ECCO

Selection of Case Studies

Charles Eickhoff (Progressive Energy)

ECCO Conference
Trondheim, 14 June 2011

Structure of Presentation

Approach to Case Study selection
Criteria
Opportunities
Selected Cases
Sensitivities
Summary

Approach

The approach taken to derive a set of case studies was as follows:

Ideas for the issues which the case studies should illustrate and from which useful economic and other conclusions could be drawn were derived through a series of brainstorming events

This collection process was carefully designed to include all partners:

- selection driven by partner sponsorship to ensure the cases are well grounded,
- collaboration with other bodies and projects to ensure consistency
- diversity in order to illustrate a broad range of important issues including economics and early mover barriers.

Cases do not necessarily represent the most likely initial chains but selected to illustrate the key factors which commercial companies will encounter in making those decisions

Criteria for case selection

A set of questions from project workshops were distilled into criteria in the following categories:

- Technical
- Infrastructure / Geography
- Market and economic
- Legal / Social / Political
- Philosophical
- Tool Issues / Module Data

Weightings were applied according to perceived importance and then proposed cases were evaluated against these using their overall scores

	Geographical Spread	
14	Where is the main value from CO2 EOR located geographically?	4
15	What are the main generic clusters of sources around the North Sea?	3

	Economic	
21	Required rates of return, capture transport and EOR	3
22	Cost of capital for different parts of chain?	3
23	Who are the main actors / stakeholders? Capture, transport, storage?	2
24	Chain commercal contracts; incl ToP	5
25	Balance between EOR and CO2 mitigation / storage	4
26	What is the commercial role of aquifer storage in a CO2 EOR chain?	4

	Timing	
32	What can be done before 2020?	5
33	Role of Norway in EC regulation (transboundary issues) ?	1

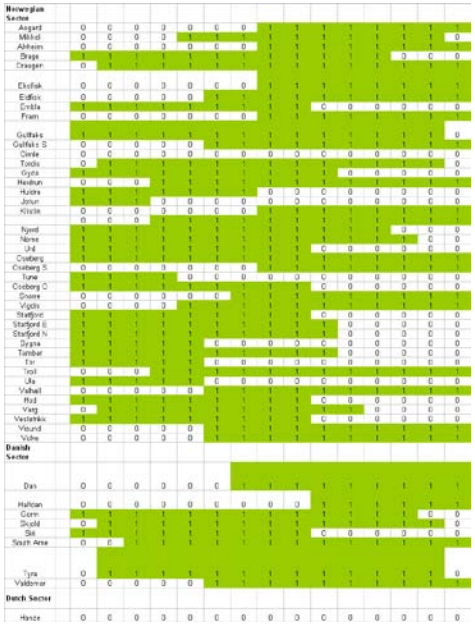
	Overview Issues	
36	How much additional/less fossil fuel will be consumed?	3
37	How much CO2 is required to meet the full potential for CO2 EOR, and over what timescale?	3
38	EOR potential estimation (onshore/offshore)	3
39	How do we best realise the full potential in the North Sea?	4
40	How much CO2 will be avoided?	4
41	How much additional oil or gas will be produced?	4
42	What is the impact on production cost of electricity or other commodities?	4
43	What is the impact on employment?	3
44	Cost of CO2 captured/abated?	5

Typical criteria

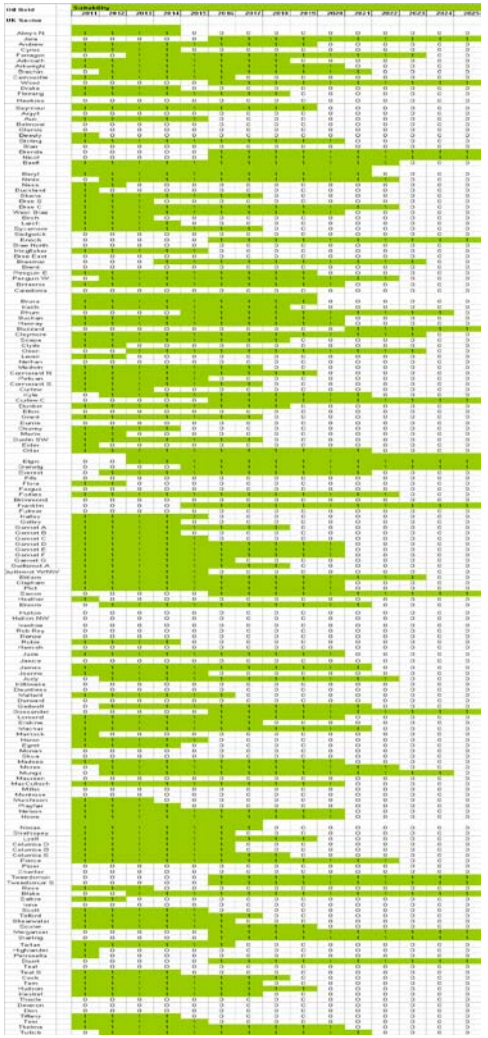
Focus on Early-movers

A key driver is the availability of a suitable oil field for EOR. Factors affecting this are:

- Maturity of the field – potential windows of opportunity are plotted for N sea fields
- Technical suitability of field
- Strategy of field owner



2010 Norwegian sector 2025



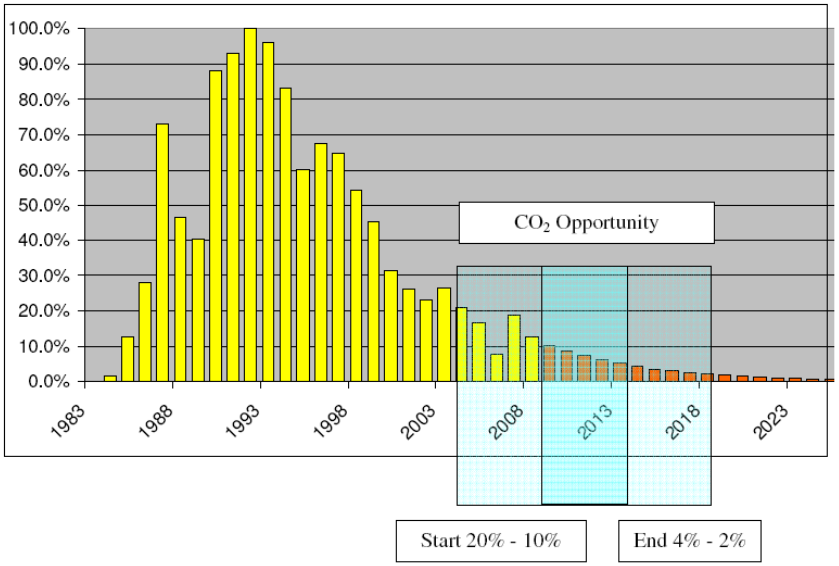
2010 UK sector 2025

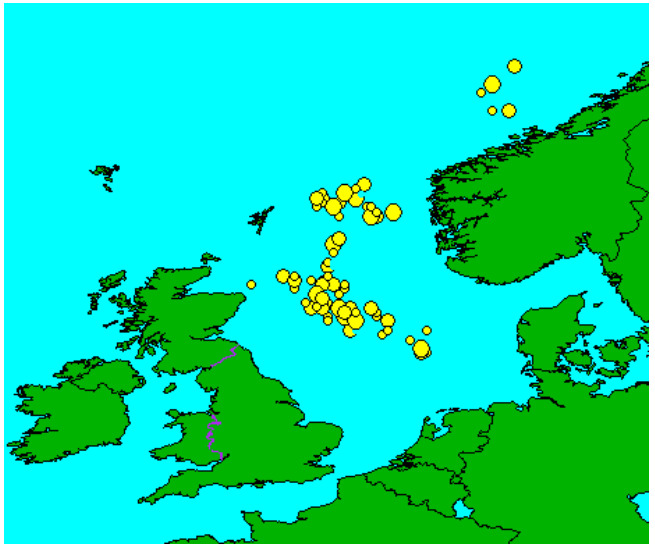
ECCO fortunate to be able to draw on the experience of MOL and INA in on-shore injection

EOR Opportunities

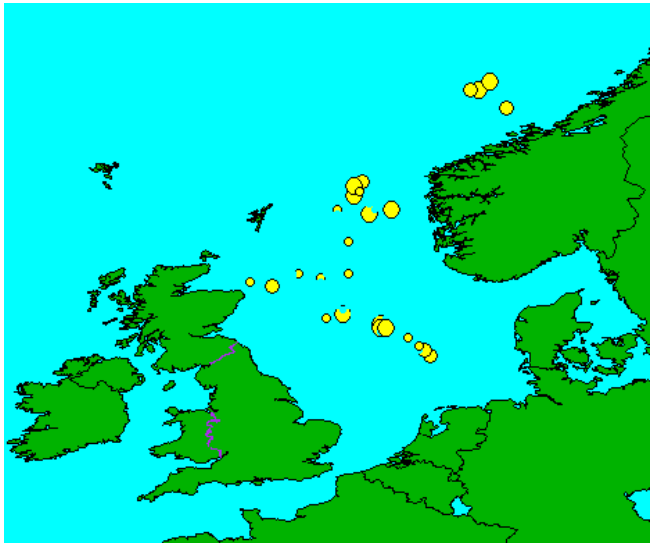
N Sea oil fields were evaluated by extrapolating public production figures and then using a 4% peak production economic cut-off.

Typical field production curve





2015



2025

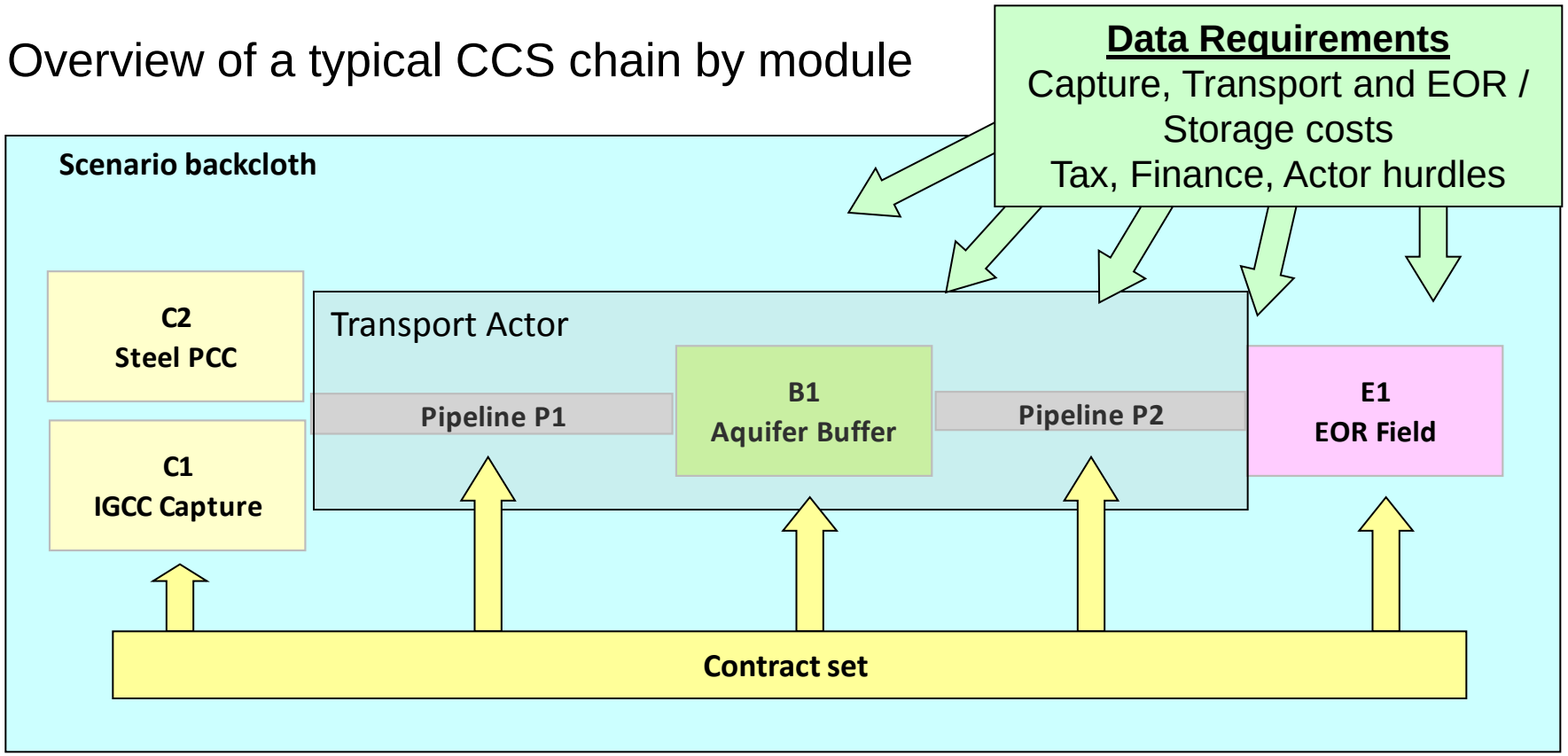
Six case studies selected

Chosen to give a good range of geography, source, transport, storage

Case	Proposed	Source(s)	Transport	Buffer	Sink(s)
Baltic Basin	Fortum VRD	Mainly PCC around Baltic rim	Ship Pipeline	Hub in Skagerrak, Gassum off Denmark	EOR Northern N Sea
Hungary	MOL	Refinery & CCGT PCC New Coal PCC	Pipelines onshore	None	Ursa EGR Central EOR
Denmark, Germany	Fortum VRD Dong	Esbjerg PCC, Dutch and North Germany sources	Pipeline via Dornum Hub	German Bunter Aquifer	Danish chalk EOR & Ekofisk
Holland	Europipe TNO	Various in Rotterdam	Pipeline to DGF Pipeline to EOR	None	Dutch K/L sector & Ekofisk
UK East Coast	PEL	IGCCs & Steel PCC NE England cluster	Pipelines	N Sea Aquifer	Central N Sea EOR & Northern N Sea
Norway	SINTEF STATOIL	Mongstad CHP & Refinery	Pipeline	None	Norwegian JFB EOR

Setting up a Case Study

Overview of a typical CCS chain by module



Key Performance Indicators including CO_2 stored, oil produced, employment etc and financial measures (NPV, IRR for components and whole chains, cost per ton stored….)

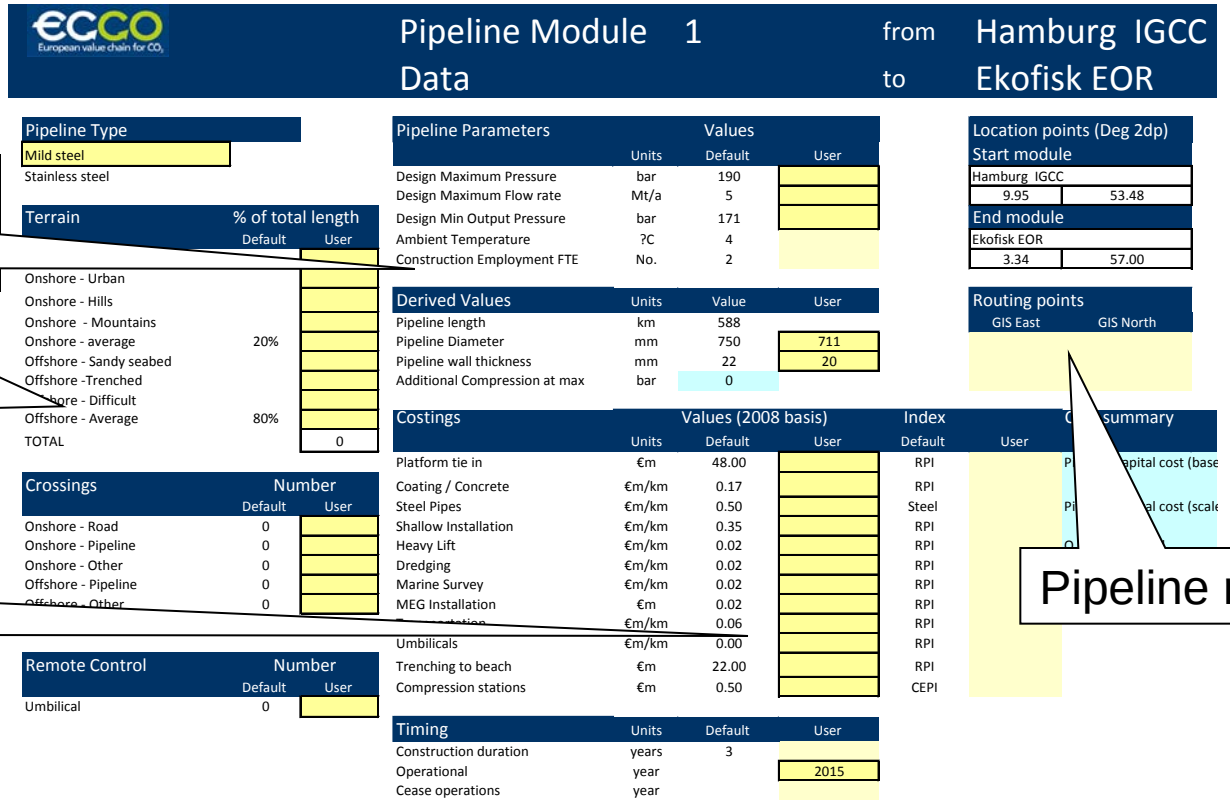
Example – Pipeline module input sheet

Pipeline parameters eg size, pressure

Pipeline terrain, crossings, material

Costings and indexation

Pipeline route



Pipeline Module Data 1 from Hamburg IGCC to Ekofisk EOR

Pipeline Type: Mild steel; Stainless steel

Terrain — % of total length

	Default	User
Onshore - Urban		
Onshore - Hills		
Onshore - Mountains		
Onshore - average	20%	
Offshore - Sandy seabed		
Offshore -Trenched		
Offshore - Difficult		
Offshore - Average	80%	
TOTAL		0

Crossings — Number

	Default	User
Onshore - Road	0	
Onshore - Pipeline	0	
Onshore - Other	0	
Offshore - Pipeline	0	
Offshore - Other	0	

Remote Control — Number

	Default	User
Umbilical	0	

Pipeline Parameters — Values

	Units	Default	User
Design Maximum Pressure	bar	190	
Design Maximum Flow rate	Mt/a	5	
Design Min Output Pressure	bar	171	
Ambient Temperature	?C	4	
Construction Employment FTE	No.	2	

Derived Values

	Units	Value	User
Pipeline length	km	588	
Pipeline Diameter	mm	750	711
Pipeline wall thickness	mm	22	20
Additional Compression at max	bar	0	

Costings — Values (2008 basis) — Index

	Units	Default	User	Index Default	Index User
Platform tie in	€m	48.00		RPI	
Coating / Concrete	€m/km	0.17		RPI	
Steel Pipes	€m/km	0.50		Steel	
Shallow Installation	€m/km	0.35		RPI	
Heavy Lift	€m/km	0.02		RPI	
Dredging	€m/km	0.02		RPI	
Marine Survey	€m/km	0.02		RPI	
MEG Installation	€m	0.02		RPI	
[illegible]	€m/km	0.06		RPI	
Umbilicals	€m/km	0.00		RPI	
Trenching to beach	€m	22.00		RPI	
Compression stations	€m	0.50		CEPI	

Timing

	Units	Default	User
Construction duration	years	3	
Operational	year		2015
Cease operations	year		

Location points (Deg 2dp)

Start module	
Hamburg IGCC	
9.95	53.48
End module	
Ekofisk EOR	
3.34	57.00

Routing points

GIS East	GIS North

C[illegible] summary

P[illegible]apital cost (base

Pi[illegible]al cost (scale

O[illegible]

Default data provided by module with User ability to change

Costings – default module data

Flow Mt/a	Diameter inches	mm	Wall mm	Hoop MPa
0	6	152	6	241
0.3	12	305	12	241
2	18	457	18	241
5.4	22	559	22	241
8.9	24	610	24	241
11.1	28	711	28	241
16.3	32	813	32	241
22.8	36	914	36	241
30.5	44	1118	44	241
50.5	48	1219	48	241

Pipeline diameter selection from flow parameters

Costings for offshore

Additional capital costs for offshore pipelines	€m /km	€m
Platform tie in		48.00
Shallow Installation	0.35	186.01
Heavy Lift	0.015	7.97
Dredging	0.02	10.63
Marine Survey	0.015	7.97
Transportation	0.015	7.97
Umbilicals	0.055	29.23
Trenching to beach		22
Materials - coating/concrete	0.17	90.35
TOTAL		410.14

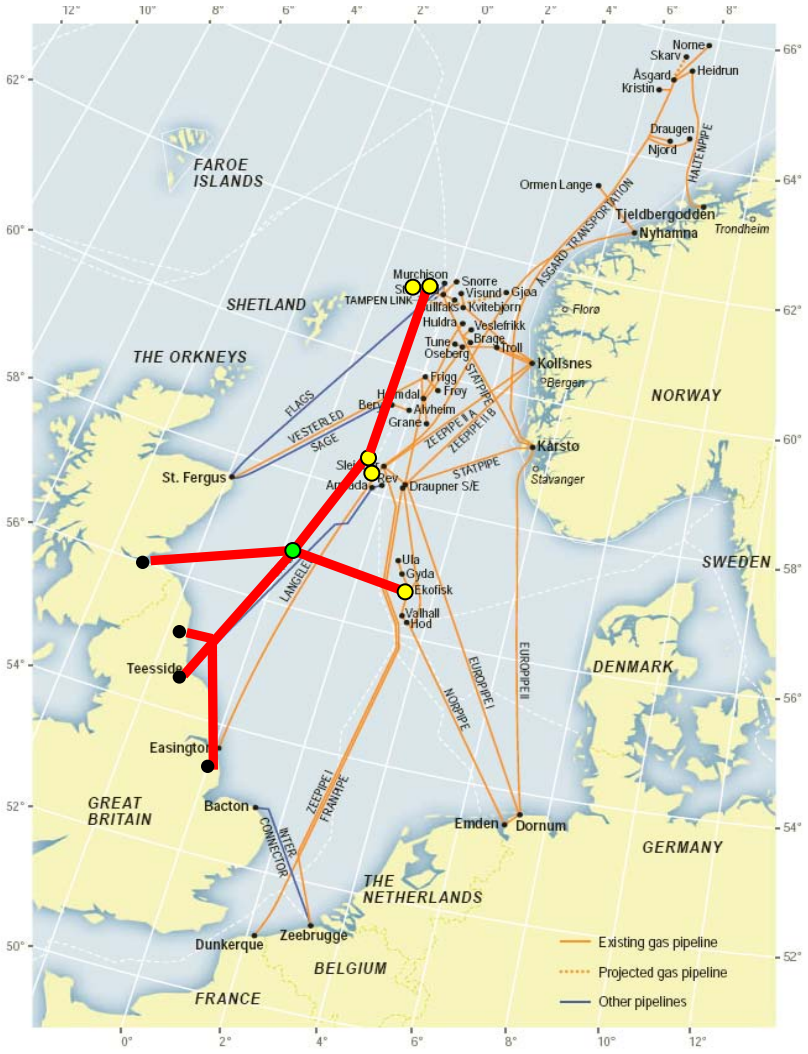
Coal PF Super-C Post-CC	663	Lignite Post-CC	680	CCGT Post-CC	520	IGCC Pre-CC	694
	MW		MW		MW		MW
Costings Default	€m 2010	**Costings Default**	€m 2010	**Costings Default**	€m 2010	**Costings Default**	€m 2010
Fuel Handling / Utilities	333	Fuel Handling / Utilities	340	Fuel Handling / Utilities	95	Fuel Handling / Utilities	341
Boiler / HRSG	316	Boiler / HRSG	297	Boiler / HRSG	34	Gasifier	355
Turbines & Generator	101	Turbines & Generator	99	Turbines & Generator	57	Boiler / HRSG	44
Flue Gas Cleansing	131	Flue Gas Cleansing	141	Flue Gas Cleansing	188	Turbines & Generator	143
CO2 Removal & Compression	363	CO2 Removal & Compression	384	CO2 Removal & Compression	74	Flue Gas Cleansing	183
						CO2 Removal & Compression	29
TOTAL Capex	**1243**	TOTAL Capex	**1262**	TOTAL Capex	**448**	TOTAL Capex	**1094**
Fixed Opex	16.3	Fixed Opex	16.3	Fixed Opex	6.4	Fixed Opex	17.9
Variable Opex (excl fuel)	0.00710	Variable Opex (excl fuel)	0.00741	Variable Opex (excl fuel)	0.00203	Variable Opex (excl fuel)	0.00637

CC Power plant cost database for a cross-section of different power and industrial plant

User always retains ability to refine costing data

ECCO European value chain for CO_2
CO-FUNDED BY THE EUROPEAN UNION
SEVENTH FRAMEWORK PROGRAMME

WP2.2: Case study example:



“UK case”

Attributes:

- Use of non-platform aquifer buffer
- EOR in abandoned CNS field
- Economics of extension to NNS EOR
- Add-in of Scottish cluster
- Link to CNS Chalk field

Sensitivities

A number of case sensitivities have also been established which are designed to illustrate interesting aspects of the CCS chain which are relevant to ECCO strategy recommendations

Financing

Topic	Question
Required contractual price levels between actors	What CO2 price is needed at the various points in the chain to become marginally economic?
Impact of tax	Look at the impact of varying the oil field tax regimes
Case study on impact of tax by ownership	Impact of ownership of pipelines by oil field operators on economics due to tax regimes

Regulatory

Topic	Question
Issue of field re-commissioning	How does recommissioning of an abandoned oil field affect the economics of the chain?
Licensing of field re-commissioning	Effect of delayed approval for recommissioning on the economics of the chain?

Policy

Topic	Question
Effect of the global environment	How will a given CCS chains perform in a variety of global environments?
Effect of the global environment	What type of CCS chain is most promising under a given global environment scenario?

Infrastructure

Topic	Question
Bulk Pipeline	What are the outcomes/advantages of investing into [oversized] backbone structure?
Pipeline ownership and investments (open season suggestion..)	How will governmental investment into an oversized common infrastructure affect the economy of the chain and economies of particular actors?
Oversized Pipeline	What are the disadvantages / advantages of investing into oversized pipeline (and which dimension of the pipeline is the most optimal)?
Economics of sub-sea aquifer	What are the cost/benefits of including a sub-sea completed aquifer for buffering (one way)?
Offshore vs Onshore	What are the economics of onshore versus off shore pipelines?
Flexibility of CO2 captured	what is the impact of fluctuations in amount of CO2 captured
Economics of long distant extension for EOR	Is it viable to fund a pipeline connection to the NNS?
Influence of ETS C prices or oil price on economics of infrastructure	What distance of infrastructure can be supported at what carbon price and what oil price?
Economics of additional connections	How economic is it to branch into an existing network?

Summary

- A set of questions were created to underpin the ECCO themes
- Six Case studies have been established containing important aspects of early mover CCS chains
- Technical and cost data created to populate modules – accuracy is down to the user
- Further sensitivities were devised to illustrate particular issues
- Cases and sensitivities currently being run to create data for final recommendations