EUROPEAN PARLIAMENT

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT A
ECONOMIC AND SCIENTIFIC POLICY

Economic and Monetary Affairs

Employment and Social Affairs

Environment, Public Health and Food Safety

Industry, Research and Energy

Internal Market and Consumer Protection

Carbon Capture and Storage Technology in Europe

WORKSHOP

EN

2013

Carbon Capture and Storage Technology in Europe

EUROPEAN PARLIAMENT

DIRECTORATE GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICY

WORKSHOP

Carbon Capture and Storage Technology in Europe

Brussels, 18 June 2013

PROCEEDINGS

Abstract

This workshop was held at the European Parliament in Brussels on 18 June 2013 by the ENVI committee in the context of its implementation report on 'Developing and Applying Carbon Capture and Storage (CCS) Technology in Europe'. The aim of the workshop was to discuss the potential role of CCS in reducing carbon pollution, as well as its barriers and challenges and possible ways to move forward with CCS in Europe.

IP/A/ENVI/WS/2013-19 July 2013

PE 507.467 EN

This document was requested by the European Parliament's Committee on Environment, Public Health and Food Safety.

CONTRIBUTING EXPERTS

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Giles Dickson, Vice President Environmental Policies and Global Advocacy, Alstom Power
John Scowcroft, General Manager Europe, Middle East & Africa of the Global CCS Institute
Mike Fernandez, Executive Director, Sustainable Energy Branch, Alberta Energy (Ministry of the Alberta Government)
Tom Howes, Deputy Head of Unit in the renewable energy and CCS policy unit, European Commission
Isabelle Czernichowski-Lauriol, CO_2GeoNet President and CO_2 Geological Storage (CGS) Europe Coordinator, BRGM (French Geological Survey)
Paal J. Frisvold, Chairman of the Board Bellona Europa aisbl
Beatrice Coda, Low Carbon Technologies Unit, European Commission, DG CLIMA
Bill Spence, Vice President for CCS and Strategic Issues, Shell
Dr. Graeme Sweeney, Chairman of the Advisory Council of the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

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LINGUISTIC VERSIONS

Original: EN

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Manuscript completed in July 2013.

This document is available on the Internet at:
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EXECUTIVE SUMMARY

On 18 June 2013, the Committee on the Environment, Public Health and Food Safety (ENVI) of the European Parliament held a well-attended workshop on 'Carbon Capture and Storage Technology in Europe', which was hosted by MEP Chris Davies (ENVI-Rapporteur on the implementation report on developing and applying carbon capture and storage (CCS) technology in Europe) and co-chaired by MEP Vicky Ford (Rapporteur on CCS in the Committee on Industry, Research and Energy (ITRE).

The workshop was divided into three parts, the first one illuminating CCS as a strategic tool for reducing CO_2 emissions, the second one looking at the reasons why carbon capture and storage did not work in Europe and the third one concentrating on the necessary steps to overcome these obstacles and to move forward with CCS in Europe.

The workshop was opened by Chris Davies MEP who welcomed the speakers and introduced the subject. In part 1, Chris Hendriks from Ecofys, a consultancy specialised among other things in carbon efficiency and energy and climate policy, set the scene in describing the role of CCS in achieving CO2 reduction targets. Giles Dickson, Vice President Environmental Policies and Global Advocacy of Alstom Power then addressed the questions of whether CCS technology worked and whether it could be cost-effective. After that, John Scowcroft, General Manager Europe, Middle East & Africa of the Global CCS Institute, spoke about the global CCS experience and whether Europe was being left behind. Concluding the first part, Mike Fernandez, Executive Director of the Sustainable Energy Branch of Alberta Energy (regional Canadian government), gave some valuable insight into the experience of the Canadian province of Alberta with CCS.

Part 2 of the workshop, chaired by Vicky Ford MEP, started with Tom Howes, Deputy Head of Unit of the Renewables and CCS policy unit of DG Energy of the European Commission, who presented the barriers to the planned development of CCS technology in Europe. This was followed by a contribution by

Dr. Isabelle Czernichowski-Lauriol, CO_2GeoNet President and CO_2 Geological Storage (CGS) Europe Coordinator and Member of the French Geological Survey (BRGM) who elaborated on the question whether CO_2 could be stored underground safely. Paal J. Frisvold, Chairman of the environmental NGO Board Bellona Europa aisbl finally commented on the environmental challenges related to CCS.

Part 3, again chaired by Chris Davies, opened with an overview of the state of play of the EU CCS Demonstration projects and a further outlook by Beatrice Coda, senior policy officer at the Low Carbon Technology Unit of DG Climate Action of the European Commission. After that, Bill Spence, Vice President for CCS and Strategic Issues at Shell explained what industry expected from CCS. Finally, Dr. Graeme Sweeney, Chairman of the Advisory Council of the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) explained what needed to be done next to move forward with the development and deployment of CCS in Europe.

KEY ISSUES

The role of CCS in meeting climate targets

There was broad agreement among experts that CCS was a vital technology to tackle climate change and provide energy security. It was said that it should be part of a future broad energy mix alongside other low carbon technologies and should be deployed to improve the efficiency of power plants in order to be able to achieve the two degree emission reduction target.

Safe storage

Technical challenges for storage would include the need for at least 1000 years containment and the safety of storage. Storage was highly site-specific and therefore needed a tailor-made approach. Multidisciplinary expertise was necessary to optimise storage, ensure confinement and control storage and vicinity. Thus assuring a proper site selection, an appropriate risk assessment, correct operations during injection and closure, careful monitoring and a plan for adequate mitigation and remediation actions would be necessary in order to ensure that CO_2 could be stored safely underground.

Costs of inaction

Adding CCS to any process would increase capital costs as well as ongoing operating and maintenance costs. But this would need to be put into context: Alternative methods of reducing or avoiding CO_2 emissions were also generally more expensive than non-abated industrial or electricity production processes.

Compared to other CO_2 mitigation options CCS was to be considered a cost-competitive technology. According to the International Energy Agency (IEA) without CCS costs to halve emissions by 2050 would be 40% higher. Investing in CCS now would avoid having to make huge investments in the future.

CCS and the EU

1 billion EUR had been set aside for six large-scale CCS demonstration projects within the framework of the European Energy Programme for Recovery (EEPR, set up in 2009 to co-finance projects designed to make energy supplies more reliable and help reduce greenhouse gas emissions, while simultaneously boosting Europe's economic recovery.)

Furthermore, 300 million allowances had been reserved in the New Entrants Reserve of the European Emissions Trading Scheme for the financing of commercial-scale CCS and innovative renewable energy technology demonstration projects ("NER 300"). However the outcome of the NER300 programme in Europe had been disappointing so far due to the collapse in the value of the EU ETS revenues. This has put more pressure on individual European governments for co-funding to cover project costs. A second call for proposals was running until 3 July 2013.

The recent CCS Consultative Communication issued by the European Commission acknowledged the long-term interest in progressing CCS to demonstration and subsequent commercial roll-out aiming at reducing risks and costs, demonstrating safe storage and generating knowledge that could be shared. With current ETS prices too low, other policy options (implemented in other countries) needed to be explored (CCS mandatory certificate system; Emissions Performance Standards; Feed-in-tariffs (established by Member States), etc.).

Major challenges for deployment of CCS in Europe

Like many emerging technologies, CCS would face barriers that discourage new projects from emerging and prevent planned projects moving forward. The main barriers were said to be:

- Lack of a long-term commercial business case for CCS in Europe
- Insufficient funding for demonstration projects
- Delayed or incomplete transposition of the CCS Directive
- Public awareness and acceptance for CO_2 onshore storage
- Insufficient incentives for investment in transport and storage infrastructure
- Lack of a clear and coordinated 'CCS message'

Overcome existing barriers

Above all, a positive business case would have to be demonstrated to drive industry confidence, encourage more innovation and, ultimately, reduce capital and operating costs. The implementation of CCS would also require timely, strong, stable and enduring government policy support that was technology neutral. Governments should ensure that CCS was not disadvantaged. On the other hand CCS should neither be used as an excuse to slow down development and implementation of other options such as renewable energy or energy efficiency– nor to justify fossil fuel investments.

Funding for CCS demonstration projects by governments and industry should be accelerated and incentives increased to develop the technology and bring down costs through innovation. But the current political climate, operating under austerity policies, was constraining government funding support for R&D and demonstration. With the exception of North America and Norway – the allocation of funds from substantial funding has often been low whereas in many countries government support for renewables has been large and longstanding. The United States and Canada would remain leaders – together contributing around half of the funding available to CCS projects. Besides the funding issue, CCS would need to be promoted and public knowledge of CCS improved in order to win acceptance for this technology.

Last but not least, sharing expertise and learning from CCS projects around the world must be encouraged to ensure that progress is made as quickly as possible and in order to improve costs. This expertise should in addition be shared with developing countries where a significant share of CCS deployment must occur within the next decades.

Urgent deployment for CCS in the EU essential

The technical experience and skills as well as a solid foundation for a policy framework were available in Europe to deliver CCS. However progress was too slow at the moment and therefore the EU was losing ground to China, Canada, Australia and the United States. Therefore a fast and fundamental re-set was needed to ensure competitiveness and future prosperity along with the fulfilment of the climate targets on carbon reduction.

ANNEX 1: PROGRAMME

WORKSHOP

Carbon Capture and Storage Technology in Europe

Tuesday, 18 June 2013 from 15.00 to 17.30
European Parliament, Room P7C050, Brussels

Organised by the Policy Department A-Economy & Science for the Committee on the Environment, Public Health and Food Safety (ENVI)

AGENDA

15h00-15h05
Welcome and opening by the Chair
Chris Davies MEP, ENVI-rapporteur on the implementation report on developing and applying carbon capture and storage technology in Europe

Part 1

CCS - A strategic tool for reducing CO_2 emissions

15h05-15h15
The role of CCS in achieving CO_2 reduction targets
Dr. Chris Hendriks, Ecofys

15h15-15h25
Does the CCS technology work and can it be cost-effective?
Giles Dickson, Vice President Environmental Policies and Global Advocacy, Alstom Power

15h25-15h35
The global CCS experience - Is Europe being left behind?
John Scowcroft, General Manager Europe, Middle East & Africa of the Global CCS Institute

15h35-15h45
The practical example: CCS in Alberta (Canada)
Mike Fernandez, Executive Director, Sustainable Energy Branch, Alberta Energy (Ministry of the Alberta Government)

15h45-15h55
Q&A, open discussion

Part 2

Why does CCS not work in Europe? Barriers and Concerns

15h55-16h00
Introduction by the Chair
Vicky Ford MEP, ITRE-rapporteur on CCS

16h00-16h10
Barriers to the planned development of CCS technology in Europe
Tom Howes, Deputy Head of Unit, Renewables and CCS policy, DG Energy, European Commission

16h10-16h20
Can CO_2 be stored underground safely?
Isabelle Czernichowski-Lauriol, CO_2GeoNet President and CO_2 Geological Storage (CGS) Europe Coordinator, BRGM (French Geological Survey)

16h20-16h30
Environmental Challenges related to CCS
Paal J. Frisvold, Chairman of the Board Bellona Europa aisbl

16h30-16h40
Q&A, open discussion

Part 3

Moving forward with CCS

16h40-16h45
Introduction by the Chair
Chris Davies

16h45-16h55
CCS Demonstration projects: State of play and what comes next
Beatrice Coda, Low Carbon Technologies, DG Climate Action, European Commission

16h55-17h05
What does the involved industry expect from CCS?
Bill Spence, Vice President for CCS and Strategic Issues, Shell

17h05-17h15
What needs to be done now?
Dr. Graeme Sweeney, Chairman of the Advisory Council of the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

17h15-17h25
Q&A, open discussion

17h25-17h30
Conclusions

ANNEX 2: SHORT BIOGRAPHIES OF THE EXPERTS

Chris Hendriks

Dr. Chris Hendriks is managing consultant at Ecofys, an international leading consultancy on sustainable energy with expertise ranging from strategic policy support to applied technology solutions. Chris has over 20 years of experience in consulting in energy and environmental projects in a wide range of topics.

Chris studied analytical chemistry at Utrecht University and received his Ph.D. degree in 1994 on a thesis 'Carbon Dioxide Removal from Coal-Fired Power Plants'. From 1995 to 1998 he was employed at the Institute of Prospective Technological Studies (IPTS), one of the Joint Research Institutes of the European Commission in Seville. This institute advises directly to the Commission and the European Parliament.

Since the beginning of 1998, he works at Ecofys. The main working fields are the assessment for CO_2 and non-CO_2 greenhouse gas reduction options, carbon dioxide capture and storage and studies to greenhouse gases emissions in relation to industrial production, and Kyoto flexible mechanisms. Chris is over 20 years involved in CCS research and development.

Giles Dickson

Giles Dickson is Vice President for Environmental Policies & Global Advocacy in Alstom. He heads Alstom's 15-strong global team that promotes the Company's thinking on energy, environment, climate and transport policies and engages governments and others on how to support the transition to the low-carbon economy. Key policy issues on which the Company campaigns are the need for clear long-term regulatory frameworks that provide the right incentives and certainty for investment in low-carbon infrastructure: including clear trajectories for emissions reduction, the effective pricing of carbon and pre-market support for low-carbon technologies. Alstom provides technology and equipment for power generation and transmission and sustainable transport.

He joined Alstom in 2008 as Director Government Relations Europe for Alstom Power, where he was involved in advocacy on CCS, smart grid and energy efficiency. He was previously a UK Government official for 16 years, working mainly on EU affairs, finally serving as Environment Counsellor at the UK Permanent Representation to the EU.

He is a Vice-Chairman of the BUSINESSEUROPE Industrial Affairs Committee and a member of the Board of the International Emissions Trading Association.

John Scowcroft

John Scowcroft, General Manager – Europe, Middle East and Africa John Scowcroft joined the Global CCS Institute as General Manager in January 2012. Prior to this, John was Head of the Environment and Sustainable Development Policy Unit at Electricity EURELECTRIC, the association which represents the European electricity industry. In this role, John was responsible for all aspects of environmental and sustainable development policy, in particular for global and European climate policy. After a long career in the British Electricity Industry where he held a number of senior posts covering the whole range of employee relations issues, John joined EURELECTRIC's predecessor, UNIPEDE in 1991 as a Senior Adviser responsible for environmental matters, and structural and organisation issues. In 1997, John became Head of the Environment and Sustainable Development Unit. John graduated as a Bachelor of Arts from the University of Liverpool.

Mike Fernandez

Mike Fernandez is the Executive Director of Sustainable Energy at Alberta Energy. In this role, he leads a team that is focussing on clean energy policy development, outreach, as well as international engagement and is responsible for several clean energy funding programs.

Prior to joining this Branch in the spring of 2009, Mike worked as the Executive Advisor to the Deputy Minister of Energy and the Deputy Minister of Environment. Mike managed a variety of energy and environment related issues and acted as the lead interface between the department and the Minister. Before this, Mike spent 10 years at Alberta Environment working in a variety of operational positions; including industrial inspections, audits, enforcement, and emergency response.

In the fall of 2012, the Alternative Energy team moved under Mike's area of responsibility. This team has a lead role in developing and advancing renewable energy in Alberta.

Tom Howes

Tom Howes studied economics and has worked on a range of resource management and environmental policies in Australia, the UK, the International Energy Agency and for the European Commission. In his current post in the European Commission he worked on and now follows up the renewable energy Directive. He is Deputy Head of Unit in the renewable energy and CCS policy unit, in particular dealing with the electricity sector, financing and subsidy regimes and post 2020 follow up.

Isabelle Czernichowski-Lauriol

Isabelle Czernichowski-Lauriol has an engineering degree in geology (ENSG Nancy) and a PhD in geosciences. She joined BRGM, the French Geological Survey, in 1984. Since 1993, she has played a leading role in BRGM's pioneering research programme on CO_2 geological storage, a promising emerging technology for combating climate change. Firstly BRGM project manager of several EC projects, she soon became a member of the projects' Steering and Technical Committees and has adopted an increasingly important role in guiding CO_2 Capture and Storage (CCS) developments at national, European and international level. Since its creation in 2004, she has been involved in the management of the CO_2GeoNet European Network of Excellence on the geological storage of CO_2, now an Association under French law registered in Orleans, and has been elected President in 2011. She is now coordinating the FP7 CGS Europe project, a pan-European coordination action on the geological storage of CO_2, involving CO_2GeoNet and 34 research institutes over 24 EU Member States and 4 Associated Countries.

She is presently Programme Officer on Geo-Energy (geothermal energy, CO_2 and energy storage) at the Direction of Research of BRGM, and has a part-time secondment at the French National Research Agency (ANR), as CCS Programme Officer.

Distinction: Chevalier (Knight) grade of the national order of merit.

Paal Frisvold

Paal Frisvold is based in the EU capital Brussels since 1997 where he runs The Bellona Foundation's European office, Bellona Europa aisbl, a leading European environmental NGO advocating energy and climate policies to meet the UN goals of limiting global temperature rise to two degrees Celsius. Frisvold has held several leadership positions in the EU Technology Platform on Zero Emission Fossil Fuel Power Plants, ZEP. He designed and directs the Bellona Environmental CCS Team, *BEST*, which, inter alia, has published road maps for CCS deployment in Poland, Romania, Greece and Hungary.

Prior to joining Bellona, Frisvold worked as advisor to the Secretary General of the European Free Trade Association, EFTA, for the Norwegian Shipowners' Association, at the Organization for Economic Cooperation and Development, OECD, as well as at the Commercial section of the Norwegian embassy in Beijing.

Frisvold was twice elected President of the European Movement of Norway, a post he held from 2009 to January 2013. Frisvold has a Master degree in International Relations from Johns Hopkins' School of International Studies (1990) and a Bachelor degree from The American University of Paris (1986). He placed 11th in epee fencing for Norway in the 1984 Olympic Games in Los Angeles.

He is married to Martine Hermans Frisvold, and has two daughters, Zoë (1995) and Ruby (1996).

Beatrice Coda

Beatrice Coda, senior policy officer at the Low Carbon Technology Unit of DG Climate Action of the European Commission, holds more than 15 years of experience in innovative energy technologies. Before joining DG Climate Action in 2010, she worked 6 years at DG RTD as a research program manager for the Energy field in the 6th and 7th Framework Program for research , with focus on research and innovation activities of hydrogen and fuel cell technologies, where she contributed to the establishing of the Fuel Cell and Hydrogen Joint Undertaking (FCH JU). In her current position, her fields of responsibility relate both the NER300 funding programme for commercial scale demonstration projects of CCS and innovative renewables technologies, and the CCS policy. She has a Master Degree in Chemical Engineering from University of Pisa, a doctoral degree in energy technologies from University of Stuttgart and a Postgraduate Degree in Economics from the London School of Economics. She conducted extensive research on technical issues related to bioenergy and fossil fuels power generation technologies.

Bill Spence

Bill Spence is the Vice President of Strategic Issues for Shell's Projects & Technologies Business and Head of CCS. In the years preceding this position Bill was the Vice President CO_2 in Shell's corporate head office. Bill graduated from Queen's University (Canada) in 1984 with an Engineering Physics degree. He subsequently joined Shell Canada as a Petroleum Engineer. In 1989 he joined Shell International where he has lived and worked in numerous countries. His career has spanned both technical and commercial roles in the Upstream, Gas & Power and Renewables.

Graeme Sweeney

Dr. Graeme Sweeney is a leading authority on energy, fuels and climate change, drawing on his extensive international experience across all aspects of the oil, gas and renewable industries.

Dr. Sweeney is currently Chairman of the Advisory Council of the European Technology Platform of Zero Emission Fossil Fuels Power Plants (ZEP). ZEP's unique coalition of stakeholders (utilities, petroleum companies, equipment suppliers, scientists, academics and environmental NGOs) have been instrumental in the development of the EU Carbon Capture and Storage (CCS) Demonstration programme, providing expert advice to the European Commission on all technical, technology, policy, commercial and other related issues.

Dr. Sweeney is the co-chair of the European Union's CCS Project Network Advisory Forum and a founding member of the Global Carbon Capture and Storage Institute. He also serves on the advisory board of the University of California (Davis) Institute of Transportation Studies; is a member of the Prince of Wales' Corporate Leaders Group and chairs the Advisory Board of the UK Energy Research Centre (UKERC).

A 35-year career with Royal Dutch Shell continues through Dr. Sweeney's work as Special Adviser on CO2. Dr. Sweeney held numerous positions around the world with Shell across Trading, Manufacturing, Strategy, Sales and Marketing, Supply and Distribution and Research and Development. Most recently, he was Executive Vice President, CO2 for Shell International Petroleum Company Ltd.

ANNEX 3: PRESENTATIONS

Presentation by Chris Hendriks

ECOFYS

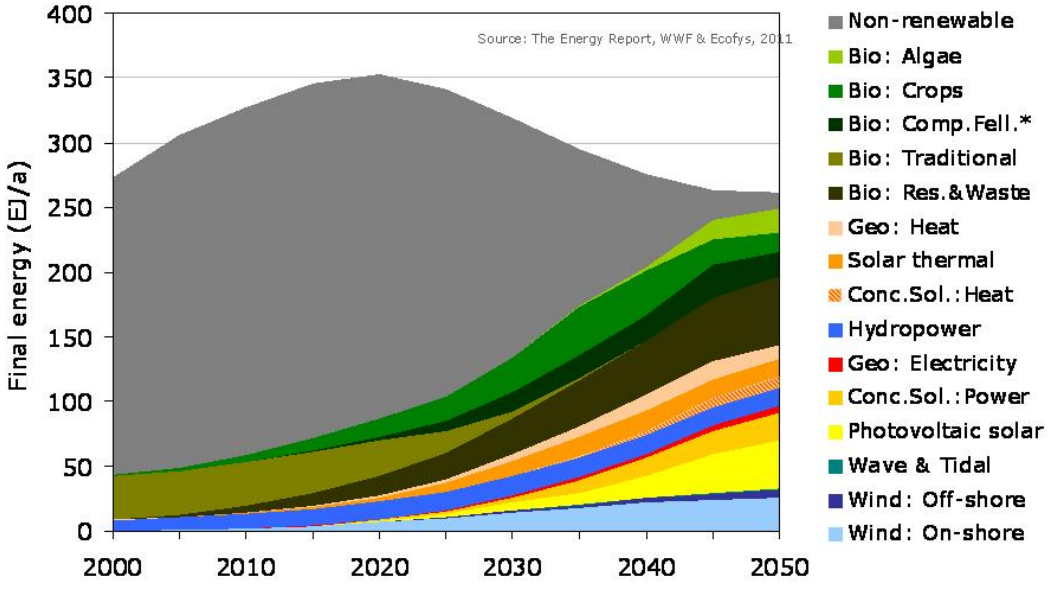
sustainable energy for everyone

Role of CCS in achieving CO_2 reduction targets

18/06/2013

Chris Hendriks

WWF/Ecofys energy supply scenario towards 2050



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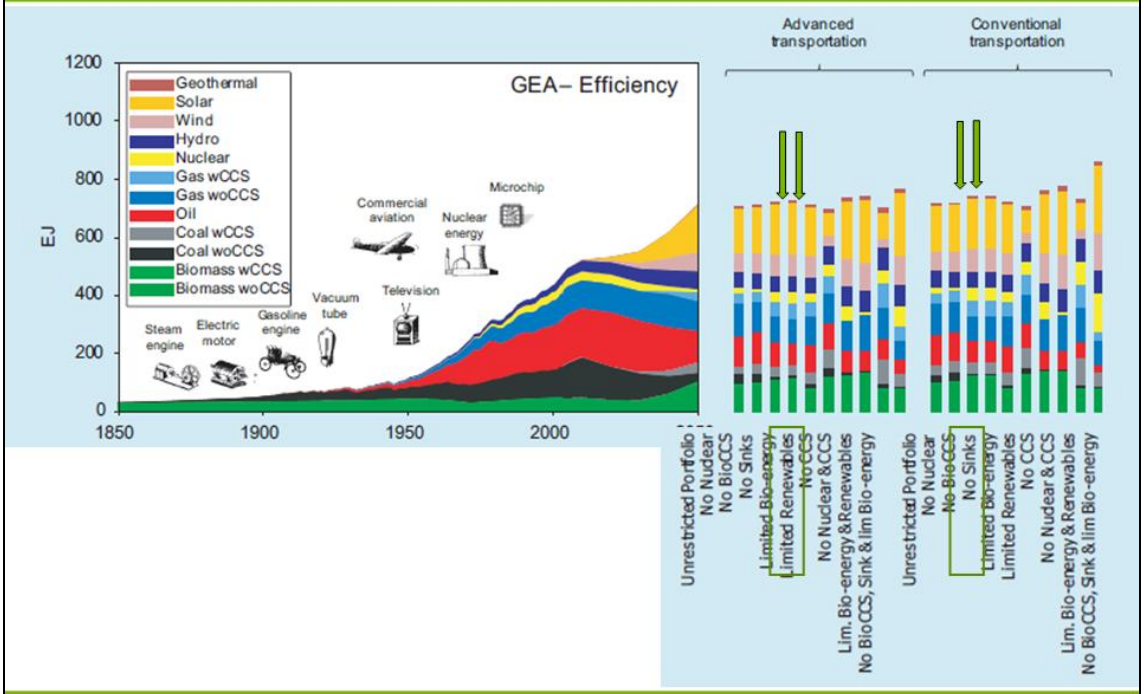
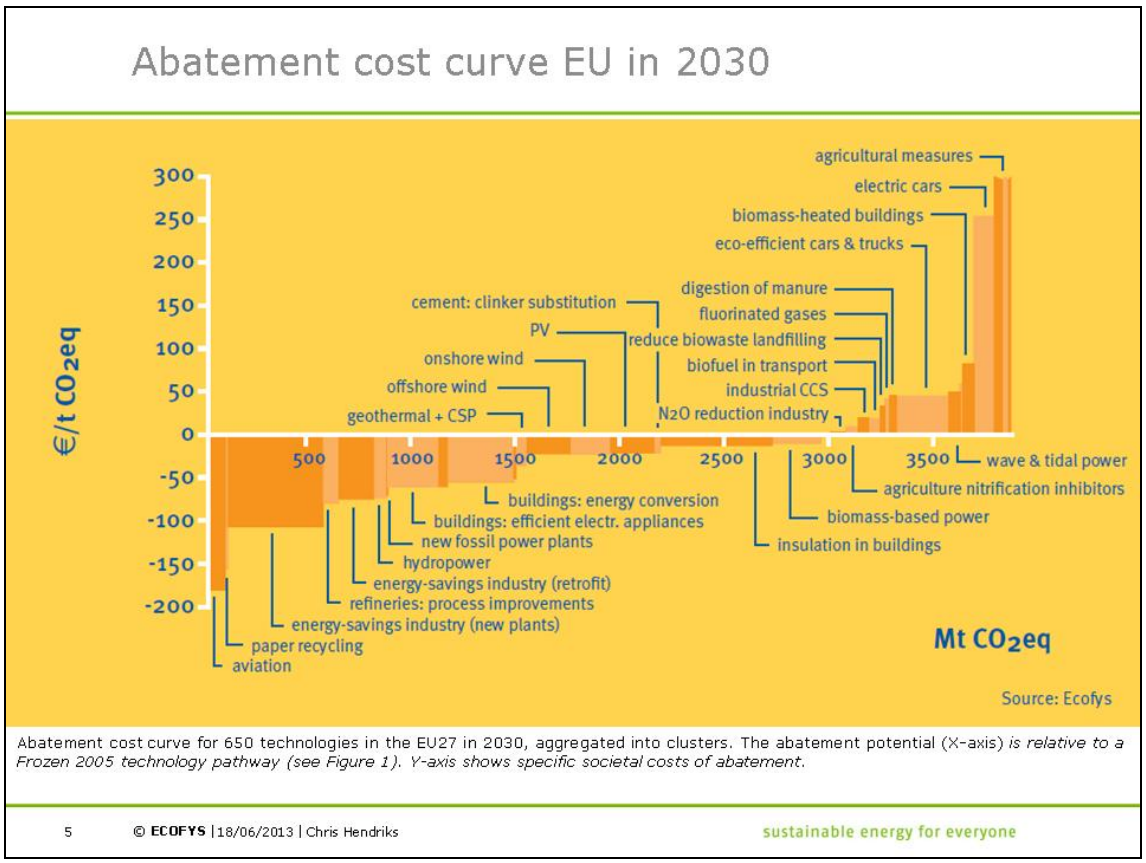
Global Energy Assessment – focus on efficiency



Wind turbines – private initiative



Abatement cost curve for 650 technologies in the EU27 in 2030, aggregated into clusters. The abatement potential (X-axis) *is relative to a Frozen 2005 technology pathway (see Figure 1). Y-axis shows specific societal costs of abatement.*

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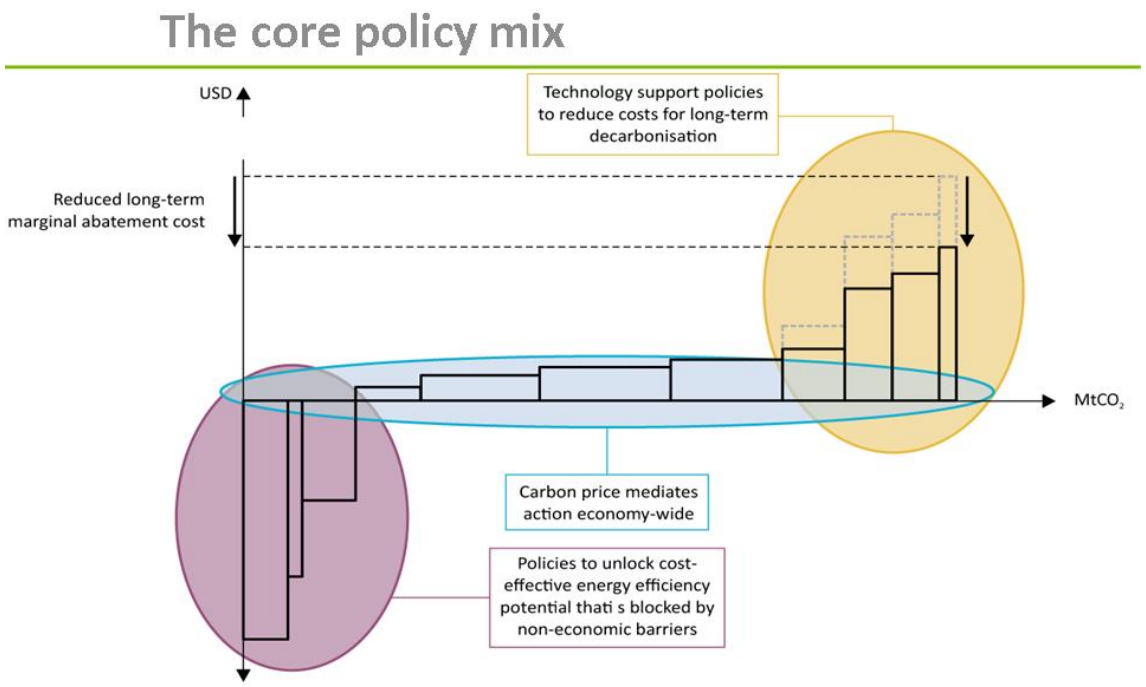

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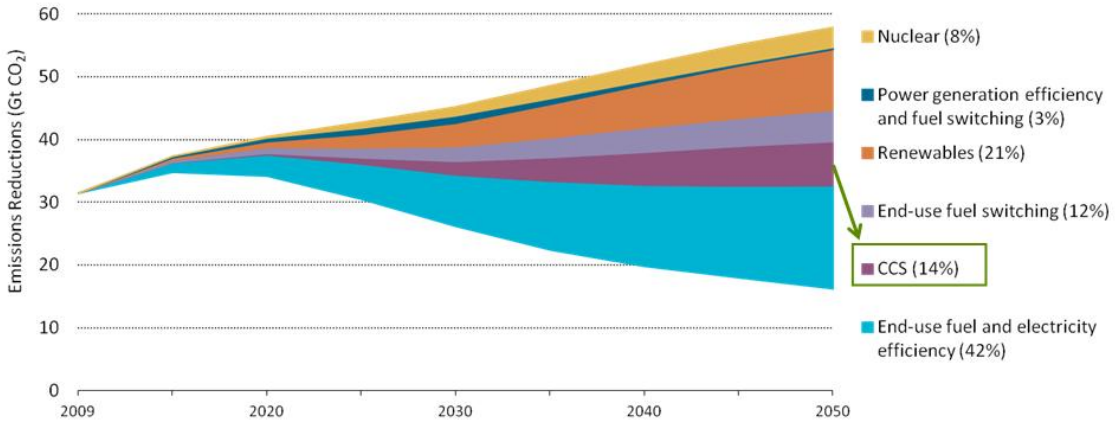
Clean energy technologies working in concert



Carbon capture and storage contributes 14% of total emissions reductions through 2050 in the IEA 2DS

source: IEA, 2013

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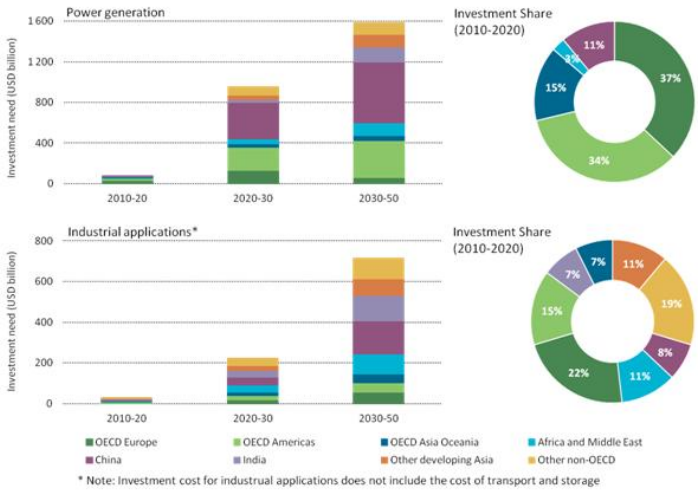
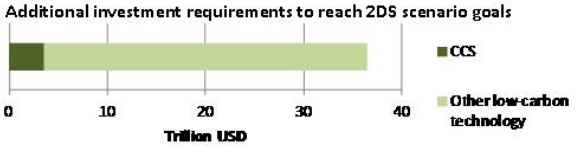
Total investment in CCS in IEA 2DS: 3.6 trillion USD



if CCS removed from portfolio, investment cost in the power sector increases by 40% until 2050…



source: IEA, 2013

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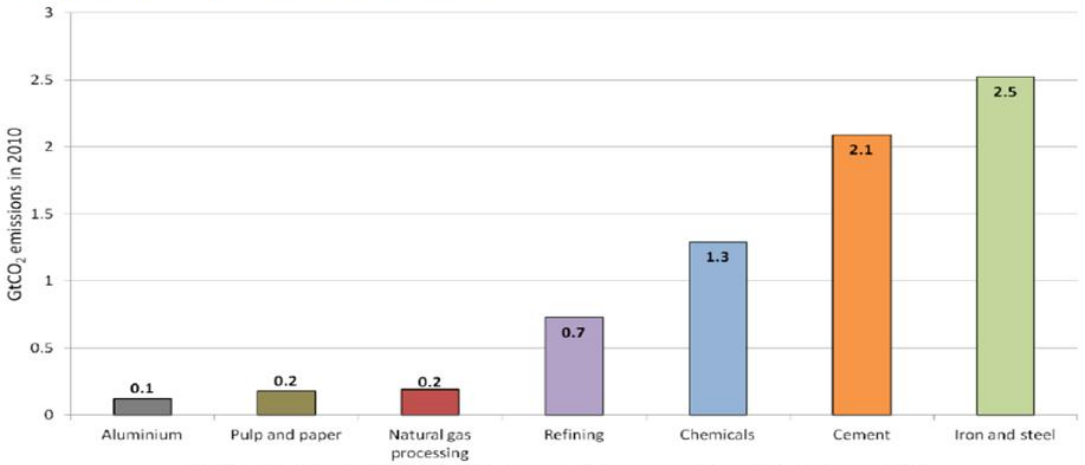
CCS in industrial sectors

Figure 1. Global emissions from the seven most CO_2-intense industrial sectors in the IEA *Energy Technology Perspectives* analysis



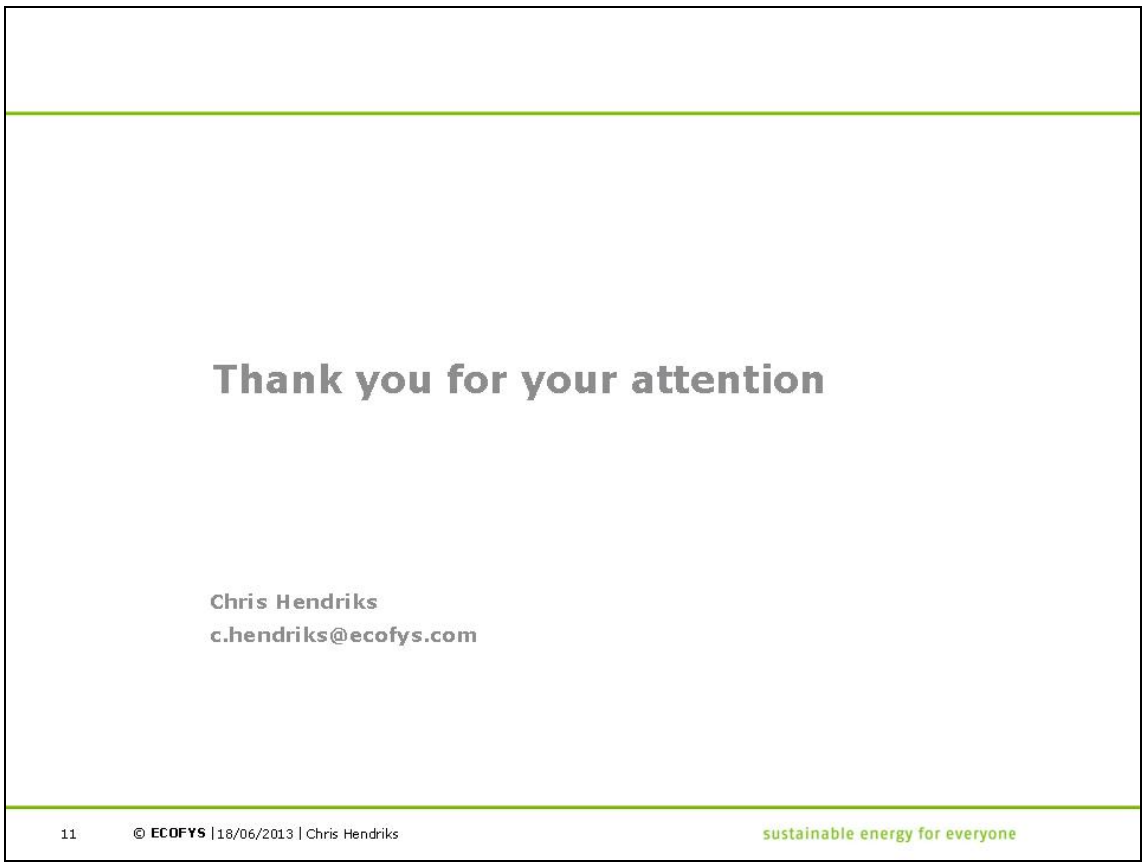
CCS is a main option for many energy-intensive industries

source: IEA, 2013

Key messages

- The technology and potential is present to reach a sustainable energy system
- Despite potential of technologies, progress is too slow at the moment
- CCS needs to be deployed to achieve the two degree emission reduction targets
  - realistically seen: required to meet emission reduction targets
  - reduces compliance costs
  - provide good opportunities for several energy intensive industries
  - can address to decarbonize locked-in fossil fuels
  - can accelerate emission reduction by combination with biomass
- Government policy is decisive in unlocking the potential, RE, EE and CCS

- But be aware of
  - unnecessary further lock-in of fossil fuels
  - CCS being abused and used as an excuse to slow down development and implementation of other options (RE/EE) – or to justify fossil fuel investments


Thank you for your attention
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Presentation by Giles Dickson

CCS technology: can it be cost-effective ?

Giles Dickson
VP Environmental Policies and Global Advocacy

Brussels, 18 June 2013

ALSTOM

CO_2 capture technologies for power generation

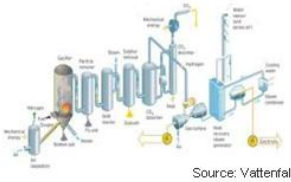
Alstom focuses on post and oxy to also address installed base

Power Plant with CO_2 capture

Post-combustion
(New + retrofit)

Oxy-combustion
(New + retrofit)

Pre-combustion
(New only)



Source: Vattenfall

Alstom – CO2 Capture Systems - P 2

ALSTOM

Technologies developed by Alstom

CO_2 capture technologies pursued by Alstom

Post-combustion
(New + retrofit)

- Advanced Amines Process
- Chilled Ammonia Process

2nd generation

- Regenerative Calcium Cycle (RCC)

Oxy-combustion
(New + retrofit)

- Oxy-combustion with ASU

2nd generation

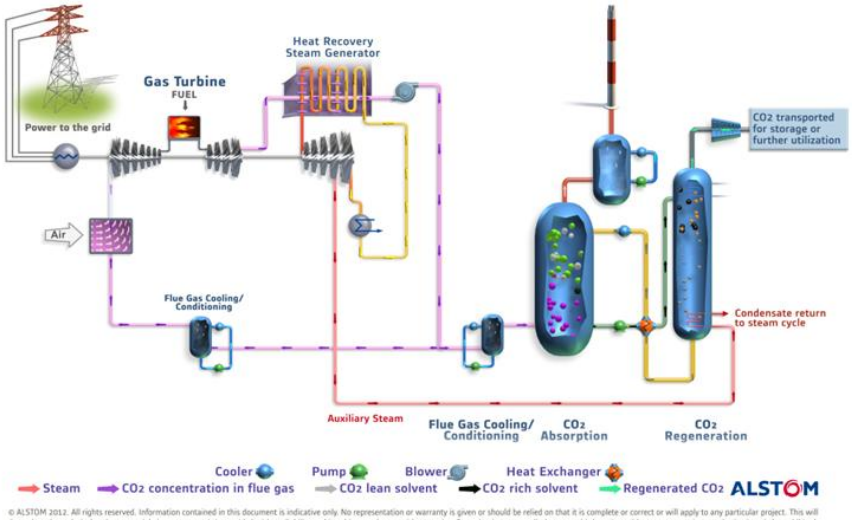
- Chemical Looping Combustion (CLC)

Alstom – CO2 Capture Systems - P 3

ALSTOM

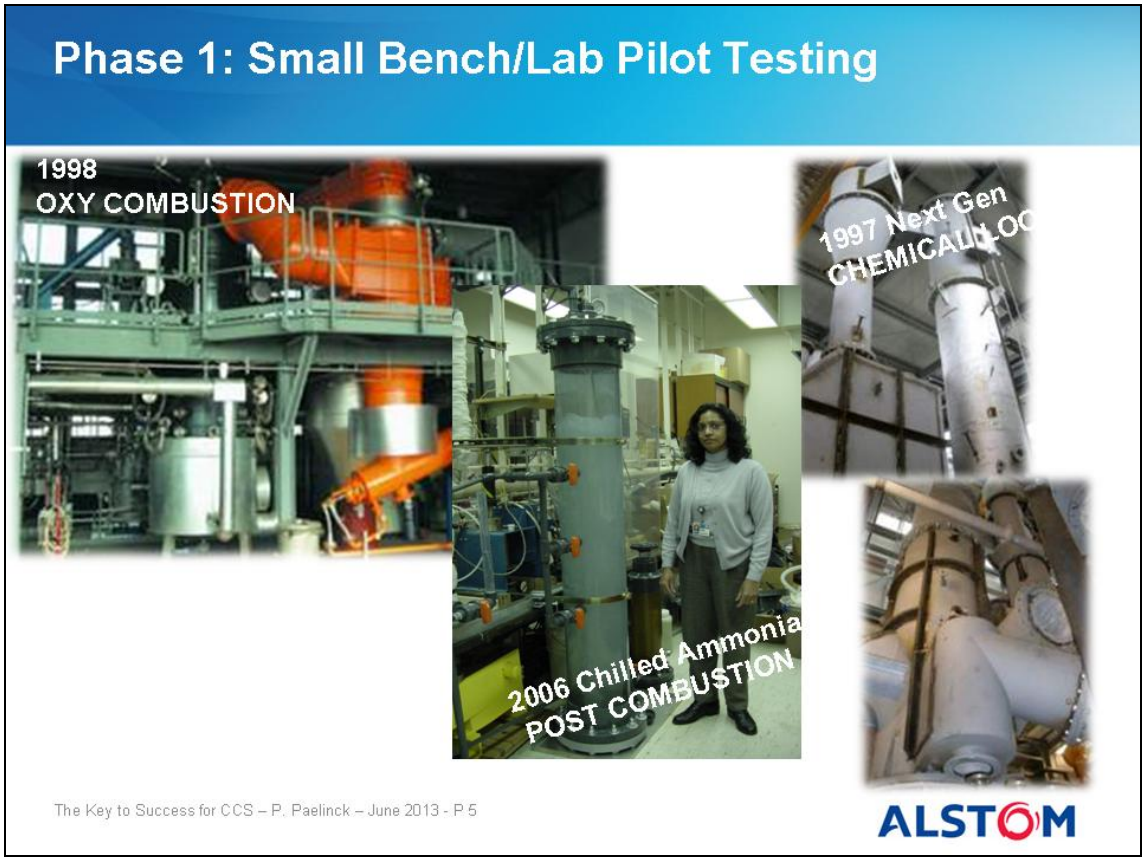
CCS on Gas

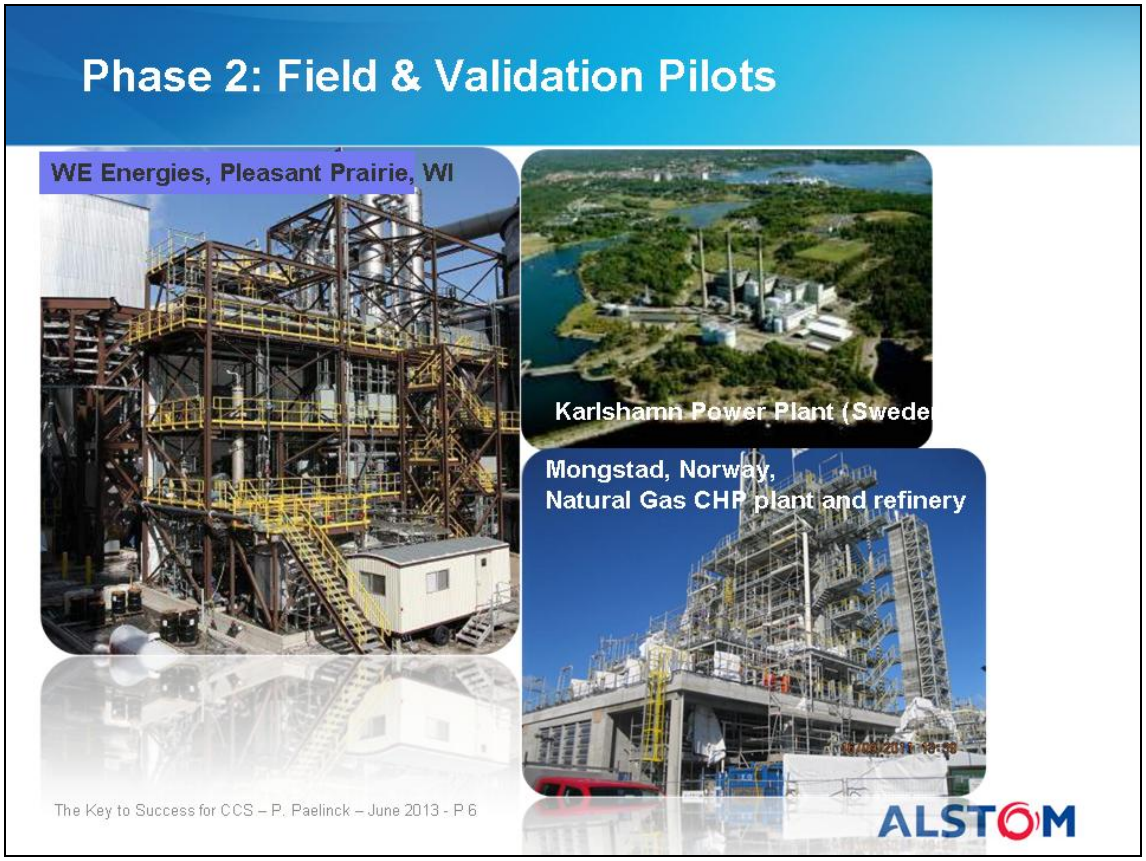
Combined Cycle Power Plant integrated with CO2 capture and FGR



Gas-fired power plants with CCS - 20/06/2013 - P 4

ALSTOM


Phase 1: Small Bench/Lab Pilot Testing
1998
OXY COMBUSTION
1997 Next Gen
2006 Chilled Ammonia
POST COMBUSTION
The Key to Success for CCS – P. Paelinck – June 2013 - P 5
ALSTOM


Phase 2: Field & Validation Pilots
WE Energies, Pleasant Prairie, WI
Karlshamn Power Plant (Swede
Mongstad, Norway,
Natural Gas CHP plant and refinery
The Key to Success for CCS – P. Paelinck – June 2013 - P 6
ALSTOM

Phase 3: COMMERCIAL SCALE DEMONSTRATION

WHITE ROSE CARBON CAPTURE & STORAGE PROJECT

Example : the White Rose CCS Project, located at DRAX Power Plant (Selby-UK)

CAPTURE POWER

The Key to Success for CCS – P. Paelinck – June 2013 - P 7

CCS is happening

TESTS COMPLETE

AEP Mountaineer
USA – 58 MWth
Chilled Ammonia, Coal

EoN Karlshamn
Sweden - 5 MWth
Chilled Ammonia, Fuel

WE - Energie
USA WI - 5 MWth
Chilled Ammonia, Coal

DOW Chemical Co.
USA, WV
Adv. Amines - Coal

OPERATING

Vattenfall Schwarze Pumpe, Germany
30 MWth, Oxy - Lignite

TCM Mongstad Norway
40 MWth, Chilled Ammonia, CHP & Refinery Offgas (RCC)

Total Lacq
France - 30 MWth
Oxy - Gas

Alstom GPU Pilot (Mobile)
0.3 MWth

Alstom BSF Windsor
US - 15 MWth
Oxy - Coals

Alstom Labs Växjö
Sweden – 0.25 MWth
Post C.-multi purpose

2nd Gen

DOE/Alstom Windsor
US - 3 MWth
Chemical Looping, Coal

2nd Gen

RFCS EU - Darmstadt
Germany - 1 MWth
Chemical Looping - Coal

COMMISSIONING

EDF Le Havre
France - 5 MWth Adv. Adv. Amines - Coal

LARGE-SCALE PROJECTS (under development)

White Rose CCS Project
UK - 426 MWe
Oxy Hardcoal

Getica - CET Turceni
Romania - >250 MWe
Chilled Ammonia-Lignite

CCM Mongstad (Gas Turbine based CHP)
Norway – 280 MWe + 350 M Wth
Chilled Ammonia

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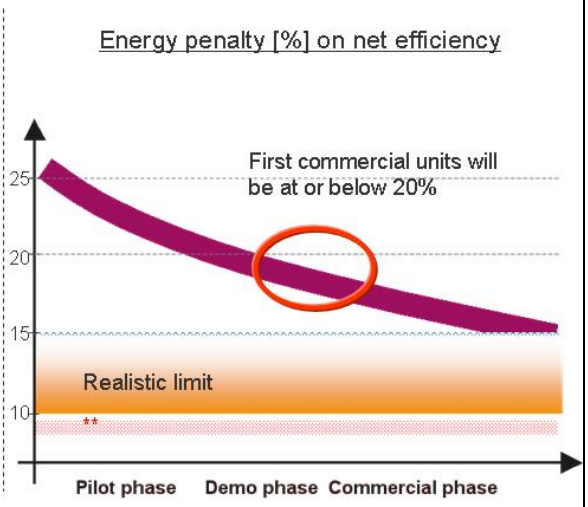
CCS : a competitive clean power option – February 11th, 2012 - P 8

CCS works

	CO_2 capture rate	CO_2 purity
 Pleasant Prairie, US Chilled Ammonia	90%	>99%
 Mountaineer , US Chilled Ammonia	75-85%	>99.9%
 Charleston , US Advanced Amines	90%	>99.5%
 Schwarze Pumpe Germany Oxy-Combustion	90%	>99.7%



Pilot operation confirm CO_2 capture works and performance is improving

*Theoretical limit assumes ideal separation and compression processes (110bar): isentropic, no losses

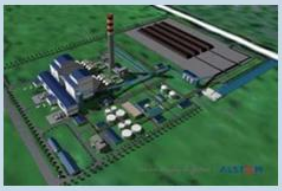
ALSTOM

Alstom CCS costs study

13 pilots, several demo projects in development

CCS experience

Global supply of turnkey power plants



Plant Integration experience

Robust CCS-CoE study built on Alstom know-how

Key component OEM

Independent Validation

Methodology and hypothesis

CCS : a competitive clean power option – February 11th, 2012 - P 10

ALSTOM

CCS costs study: main hypotheses

- post- and oxy- combustion
- bituminous coal, lignite and gas
- Europe, NAM and South East Asia
- Base load operation: coal 7446 h/y; gas 6570 h/y
- CO_2 Capture rate: 90%
- full CCS Chain CAPEX and 10 years OPEX
- 200 km transport to on-shore saline aquifer

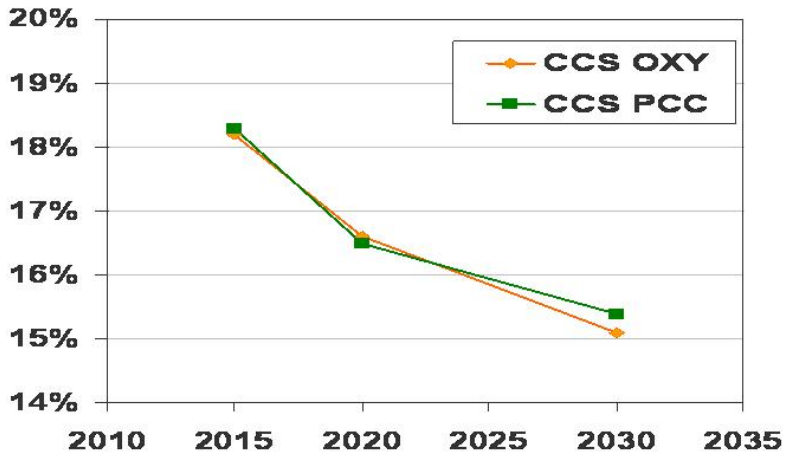
CCS : a competitive clean power option – February 11th, 2012 - P 11

ALSTOM

Result: Energy penalty will fall

CCS PLANT – ENERGY PENALTY

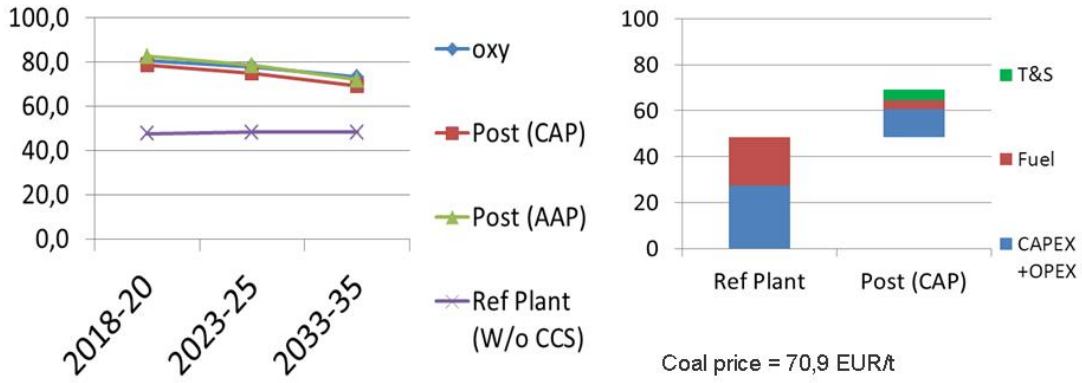
(% AGAINST MWe net REF PLANT)



Source : Alstom cost of electricity study 2013

ALSTOM

Bituminous coal Europe LCoE (No CO_2 price)



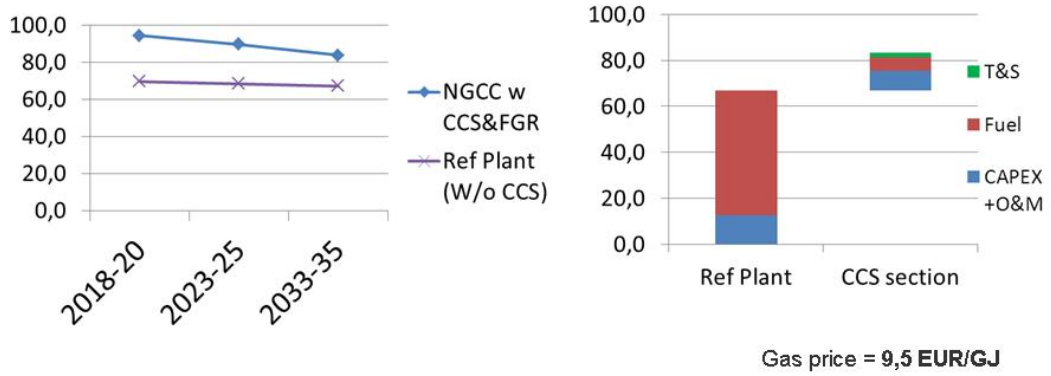
Source : Alstom cost of electricity study 2013

All technologies in the same cost range : differences will be site-specific

Competitiveness of CCS power plants – Power-gen Europe - June 2013- P 13

ALSTOM

Gas Combined Cycle Europe LCoE (without CO_2 price)



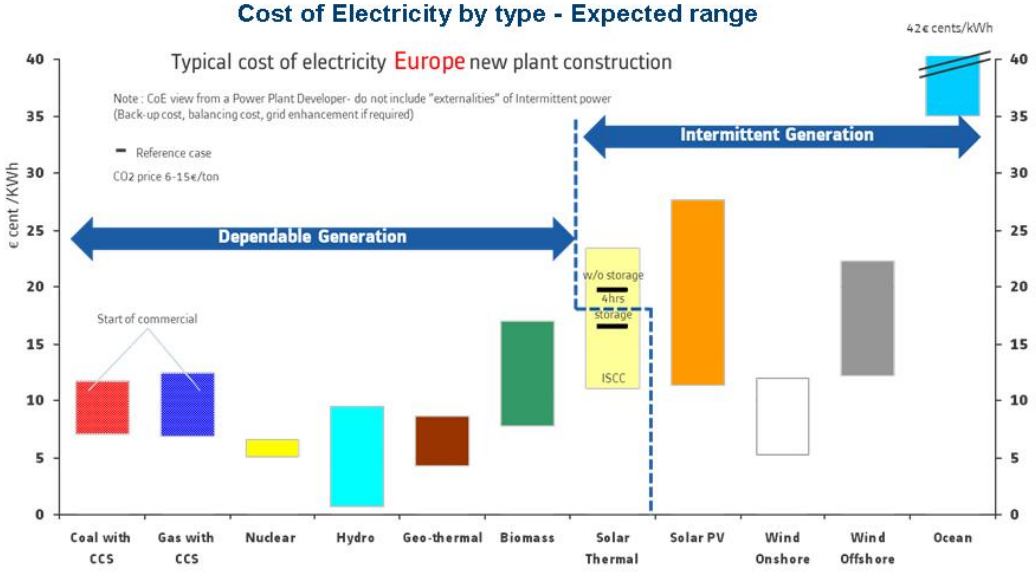
Source : Alstom cost of electricity study 2013

ALSTOM

CCS costs vs. low carbon alternatives

Investment decision for low carbon New PP over next 5 years

Cost of Electricity by type - Expected range



Competitiveness of CCS power plants – Power-gen Europe - June 2013- P 15

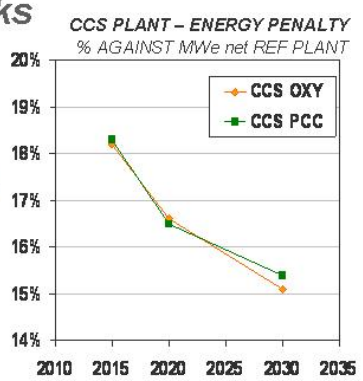
Source : Alstom analysis 2013

ALSTOM

Major challenges remain .....

Technology not an issue ...CCS works

- Capture rates as high as **90%**
- CO2 purity about **99%**
- Energy penalty <20%, on the way to 15%
- Demonstration projects now needed to optimise technology and reduce costs



Government financial support

- need feed-in tariffs / rate recovery / certificates
- and, ideally, a strong carbon price

Government regulation

- to enable CCS to happen including clear rules on liability and the transfer of storage sites from operators to government
- to drive investments in CCS
  - require new fossil plants to be CCS-ready; and
  - keep alive expectation of future mandation for new plants and retrofit of CCS-ready plants

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Policies needed to drive CCS

Support schemes / Certificates

CO2 price

Targets

Legal frameworks for transport and storage

CCS readiness

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Thank you

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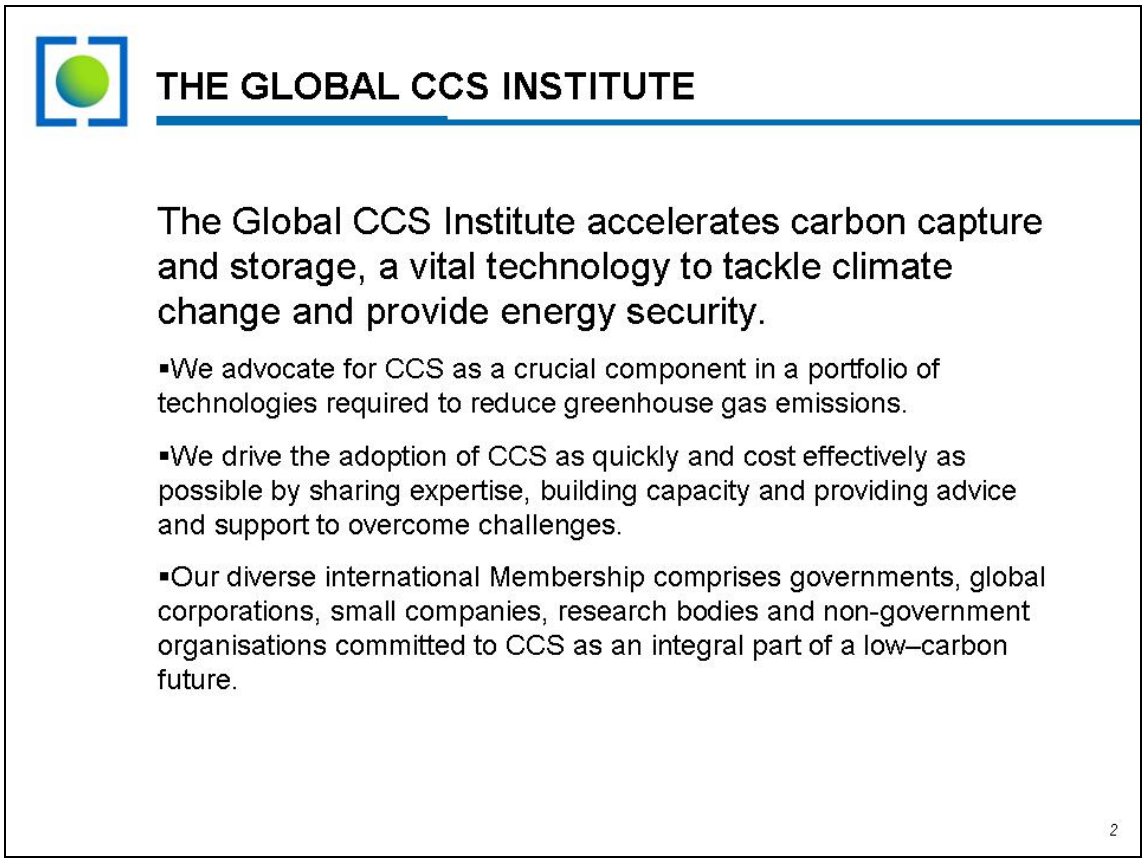
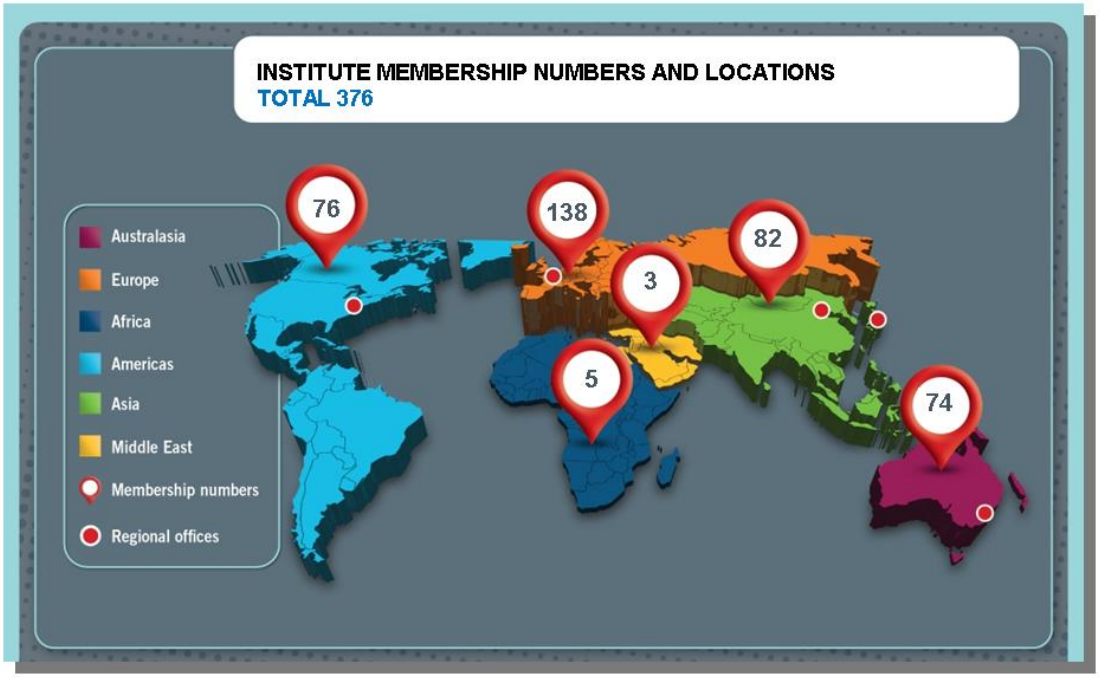
Presentation by John Scowcroft

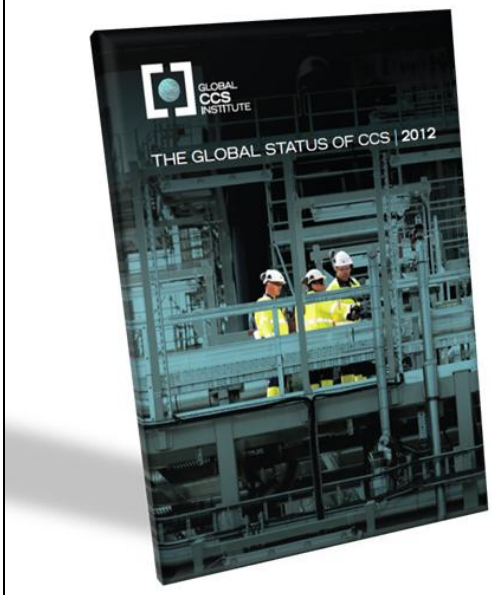


GLOBALLY-CONNECTED MEMBERSHIP



THE GLOBAL STATUS OF CCS: 2012

Key Institute publication



- Released October 2012, and updated in January 2013.
- Comprehensive coverage on the state of CCS projects and technologies.
- Progress outlined since 2011.
- Challenges and recommendations for moving forward.

CCS IS ALREADY CONTRIBUTING, BUT PROGRESS MUST BE ACCELERATED

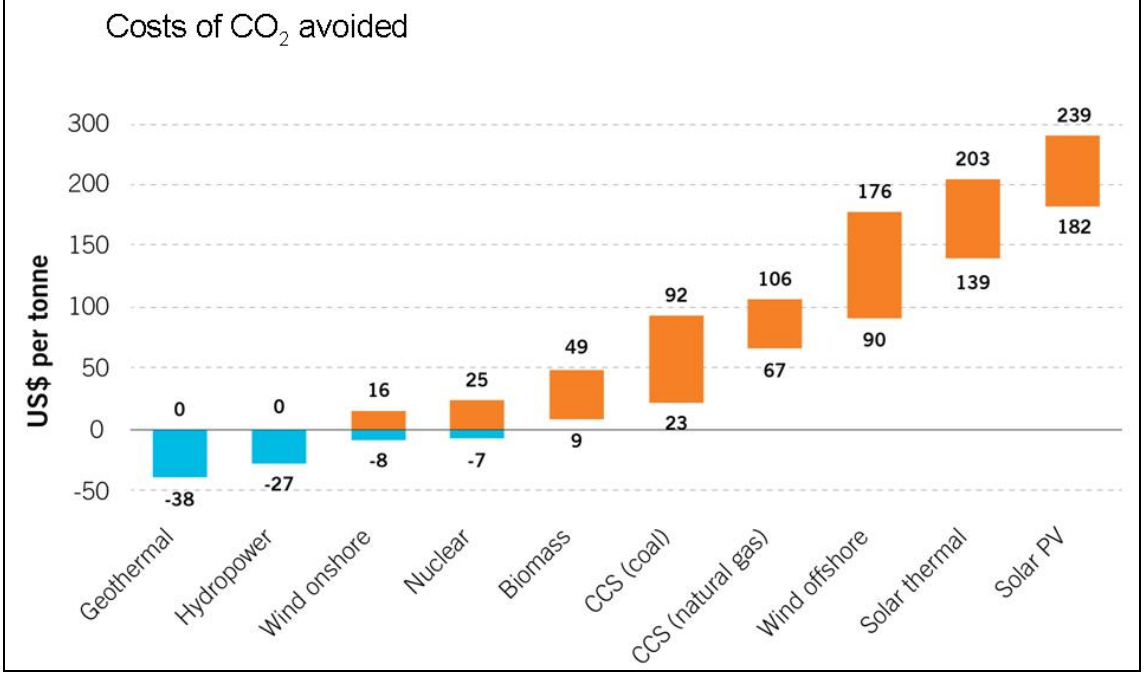
8 operating large-scale CCS projects:

- 6 natural gas processing plants (Norway, Algeria, US)
- 1 fertiliser plant (US)
- 1 synthetic natural gas plant (Canada)

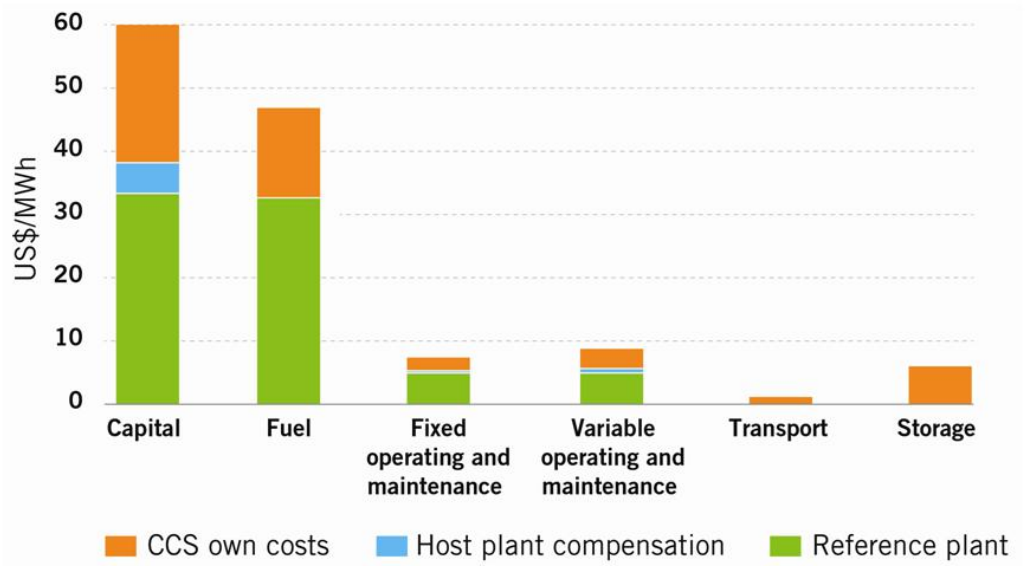
8 projects under construction:

- 2 electricity generation plants (US, Canada)
- 2 natural gas processing plants (US, Australia)
- 2 hydrogen plants (US, Canada)
- 1 fertiliser plant (Canada)
- 1 ethanol plant (US)

BARRIERS MUST BE OVERCOME TO REALISE THE BENEFITS OF CCS

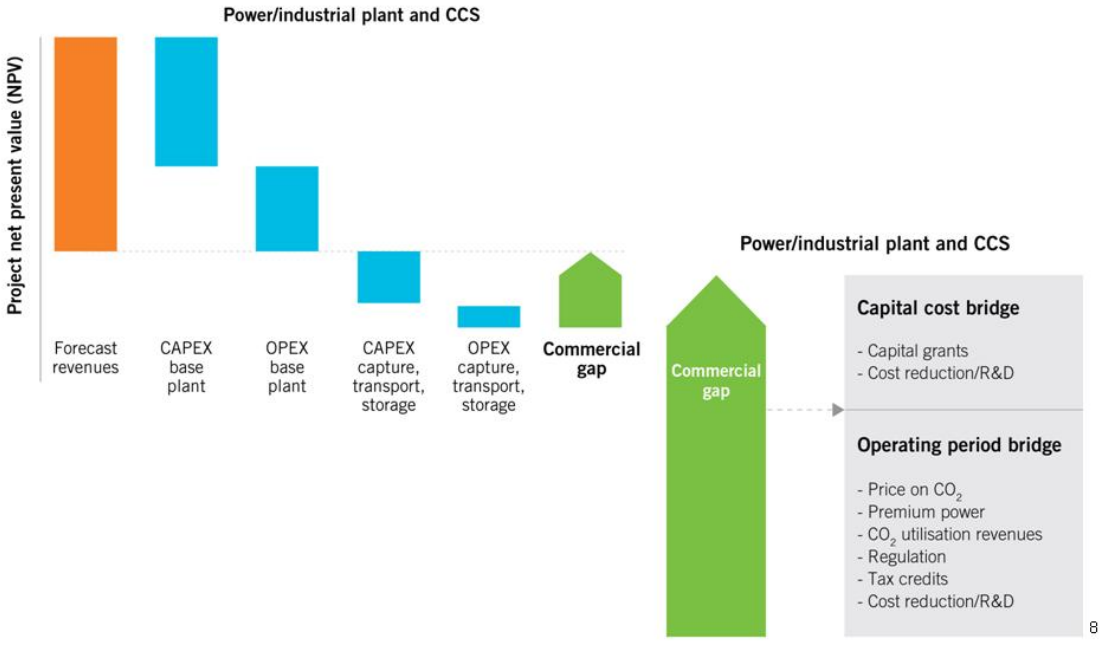


Challenges to deployment: Costs



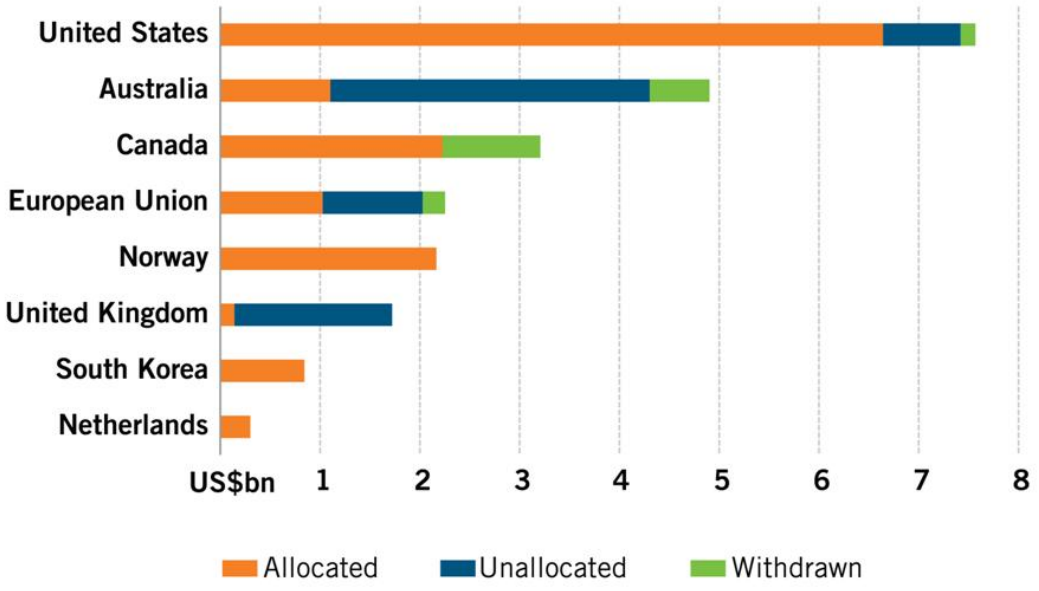
7

CHALLENGES TO DEPLOYMENT: REVENUE



8

CCS POLICY AND FUNDING SUPPORT



9

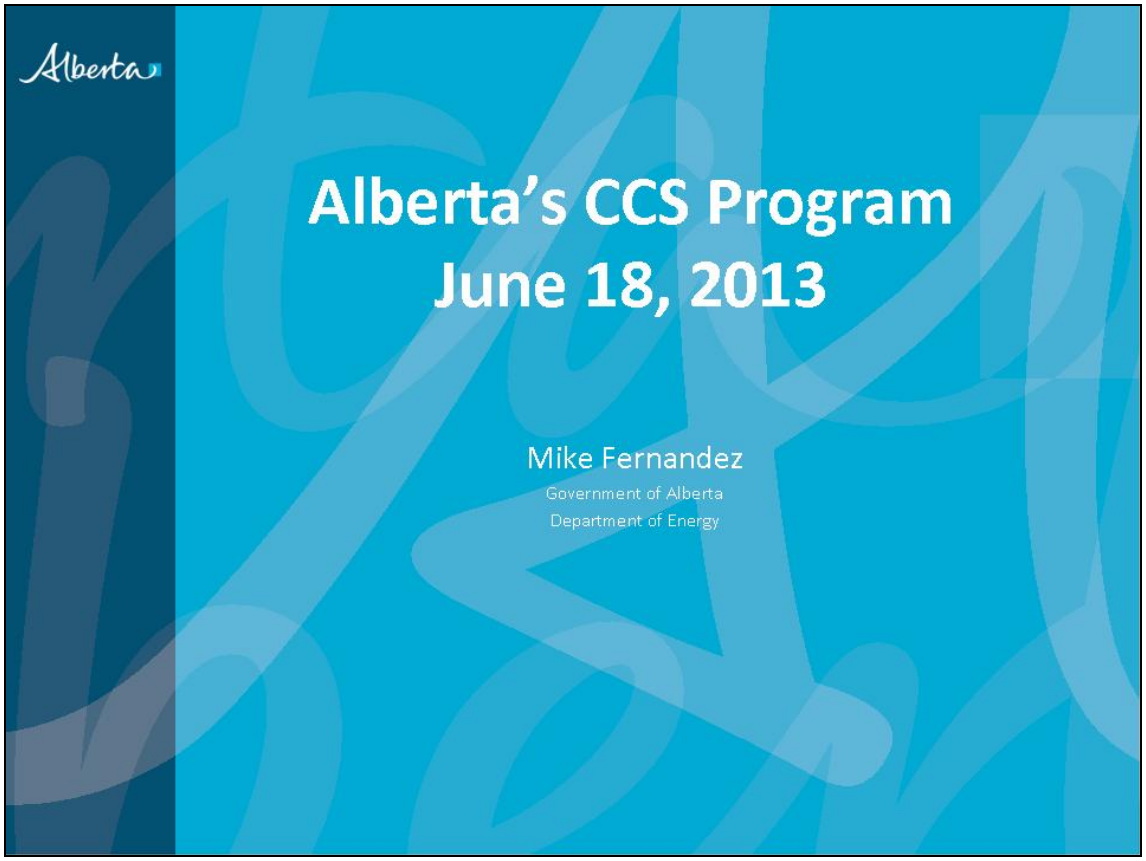
WHAT NEEDS TO BE DONE

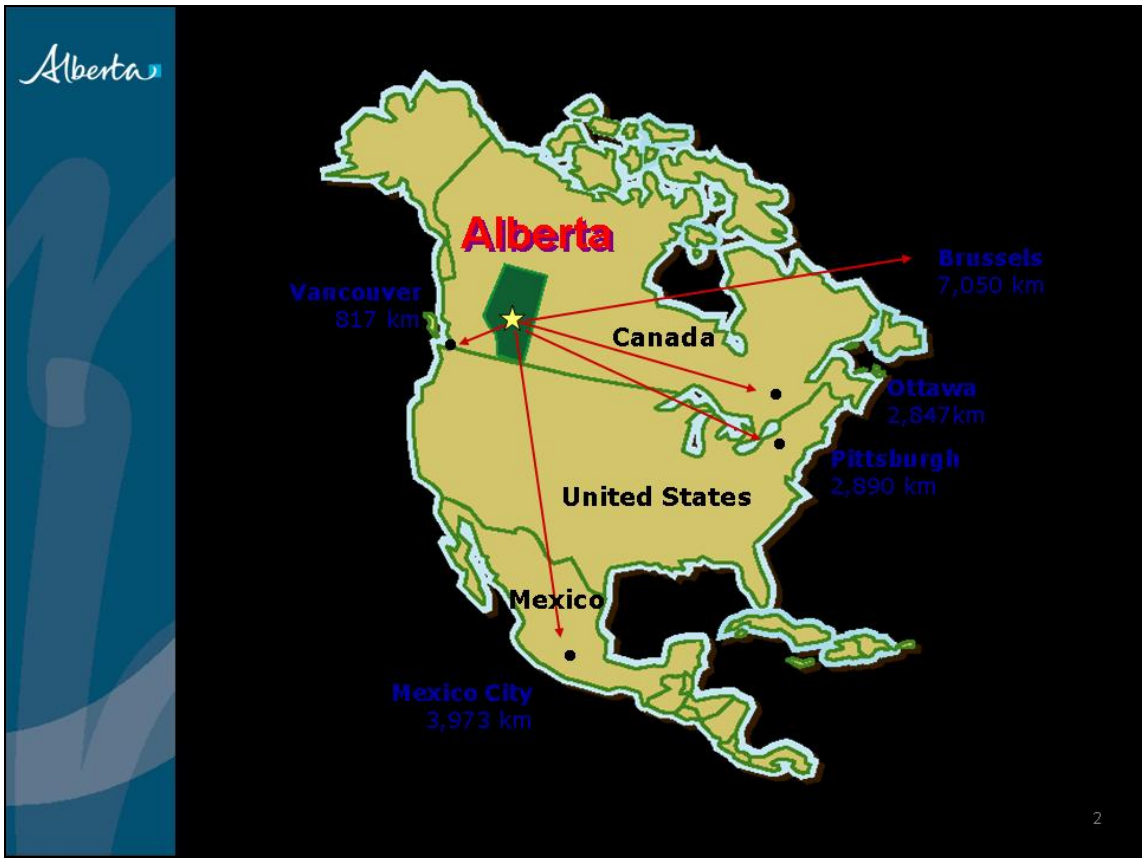
- Climate change **legislation not progressing sufficiently.**
- Need to include **CCS** in the portfolio of clean technologies with **equitable incentives and treatment** - lowering cost of meeting reduction targets in the long run.
- **Funding for CCS demonstration** projects should be accelerated and **incentives increased** from current base.
- Encourage CCS **capacity building in developing economies**.

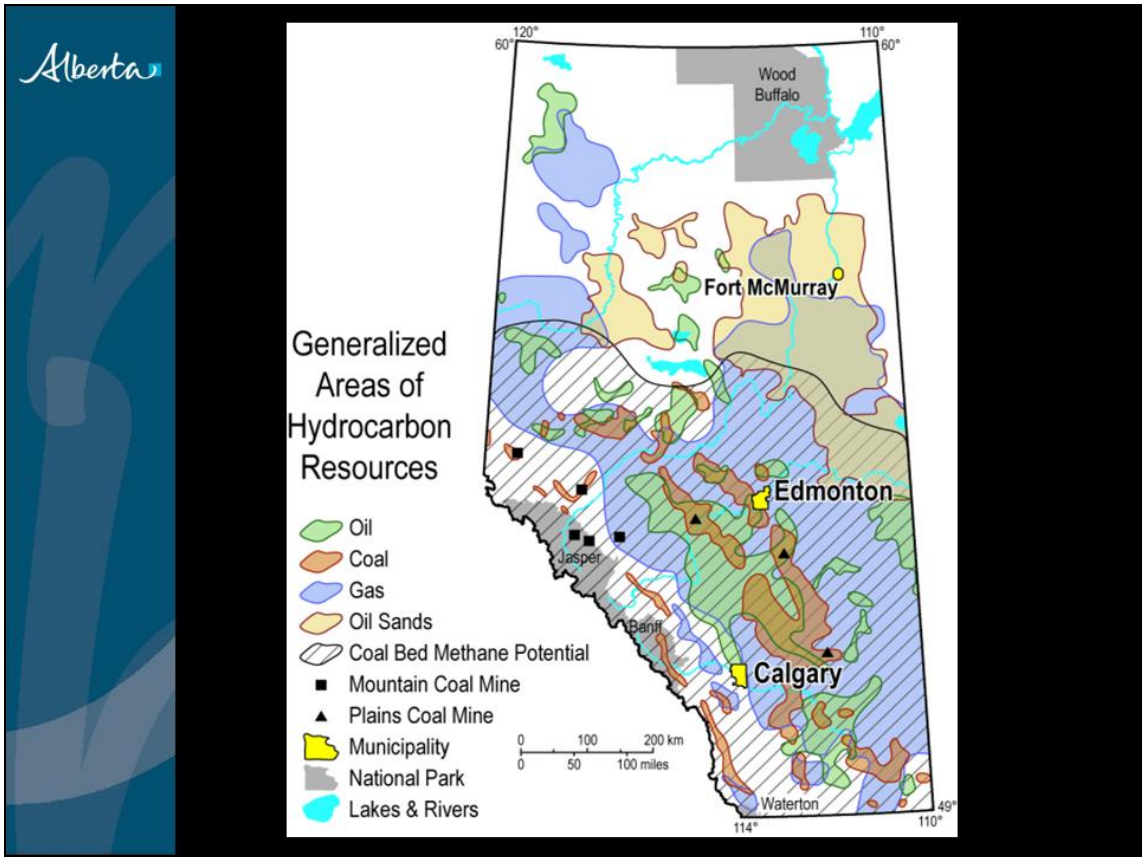
10

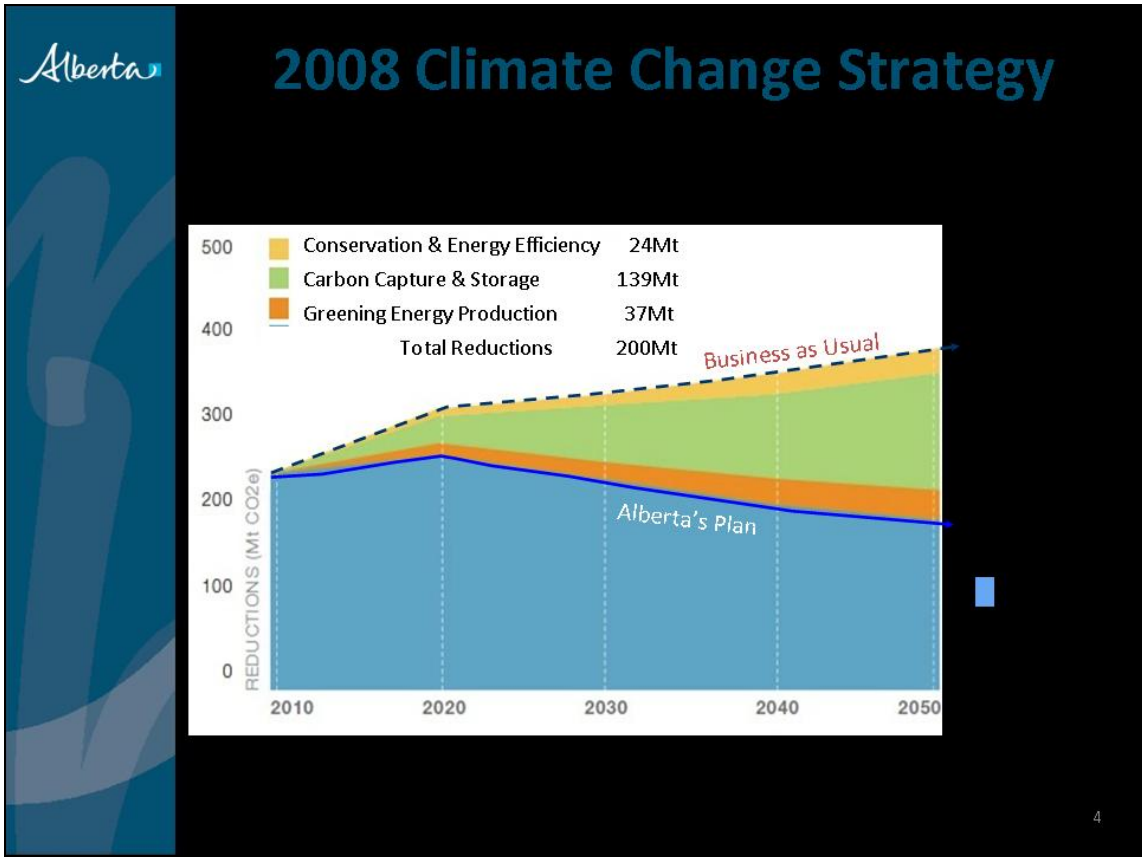

GLOBALCCSINSTITUTE.COM

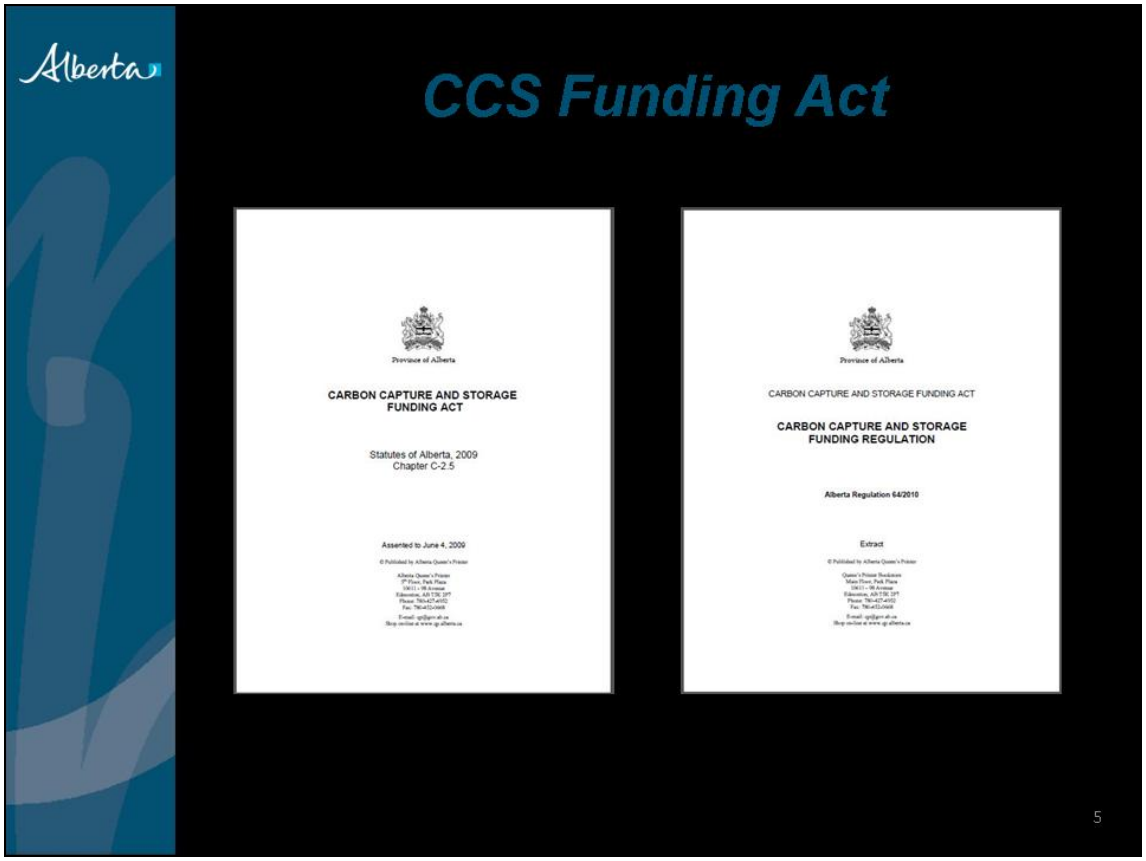
Presentation by Mike Fernandez






Alberta
Generalized Areas of Hydrocarbon Resources
Oil
Coal
Gas
Oil Sands
Coal Bed Methane Potential
Mountain Coal Mine
Plains Coal Mine
Municipality
National Park
Lakes & Rivers
0 100 200 km
0 50 100 miles
Wood Buffalo
Fort McMurray
Edmonton
Jasper
Banff
Calgary
Waterton
120°
110°
60°
49°
114°

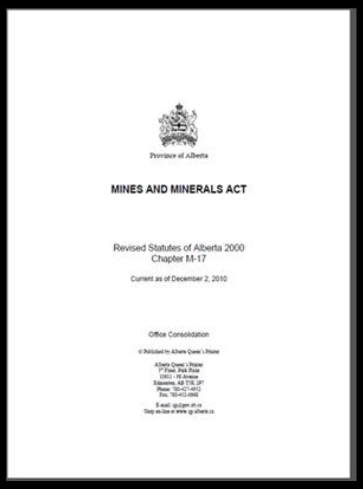

Alberta
2008 Climate Change Strategy
Conservation & Energy Efficiency 24Mt
Carbon Capture & Storage 139Mt
Greening Energy Production 37Mt
Total Reductions 200Mt
Business as Usual
Alberta's Plan
REDUCTIONS (Mt CO2e)
500
400
300
200
100
0
2010
2020
2030
2040
2050
4


Alberta
CCS Funding Act
Province of Alberta
CARBON CAPTURE AND STORAGE FUNDING ACT
Statutes of Alberta, 2009
Chapter C-2.5
Assented to June 4, 2009
Province of Alberta
CARBON CAPTURE AND STORAGE FUNDING ACT
CARBON CAPTURE AND STORAGE FUNDING REGULATION
Alberta Regulation 64/2010
Extract
5


Alberta
CANADA
ALBERTA
U.S.A.
Quest
ACTL
Edmonton
Calgary

CCS Statutes Amendment Act (2010)

- Pore space
- Long term liability
- Post closure Stewardship Fund


Province of Alberta

MINES AND MINERALS ACT

Revised Statutes of Alberta 2000
Chapter M-17

Current as of December 2, 2010

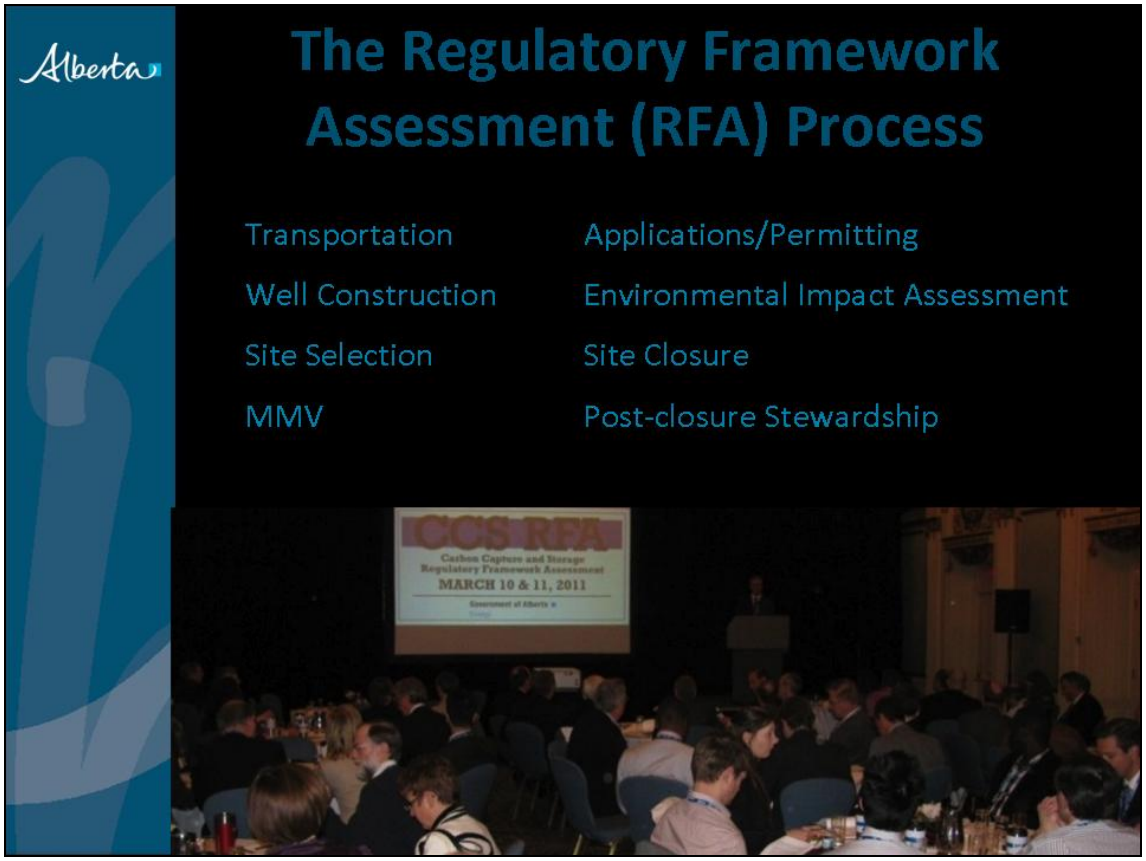
Office Consolidation

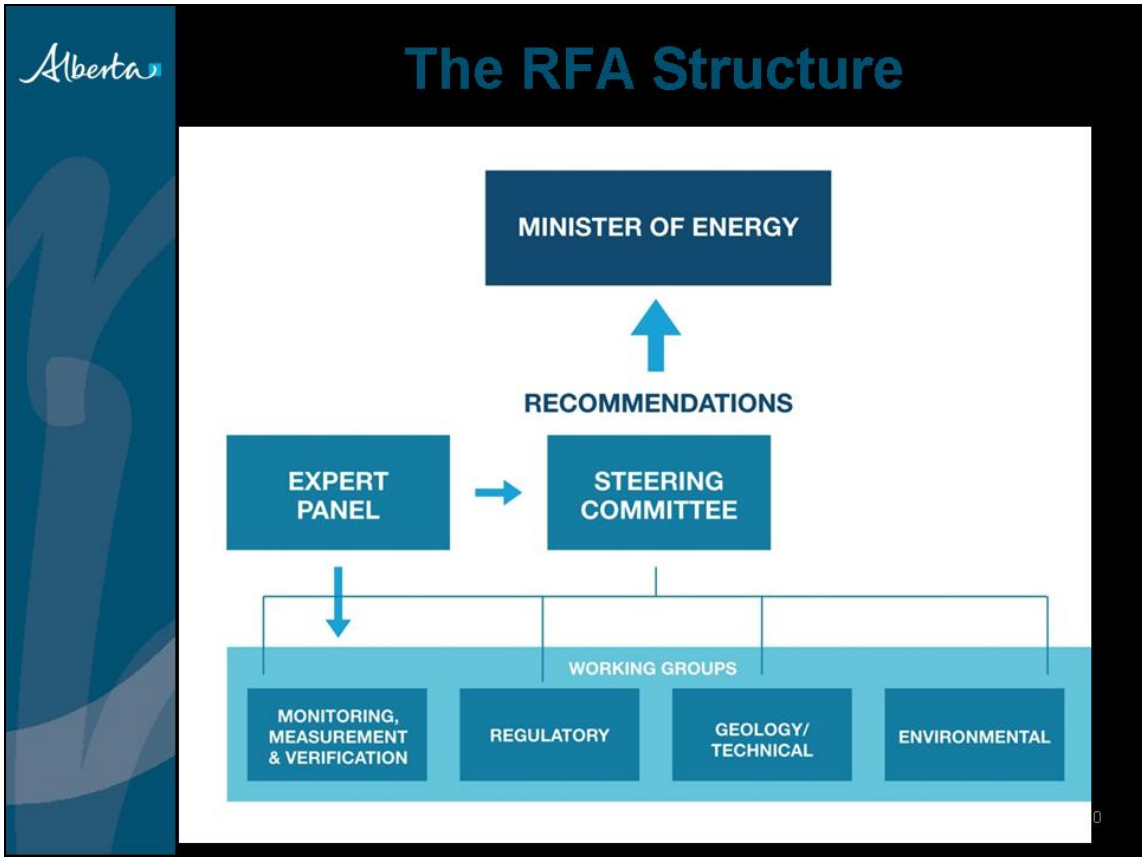
7

Carbon Sequestration Tenure Regulation

- April 2011
- Creates two separate agreements
  - evaluation permit
  - carbon sequestration lease

8


Alberta
The Regulatory Framework Assessment (RFA) Process
Transportation
Well Construction
Site Selection
MMV
Applications/Permitting
Environmental Impact Assessment
Site Closure
Post-closure Stewardship
CCS RFA
Carbon Capture and Storage
Regulatory Framework Assessment
MARCH 10 & 11, 2011


Alberta
The RFA Structure
MINISTER OF ENERGY
RECOMMENDATIONS
EXPERT PANEL
STEERING COMMITTEE
WORKING GROUPS
MONITORING, MEASUREMENT & VERIFICATION
REGULATORY
GEOLOGY/ TECHNICAL
ENVIRONMENTAL

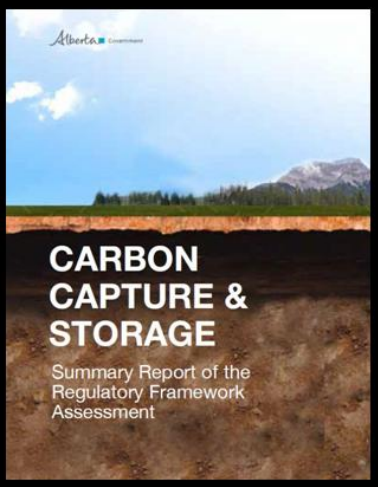
Expert Panel

- Stefan Bachu - Alberta Innovates-Technology Futures (Canada)
- Andy Chadwick - British Geological Survey (U.K.)
- Peter Cook - Cooperative Research Centre for Greenhouse Gas Technologies (Australia)
- Ed Rubin - Carnegie Mellon University (U.S.A.)
- Don Thompson - formerly of the Oil Sands Developers Group (Canada)

11

Current Status of the RFA

- Final Report submitted to the Minister of Energy on April 3, 2013
- Implementation over the next three years
- Share knowledge gained through the RFA to advance CCS development



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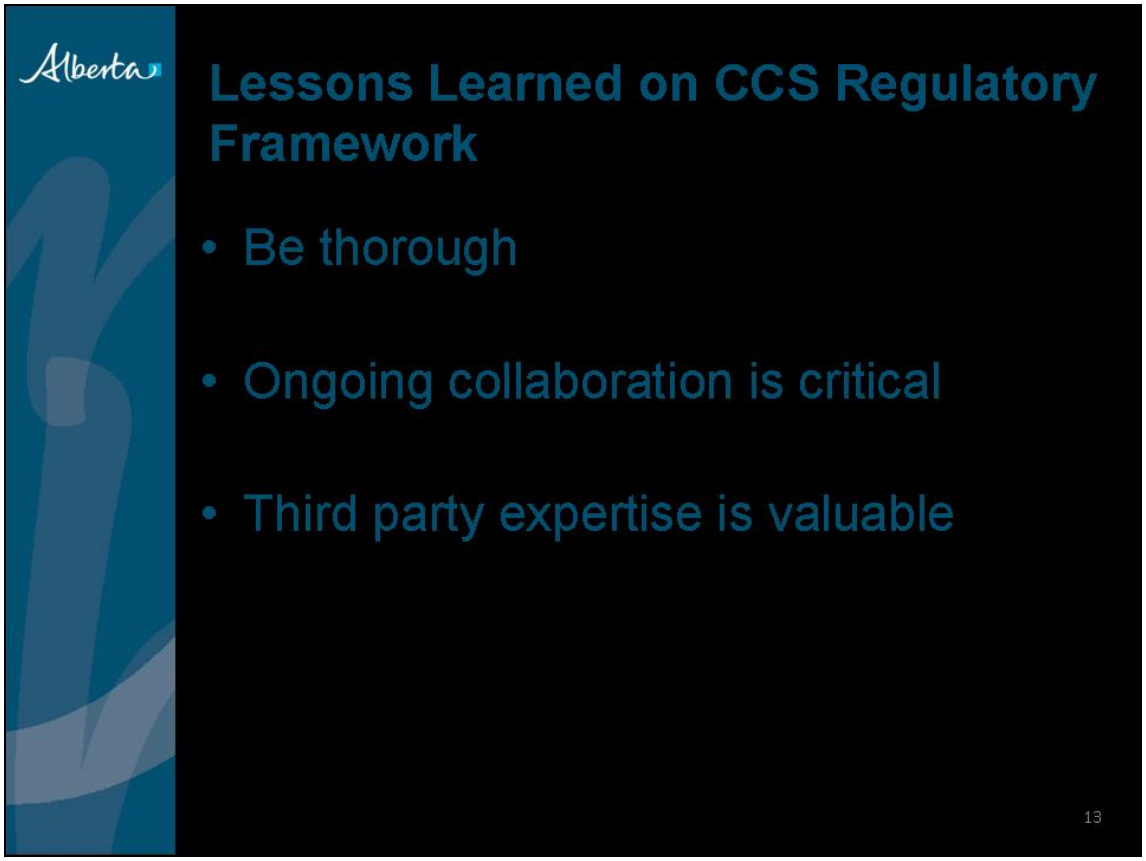

Alberta
Lessons Learned on CCS Regulatory Framework
• Be thorough
• Ongoing collaboration is critical
• Third party expertise is valuable
13


Alberta
Thank You
Mike.Fernandez@gov.ab.ca
www.energy.alberta.ca

Presentation by Tom Howes

Six years later.....

CCS Directive - transposed in most MS	?
EEPR Eur 1bn for 6 demonstration projects, but none is operational	?
Approx. Eur 200M under FP7 on CCS (and CCT); Eur 15M from the Research Fund for Coal & Steel; CCS in the SET Plan	√
CO2 pipelines in the Guidelines for trans-European energy infrastructure Regulation	√
Estimated storage capacity in Europe 117 Gt CO2	√

WHY?

Commercial Viability: no long-term commercial business case for CCS in Europe

Insufficient funding for demonstration projects

Delayed or incomplete transposition of the CCS Directive

Public awareness and acceptance issues

Insufficient incentives for investment in transport and storage infrastructure

Lack of a clear and coordinated 'CCS message'

CCS Consultative Communication

1. Should Member States that currently have a high share of coal and gas in their energy mix as well as in industrial processes, and that have not yet done so, be required to:
   - develop a clear roadmap on how to restructure their electricity generation sector towards non-carbon emitting fuels (nuclear or renewables) by 2050,
   - develop a national strategy to prepare for the deployment of CCS technology?

2. How should the ETS be re-structured, so that it could also provide meaningful incentives for CCS deployment? Should this be complemented by using instruments based on auctioning revenues, similar to NER300?

3. Should the Commission propose other means of support or consider other policy measures to pave the road towards early deployment, by:
   - support through auctioning recycling or other funding approaches
   - an Emission Performance Standard
   - a CCS certificate system
   - another type of policy measure

4. Should energy utilities be required to install CCS-ready equipment for all new investments (coal and potentially also gas) in order to facilitate the necessary CCS retrofit?

5. Should fossil fuel providers contribute to CCS demonstration and deployment through specific measures that ensure additional financing?

6. What are the main obstacles to ensuring sufficient demonstration of CCS in the EU?

7. How can public acceptance for CCS be increased?

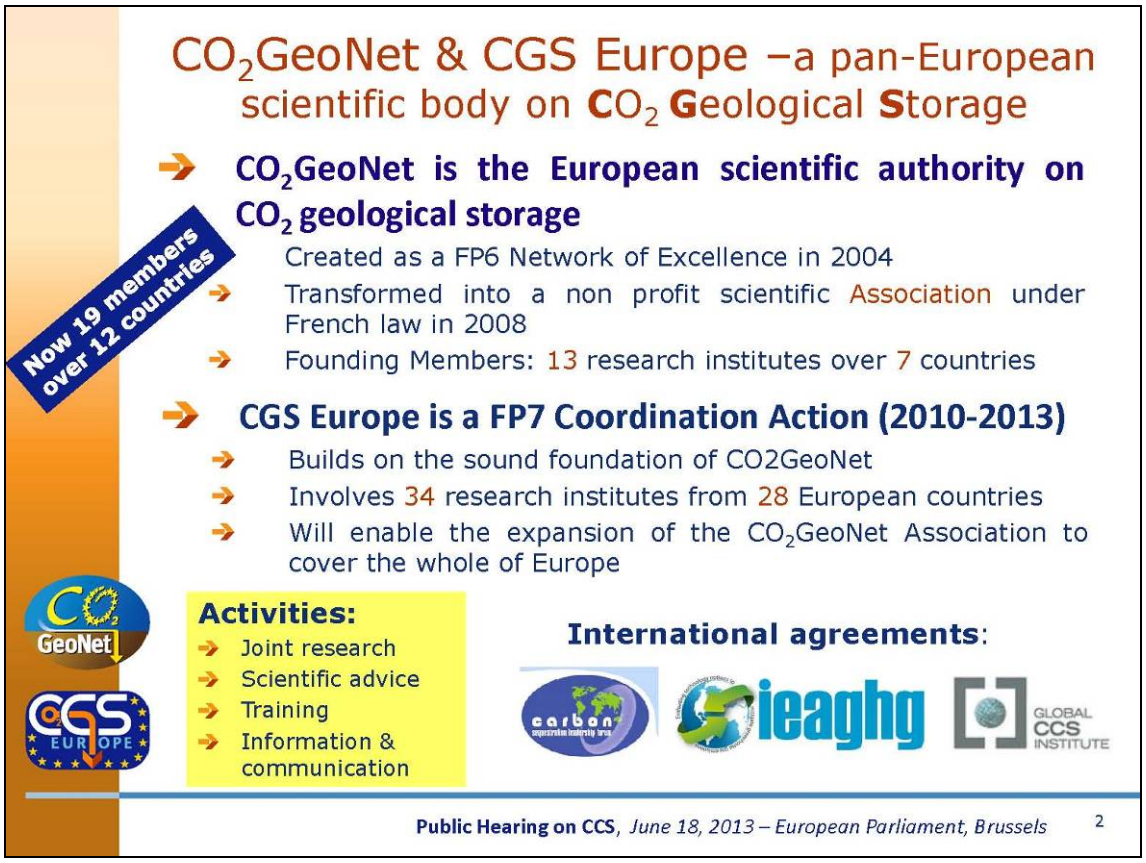
Thank for your attention

More information:
http://ec.europa.eu/energy/coal/ccs_en.htm

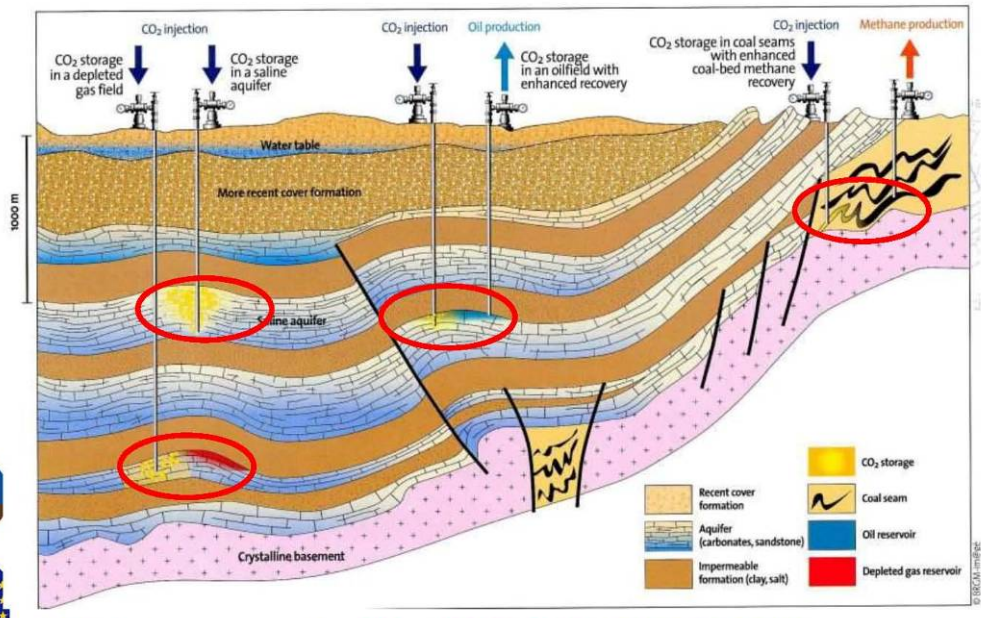
Contributions should be sent **by 02/07/2013** to
European Commission
Directorate General Energy
Unit C1 – Renewables and CCS
Rue De Mot 24, B-1049 Bruxelles, Belgium

E-mail : ENER-CCS-COMMUNICATION@EC.EUROPA.EU

Presentation by Isabelle Czernichowski-Lauriol



Yes, CO_2 can be stored safely underground!



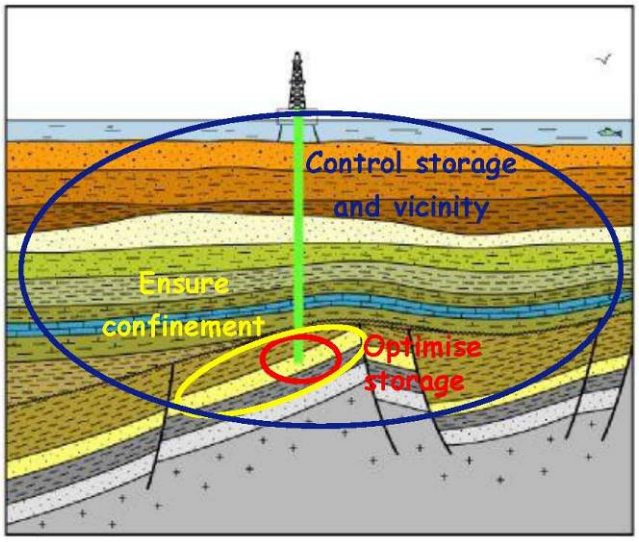
Global storage capacity: at least 2000 Gt CO_2 (IPCC SR 2005)

A good level of confidence that CO_2 storage can be done safely has been reached:

- Studies of many natural CO_2 accumulations in the subsurface
- Pre-existing know-how of the Oil & Gas industry:
  - Enhanced Oil Recovery (EOR) by CO_2 injection
  - Seasonal natural gas storage (CH_4)
- Large cooperative research programmes on CO_2 geological storage since 1993
- Pioneer large-scale industrial CCS projects (e.g. Sleipner (Norway) from 1996, Weyburn (Canada) from 2000, In Salah (Algeria) from 2004
- Small-scale CO_2 injection pilots: Frio (USA), Nagaoka (Japan), Ketzin (Germany), Otway (Australia), K12B (NL), Lacq (France), etc.
- Development of best practice manuals
- Networking & knowledge-sharing activities at national, European and international levels
- Development of laws and regulations, such as the EU Directive on the geological storage of CO_2 (2009), ISO norm soon

Technical challenges for storage

- At least 1000 years containment (Global issue)
- Safety (Local issue)



Storage is highly site-specific:

- Unique geology
- Unique environmental and socio-economical setting

→ Tailor-made approach

CO_2GeoNet & CGS Europe - an integrated community of researchers

- Multidisciplinary expertise:
  - geology, geophysics, geochemistry, geomechanics, hydrology, microbiology, reservoir engineering, oceanography, psycho-social science, …
- Masters every facet of CO_2 storage:
  - site selection and characterization, modelling and monitoring CO_2 fate and site behaviour, environmental impacts, risk assessment, and safety protocols
- Provides integrated research results, synthesized knowledge and advice, *shared* by a large and independent scientific community

Our **activities** are oriented to consolidate and develop a **scientific community** able to **answer to requests for knowledge** on geological storage of CO_2 coming **from all sectors of our society**

Criteria to ensure CO_2 storage safety

1. Proper site selection and characterisation - main components of a storage: reservoir, caprock, overburden, faults, pre-existing wells, aquifers, surface environment
2. Appropriate risk assessment (leakage, brine displacement, ground movement…)
3. Correct operations during injection and closure: control of injected gas composition, pressure management, good interplay between modelling and monitoring, well plugging before abandonment
4. Careful monitoring: CO_2 migration, brine displacement, well and caprock integrity, groundwater quality, surface impacts and CO_2 emissions
5. Plan for adequate mitigation and remediation actions

A wide range of tools & methodologies have already been developed for each of these 5 criteria

Seismics | Modelling | Soil sampling | Remote sensing

7

Directive 2009/31/EC on the geological storage of CO_2

- Storage sites should not be operated without a storage permit
- The permit application shall include at least the following information:
  - the characterisation of the storage reservoir and caprock and an assessment of the expected security of the storage
  - the total quantity of CO_2 to be injected and stored, the composition of CO_2 streams, the injection rates and pressures
  - a description of measures to prevent significant irregularities
  - a proposed monitoring plan
  - a proposed corrective measures plan
  - a proposed provisional post-closure plan
- Annex 1 CRITERIA FOR THE CHARACTERISATION AND ASSESSMENT OF STORAGE SITES
- Annex 2 CRITERIA FOR ESTABLISHING AND UPDATING THE MONITORING PLAN

Public Hearing on CCS, *June 18, 2013 – European Parliament, Brussels* 8

More field experience is needed

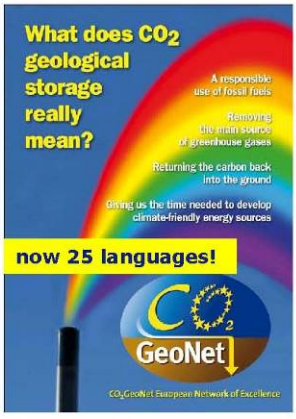
- Each site is unique. More field experience leads to greater confidence in tackling other new situations
- CCS Demonstration projects as a stepping stone to commercial deployment:
  - Demos = full chain of technologies for CO_2 capture, transport and storage at an industrial scale of several Mt of CO_2, e.g. on a power plant or a steel plant
  - CO_2GeoNet – CGS Europe to cooperate with operators e.g. through 'independent research block'
- CO_2 Storage Pilot projects to help advance research:
  - Pilots = CO_2 injection tests less than 0.1 Mt in order to perform research
  - Aim: Make tools and methodologies the most efficient, reliable, cheap and as widely applicable as possible
  - CO_2GeoNet – CGS Europe is elaborating a document with ZEP, regarding potentialities for pilots across Europe
  - Pilots helpful for enhancing a dialogue approach with the civil society and demonstrating that CO_2 storage can be safe

CO_2GeoNet & CGS Europe are fully committed to the safe development of CO_2 storage

Latest publications:

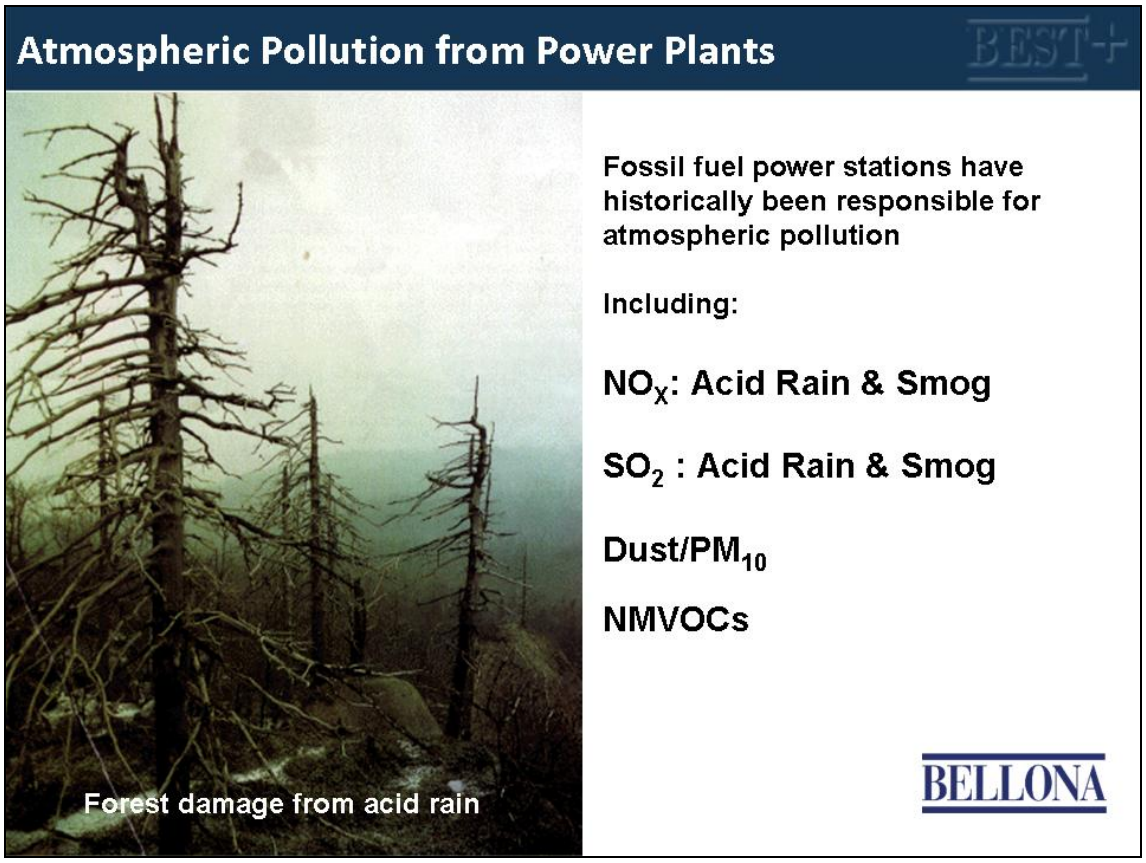
- State-of-Play of CO_2 storage in 28 European countries
- Quantification techniques for CO_2 leakage
- Monitoring methods
- Potential impacts on groundwaters
- Mitigation & Remediation

Spring School in Poland, 2012



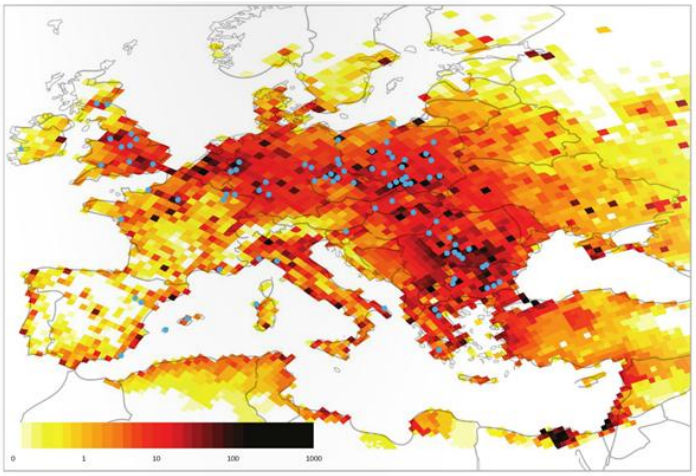
Booth at SciTechEurope event in Brussels, 2011

Presentation by Paal Frisvold



The current situation

Air pollution from Europe's 300 largest coal plants:
- Causes 22,300 premature deaths a year
- 240,000 years of life lost in 2010
- 480,000 work days a year lost in UK – fifth most coal polluted



Map source: Greenpeace modelling using the EMEP MSC-W atmospheric chemistry-transport model, input data provided by EMEP and power plant emission data from the E-PRTR database.

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CO_2 Capture Technologies at Power Plants

- CO_2 capture technologies reduce atmospheric pollutants at Coal and Gas power stations

- Different capture technologies require the removal of pollutants at different stages

CO_2

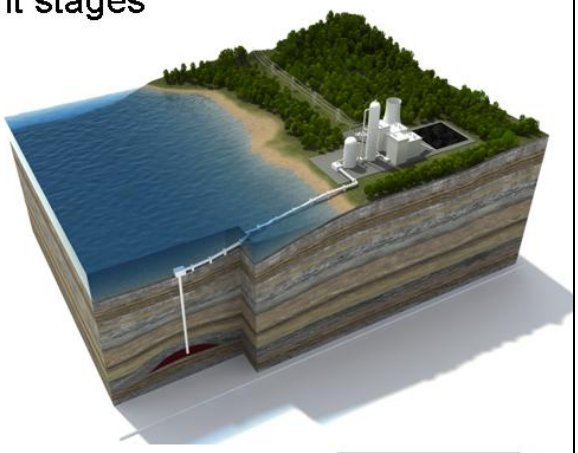
NO_X

SO_x

NH_3

NMVOCs

$Dust/PM_{10}$



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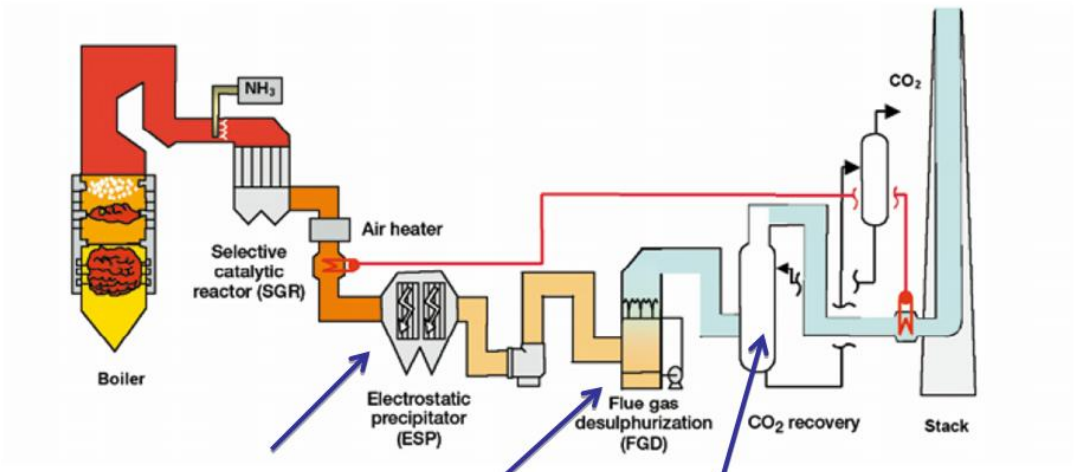
Post-Combustion Capture



Dust & PM Removal

Stringent SO_2 Removal

CO_2 Capture

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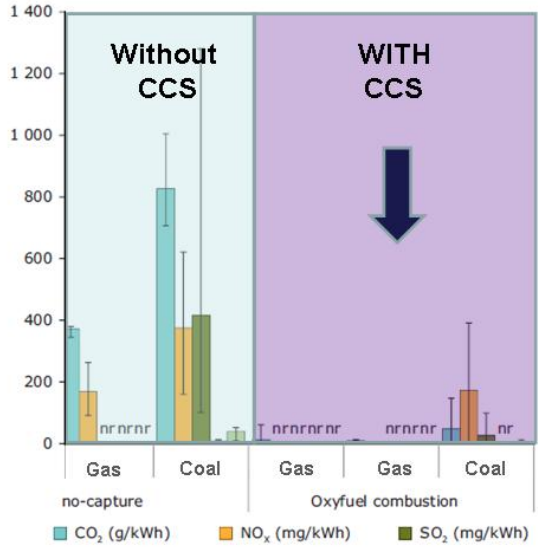
CCS Reduces So_x Emissions

Post-Combustion CO_2 capture at Boundary Dam Coal power plant (Saskatchewan, Canada)

- So_x removal installed = Reduction in acid emissions

Oxy-Fuel Capture



- Pollutants concentrated in CO_2 stream
- Removed during drying and compression

Notes: The indicated values are based on various fuel specifications and are dependent on the configuration and performance of the power plant and CO_2 capture process.
'nr' = not reported; IGCC = Integrated Gasification Combined Cycle; NGCC = Natural Gas Combined Cycle; PC = Pulverised Coal; GC = Gas Cycle.

Source: Horssen et al., 2009; Koornneef et al., 2010, 2011.

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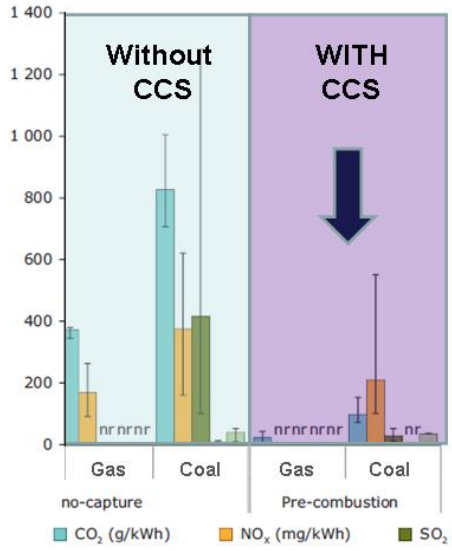
European Environment Agency

Pre-Combustion Capture



- Pollutants separated prior to combustion

Notes: The indicated values are based on various fuel specifications and are dependent on the configuration and performance of the power plant and CO_2 capture process.
'nr' = not reported; IGCC = Integrated Gasification Combined Cycle; NGCC = Natural Gas Combined Cycle; PC = Pulverised Coal; GC = Gas Cycle.

Source: Horssen et al., 2009; Koornneef et al., 2010, 2011.

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European Environment Agency

Managable challenges

- The energy penalty
  - Additional fuel needed
- Life-cycle emissions
  - Fuel preparation (mining and transport of fuel);
  - Manufacture of CO_2 capture chemicals (amines);
  - Treatment of spent CO_2 capture chemicals (amines);
- Water consumption increases

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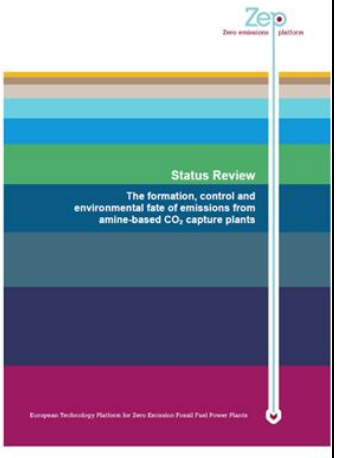
Amines: Not a problem

Preventing emissions with effective and basic engineering techniques:

- An extra water wash section on top of the absorber
- High efficiency demisters and filters
- Acid wash in the final washing section on the absorber top
- UV treatment of lean amine, wash water or gaseous outlet



Amines do not degrade into any harmful substances

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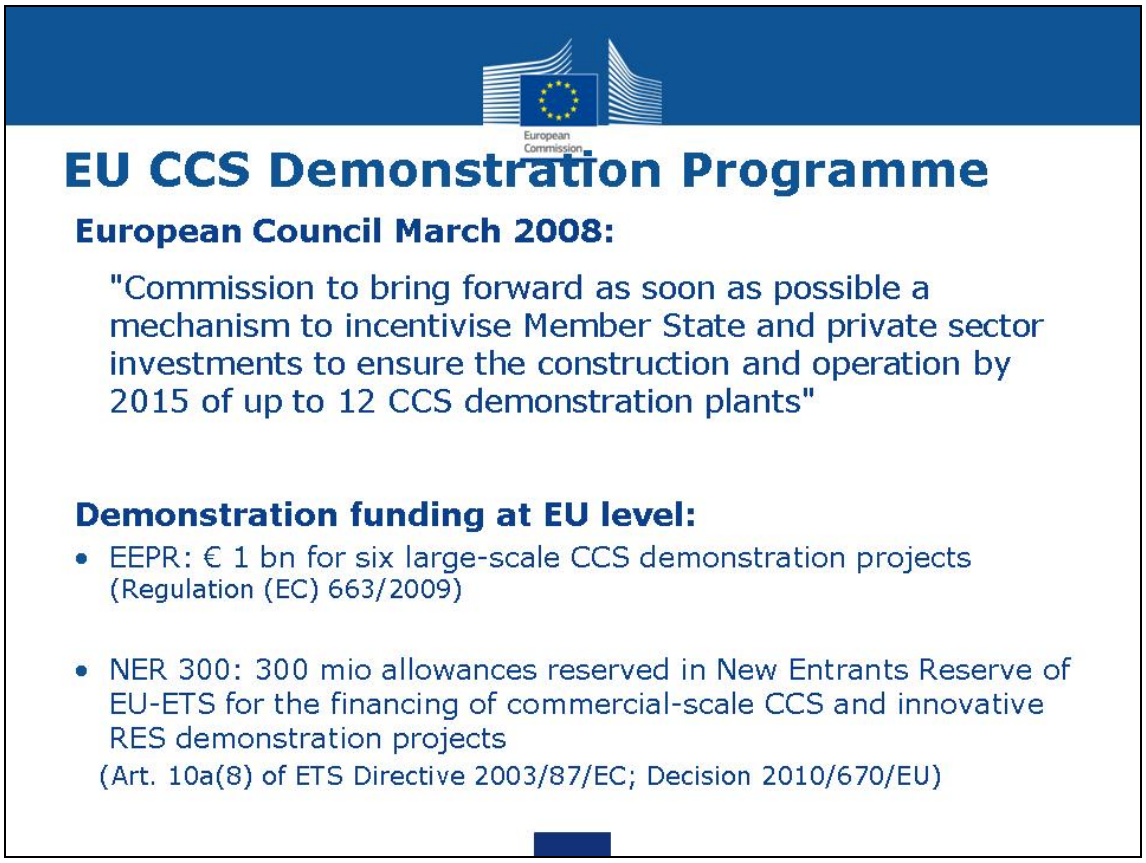
Conclusions

- CCS is necessary to be able to go carbon negative
- CCS is necessary to decarbonise industry
- CCS reduce local pollution
- CCS can use CO_2 to new products: Algae
- CCS can enable EOR/EGR
- CCS reduce costs costs of meeting 2 degrees target by 40 per cent
- CCS is safe if reservoirs are investigated and researched properly
- Excluding CCS from the global warming tool box is not taking climate change seriously

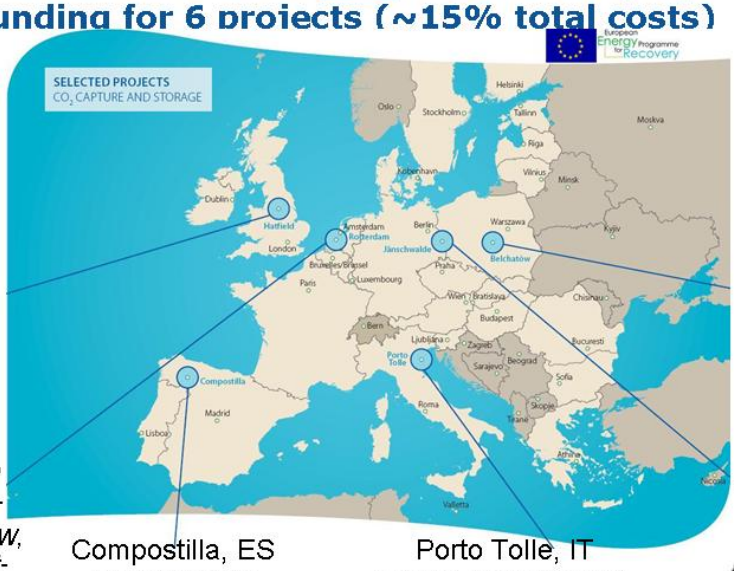
BELLONA

Presentation by Beatrice Coda



EEPR CCS demonstration projects

€1bn funding for 6 projects (~15% total costs)



European Commission

EEPR Projects- state of play

2 projects officially terminated:

Jänschwalde (DE): delays in regulatory framework, public acceptance issues

Belchatow (PL): absence of a realistic plan to close financial gap, delays in regulatory framework, public acceptance issues, technological difficulties

Other 4 projects progressing, but not yet reached FID:

Don Valley (UK):ongoing, aiming at securing UK national support

ROAD (NL): ongoing, working towards closing a financing gap (€130 million)

Compostilla (ES): pilot phase succesful, not likely to proceed to demonstration phase due to a financing gap

Porto Tolle (IT): FID decision postponed not before 2016, operation delayed to 2020, environmental permit cancelled

NER 300 first call - outcome

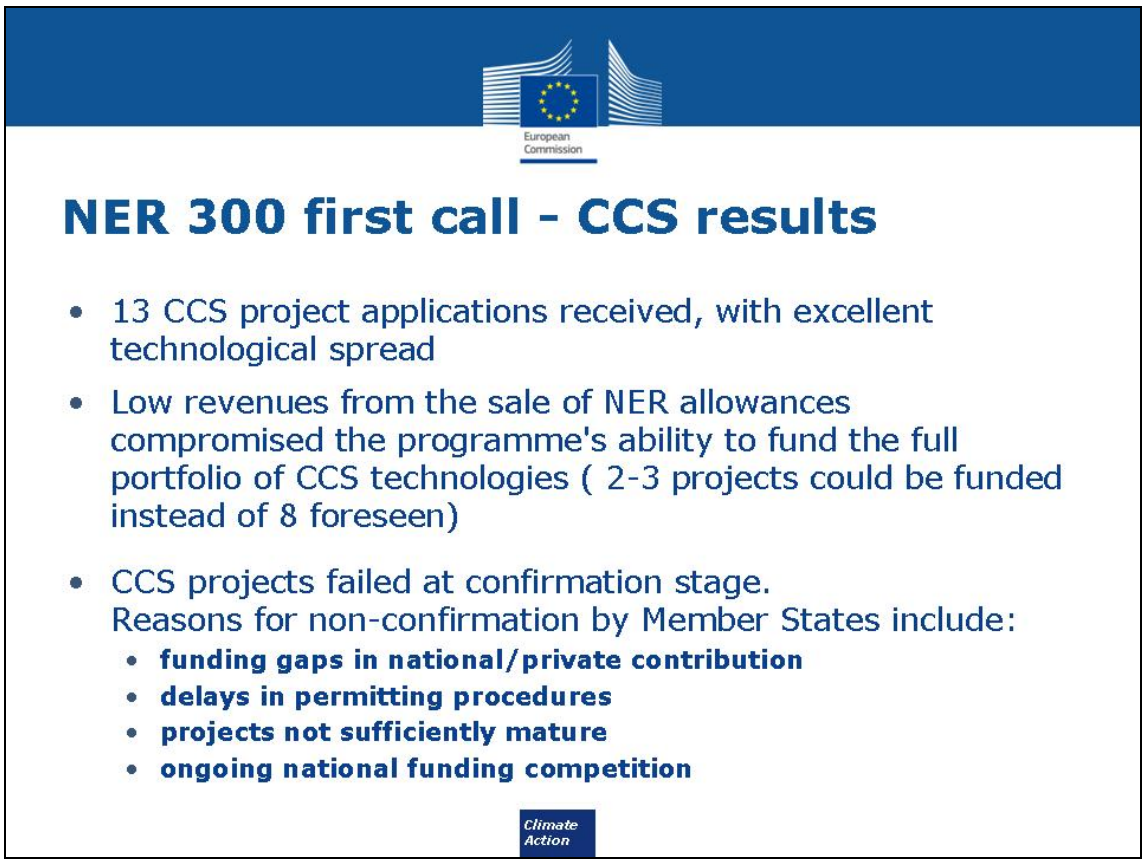
- Launched on 9 November 2010, Award Decision adopted on 18 December 2012
- Awards worth € 1.2 billion to 23 RES projects, 16 Member States
- Strong performance of the first call on NER 300 objectives:
  - **Leverage: 3 euro for every euro of NER 300 funding**
  - **Strong response from industry and MS**
  - **High quality applications across the board**
  - **Good geographical and technological spread**
- BUT: No awards to CCS projects

Climate Action

NER300 first call- CCS Statistics

	Number of awards foreseen in the NER300 Decision	Applications Received (total: 9 Member States)	Number Shortlisted after positive due diligence assessment	Withdrawn by MS during/after due diligence assessment	Not adequately confirmed by Member States
CCSpre (pre-combustion)	Min 1: Max 3	3	3	0	3
CCSpos (post-combustion)	Min 1: Max 3	6	4	2	4
CCSoxy (Oxyfuel)	Min 1: Max 3	2	1	1	1
CCSind (Industrial Applications)	Min 1: Max 3	2	2	0	2
TOTAL		13	10	3	10

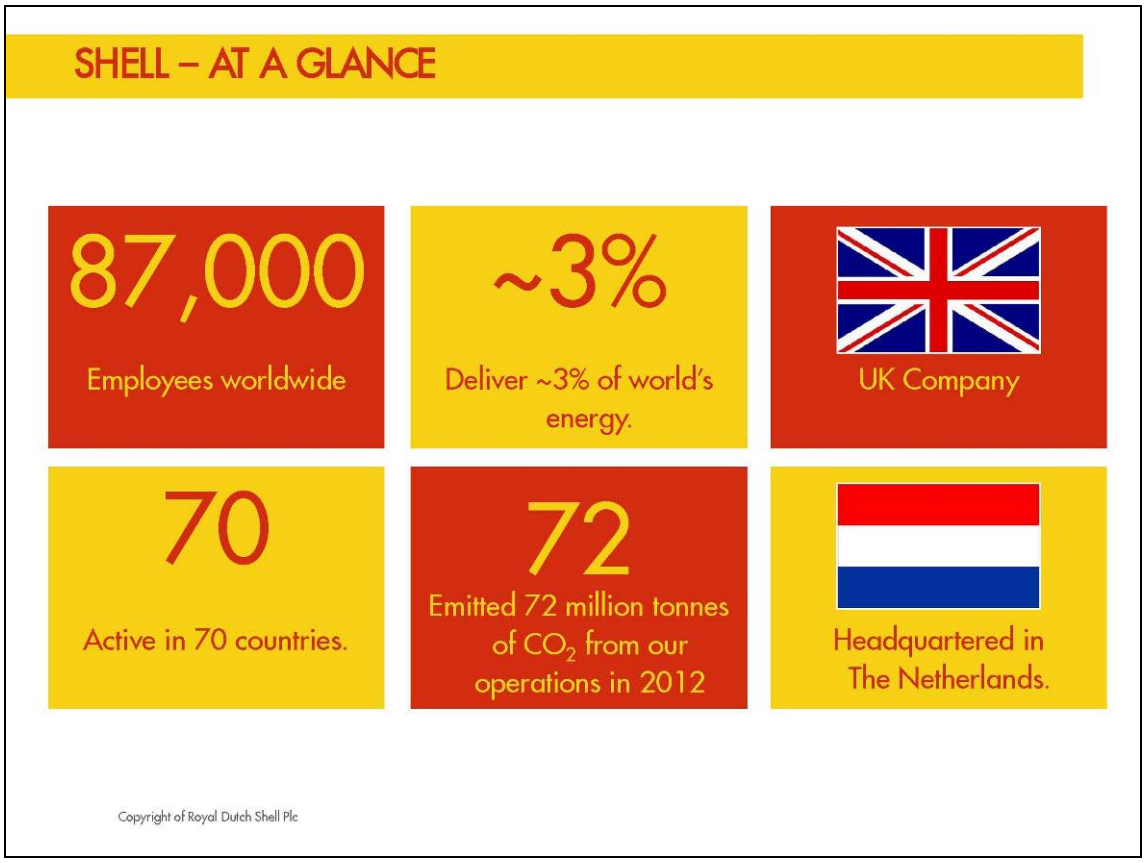
Climate Action


European Commission
NER 300 first call - CCS results
• 13 CCS project applications received, with excellent technological spread
• Low revenues from the sale of NER allowances compromised the programme's ability to fund the full portfolio of CCS technologies (2-3 projects could be funded instead of 8 foreseen)
• CCS projects failed at confirmation stage.
Reasons for non-confirmation by Member States include:
• funding gaps in national/private contribution
• delays in permitting procedures
• projects not sufficiently mature
• ongoing national funding competition
Climate Action


European Commission
Conclusions and next steps
• Good progress achieved so far in preparatory work (EEPR) but outlook of CCS demonstration still uncertain
• Main barriers:
• Business case unattractive due to low carbon price under ETS
• Public acceptance for CO_2 onshore storage
• Consultative Communication on the future of CCS in Europe
• Initiate a debate on how best to encourage demonstration and early deployment of CCS
• NER300 second call for proposals (deadline 3 July): a second opportunity for Member States and industry to improve the prospects of CCS demonstration
• Interim communication from MS : (up to) 9 CCS projects applications expected under NER300 second call
Climate Action


European Commission
More information
CCS Directive website:
http://ec.europa.eu/clima/policies/lowcarbon/ccs
NER 300 website:
http://ec.europa.eu/clima/funding/ner300/index_en.htm
Consultative Communication on the Future of CCS in Europe (deadline for contribution: 2 July 2013)
http://ec.europa.eu/energy/coal/ccs_en.htm
European Energy Programme for Recovery
http://ec.europa.eu/energy/eepr/
Climate Action

Presentation by Bill Spence



Reserves: Our use of the term "reserves" in this presentation means SEC proved oil and gas reserves.

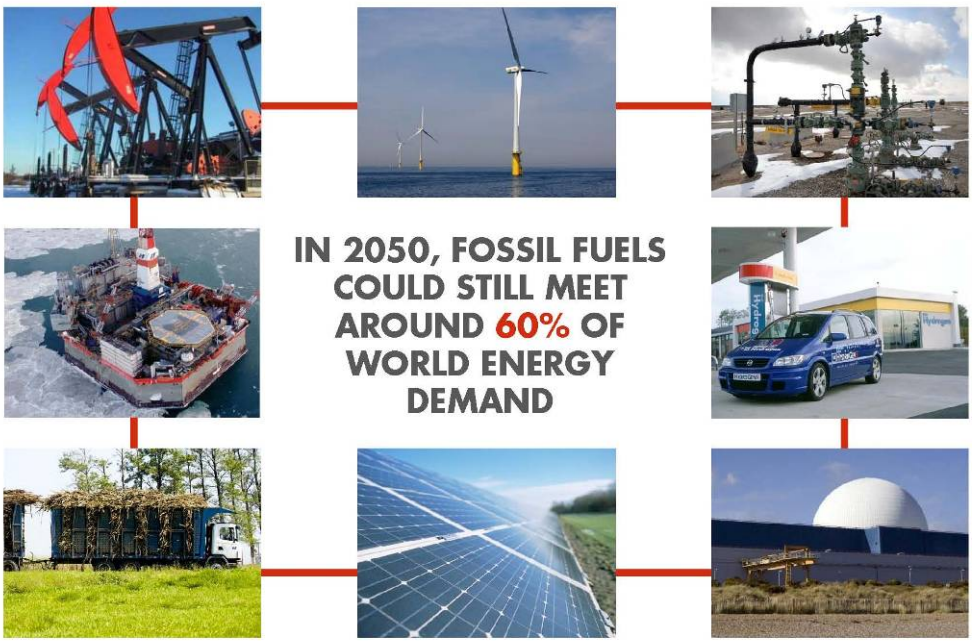
Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

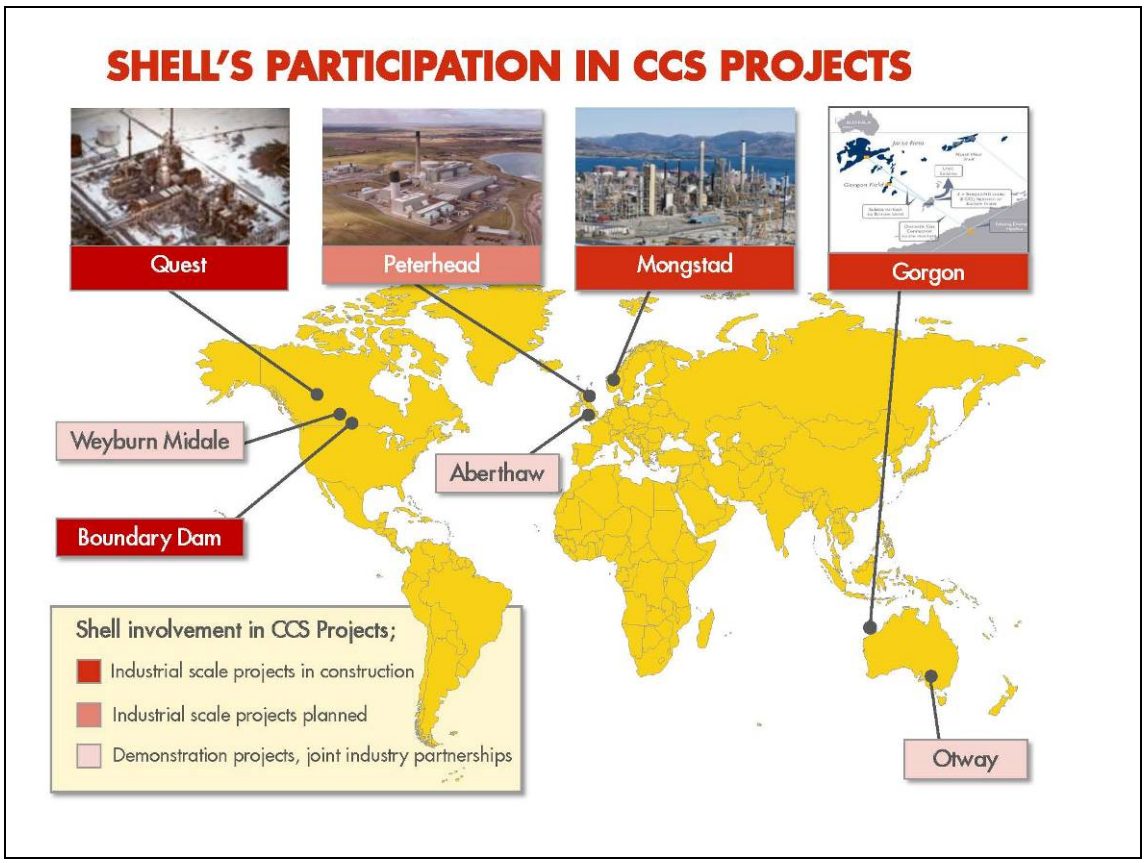
Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this announcement "Shell", "Shell Group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. "Subsidiaries", "Shell subsidiaries" and "Shell companies" as used in this announcement refer to companies in which Shell either directly or indirectly has control, by having either a majority of the voting rights or the right to exercise a controlling influence. The companies in which Shell has significant influence but not control are referred to as "associated companies" or "associates" and companies in which Shell has joint control are referred to as "jointly controlled entities". In this announcement, associates and jointly controlled entities are also referred to as "equity-accounted investments". The term "Shell interest" is used for convenience to indicate the direct and/or indirect (for example, through our 23 per cent shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

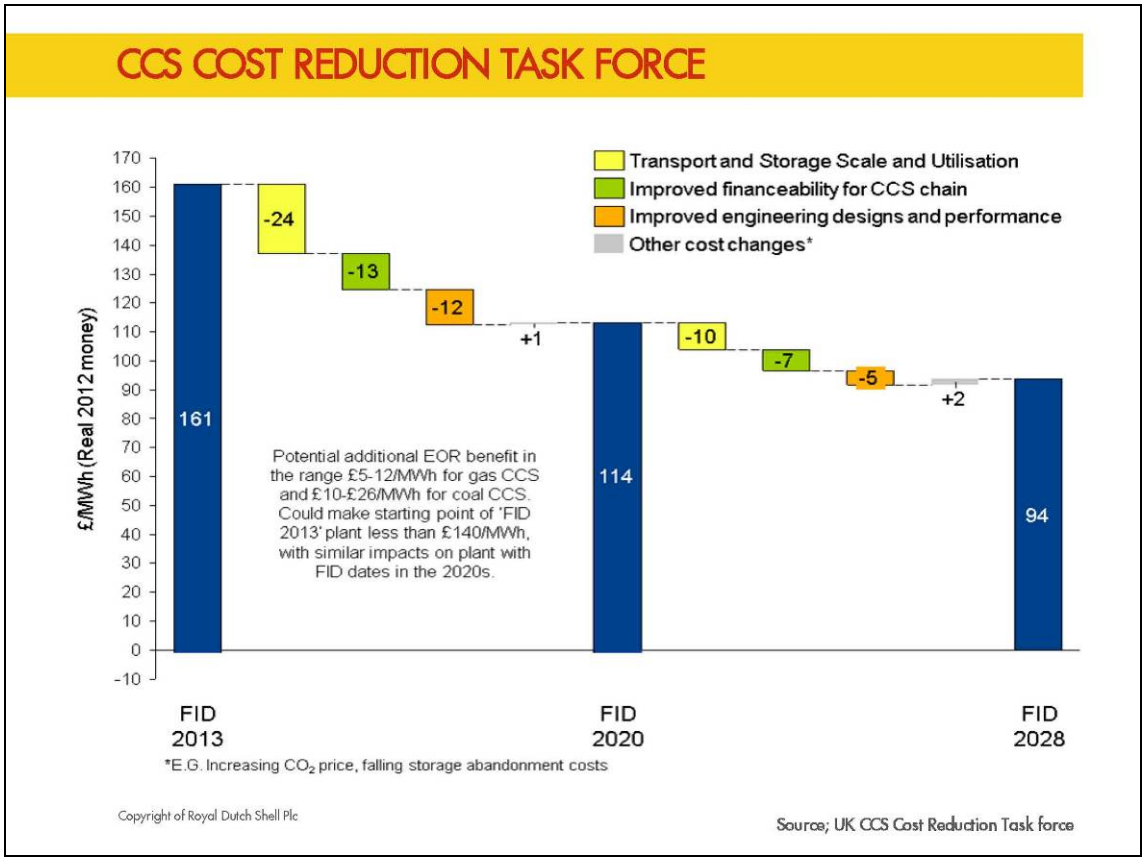
This announcement contains forward looking statements concerning the financial condition, results of operations and businesses of Shell and the Shell Group. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Shell and the Shell Group to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward looking statements are identified by their use of terms and phrases such as "anticipate", "believe", "could", "estimate", "expect", "goals", "intend", "may", "objectives", "outlook", "plan", "probably", "project", "risks", "seek", "should", "target", "will" and similar terms and phrases. There are a number of factors that could affect the future operations of Shell and the Shell Group and could cause those results to differ materially from those expressed in the forward looking statements included in this announcement, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward looking statements contained in this announcement are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward looking statements. Additional factors that may affect future results are contained in Shell's 20-F for the year ended 31 December 2011 (available at www.shell.com/investor and www.sec.gov). These factors also should be considered by the reader. Each forward looking statement speaks only as of the date of this announcement, 31 January 2013. Neither Shell nor any of its subsidiaries nor the Shell Group undertake any obligation to publicly update or revise any forward looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward looking statements contained in this announcement.

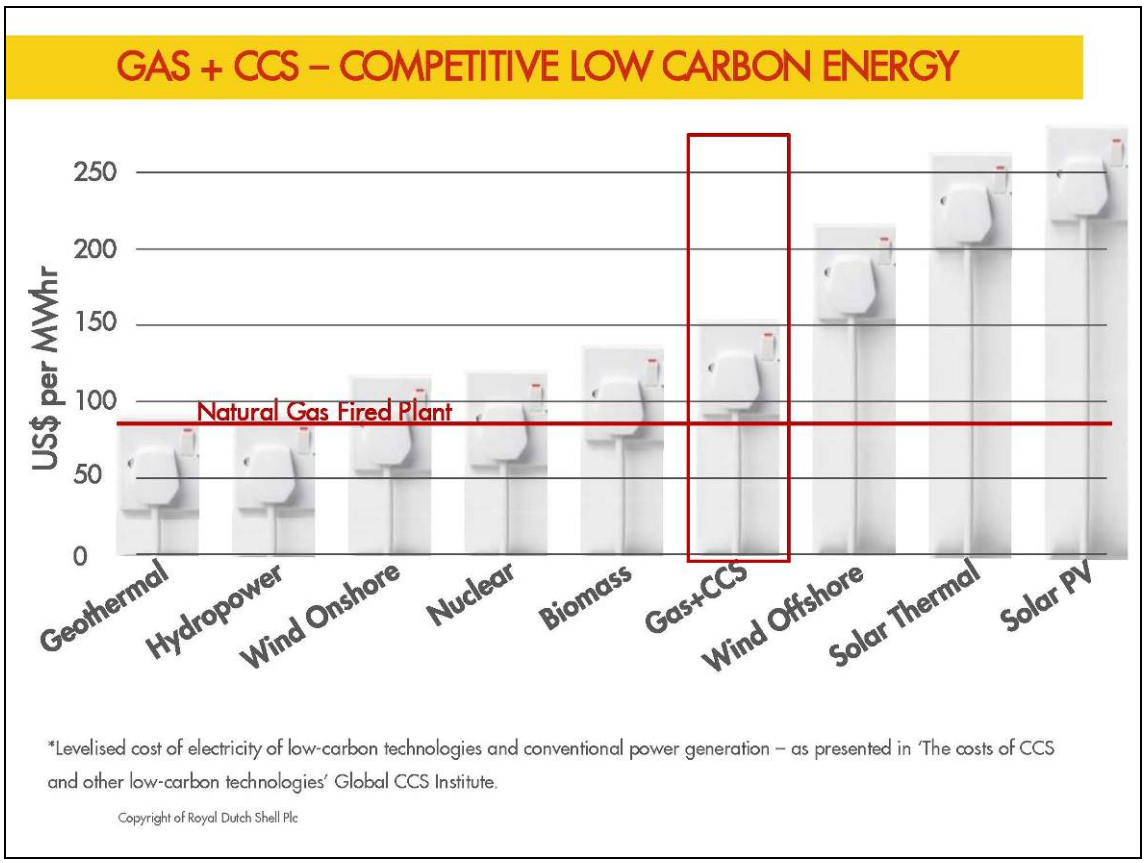
Shell may have used certain terms, such as resources, in this announcement that the SEC strictly prohibits Shell from including in its filings with the SEC. U.S. investors are urged to consider closely the disclosure in Shell's Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.




SHELL'S PARTICIPATION IN CCS PROJECTS
Quest
Peterhead
Mongstad
Gorgon
Weyburn Midale
Aberthaw
Boundary Dam
Otway
Shell involvement in CCS Projects;
Industrial scale projects in construction
Industrial scale projects planned
Demonstration projects, joint industry partnerships


MOBILE PHONES - LEARNING CURVES
First of a Kind (FOAK)
Nth of a Kind (NOAK)
Carbon Capture & Storage
Wind & Solar
Gas Fired Power
Cost of each phone
Total number of phones ever built
Copyright of Royal Dutch Shell Plc
Credit; http://itsasmallweb.files.wordpress.com/2011/02/3.jpg


CCS COST REDUCTION TASK FORCE
£/MWh (Real 2012 money)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
Transport and Storage Scale and Utilisation
Improved financeability for CCS chain
Improved engineering designs and performance
Other cost changes*
161
-24
-13
-12
+1
114
-10
-7
-5
+2
94
Potential additional EOR benefit in the range £5-12/MWh for gas CCS and £10-£26/MWh for coal CCS. Could make starting point of 'FID 2013' plant less than £140/MWh, with similar impacts on plant with FID dates in the 2020s.
FID 2013
FID 2020
FID 2028
*E.G. Increasing CO_2 price, falling storage abandonment costs
Copyright of Royal Dutch Shell Plc
Source; UK CCS Cost Reduction Task force


GAS + CCS – COMPETITIVE LOW CARBON ENERGY
US$ per MWhr
250
200
150
100
50
0
Natural Gas Fired Plant
Geothermal
Hydropower
Wind Onshore
Nuclear
Biomass
Gas+CCS
Wind Offshore
Solar Thermal
Solar PV
*Levelised cost of electricity of low-carbon technologies and conventional power generation – as presented in 'The costs of CCS and other low-carbon technologies' Global CCS Institute.
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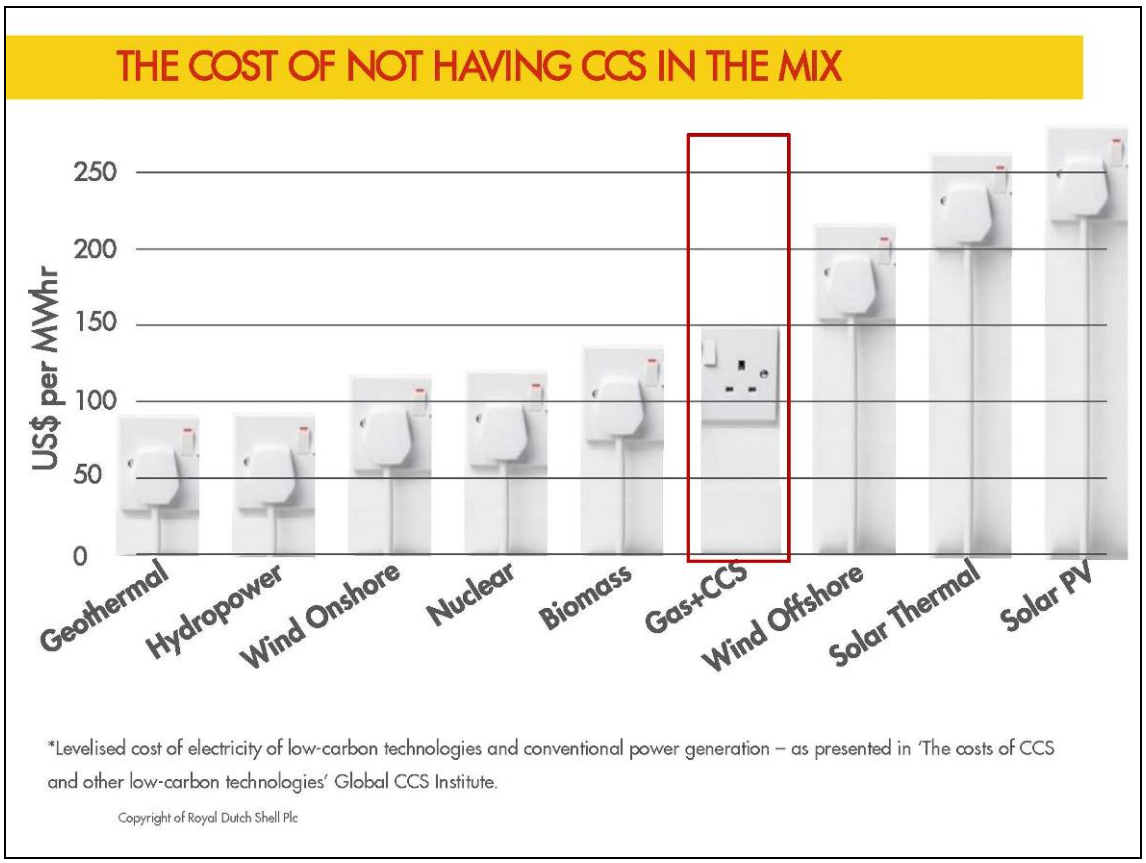
THE COST OF NOT HAVING CCS IN THE MIX
US$ per MWhr
250
200
150
100
50
0
Geothermal
Hydropower
Wind Onshore
Nuclear
Biomass
Gas+CCS
Wind Offshore
Solar Thermal
Solar PV
*Levelised cost of electricity of low-carbon technologies and conventional power generation – as presented in 'The costs of CCS and other low-carbon technologies' Global CCS Institute.
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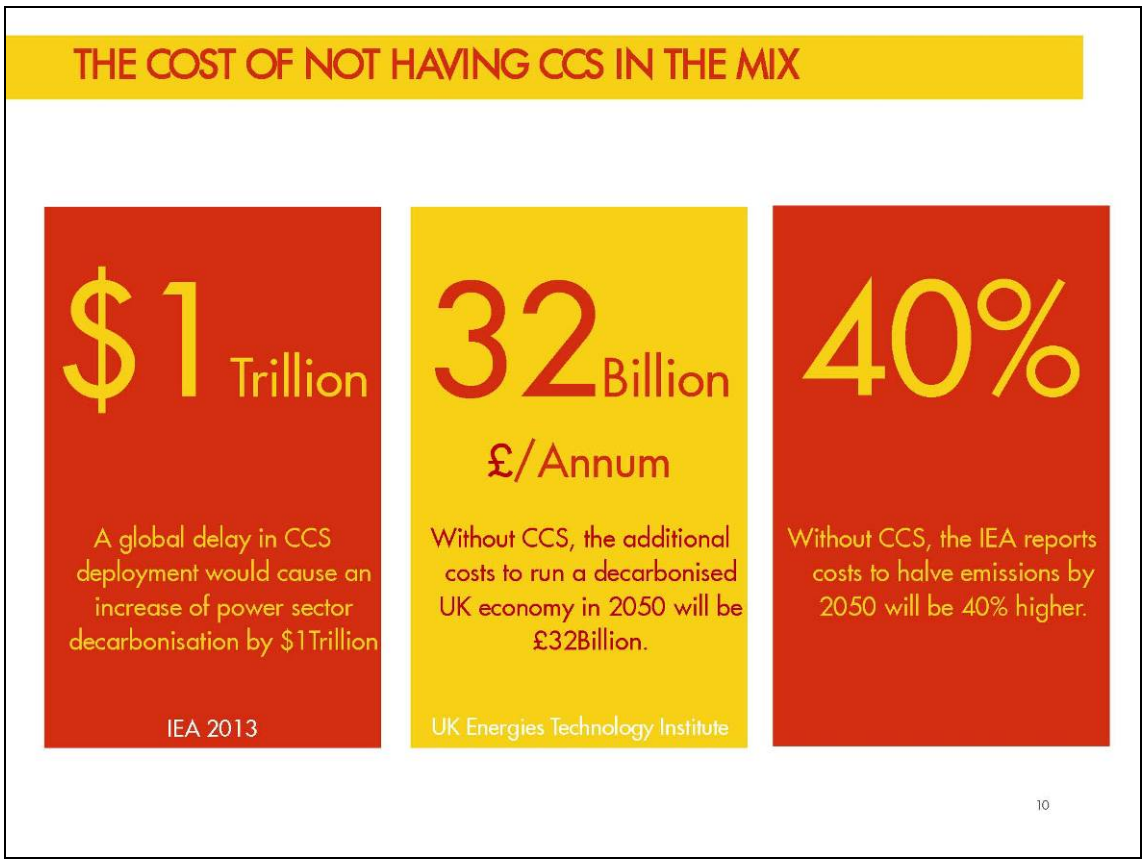
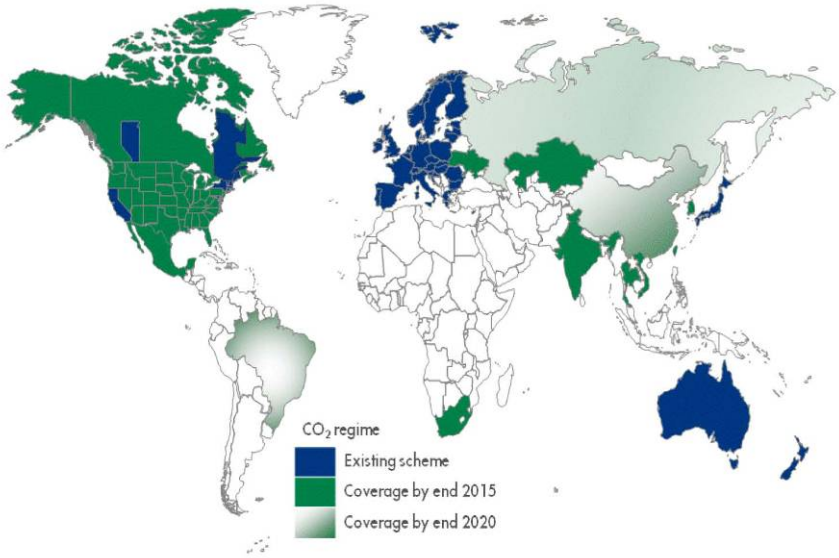
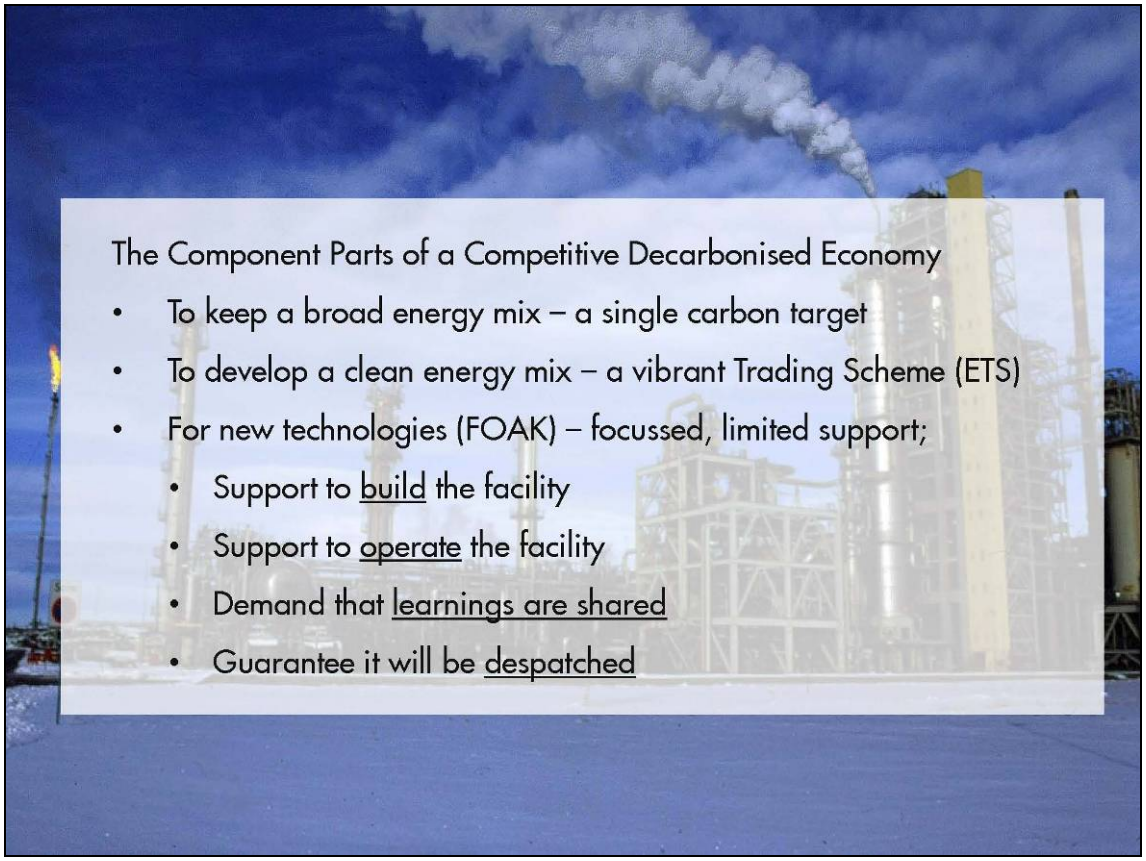
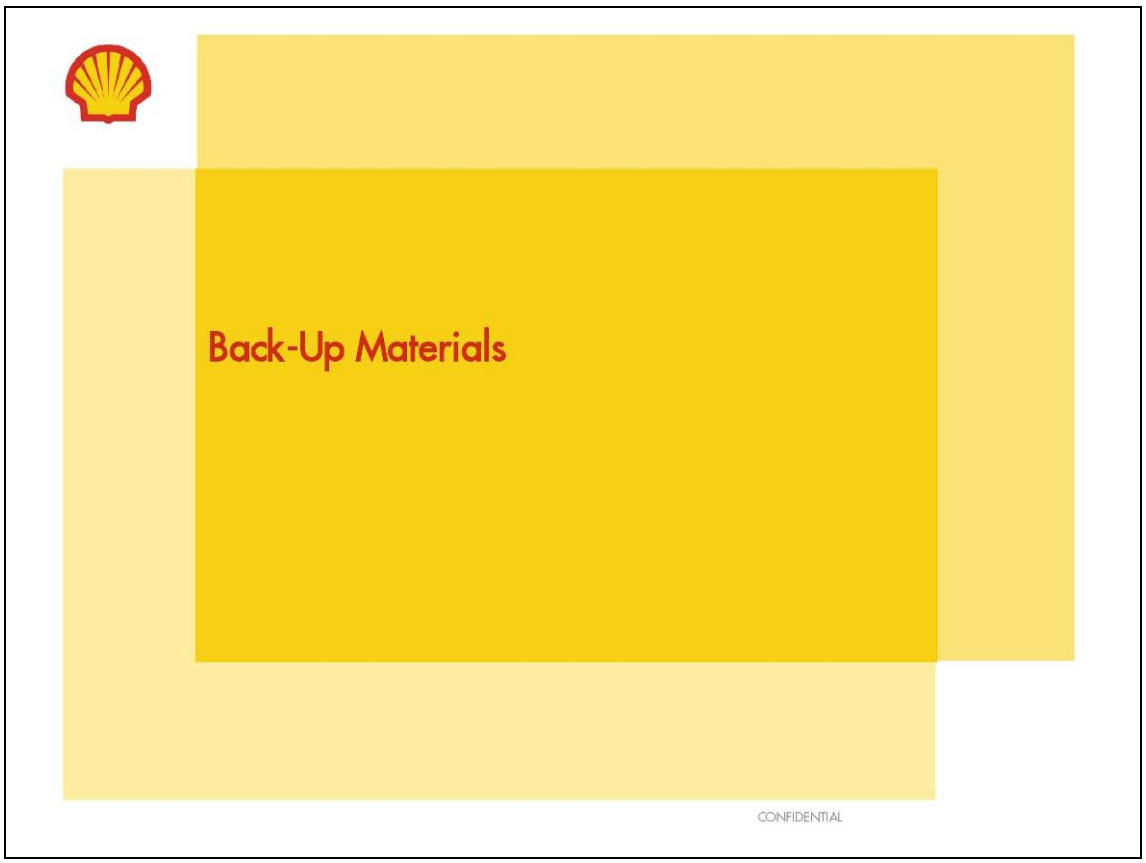

THE COST OF NOT HAVING CCS IN THE MIX
$1 Trillion
A global delay in CCS deployment would cause an increase of power sector decarbonisation by $1Trillion
IEA 2013
32 Billion
£/Annum
Without CCS, the additional costs to run a decarbonised UK economy in 2050 will be £32Billion.
UK Energies Technology Institute
40%
Without CCS, the IEA reports costs to halve emissions by 2050 will be 40% higher.
10

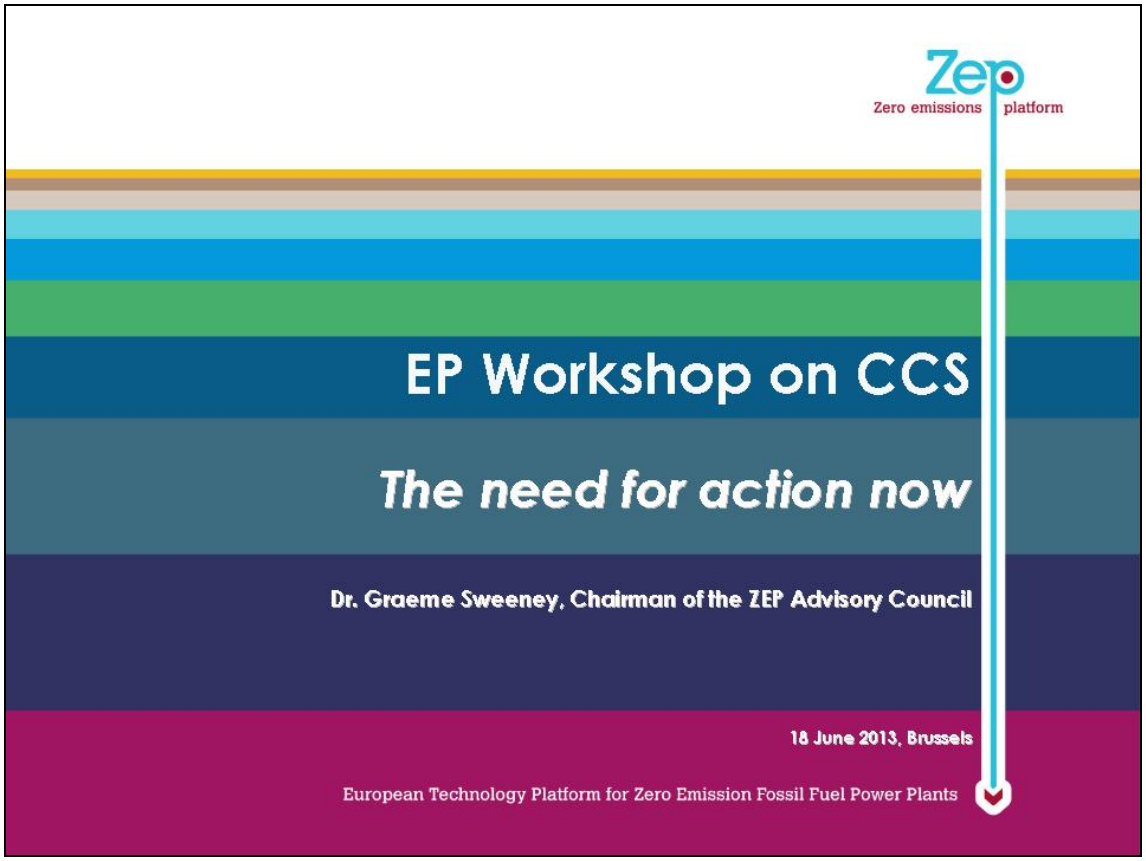
CO_2 POLICIES AROUND THE WORLD

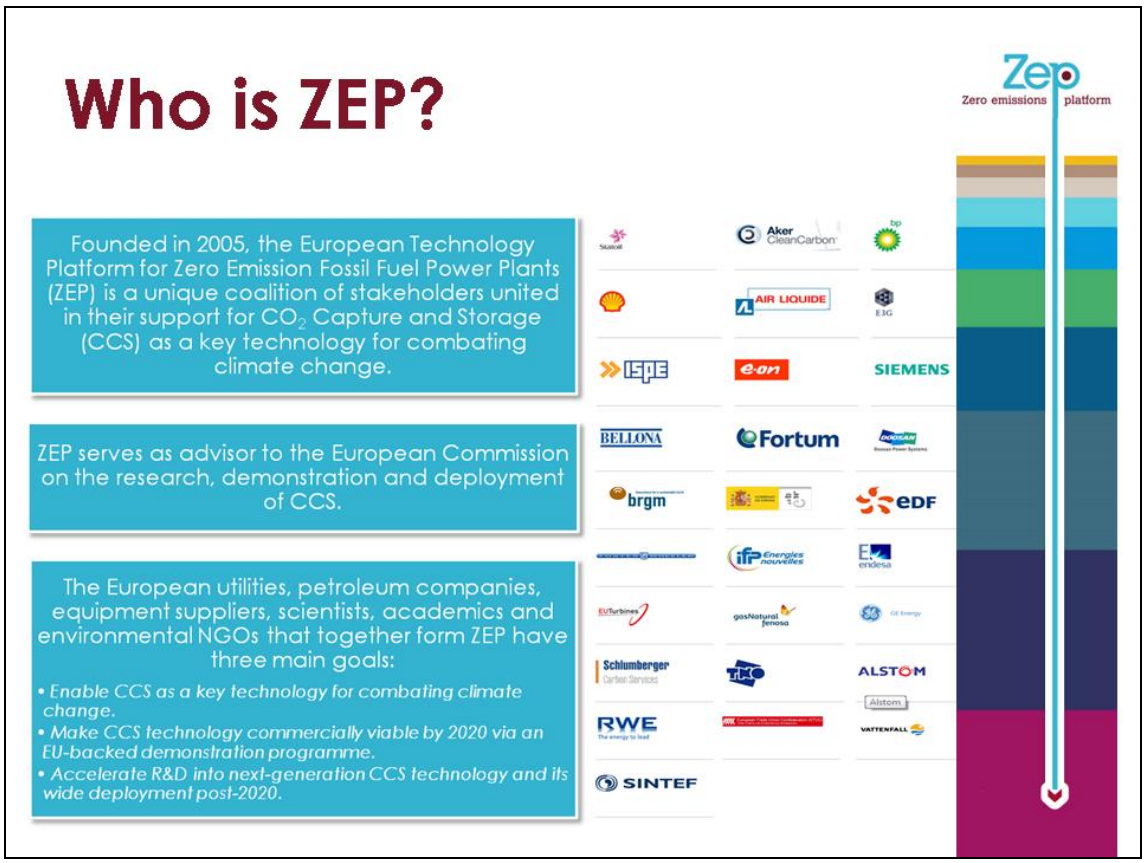


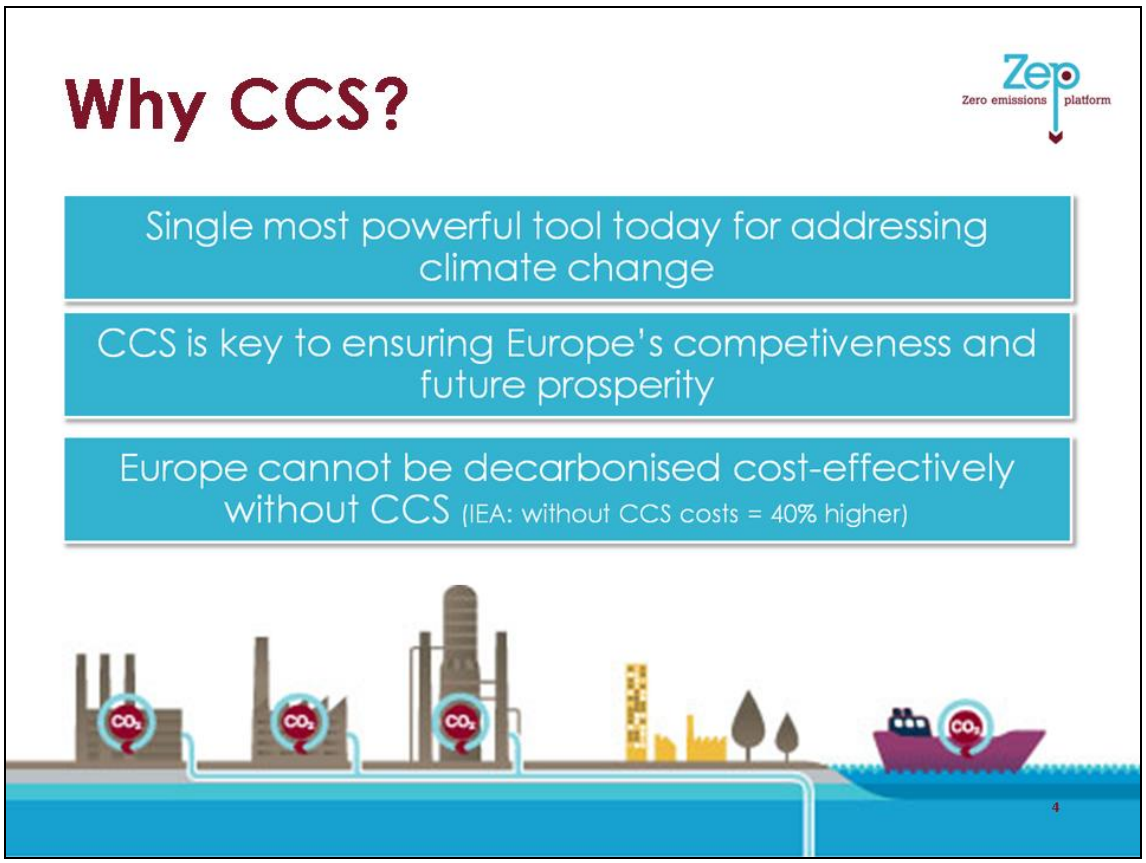



Back-Up Materials
CONFIDENTIAL

Presentation by Graeme Sweeney




Who is ZEP?
Zep
Zero emissions platform
Founded in 2005, the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) is a unique coalition of stakeholders united in their support for CO_2 Capture and Storage (CCS) as a key technology for combating climate change.
ZEP serves as advisor to the European Commission on the research, demonstration and deployment of CCS.
The European utilities, petroleum companies, equipment suppliers, scientists, academics and environmental NGOs that together form ZEP have three main goals:
• Enable CCS as a key technology for combating climate change.
• Make CCS technology commercially viable by 2020 via an EU-backed demonstration programme.
• Accelerate R&D into next-generation CCS technology and its wide deployment post-2020.
Aker CleanCarbon
AIR LIQUIDE
SIEMENS
Fortum
EDF
ALSTOM
RWE
SINTEF


Why CCS?
Zep
Zero emissions platform
Single most powerful tool today for addressing climate change
CCS is key to ensuring Europe's competiveness and future prosperity
Europe cannot be decarbonised cost-effectively without CCS (IEA: without CCS costs = 40% higher)
CO_2
4

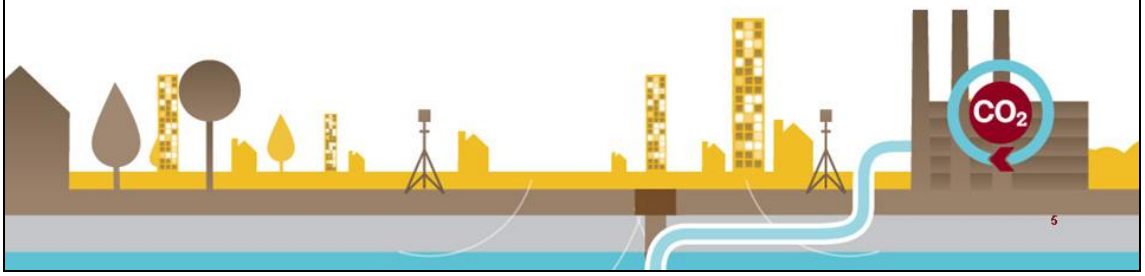
What do we need to do?

Zep Zero emissions platform

The EU has been a strong supporter of CCS but due to many factors we are behind: we need a fast and fundamental re-set

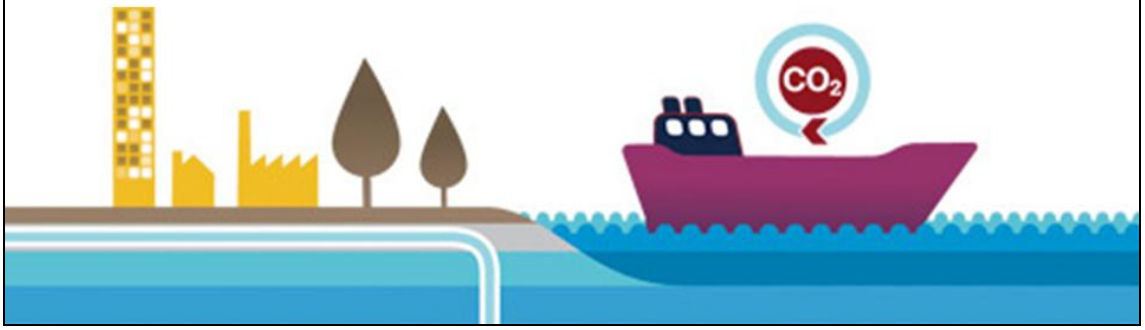
We have the technology and the skills but losing ground to China, Canada, Australia and the US

We need the finance to get a defined volume of CCS delivered



Zep Zero emissions platform

We can either invest in CCS technology now or will be forced to make enormous investments in the coming decades

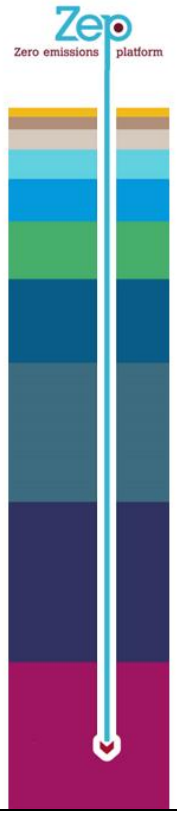


How do we reset?

A **robust ETS:** ZEP sees the **need for structural measures** and **supports backloading**

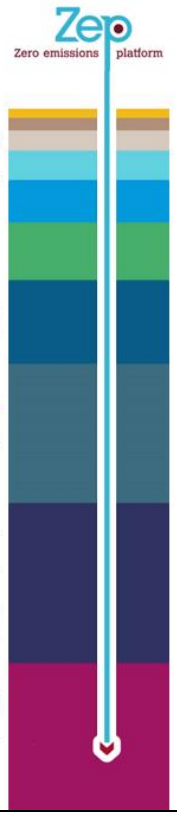
EU funding instruments: including NER 300 II + an **extension of the NER300.** An option could be a **tradable CCS certificates scheme, if carefully designed. But could also recycle EEPR funding – the entire EU CCS programme could be** financed by using "***left over money***"

At **Member State level actions to stimulate CCS** using CFDs and FiTs would be welcome.



To sum up

- **Without CCS it is impossible to meet European emissions objectives.** ZEP appreciates the EU efforts but more needs to be done
- **CCS represents tremendous value for money**
- There is **the technical experience available in Europe to deliver CCS** and solid foundation for **a policy framework**
- **Funding solutions should be further mobilised to support the CCS demonstration programme,** e.g. using left over money from the EEPR to support funds delivered through NER 300
- Future options include the use of **innovative measures** such as the creation of a tradable CCS certificate scheme, if carefully designed and for example **FiTs or CFDs at Member State level.**
- But we need **your help** to make it happen. **ZEP looks forward to contributing to the debate** and we are available for any information required



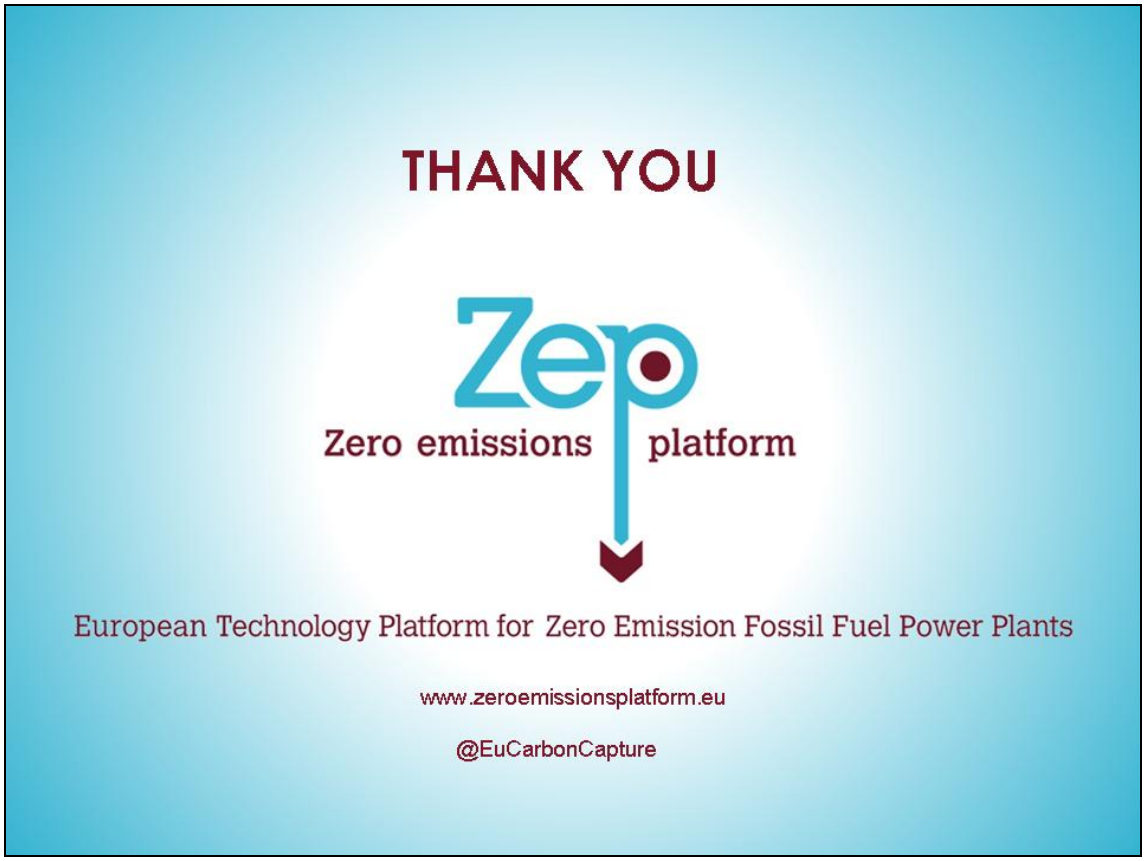

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PHOTO CREDIT: iStock International Inc.

ISBN 978-92-823-4603-7
doi: 10.2861/28501

Publications Office

Carbon Capture and Storage Technology in Europe