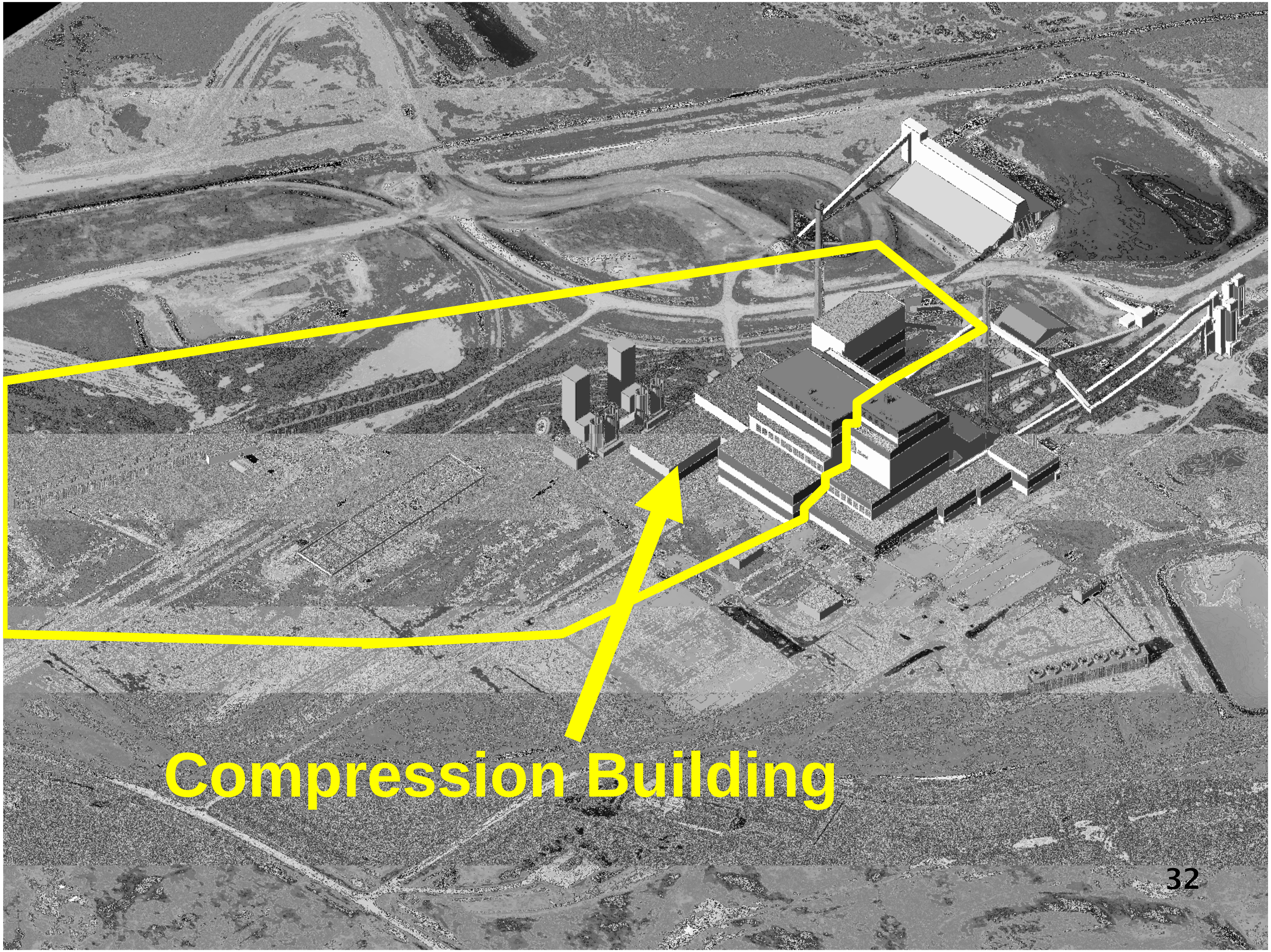

Existing Turbine/Boiler House


Heat
Rejection


ASU


Turbine/Boiler House


Start Up Vent (Stack)


Compression Building

Clean Coal Project – Technical Proposal: In-Service Date & Capacity Factor

- Air Fired Operation Date
  - ➢March 1, 2012
- Oxyfuel In-Service Date
  - ➢September 1, 2012
- Forecast Capacity Factor
  - ➢85%

Clean Coal Project – Technical Proposal: Operating Costs

- $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

Clean Coal Project – Technical Proposal: CO_2 & Electrical Production

- Forecast Annual CO_2 For Sale
  - ➢3.15 million Mt per year - net
- Annual Electrical Production
  - ➢2.2 million MWh - net

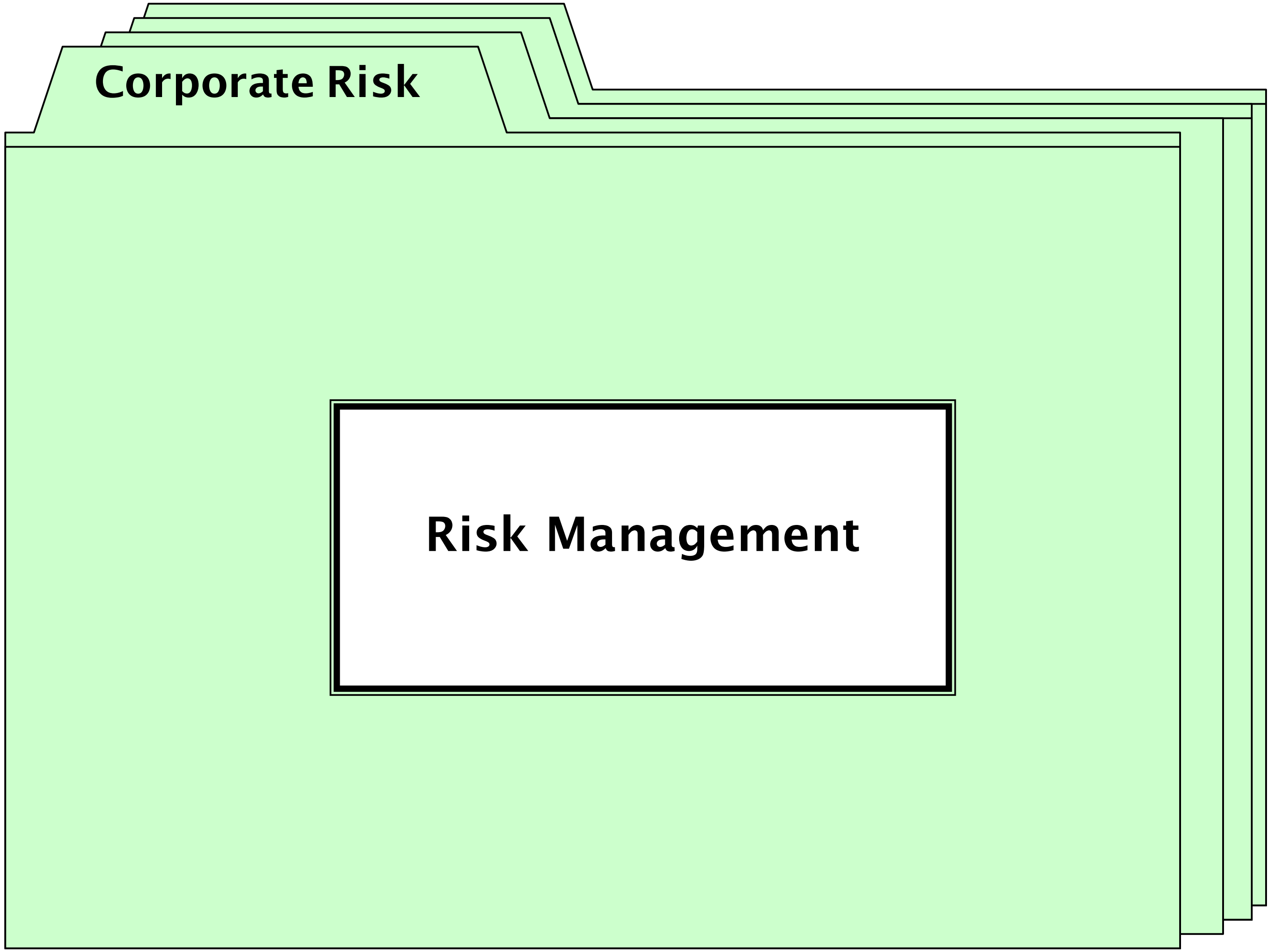
Atmospheric Emissions Performance Comparison

	2006 Compliance[1]	Conventional Unit (Approved 1988)	Clean Coal
SO_2, kg/MWh	2.9	2.86	~ 0 ✓
NO_x, kg/MWh	0.69	2.86	0.02 ✓
Particulate Matter, kg/MWh	0.095	0.49	~ 0 ✓
Mercury, kg/TWh	15.0	-	~ 0 ✓
CO_2, kg/MWh	1000 (unregulated)	1044.0	44.0 ✓

1. These compliant guidelines reflect the current guidelines issued as New Source Emission Guidelines of the Canadian Environment Protection Act (CEPA) for SOx, NOx and PM, and the Canadian Council of Ministers of The Environment (CCME) Canada Wide Standard for Mercury.

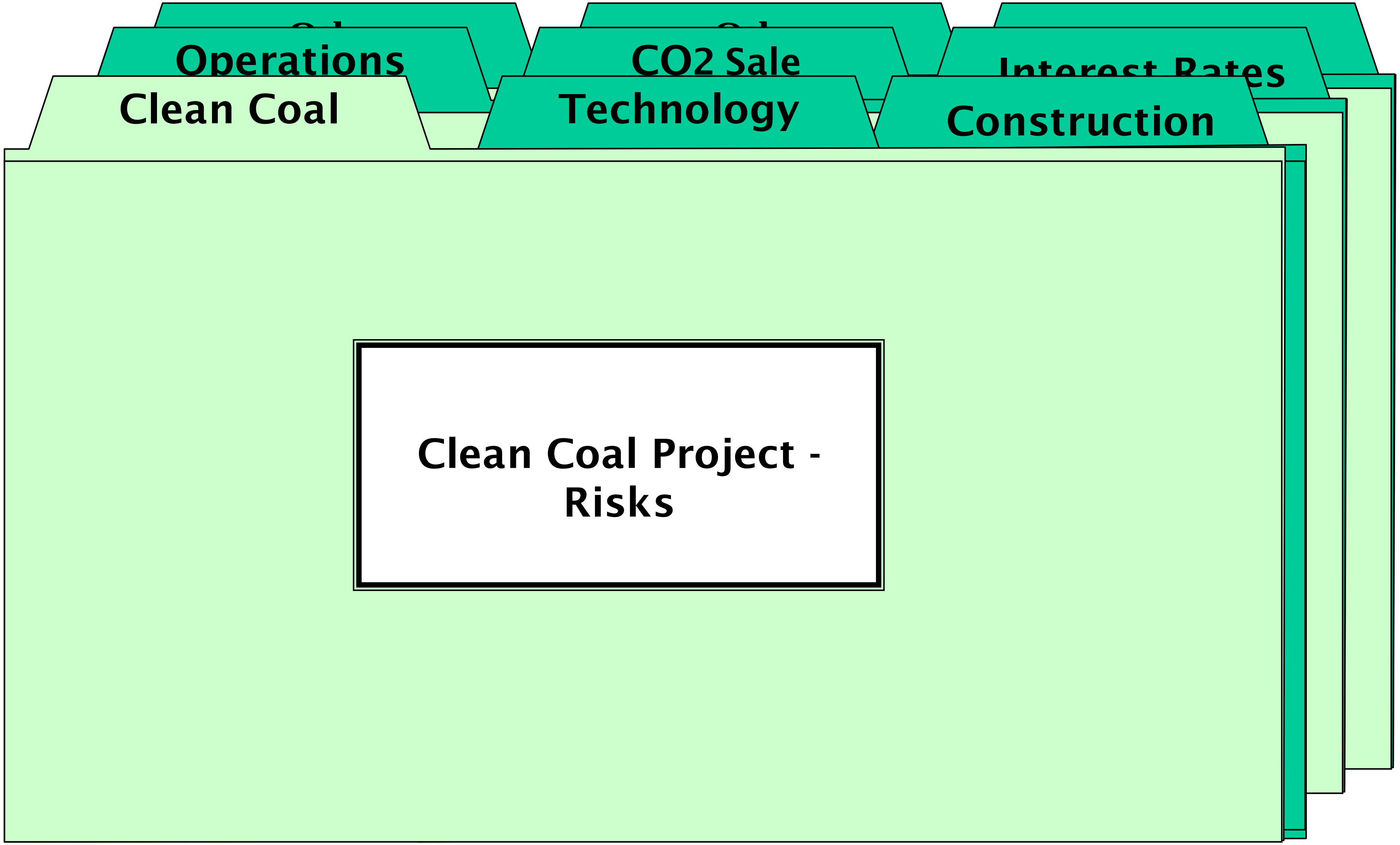
Environmental Issues

- Project is an addition to an existing site
- Site was approved as a two unit site in 1988
  - One unit built – on line in 1992
  - Second unit approved as IGCC in early 1990's – not built
- EIS being updated now to cover the proposed clean coal unit at this site
  - Need to update EIS to current standards


Corporate Risk
Risk Management

GHG Regulations

- Canada issued a "Regulatory Framework for Air Emissions" in April 2007
  - Will cover all air emissions, including CO2
  - Reductions in GHG intensity – 18% by 2010, 26% by 2015
  - $15/tonne beginning in 2010
  - $20/tonne in 2013
- Detailed regulations for a specific industry to be developed this year and issued spring of 2008
  - Several instruments being proposed
  - Still difficult to develop detailed plans


Operations
CO2 Sale
Interest Rates
Clean Coal
Technology
Construction
Clean Coal Project -
Risks

Technology

Issues

- (Safety – managed through HAZOP)
- Oxyfuel Process
  - Flue Gas Cooling
  - Furnace Heat Transfer
  - Burner Performance
- CO_2 Compression & Clean Up
- Air Separation Unit
- Process Integration
- Waste Water Management
- ..more….

Conceptual Risk Assessment

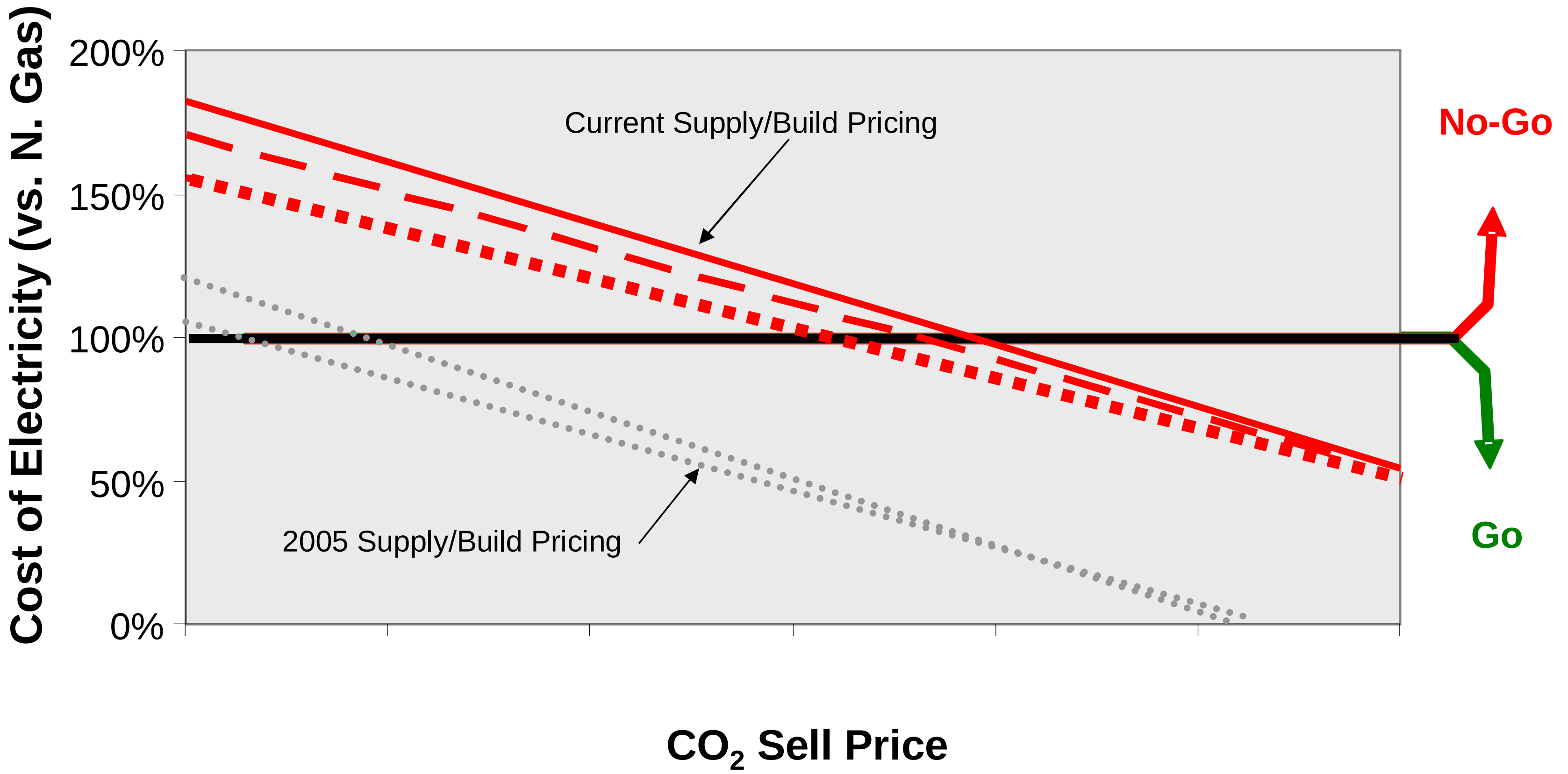
(Values are for demonstration only)

Issue	Clean Coal: Expected Loss	Clean Coal: Maximum Exposure	Compliant Coal: Expected Loss	Compliant Coal: Maximum Exposure
Construction Labour	$ 55,000,000	$ 550,000,000	$ 38,465,250	$ 384,652,505
CO2 Sale Price	$ 96,000,000	$ 480,000,000	$ -	
Electricity Sale Price	$ 48,000,000	$ 240,000,000	$ 48,000,000	$ 240,000,000
Change in Interest Rates	$ 20,000,000	$ 200,000,000	$ 13,987,364	$ 139,873,638
Long Term OM&A Costs	$ 32,000,000	$ 160,000,000	$ 16,000,000	$ 80,000,000
Technical Risks - Oxyfuel	$ 34,375,000	$ 137,500,000	$ -	$ -
Material Price Risk	$ 25,000,000	$ 100,000,000	$ 17,484,205	$ 69,936,819
GHG Regulations			$ 240,000,000	$ 960,000,000
	$ 310,375,000	$ 550,000,000	$ 373,936,819	$ 960,000,000

?

GHG Exposure for Compliant Coal may offset the project execution risks around "First Of" Clean Coal

Shand #2 CO_2 Cogen Plant - 2007 Supply/Build Prices




QUESTIONS?

Progressive Energy

Financing a First of a Kind CCS Project based on IGCC

Brian Count

Agenda

- **The Market Opportunity**
- The Technology
- Economics
- Financing

The UK Electricity Market

- Requirement for new generating capacity over next decade is around 15GW
- It is unlikely that excess capacity will be built over this period and therefore market will be structurally short and remunerate new entry
- Carbon Market now working but policy position and price confidence post 2012 is still uncertain
- Carbon Capture and Storage firmly on the agenda of clean energy options

Strategic Issues for New Capacity

- Fossil fuel prices likely to remain firm in the medium to long term
- Governments determined to significantly reduce CO2 emissions from current levels
- UK will be importer of gas so a mix of fuel sources and supply will provide best risk mitigation against supply and price risk
- EUTS in place but still uncertainty about long term policy and hence price stability

The UK has a large technical capability for geological CO_2 storage (Mte CO_2)

- North Sea has a large potential for storage of CO2
  - End of life Oil Fields
  - End of life Gas Fields
  - Aquifers
- A considerable proportion are available for CO2 capture in the UK
- CO2 storage and the possibility of Enhanced Oil Recovery are options for UK CCS projects

Full potential of UK storage could accommodate lifetime production of CO_2 from 100GWe of coal plant

CCS in UK has best chance of Success

- UK market needs new clean power stations
- Climate Change high on the agenda and CO_2 capture likely to be rewarded
- Readily available storage for CO_2 at acceptable cost
- Opportunity for Enhanced Oil Recovery

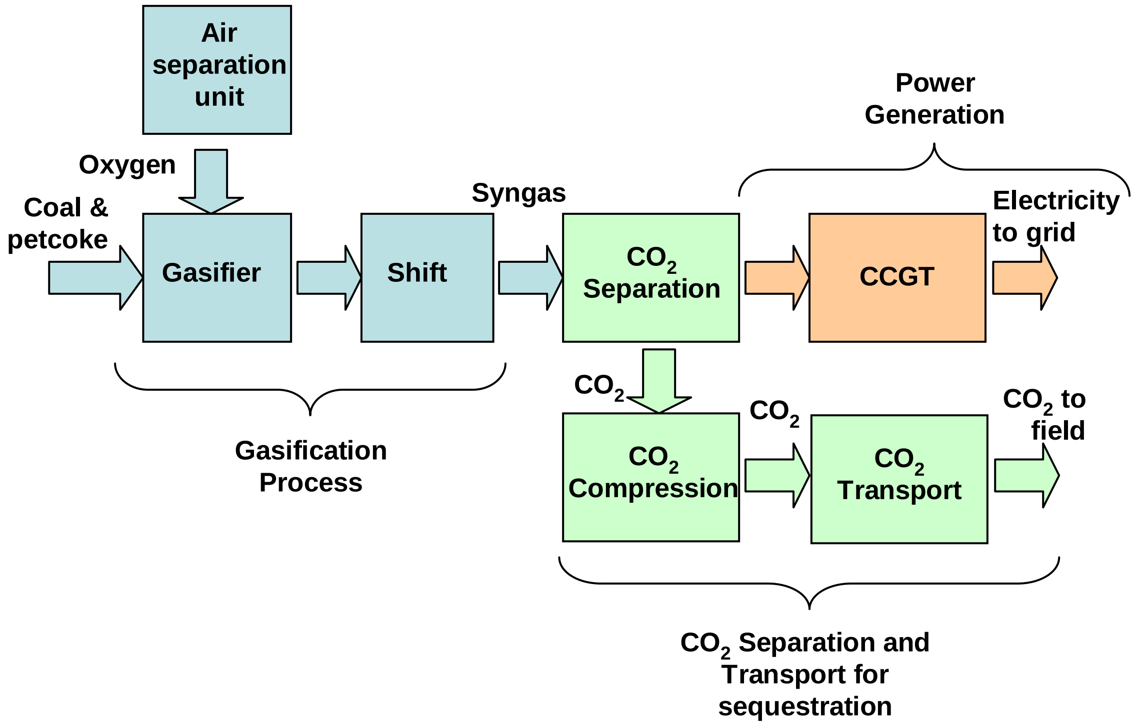
The UK has an excellent market climate for CCS to work and presents a major opportunity

Agenda

- The Market Opportunity
- **The Technology**
- Economics
- Financing

IGCC Technology

Optimised design - proven technology



Global Experience

- 160 commercial gasification plants
- 4,000MW IGCC (16 plants)
- >25m tonnes p.a. CO_2 reinjected in US
- 1,600km of CO_2 pipeline

IGCC Technology Risk

- All major components are proven at the scale
  - Gasifier
  - Gas separation plant
  - Gas Turbine burning Hydrogen
  - High Pressure CO2 pipeline
  - CO2 Storage

Key residual technical risk is system Integration

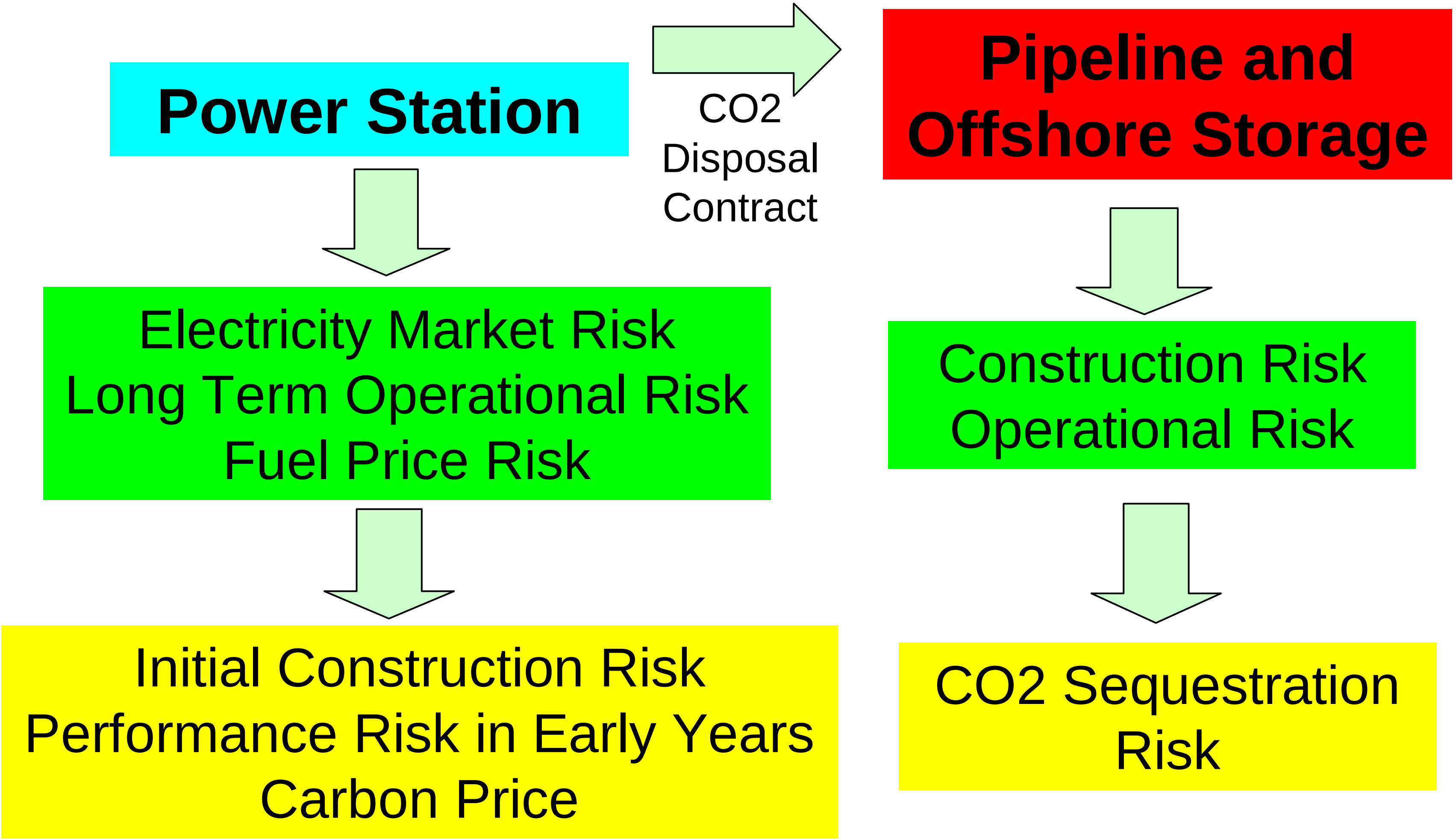
Agenda

- The Market Opportunity
- The Technology
- **Economics**
- Financing

New plant options: Plant relative Economics

- Only the lowest cost new entrant plant will be remunerated
- Gas CCGT will tend to be default option together with some new coal fired plant based on supercritical plant design without CO_2 capture
- Base load operation is preferred for new entrant plant and low short run marginal cost is important
- The present uncertainty over post 2011 implementation and future CO_2 price creates difficulty in making investment decisions on CO_2 reducing plant options that lock in cost of CO_2 reduction
  - Unless long term CO_2 prices can be confidently assessed in excess of £20 per tonne there will be minimal impact on technology choices
- Renewables will be built as they are supported with ROC's

IGCC with Carbon Capture – A Possible Risk Allocation



The Basic Economic Factors

- 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 capture, CO_2 transport and sequestration
- 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:
  - After experience these risks can be eliminated from future decisions

Agenda

- The Market Opportunity
- The Technology
- Economics
- **Financing**

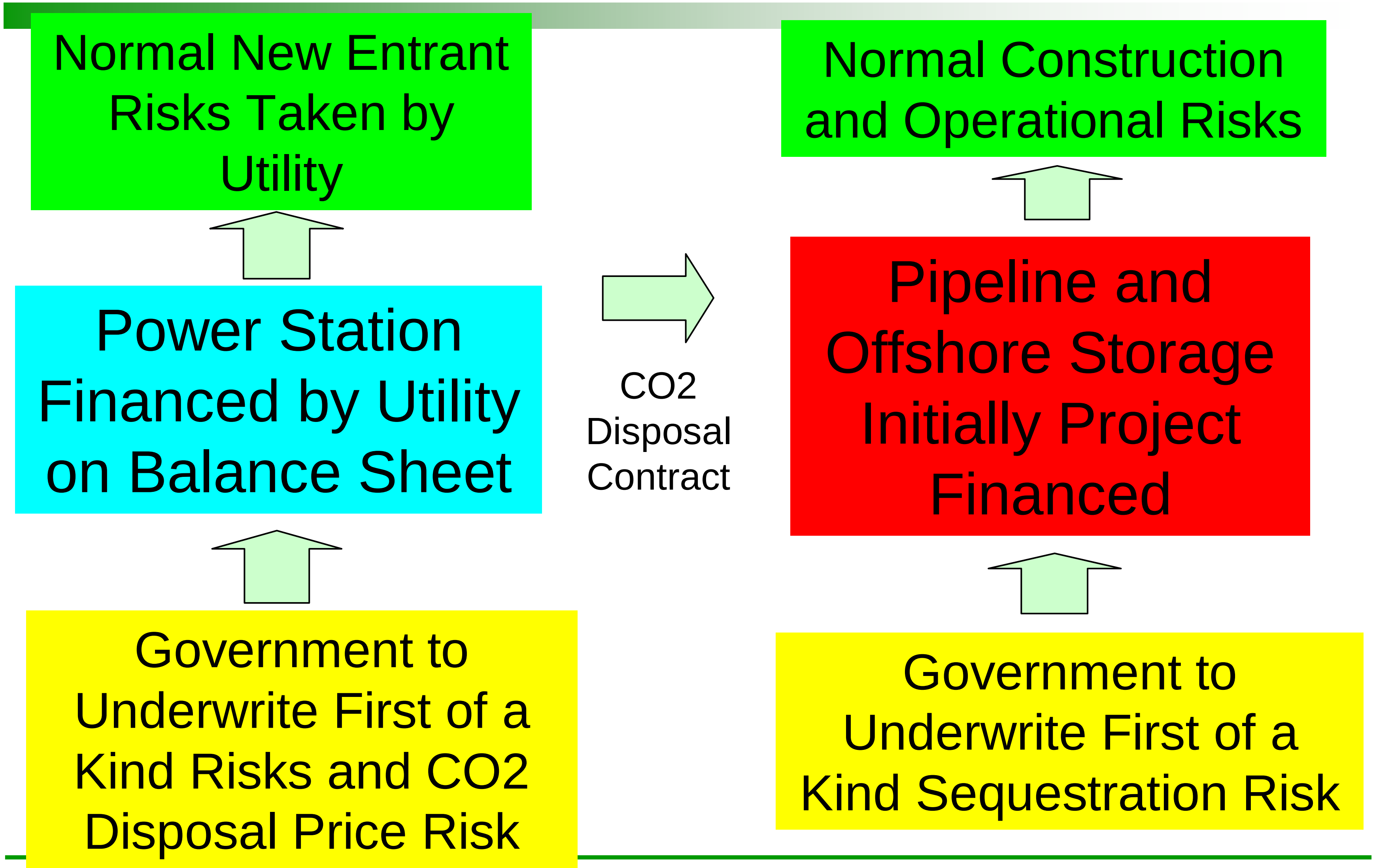
Power Station

- New Investment in the UK Power market will be dominated by large integrated players with large Balance Sheets
  - A natural consequence of a capital intensive industry
  - Portfolio players have more option value than single plant owners so should have a competitive advantage
- New Power Stations are therefore best financed on Balance Sheet as merchant plant
  - There is no reason why large players should give PPA's unless they can access projects otherwise unavailable to them
- Default new build will be CCGT's and Supercritical Coal without CO_2 capture
  - As long as all players have a similar portfolio fuel and CO_2 price risk will be passed to the consumer

Offshore Pipeline and Storage

- Sources of revenue are from:
  - Power Station that pays for it's CO_2 disposal
  - If pipeline and storage are over sized for the first project then there is opportunity to dispose of CO_2 from additional sources – eg other new Power Stations
  - Also the possibility Oil Field owners with CO_2 to Enhance Oil Recovery can be explored
- Initial contract will be credit worthy if the Utility is the owner of the Power Station
- Offshore project could therefore be project financed with a mix of debt and equity in this model
- Could also be financed by Power Station owner on Balance Sheet

A Financing Model under Consideration



Conclusion

- Power Station is most likely to be best funded by Utility on Balance Sheet with sufficient support from Government to cover first of a kind risk and cost of CO2 removal and disposal
- Power Station owner would likely require a contract for the disposal of CO2 by pipeline to offshore storage facility. This is paid for by the support given to the Power Station owner to cover the costs of CCS
- If Offshore Company is separate it may elect to build in more capacity to provide CO2 disposal to others. This additional cost would likely be equity funded. This could be re-financed with additional debt as additional CO2 disposal contracts are finalised.
- Entire structure is dependent on adequate support from Government to cover the risks over and above default new entry investment risks

Mersey & Dee Basins Carbon Capture Scheme

Inaugural Discussions

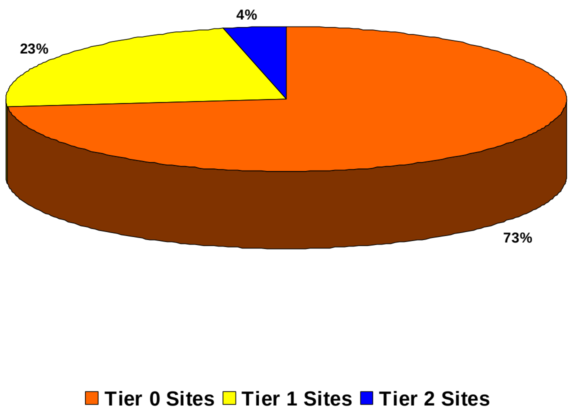
Meeting Chaired by

Mark Crowther

GASTEC at CRE and c:sense verification

To Re-Cap..technical aspects of the scheme

- Mersey & Dee Basins
- 20mtpa CO_2 within a 20 mile radius
- 3 Tiers & 3 operational network pressures



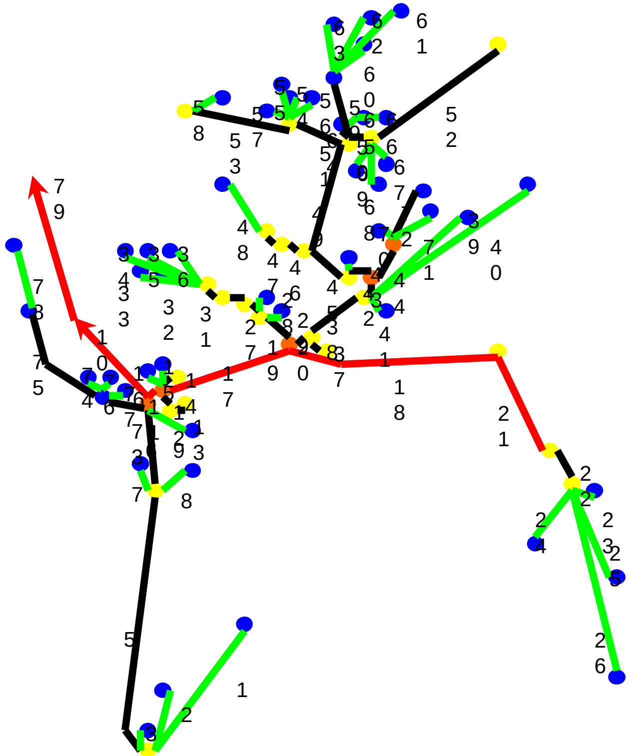
To Re-Cap

- High Pressure – Supercritical Flow 80bar+
- Medium Pressure – 10bar
- Low Pressure – 800mbar

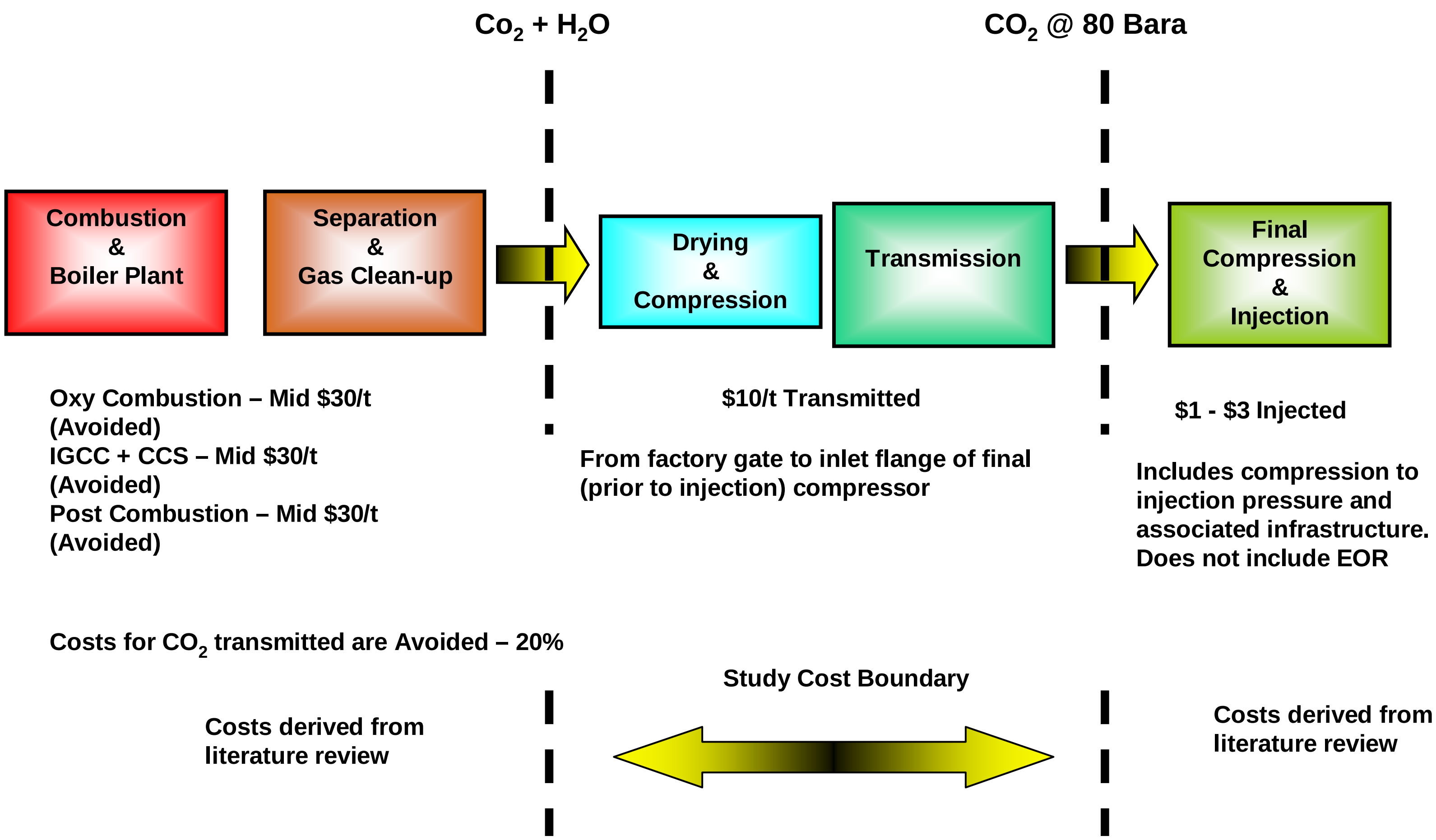
- Considerable cost savings of negative pressure network for small sources

Detailed cost estimates….AMEC

Initial safety cast discussed with UK HSE




GASTEC
at CRE
c:sense


$Co_2 + H_2O$
CO_2 @ 80 Bara
Combustion & Boiler Plant
Separation & Gas Clean-up
Drying & Compression
Transmission
Final Compression & Injection
Oxy Combustion – Mid $30/t (Avoided)
IGCC + CCS – Mid $30/t (Avoided)
Post Combustion – Mid $30/t (Avoided)
$10/t Transmitted
From factory gate to inlet flange of final (prior to injection) compressor
$1 - $3 Injected
Includes compression to injection pressure and associated infrastructure. Does not include EOR
Costs for CO_2 transmitted are Avoided – 20%
Study Cost Boundary
Costs derived from literature review
Costs derived from literature review

Estimated Capital Costs

Element in Scheme	**£ million**
Capture (very loose estimate) (all Tiers)	**2,800 – 3,000**
Transmission	
Tier 0 only	**580**
Tiers 0 & 1	**820**
Tiers 0, 1 & 2	**1,200**
Disposal (platform & well alterations)	**40 - 60**
TOTAL SCHEME (all Tiers)	**4,040 – 4,260**

c:sense
verify carbon emissions

IN SUMMARY

Likely cost of CO_2 disposal from the M&DCCB scheme:-
$50/tonne ~ 37euro/tonne

Cf value of CO2 from EUETS (avoided emissions):-

15 to 20 euro/tonne	Difficult
30 to 40euro/tonne	Possible
>50euro/tonne	Reasonable to good return

Possibility of extremely good margins if price of carbon rose
to capping price of 100euro/tonne

c:sense
verify carbon emissions

OUTSTANDING ISSUES

Value of CO_2 against essentially a politically defined price….very different to almost every other market.

Is the risk to the industry of Mersey & Dee basin GREATER by not proceeding ie might CO2 reach 100euro/tonne?

Corporate structure (Drainage board model? Garbage model?)

Gas quality

Sizing of lines vs Timing of start up for collection plant

Commercial-scale CCS operations

Sleipner

Snøhvit

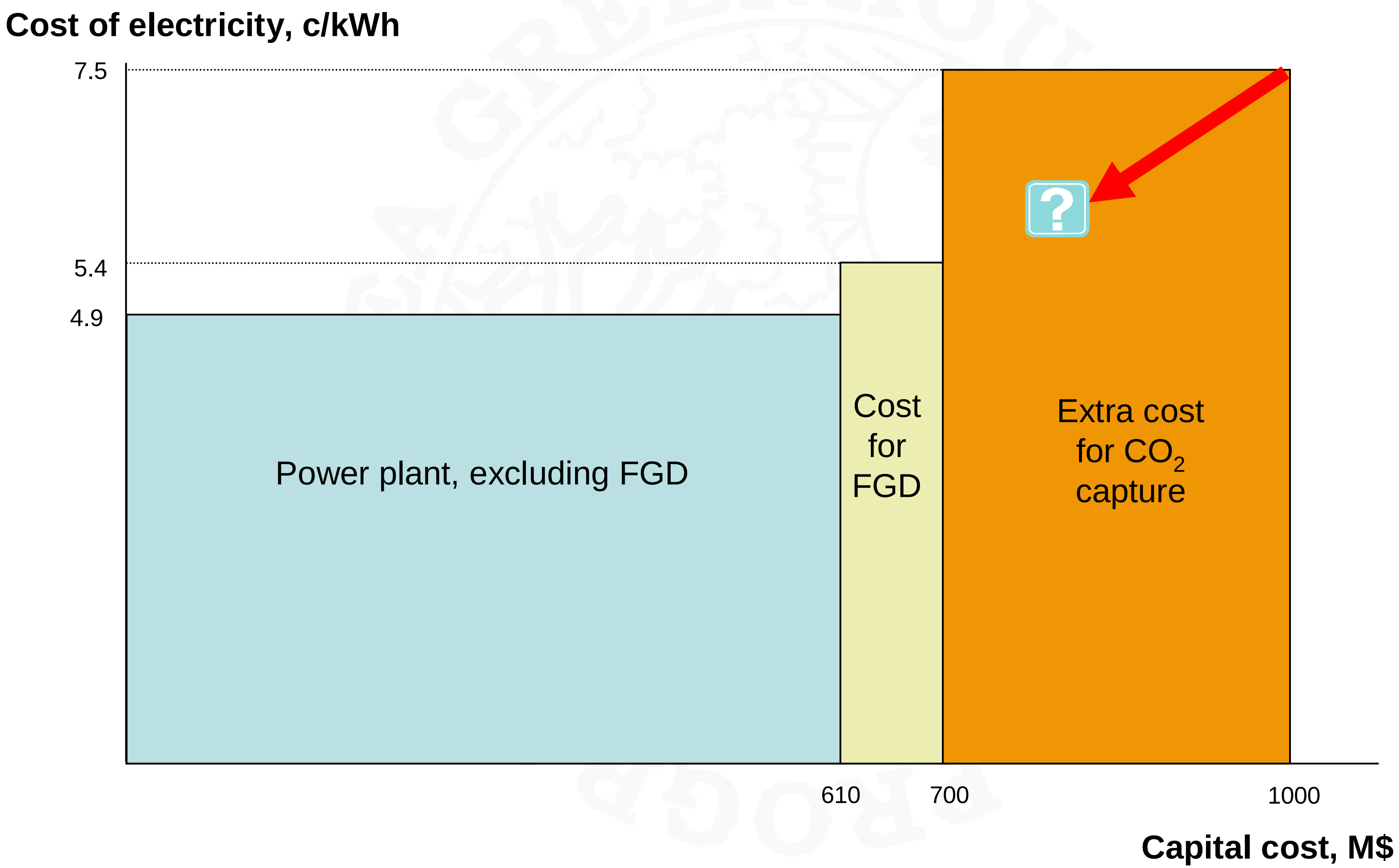
In-Salah

Weyburn

NOT POWER GENERATION

Images Courtesy of BP, Statoil, and PTRC

Risks and Rewards



MARSH

June 1st 2007

Options for managing liability in CCS projects

Matt Elkington
London

MMC Marsh & McLennan Companies

Liability Management in CCS Projects
Why is this important?

- CCS projects expose stakeholders to new, unique and potentially significant risks and liabilities
- Long-term nature of storage creates potential for liability to manifest itself over timeframes that are beyond the scope of the private sector alone
- Lack of actuarial data on integrated large scale projects coupled with an absence of uniform international regulation creates major obstacles to risk management, private investment and wide-scale deployment

BUT

- CCS potential as a primary tool against climate change, the availability of analogous information in EOR, and the commitment of global stakeholder groups is recognised and supported by the risk management industry

Liability Management in CCS Projects

Storage liability is the major sequestration risk

Capture → **Transport** → **Storage**

Capture	Transport	Storage
Post-combustion	Pipelines	Siting
Pre-combustion	Shipping	Injection
Oxyfuel		Closure
		Post-closure

CO_2 risks can have direct, indirect, local and global impacts

Pressure

Structural damage
- induced seismicity
- well seal integrity

Leakage & Migration

Drinking water pollution
- chemical
- brine displacement

Atmospheric escape
- harm to humans, flora & fauna
- climate change (ETS, Kyoto?)

Resource damage
- hydrocarbons
- land

Liability Risk Management
Exposures are complex and lack certainty

- Holistic risk assessment and quantification of CCS project exposures is a precursor to mitigating financial risk and liability, but many fundamentals remain unanswered:
  - 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 these?
  - Who could be an injured party?
    - Property owners
    - Public
  - How will MMV and remediation be undertaken?
  - What are the optimal approaches to long-term liability management?
    - Public/Private phasing

Long-term Liability Management
Structural options

- Liability during (short-term) operational phase can mainly be covered by contract and traditional risk transfer (once modelled)
- Long-term liability is much more difficult to hedge due to timeframe of when and how significant intrinsic risk manifestation could be:
  - Environmental
    - Damage to climate
    - National inventories and assigned credits
  - In-situ
    - Public health
    - Ecosystems
    - Resources
  - Cross-border
    - Leakage and migration in other countries

Underwriting the Risk
- How likely is this and when?
- How much could it cost?
- Who is responsible?

- Private to public transfer of liability seems most feasible solution and could take several structures

Long-term Liability Management
Structural options – Government backed indemnity

Example: US Price-Andersen Act

- No-fault (strict) indemnity for nuclear industry against liability caused by accidental releases
  - Aimed to provide incentive to private developers when risks and potential liabilities were unknown
- Provides a layered risk pool
  - 1st layer: each individual plant obtains $300 million primary cover
  - 2nd layer: each plant must contribute up to $95.8 million to a fund if an accident occurs (capped at $15 million annually)
  - 3rd layer: federal government finances any outstanding balance over and above individual and collective layers

CCS cost/benefit

✓ – Provides liability cap for industry

?/ ✘ – More suitable for very rare and catastrophic risks

✘ – Negative public perception

✘ – Inaccurate risk assessment and pricing could leave insurers and public exposed

Long-term Liability Management
Structural options – Hybrid compensation

Example: CERCLA (US Superfund)

- EPA administered fund created via taxes on oil and chemical corporates to address investigation and clean up of abandoned hazardous waste sites
  - Can make current and past site owners/operators strictly and joint and severally liable for clean up, as well as persons who arranged disposal or transport to site (with disposal)
- Liable parties can use hybrid instruments – risk transfer e.g. stop loss, and self insurance to cap and manage their responsibilities

CCS cost/benefit

✓ – CERCLA 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

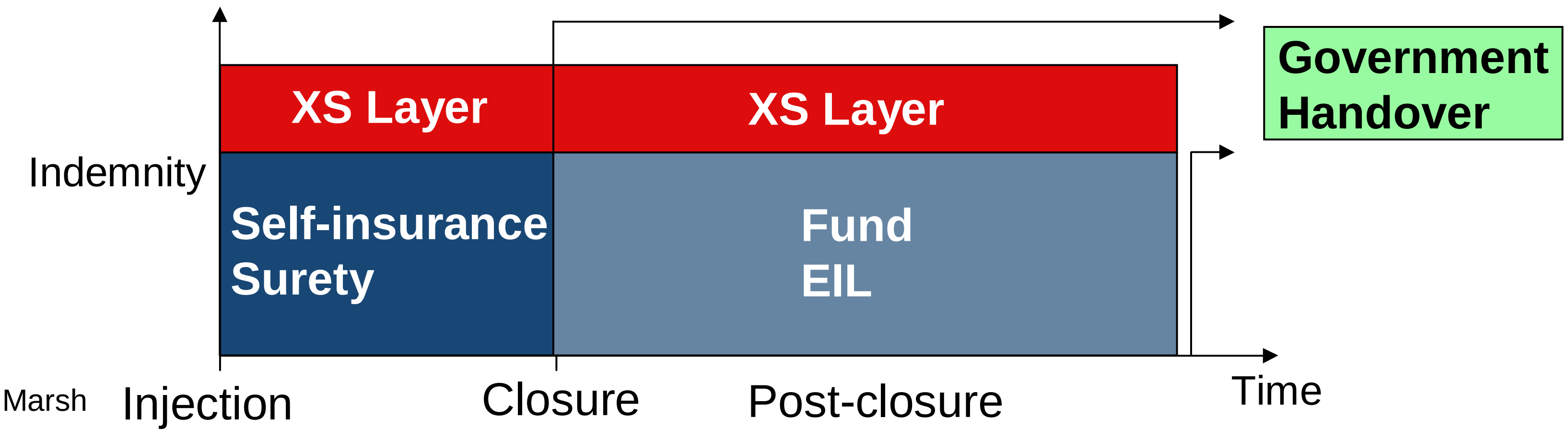
✗ – Fund is too small – insufficient collection and poor solvency hedging

?/ ✗ – Joint and several positions can be problematic

Long-term Liability Management
Structural options – Phased liability

Example: Private/Public Liability Transfer

- During operational phase of injection, closure and (agreed) post-closure period prior to transfer to government, liable party provides:
  - Self insurance or insolvency proof financial guarantee for expected costs incurred during operational period
  - Liability risk transfer for unexpected XS costs during operational phase
  - Fund with XS 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



Long-term Liability Management
Structural options – Phased liability

Example: Private/Public Liability Transfer

- 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
  - Capacity may ultimately only be available for certain project methodologies

Pricing the Risk
In addition to these factors, amount sequestered, length of term, and site risk will determine sum insured and premium rates

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

Long-term Liability Management
Conclusions

- Long-term nature of CCS liability poses major challenge to its successful large-scale deployment
- Multiple uncertainties and a lack of real actuarial data makes 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
- Insurance market is committed to supporting companies and governments manage climate change risk – talk to us!

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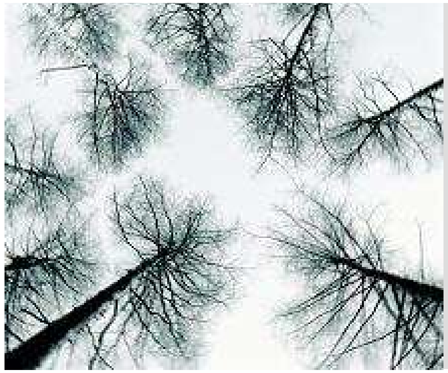

Equity and Venture Capital Investment in CCS

Anthony White

1 June, 2007

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Climate Change Capital

At what carbon price is CCS economic?

Around €25-30/tCO_2e for coal?

But far lower if you can use the CO_2

Difference Between Economics and Financing

Economics
Is it conceptually possible?

- Is it a positive NPV under-taking?
- Are all the component parts economically viable?
- Does it meet a reasonable cost of capital?

Financing
Can you raise the money?

- Are the risks correctly allocated?
- Are risks well managed?
- Is the capital structure right?
- Is there investor appetite?
- What does the asset-class look like?

Issues in clean coal exist in the gap between economics and financing

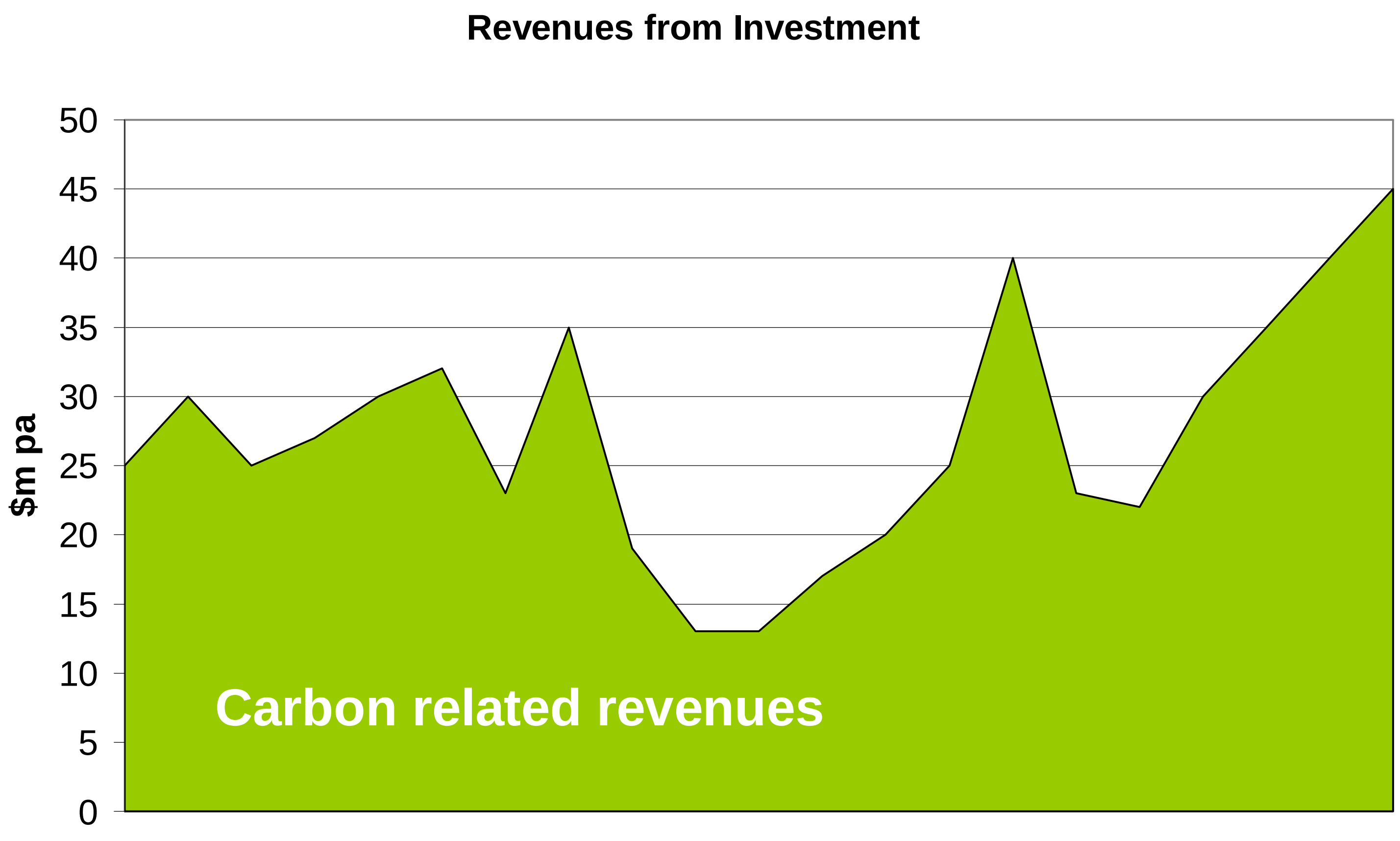
Hypothetical abatement related investment

Investment costs $200m

NPV of savings amounts to $220 m over period

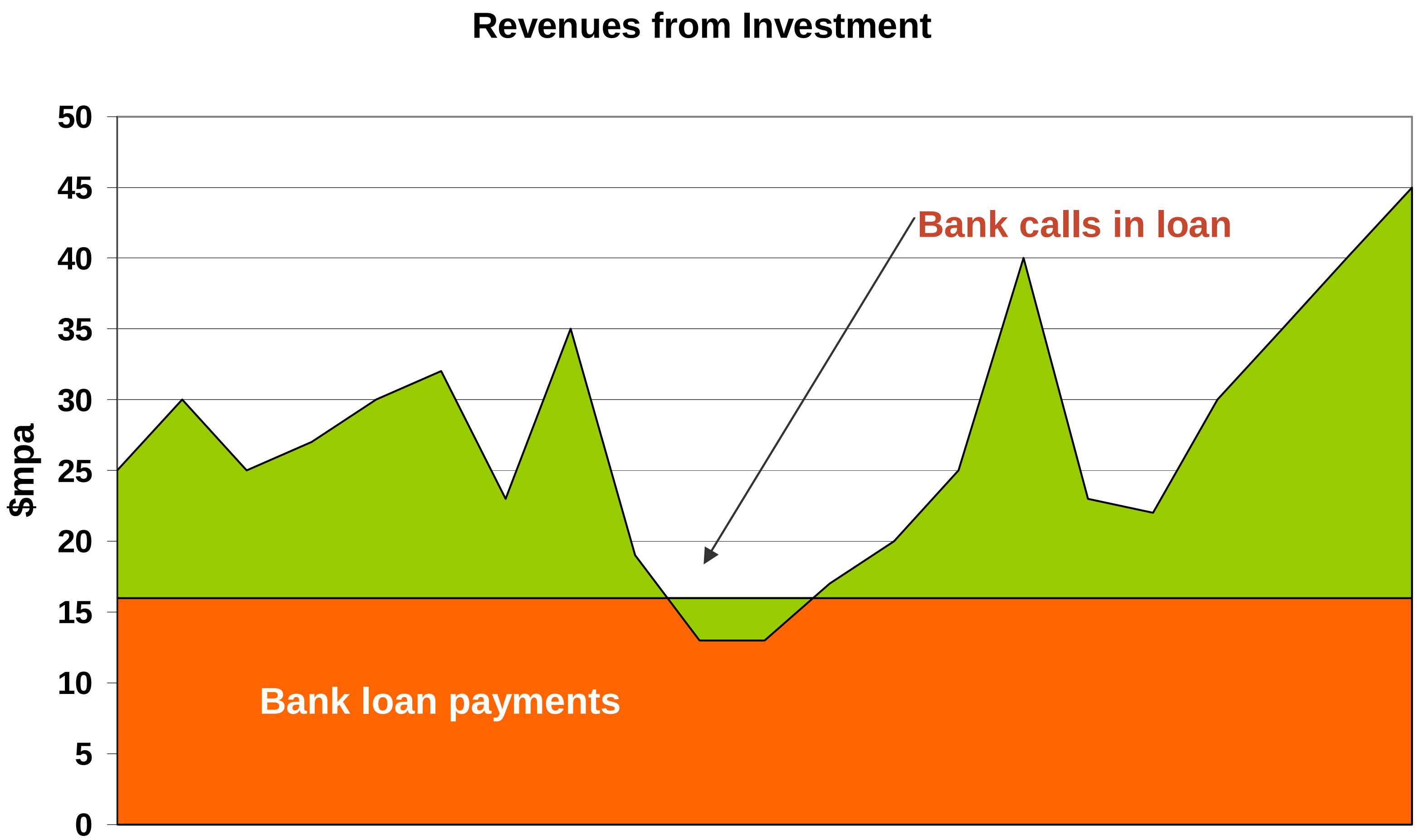
So go ahead?

Can we raise debt?



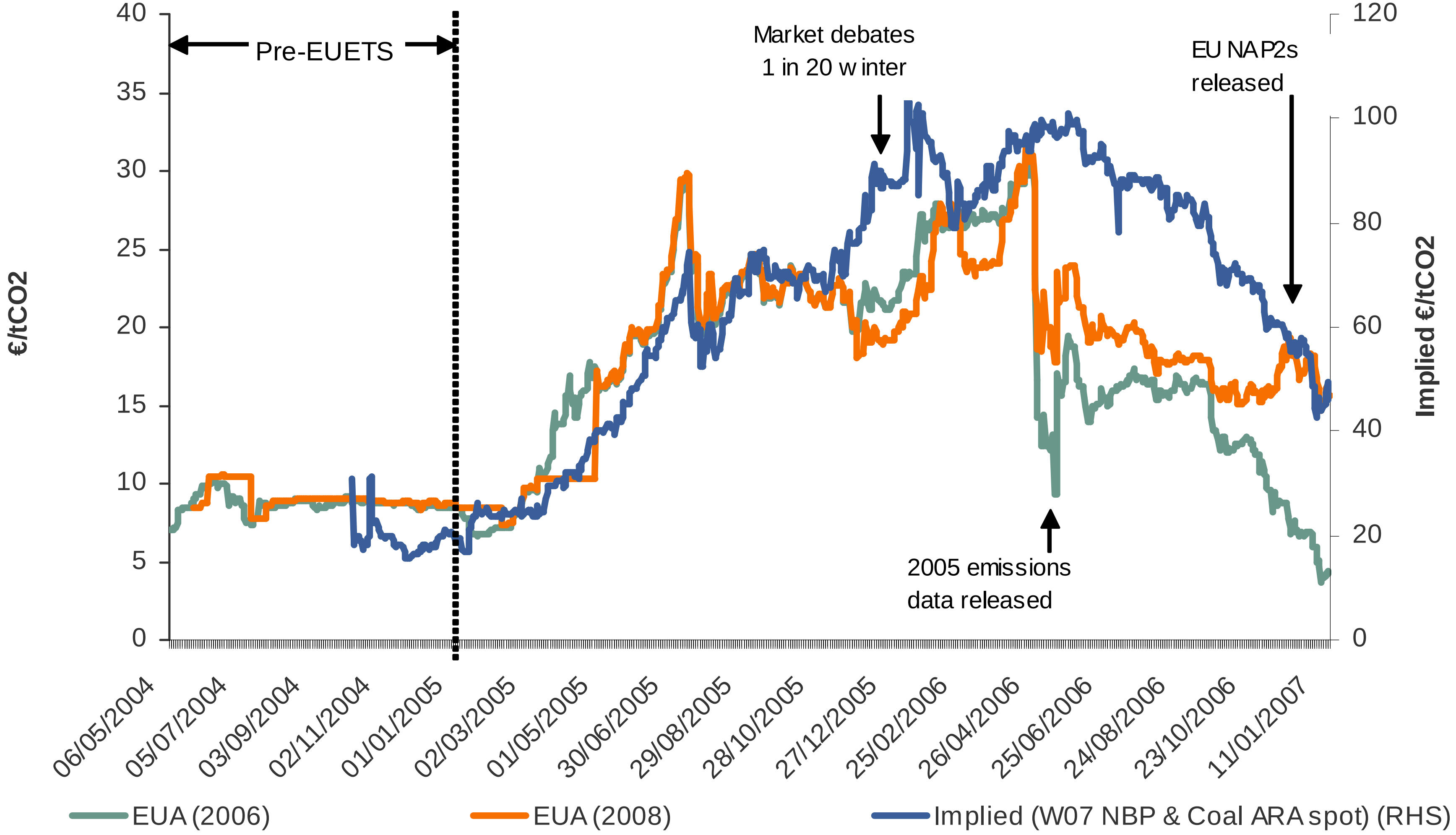
But it helps if you know how low prices can go!

- Bank interest payments of $16m pa
- Company goes bust
- Lose access to later cash-flows



EU ETS: What has happened?

Historical EUA and UK fuel prices



Consequences

- Prices driven by coal & gas prices AND policy
- Minimal change in operating behaviour
- No investment in Europe
- Large scale investment in developing world

- so a floor to carbon emission costs would be helpful

Carbon Transport and Storage: Financing Issues

Integrated Projects

Power Station

Separation / transport

Deposition

Very rigid structure
Easier to put together
Unlikely to realise much EOR value
Can one company manage whole thing?

The Value Chain

Power Station

Separation / Transport

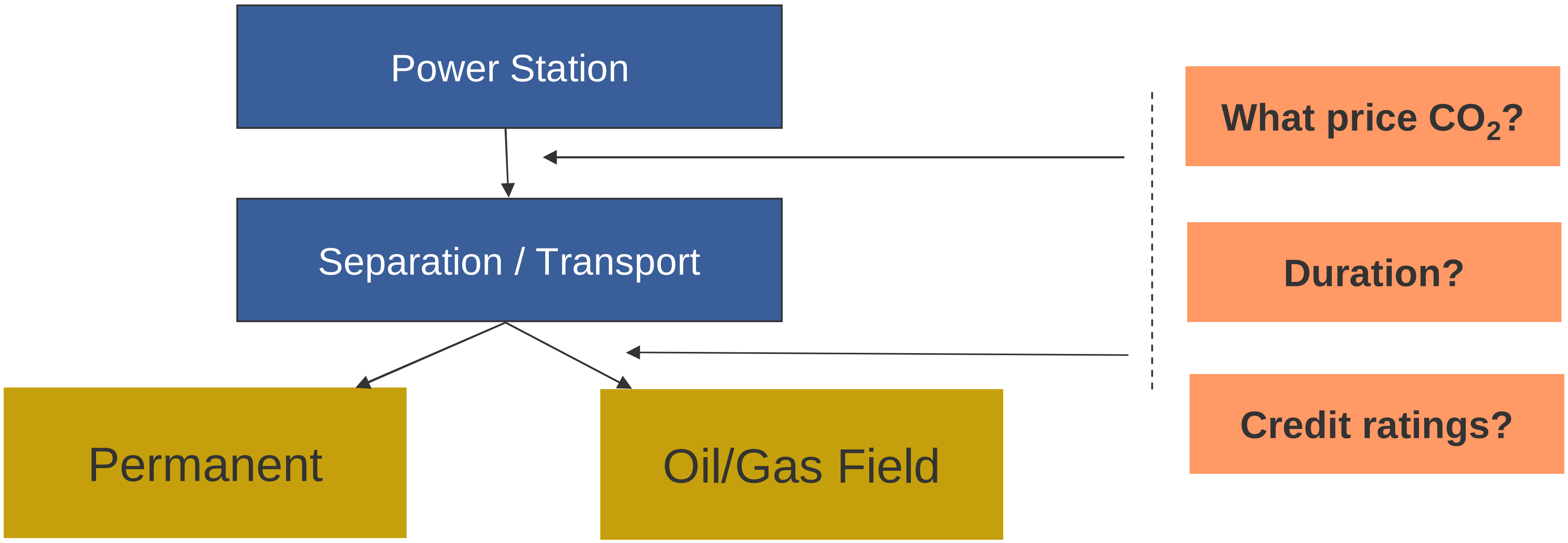
Deposition

- Flexible
- Harder to put together
- Requires ability to contract at interfaces
- Better aligns tasks of parties

Who pays?

The Value Chain

Issues



Financial Players

Players

	Short term	*Long term*
Power Station	**Venture Capital** **Power Companies**	**Power Companies**
Separation / transport	**Venture Capital** **Energy Companies**	**Energy Companies** **Banks** **Private Equity**
Deposition	**Venture Capital** **Energy Companies**	**Energy Companies** **Private Equity**

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Deloitte.

Policy Options for incentivising low carbon power generation in different jurisdictions

Adam Whitmore

IEA Expert Meeting on financing carbon capture and storage projects

1st June 2007

Audit.Tax.Consulting.Corporate Finance.

There is a wide range of mechanisms available to support low carbon power generation

Type of mechanism	**Examples**
Mandated requirements for new plant to be low carbon	• EU suggestion that all new plant be low carbon from 2020 (EU ETS would cover emissions from existing as well as new plant) • Portfolio standards in USA
Carbon pricing	• Tradable allowances • Taxes • Hybrids of taxes and tradable allowances • Potentially supported by other financial instruments
Industrial policy support	• Capital Grants • Tax breaks • Government or public utility equity
Support for new technologies, especially renewables	• Reserved market (may be implemented with tradable certificates) • Premium price set by regulator (e.g. feed-in tariffs) • Premium price set by auction, tender or negotiation

There are good reasons for using emissions trading to incentivise abatement, but it has significant limitations

- For threshold phenomena allowances have advantages over taxes
- Climate change is likely to have thresholds associated with the global stock of pollutants implying advantages in principle for emissions trading
- Obtaining international agreement on quantity limits is less difficult than obtaining agreement on taxes
  - e.g. OPEC quotas, the Kyoto Protocol, EU burden sharing agreements and EU ETS NAPs
  - common international taxes (such as the EU's attempts to introduce a carbon and energy tax) have proved difficult to achieve
- An international regime to incentivise emissions reduction based on tradable allowances therefore has significant advantages especially with:
  - wide geographical and sectoral coverage
  - tight, long-term, credible caps
- The EU ETS represents an important step towards such an international regime with prospects for USA and Australia appearing promising
- But present arrangements may not create sufficient long-term certainty to stimulate the necessary investment, with the risk of weakening future caps

Taxes also have advantages but raise political difficulties

Taxes have advantages...

- Provide stable pricing signal into long term as governments need revenue
- Avoid risk of very high or very low carbon prices and consequent economic disruption

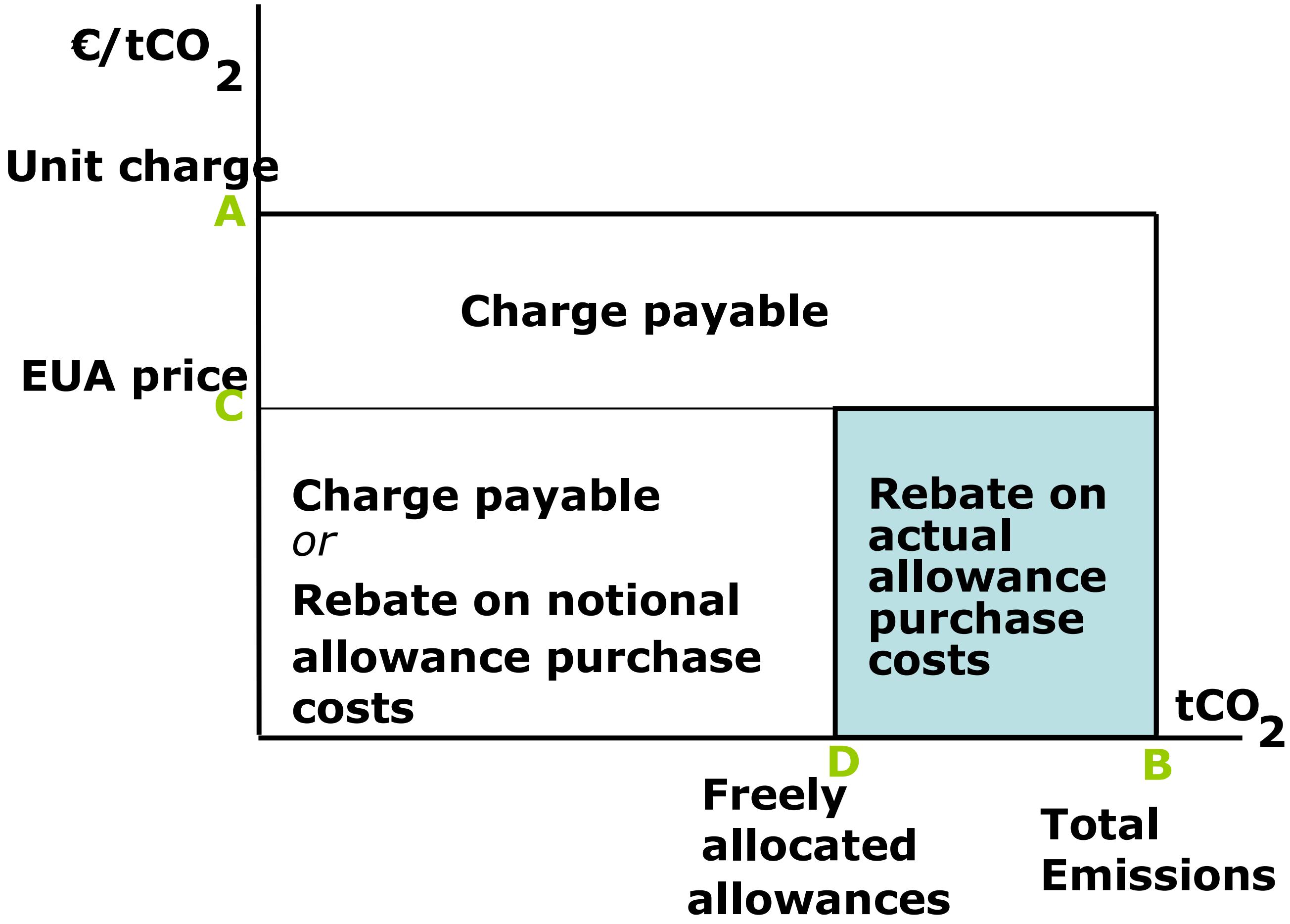
But tend to be politically unpopular...

- Inelasticity of energy demand can imply large income transfers
- Competitiveness concerns due to difficulties of international harmonisation
  - Auctioning of emissions allowances may raise similar objections

.... And do not guarantee meeting quantity targets

Fiscal measures could place a floor on the price under a cap and trade scheme, providing more stable price signals to investors

Illustration of floor with EU ETS (EUA price below floor)



Initial Bill = charge x total emissions
A x B

Allowance purchase cost = EUA price x emissions purchased
C x (B - D)

Notional allowance purchase costs = EUA price x freely allocated allowances **C x D**

Note: If extended outside the power sector may also rebate local taxes such as CCL

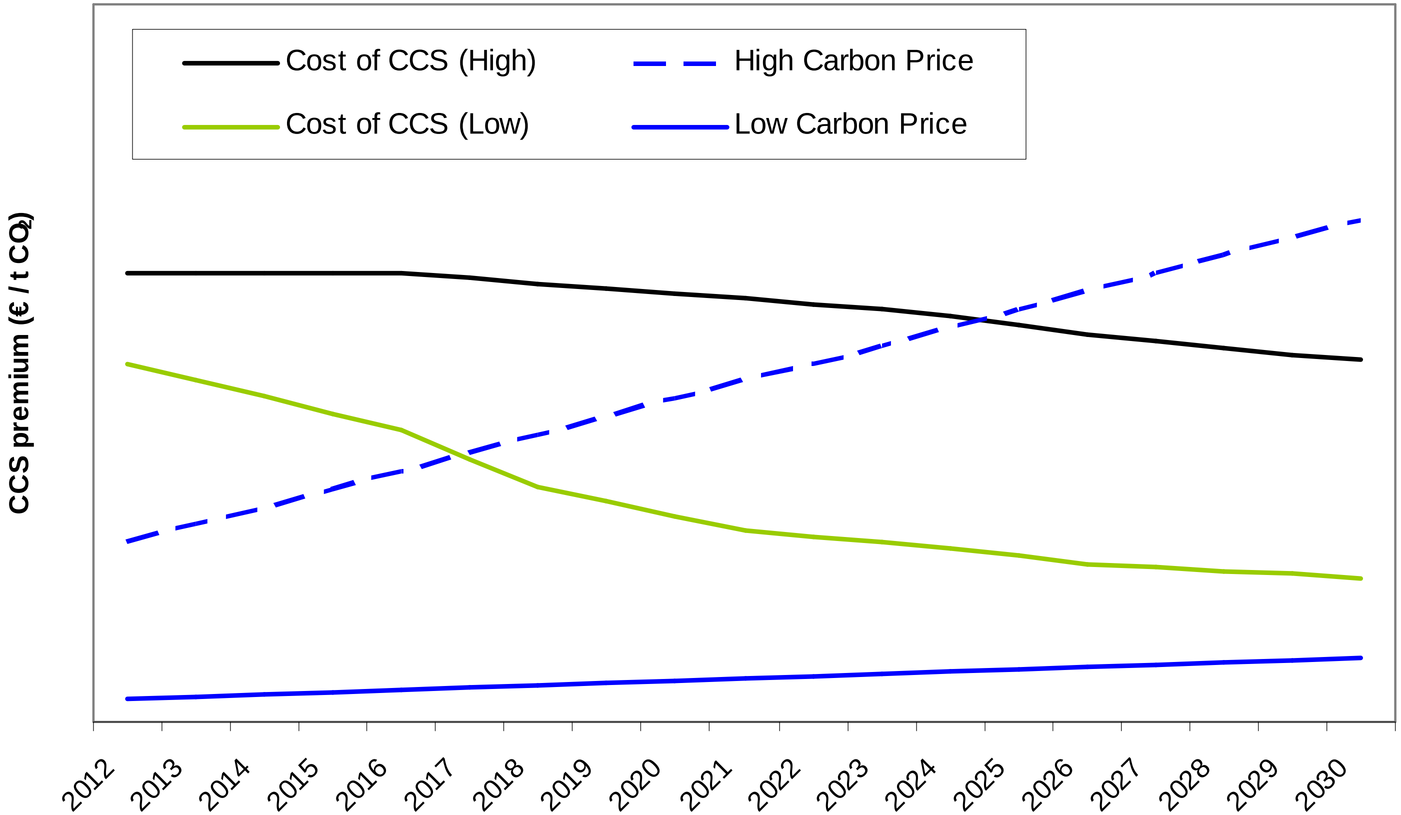
Objections to this type of scheme do not seem compelling in practice

Objections	Response
Stern: may lead to differences in international carbon prices in practice	Prices differ only if allowance prices are below the floor A harmonised global carbon price is a long way off - carbon prices will vary anyway (e.g. between schemes) Energy prices also vary for many other reasons
Stern: obstacle to linking to other schemes	Buy-back mechanism may make linkage more complex but tax and rebate mechanism does not
Climate Change Minister: This will be like ERM	May apply to buy-back mechanism but not to tax and rebate route

However CCS is likely to require incentives over and above the carbon price, perhaps for many years

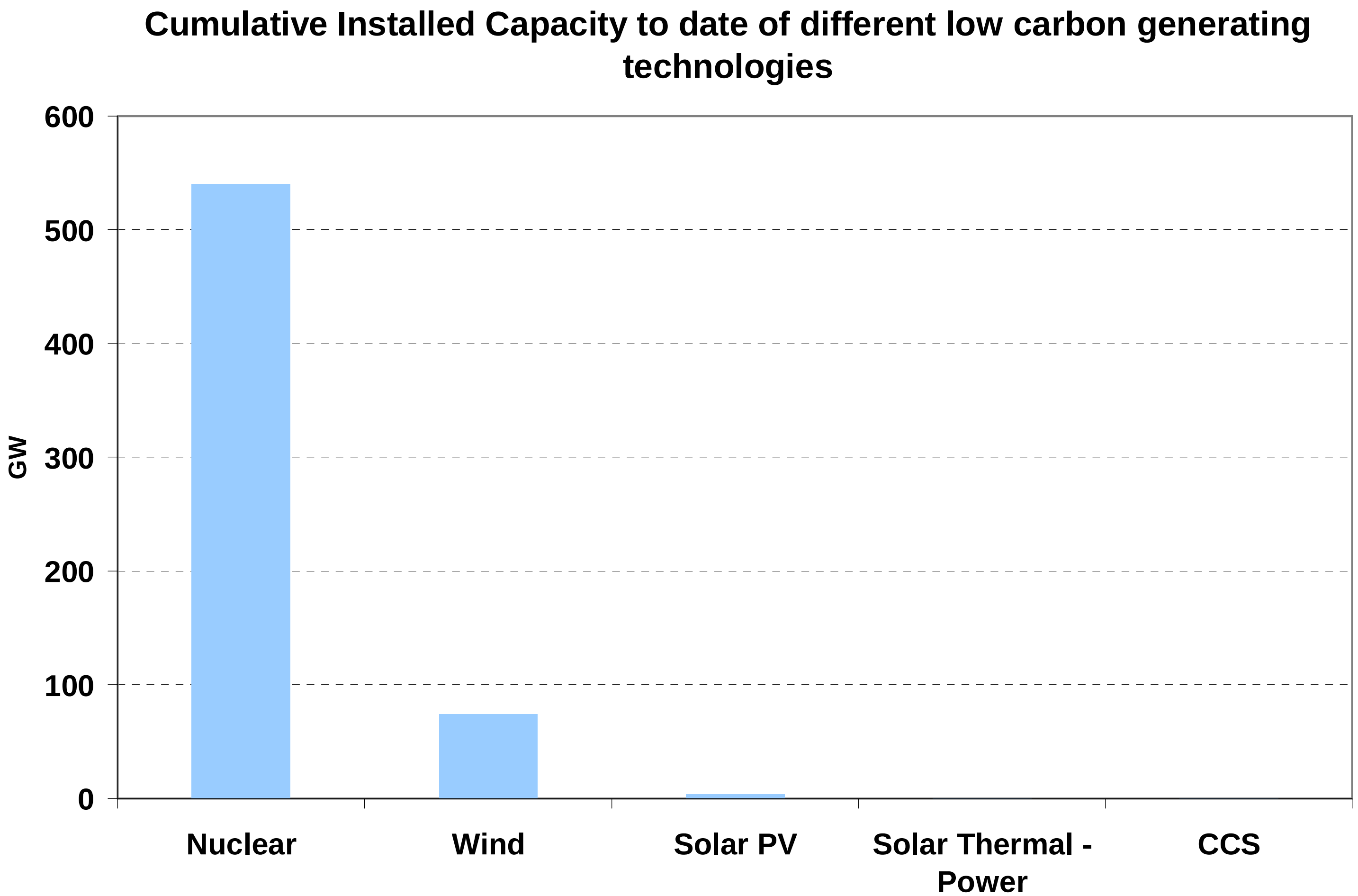
- Premium depends on level and geographical coverage of carbon price
- Total costs of incentives could be several hundred billion dollars (worldwide over time)

Premium over carbon price required to support CCS



Source: Deloitte analysis

The requirement for additional support reflects the immaturity of the technology and will also apply to other new technologies



There are various sources for funding the additional cost premium for CCS

Customers	• electricity prices are higher due to the carbon price • additional costs from quantity obligations (e.g. Renewable Portfolio Standards or Green Certificate Schemes) • separate tax or levy on the retail price or wires business charges • the cost of premium priced contracts (e.g. feed in tariffs) passed through
Tax payers	• general or earmarked taxation may fund support as grants, aids or tax breaks (capital or per MWh support) • government or publicly owned utilities may provide cheap capital (debt or equity)
Shareholders	• surplus created by free allocation of allowances can be appropriated by means of auctions, windfall taxes or price floor arrangements and channelled to clean generation • sums available are potentially substantial. Estimates of windfall gain in the UK power market alone are c. €1.1 billion p.a. • shareholders may choose to raise funds to invest to secure future gains

There are a number of advantages to using earmarked taxes to complement revenue raising via the electricity price

Objective	Advantages of earmarking
Public acceptance of taxes	Taxpayers are more likely to support a new tax if there is a connection between the tax and a particular public service
Increased transparency and control, reducing distortions by interest groups	Earmarking can limit political distortions introduced by interest groups lobbying on non-earmarked taxation and this can increase acceptance of taxes.
Sustainability of funding and investment	Gives credibility to budgetary decisions and provides a stable revenue stream.
Efficient levels of expenditure on emissions abatement	Can lead to efficient expenditure where the cost of damage resulting from emissions is difficult to estimate and it is difficult to set robust emissions caps at the efficient level
Provision of information on voters' preferences	The process of establishing earmarking can increase information on voters' preferences, especially if conducted through a referendum
Environmental taxation and a double dividend	Spending tax revenue to secure environmental benefit may lead to larger welfare gains in some cases than reducing income taxes

Capital grants, low cost capital and tax breaks have a role to play but may not be the whole solution

Capital grants

- Valuable to investors
  - Guaranteed funding
  - High present value due to upfront payment profile
- Incentives for output can be retained and allocation can be capacity related (e.g. per MW for certain type of technology)
- Simple to administer
- But can be more difficult in some political environment than others
  - E.g. may be related to regional aid, may be State Aid issues

Low cost capital

- Low cost capital via state loans or through publicly owned utility
  - Possible rationale is that it provides high risk capital at low risk rates, thus meeting the cost of technical risks
- State Aid issues in EU – must be awarded on a competitive basis

Tax breaks (e.g. enhanced capital allowances, reduced tax rate)

- Require new revenue to be foregone rather than funds from existing revenue
- Some capital intensive projects pay little tax in early years
- May include exemption from consumer taxes (e.g. CCL in UK)

A low carbon obligation gives some certainty of achieving targets (subject to a buy-out) but raises challenges

- The "lumpy" nature of new capacity (relative to the likely scope of an obligation) is likely to cause difficulties both with setting targets and liquidity of trading
  - averaging compliance (e.g. over 5 years) offers partial mitigation
  - an obligation that includes existing generation may give market power to incumbents
- There is a risk that average market prices may be distorted
  - price may rise to the buy-out level in the "compartmentalised" part of the market, with a significant impact on overall market prices
  - obligation may risk raising the cost of entry and thus wider market prices
- Does not provide signals for other carbon reduction at the margin
- Parallel to EU ETS rather than directly complementary
- May be most appropriate as a standard applying to all new plant provided costs not excessive

Feed-in tariffs (or benchmarked prices) have proved successful in stimulating investment but may be more difficult to make work for CCS, especially in liberalised markets

- Not reliant on carbon pricing
- Varies with technology and scale of plant
- Guaranteed revenue is attractive to investors
- EU review confirmed effectiveness for some technologies
  - e.g. onshore wind in Germany, Spain, Denmark
- RO banding in UK represents a move towards technology-specific character of feed-in tariffs
- But CCS plants would have exposure to movements in fossil fuel prices

A guaranteed premium over the market price may be a good alternative to feed-in tariffs in liberalised markets

- A contract offering a premium over the wholesale market price offers many of the advantages of feed-in tariffs, easier to implement in liberalised markets
- Provides hedge against energy price movements through linkage to the wholesale price (fixed premium not a fixed price)
  - May be especially important for CCS
  - Some precedent from Danish fixed premium scheme
- Contracts could be awarded by auction or tender to reveal costs
- Similar in principle to:
  - the original UK NFFO contracts for renewables (but offering a premium rather than a single price)
  - old UK ETS (but support not necessarily awarded per tCO_2 abated)
- May over-reward if carbon prices go high
  - This can be mitigated if support is in the form of a CfD on carbon price
- Need not be technology neutral

Conclusions

- There is wide consensus on the urgent need to reduce carbon 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 appear to have significant potential to reinforce the incentives from emissions trading at national level
- Other schemes will be necessary to complement carbon pricing for new technologies such as CCS
- The preferred support mechanisms will depend on policy objectives, technology stage, and market circumstances, with a role for each of
  - feed in tariffs,
  - contracts guaranteeing a price premium over the market
  - well-designed quantity obligations

Incentivizing CCS through market based mechanisms

IEA Greenhouse Gas R&D Programme
and IEA Clean Coal Centre,
May 31st/June 1st, Rembrandt Hotel, London

by

Gerhard Mulder – ABN AMRO
Jos Cozijnsen – JC Consulting Attorney

ABN·AMRO

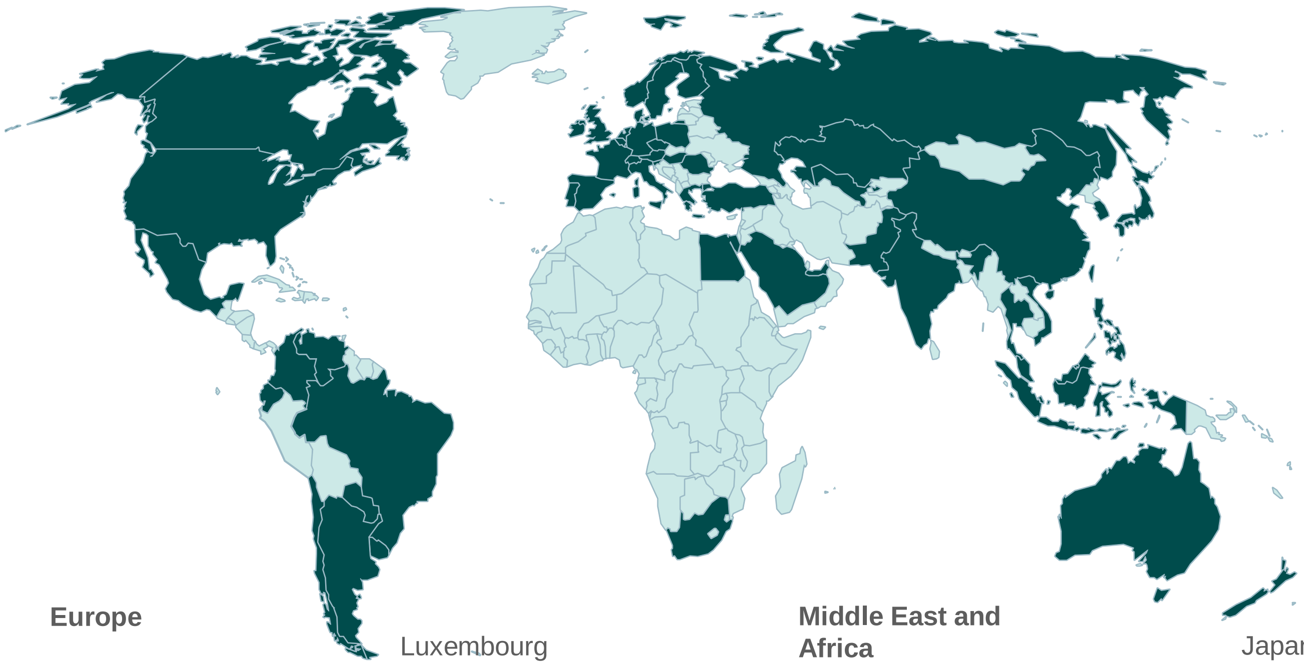
jc
consulting attorney

Outline

- Introduction
- Current state of play
- Incentivizing via Emissions Trading
- Incentivizing via CDM/JI
- Observations

ABN AMRO's Global Network

The scope of ABN AMRO's International network is virtually unmatched by any other bank



North America

United States
Canada
Mexico

Latin America

Argentina
Aruba
Brazil
Cayman Islands
Chile
Colombia
Netherlands Antilles
Paraguay
Uruguay
Venezuela
Virgin Islands

Europe

Austria
Belgium
Channel Isl.
Czech Rep.
Denmark
Finland
France
Germany
Gibraltar
Greece
Hungary
Ireland
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Malaysia
New Zealand
Pakistan
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ABN·AMRO

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Since 1998:

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- Legal advice on ETS
- Strategic advice: how to gain CO_2 market access?
- Customers: from Dutch Environment Ministry, Russian MEDT, Shell Global Solutions and Horticulture Organisation to Environmental Defense and Greenpeace

consulting attorney

Current state of play

- Currently no clear incentives exist for companies to invest in CCS
  - Some companies may be motivated by obtaining first mover advantage
  - Corporate concerns
  - Speculation on carbon economics yet to come
  - Who paid for developing the Toyota Prius?
  - Linking CCS with power generation may be too strange ‘animal’
- The regulatory framework is fragmented; there is no common approach
  - But, CCS is the only technology that all countries agree on, incl China, US, and Saudi Arabia (IPCC Special Report; IPCC AR4, Stern Review)
- Government subsidizes CCS directly or through Joint Ventures
  - But this is problematic, as the BP Peterhead project showed: timing aspect
- According to Socolow’s wedges; install CCS at 800 GW of base load coal plants by 2054 or 1600 GW of base load natural gas plants
  - Is equivalent of 3500 Sleipner size projects

Incentivizing CCS via EU ETS

- CCS is currently not explicitly allowed in the EU ETS. What would be the (dis)advantages of allowing under the ETS companies to reduce emissions through CCS?

Advantages	Disadvantages
1. Banking and borrowing allows for flexible use of EUAs	1. Allocation periods are too short – minimum of 15 years is needed
2. EUA prices are likely to be robust	2. Uncertain allocation methodologies
3. Banking from Phase II into Phase III	3. EUA prices have been volatile

- When allowing for CCS in the EU ETS, Governments can push for deeper cuts in allocation: EU focuses on allocation on the basis of x grCO2/kWh and 30% reduction
- Outstanding question is what EUA price is needed to induce CCS?

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Incentivizing CCS via EU ETS: *what is status?*

- UK NAP-2: mentions allowing CCS
- NL NAP-2: allocate Power CCS as if emissions would occur
  - Mining Act and Monitoring Decision refer to CCS, provided EC accepts Monitoring Plan
  - Dutch Tender: asking for 0,4 Mt/a service
  - EnergieNed: new 5 coal fired plants will prepare for CCS: provided some government support
- EC withdrew link of Monitoring Guidelines with ETS
  - But still accepts transmitting CO2 to food industry
  - Now prefers ‘opt-in of whole CCS chain’ or amendment
- EU Legal Enabling Framework for CCS under development
- ETS Review per 2013: 8 yr period; allow for CCS
  - ETS should also cap process CO2 emissions !

Incentivizing CCS via EU ETS: *what is playing*?

- Start CCS now would argue for gaining CO_2 credits later:
  - Early reduction gives multiplier bonus
- Why not invest ‘windfall profits’ in CCS (Vattenfall)
- Great advantage in having ZEPP for 30 years:
  - no CO_2 cost, large volume, upfront revenues
- ETS not enough understood: coal plant can sell forwards EUAs: 3 Mton @ € 23 * 5: € 345 million
  - Interest benefits and loan co-finance
  - Forward selling 2012-2020 @ 30?: Morgan Stanley and speculators / ECX has post 2012 price disclosure

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Incentivizing CCS via EU ETS: *limiting cost*

- Reduce health problems and cost: with CCS less NOx, SO2, dust, mercury ->> reduce NEC cost
- CO2 Infrastructure laid near Norway and in NL; Rotterdam Harbour interested. Companies offer capture ready service: reduce cost
- Government could ask charge for transferring CO2 waste from source to storing facility

Incentivizing CCS via CDM / JI

- CDM/JI is fundamentally different from the EU ETS. In CDM/JI projects, one receives credit after reducing the emissions rather than receiving rights upfront
- Particularly the CDM has had many methodological issues and is very bureaucratic
  - Baseline setting
  - Additionality
- JI is slightly less bureaucratic because it takes place in Annex B countries; i.e. countries with a cap under the Kyoto Protocol
- CCS is considered a sink under the Kyoto Protocol, rather than a standard project type
  - Sink based projects receive sub-category of CERs (temporary t/lCERs) How about CCS?

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Incentivizing CCS via CDM / JI

- To date, several projects have been submitted to the CDM Executive Board
  - Methodology Panels first reviews the proposed project and its methodology
- The MethPanel saw multiple objections and referred the issue back the CoP/MoP;
- CoP Dec. 2006 put CCS/CDM ‘on hold’. What were the main objections?
  - Physical seepage: there is no procedure to select an appropriate site for geographical storage projects → up to market
  - Monitoring methods for seepage: no good monitoring methodology may exist at this point, according to the MethPanel → IPCC 2007
  - Post-project seepage: CO2 may have a long-term corrosive effect
  - Liability for developing country? → CDM not sufficient regime
  - What is sustainability gains in developing country from CCS?
  - Is it really cheaper to do CCS in CDM?

Incentivizing CCS via CDM / JI

- A key question will be what long-term levels of physical leakage (seepage) risk and associated uncertainty is acceptable
  - Is 0.01% per year acceptable?
  - Can be insured / set aside offsets
- Ultimately, who is liable if seepage occurs and the credits are already sold?
  - Is this risk insurable?
- Will the UN propose to create a sub-set of CERs, as they have done with forest based projects?
  - If so, will this sub-set be admissible in the EU ETS and other scheme?
  - Is it tradable enough when it is conditional?

Incentivizing CCS via CDM / JI

- Unlikely that a solution will be found soon. The process is slow and bureaucratic
- EU sees CCS in CDM as bargaining chip: to get OPEC and China/India in, but
- Fear of CDM 'lock-in': would China/India be willing to accept an emission s cap if they have assured CDM investments for 20-30 years?
- With national or energy sectoral cap for developing country CCS could be paid with JI investments with less liability concerns and less transaction costs

Observations

- A quick solution from environmental markets such as the EU ETS and CDM/JI is unlikely: but ETS market not too well understood
- More urgency needed to turn political support into practical means
- 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: problem is partly a power market problem
- The climate problem is too serious to allow for thousands new facilities without CCS to come on line
  - A more pragmatic approach is needed
- The current ongoing research and experimental plants should provide guidance on the way forward

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Carbon Capture & Storage Association

Expert Meeting on Financing Carbon Capture and Storage Projects

Possible Regulatory Options for the UK Government to enable CCS Projects

1st June 2007

Dr Jeff Chapman

Carbon Capture & Storage Association

Business model 1

- **A company builds a power plant, a pipeline and accesses a store**

Business model 2

- **PF or IGCC power generator with CCS**
- **Pipeline operator**
- **Storage site operator**

Business model 3

- Air separation company
- PF power generator with CCS
- Pipeline operator
- Storage site operator

Business model 4

- **Gasifier hydrogen supplier with CCS**
- **Hydrogen power plant operator**
- **Pipeline operator**
- **Storage site operator**

Who's the Regulator?

- DTI for capture as part of industrial plant
- DEFRA(EA) for capture on environmental issues
- DEFRA(EA) for EU ETS
- DTI for Pipeline Act
- DTI for Petroleum Act so EOR and offshore pipelines
- DEFRA regulates FEPA so saline formations offshore in England & Wales and SE in Scotland

Carbon Capture Plant

- **Planning Permission (Section 36 Electricity Act)**
- **Environmental impact assessment**
- **IPPC**
- **Health & Safety**

Pipeline Matters

- Planning consent
- Pipelines Act
- Off shore pipelines regulated by Petroleum Act
- Health & Safety
- Re-use of pipelines
- Third Party Access

Health & Safety

- Industrial CO_2 applications commonplace
- Experience of large scale CO_2 handling in USA
- No UK experience of these volumes of inventory
- CO_2 not listed as hazardous under COMAH
- CCSA/EI in discussion with HSE
- HSE will decide if they have sufficient data on which to base regulation. Industry group will review.
- EC Centralised verification of safety?

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On-Shore Matters

- **Landfill Directive**
- **Water framework Directive**
- **Planning consent – Town & Country Planning Act**
- **If CO_2 classed as hazardous under COMAH then HSE gets involved in planning and regulation**

Off-Shore Matters

- London & OSPAR
- Environmental Impact Statements
- Safety Navigation Zones
- Air Navigation Order
- Exclusive Economic Zone, 12-200 miles
- Criminal & Civil Law

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Licensing Phases

1. ***Exploration*- period in which potential store is evaluated**
2. ***Retention*- time limited project development phase**
3. ***Operational*- injection of CO_2 – could be time or volume limited or contract with decision points**
4. ***Closure*- monitoring & decommissioning**
5. ***Decommissioned*- site abandoned and responsibility/liability handed back to Crown**

Storage Licensing Issues

- **Site characterisation**
- **Condition of the site**
- **Extent of license**
- **Monitoring of the site**
- **CO_2 Purity?**
- **Termination conditions**
- **Insolvency**
- **Terms of closure**
- **Parallels in gas storage**

Long Term Liabilities

- On-going monitoring
- Remediation in a failure event
- Compensation claims
- Cost of CO_2 emissions credits

- State must assume long term liabilities terms to be discussed

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EU Emissions Trading Scheme

- **Opt-in for Phase II**
- **Opt-in categories for Phase III? Or full recognition?**
- **Draft Monitoring & Reporting Guidelines made in UK**
- **In the different business models which is the installation?**

Mandatory CCS

- Workable but with:
- Perverse consequences
- ‘Capture ready’ should be left to the market

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