Industry CCS Workshop

Monday 7th September 2015,

University of Strathclyde

www.ukccsrc.ac.uk

Overview 2
Speakers 2
Agenda 2
Attendees 3
Mark Lewis - A blueprint for an industrial CCS network 4
James Watt - Challenges in the steel industry and the network 13
Jay Brooks - Challenges in the chemical industry 23
Tim Dumenil - Overall network issues 33

INDUSTRY CCS WORKSHOP

TECHNOLOGY AND INNOVATION CENTRE, UNIVERSITY OF STRATHCLYDE, 7 SEPTEMBER 2015

On 24 July the EPSRC launched a funding call for Research Challenges in Industrial CCS and in that month the DECC funded Teesside Collectives report: Blueprint for Industrial CCS in the UK was released.

To encourage links between academics working on CCS and industry, the UKCCSRC and Teesside Collective are holding a workshop. Three members from the team who prepared the report are coming together on the 7th September with the aim of discussing aspects of the study that might relate to future research.

SPEAKERS INCLUDE:

- Mark Lewis - Mark is the Low Carbon Lead on the Teesside Collective project and will be giving an overview on the report and major findings.
- James Watt - James is the technical manager for CCS at Amec and was heavily involved in the detailed engineering of the proposed network. He will be discussing the research challenges in the steel industry and more widely in the network design.
- Jay Brookes - Jay is an area manager for BOC and was involved specifically in the capture from hydrogen manufacture as well as advising on the overall concept. He will be discussing the research challenges in the chemical industry.
- Tim Dumenil - Tim is an Energy Consultant for Pale Blue Dot Energy who completed the Project Management and Business Case Development aspects of the Teesside Collective project. He will be discussing what issues were identified for both the overall network and within the business case development.

AGENDA

14:00 - 14:30 **Overall Concept and Approach** - *Mark Lewis (Tees Valley Unlimited)*

14:30 - 15:15 Presentation/Discussion - **Challenges in the steel industry and the network** - *James Watt (Amec Foster Wheeler)*

15:15 - 15:30 Break

15:30 - 16:00 Presentation/Discussion - **Challenges in the chemical industry** - *Jay Brookes (BOC)*

16:00 - 16:30 Presentation/Discussion **– Overall network issues** - *Tim Dumenil (Pale Blue Dot)*

16:30 - 17:30 Closed Discussion

17:30 – Dinner

ATTENDEES

Name	Organisation
Emilie Brady	UKCCSRC
Jay Brookes	BOC
Tim Dumenill	Pale Blue Dot
Mike Edwards	UKCCSRC
David Fitzgerald	Doosan Babcock Limited
Susana Garcia Lopez	Heriot-Watt University
Jon Gibbins	UKCCSRC
Mark Lewis	Tees Valley Unlimited
Chris Littlecott	E3G
Mathieu Lucquiaud	University of Edinburgh
Mercedes Maroto-Valer	Heriot-Watt University
Ondrej Masek	University of Edinburgh
Kumar Patchigolla	Cranfield University
Belinda Perriman	Teesside Collective
Richard Porter	University College London
David Reiner	University of Cambridge
Marcus Simoes	University of Sheffield
Andrew Smallbone	Newcastle University
Chenggong Sun	University of Nottingham
James Watt	Amec Foster Wheeler
Thomas Yip	University of Strathclyde

UK Carbon Capture and Storage Research Centre (UKCCSRC)

The UKCCSRC brings together over 1000 members including over 200 of the UK's world-class CCS academics to provide a national focal point for CCS research and development. The Centre is a virtual network where academics, industry, regulators and others in the sector collaborate to analyse problems devise and carry out world-leading research and share delivery, thus maximising impact. A key priority is supporting the UK economy by driving an integrated research programme and building research capacity that is focused on maximising the contribution of CCS to a low-carbon energy system for the UK.

*The UKCCSRC is supported by the **Engineering and Physical Sciences Research Council (EPSRC)** **www.epsrc.ac.uk** as part of the Research Councils UK Energy Programme, with additional funding from the Department of Energy and Climate Change (DECC) **www.decc.gov.uk** for the UKCCSRC PACT Facilities **www.pact.ac.uk***

EPSRC
Engineering and Physical Sciences Research Council

Department of Energy & Climate Change

www.ukccsrc.ac.uk

TEESSIDECOLLECTIVE

A NEW INDUSTRIAL FUTURE FOR THE UK

A Blueprint for an industrial CCS network in the Tees Valley

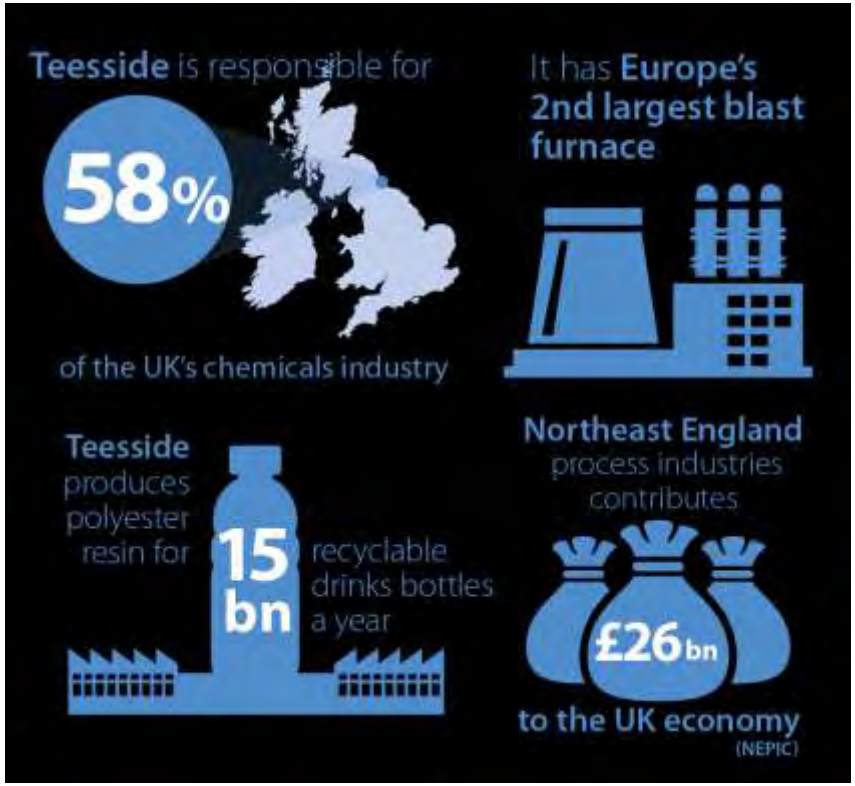
Mark Lewis

Low Carbon Consultant
Tees Valley Unlimited

www.teessidecollective.co.uk

Why ICCS and Why Teesside?

TEESSIDE CO_2 LLECTIVE
A NEW INDUSTRIAL FUTURE FOR THE UK



Tees Valley Integrated Complex

Tees Valley Unlimited

Over £3bn investment over last 5 years

Company	Capex
SSI	£1.9 billion
Air Products	£600 million
Sembcorp and SITA	£200 million
SNF Oil & Gas	£150 million
BOC Linde	£100 million
Huntsman Tioxide	£65 million
Lotte Chemicals	£60 million

Who are Teesside Collective?

TEESSIDE CO2 LLECTIVE
A NEW INDUSTRIAL FUTURE FOR THE UK

Multinational companies based in Teesside with an interest developing a CCS network on Teesside

BOC	Largest steam methane reformer in UK
Growhow	Largest UK ammonia fertiliser producer
SSI	Europe's second largest blast furnace
Lotte	produces PET for15bn drinks bottles per year
National Grid	Store developer
TVU	Local Government
NEPIC	Cluster representative

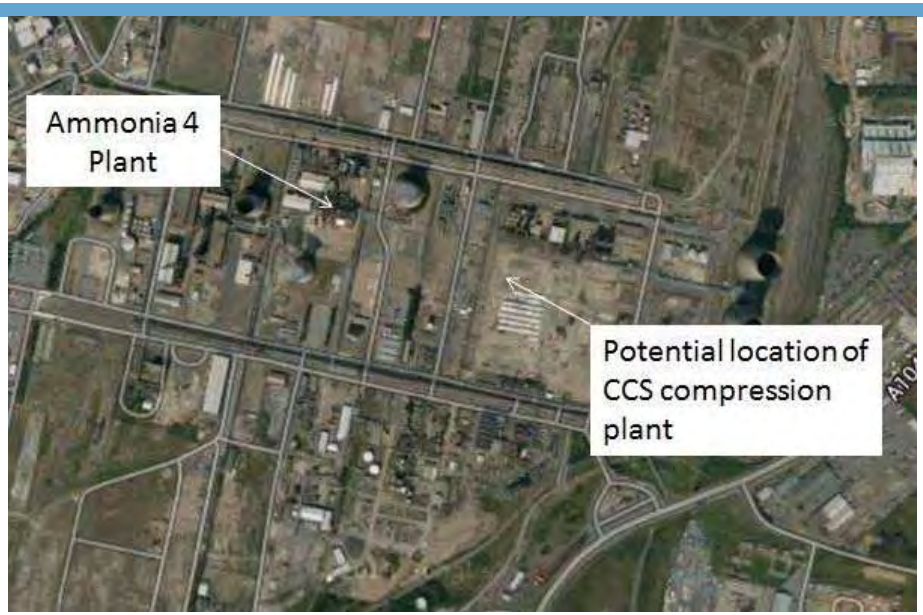
"CCS on industrial plants is going to be a critical part of the global effort to prevent serious climate change. Teesside is in the right place, at the right time, to get ahead of the curve."
Sir David King, UK's Special Representative for Climate Change

"A CCS network in Teesside is a critical step, giving a shot in the arm to British industry's long-term future."
Dianne Sharp, North East Director, CBI

Growhow – 35% of UK's fertilisers

TEESSIDE CO2 LLECTIVE
A NEW INDUSTRIAL FUTURE FOR THE UK

- Produces CO2 as part of process, sells to Greenhouses and Drinks industry
- Average of 375,000 tonnes of CO2 per year
- New 100barg compression plant required (2 x 50tonne/hr compressors)
- Proven technology from existing suppliers
- No operation or integration issues identified



Tees Valley Unlimited
Department of Energy & Climate Change
BOC
SSI UK
GrowHow
LOTTE CHEMICAL UK
nationalgrid
repic

Lotte - Produces enough PET for 15billion drinks bottles every year

TEESSIDECO2LLECTIVE
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- 50,000 tonnes of CO2 captured
- Amine capture solution selected
- Pre-designed amine units available – American – no European pricing available
- 90% CO2 captured

What has Teesside Collective done?

TEESSIDE CO2 LLECTIVE
A NEW INDUSTRIAL FUTURE FOR THE UK

- Used the £1million received from DECC to:
  - Engineer and cost capturing CO2 from 4 industrial plants, an onshore & offshore network and developing a new store (Amec Foster Wheeler)
  - Develop the Business Case for an industrial CCS network (Pale Blue Dot)
  - Propose a solution to 'how can Industrial CCS be funded?' (Societe Generale)
- We have:
  - Shown we can cut industrial CO2 emissions by 2.8million te/yr for at least 20 years
  - Shown it supports retaining 5,900 local jobs
  - Shown it can be done by 2025 for less than £95/te CO2 stored at current prices.
  - Readily expand by a factor of 3 for less than 10% cost increase
- We are
  - Developing the project proposal and plans for FEED towards a FID
  - Identifying additional partnerships

Research needs summary

- The technical needs include:
  - *Opportunities to improve efficiency & operational costs*
  - *Small scale capture is very expensive*
  - *Best approach for integrated steelworks*
  - *Operation of network – management, control & measurement*
  - *Reliability & Asset management*
  - *Large scale use possibility*
  - *Challenge of integration of other processes*
  - *Retrofitting of existing assets*
    - *New processes*
- Storage options need development
  - *How to reduce costs and risks further - monitoring*

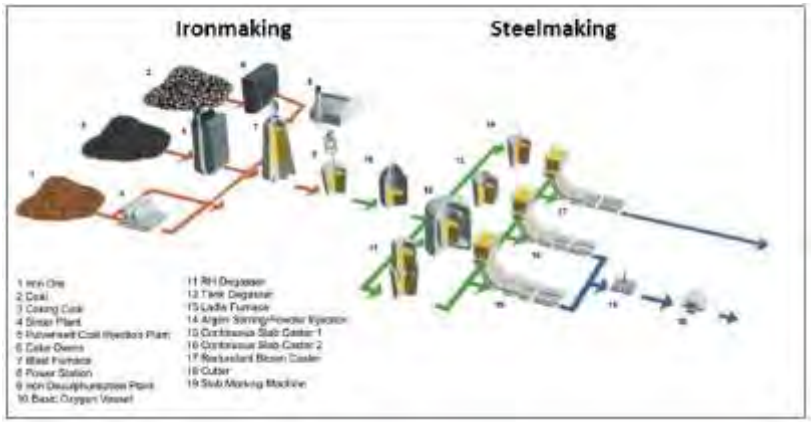
Teesside Collective
Steel and Transport Challenges

07 09 2015

Iron and Steel

What we did

- SSI Teesside
- Iron and steel works
  - 3.2 million tonnes/year steel
  - 7.1 million tonnes/year CO2
  - Onsite power generation
- Examined the emission points for the site
- Determined screening factors and issues
  - Provides basis for decision making
  - Identifies drivers and restrictions
  - Screen options
- Technology options
  - Based on each emission source and the whole site
- Considered 3 options, out of an initial 26,
  - ~2 million tonnes/year of CO2
  - Power plant PC unit
  - BFG, pre-combustion capture
  - BFG & BOS gas pre-combustion w/h shift



Key considerations

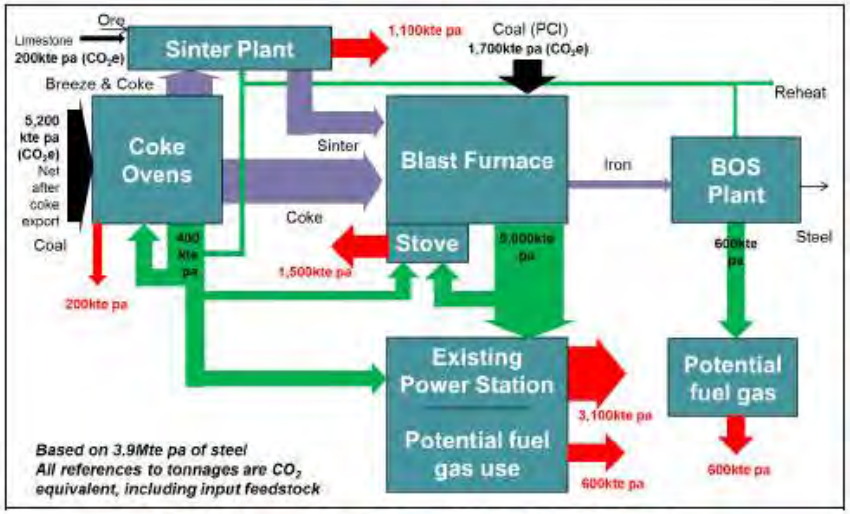


Figure 3-4 Carbon pathways through the Redcar Steel works

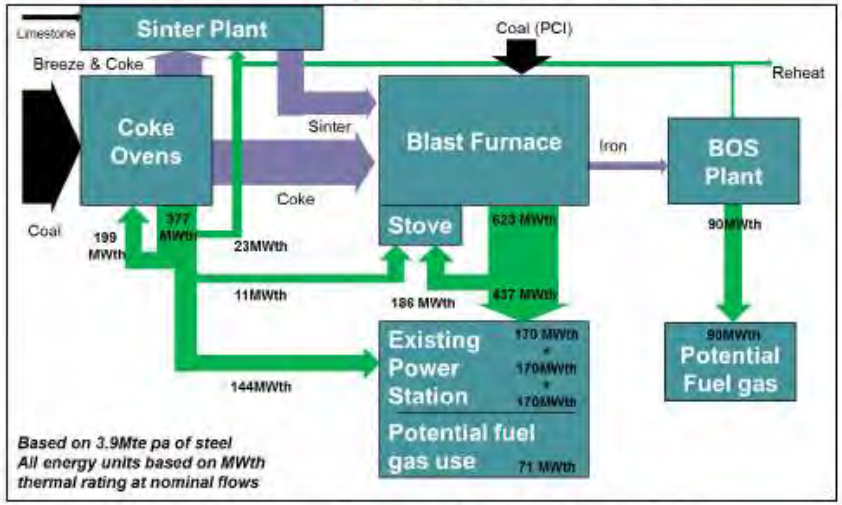
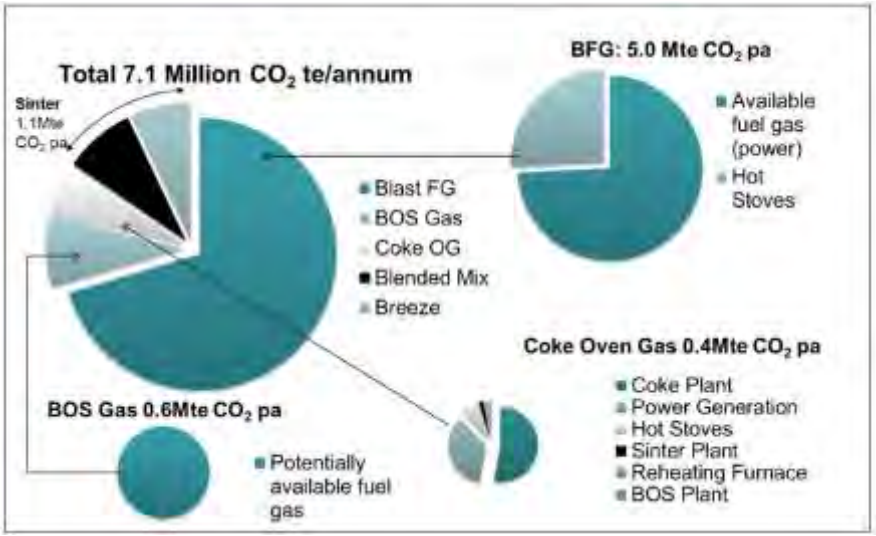
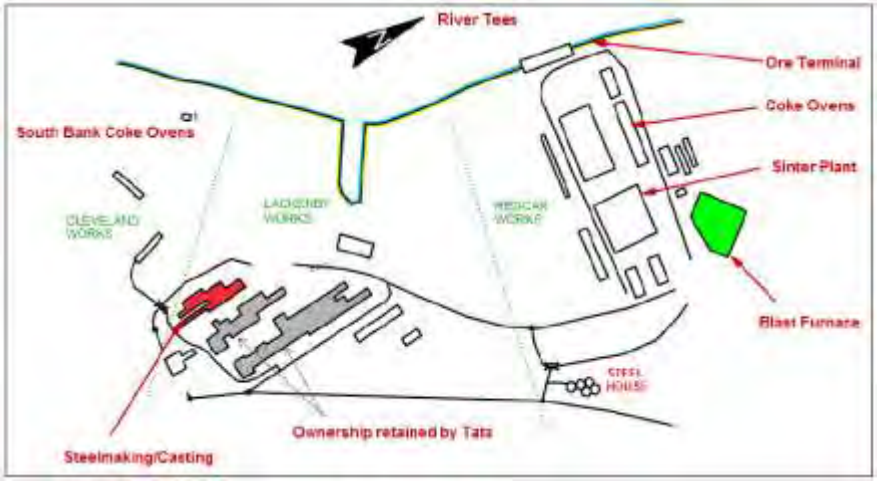


Figure 3-5 Primary Energy Flows through the Redcar Steelworks





Challenges

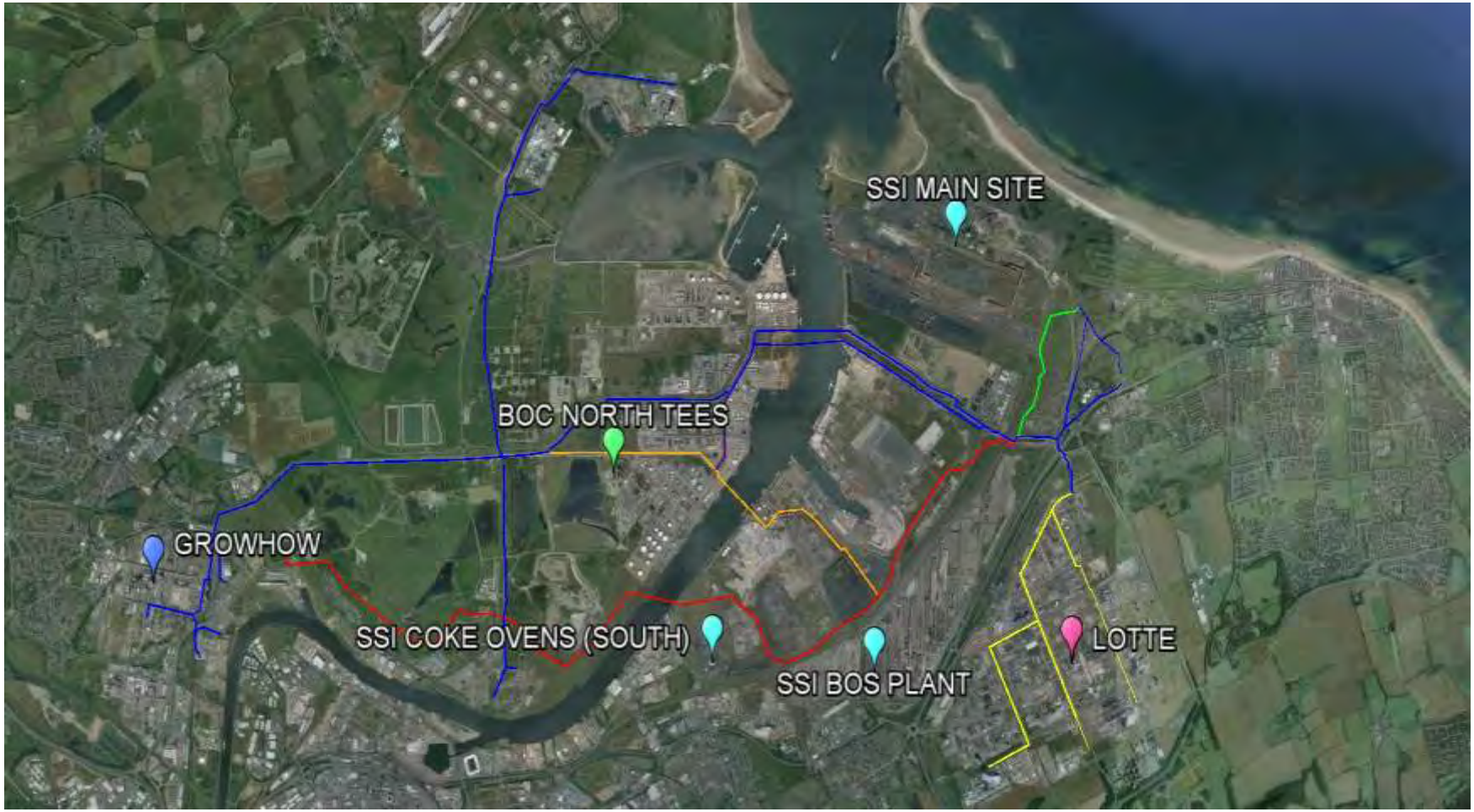
- Diverse point source in a steel works
  - Compatible technology
- For SSI
  - Addressing some of the more “problematic” streams/processes
  - Cost
  - Retrofit – can the work be done on plant that is significantly old?
  - Space & distance in site
- Different challenges
  - All sites are different
  - What do you do for major existing plant?
    - Reluctant to modify
    - What can we do to reduce carbon input?
  - What technology is coming forward (ULCOS, DRI)
  - Need to address more challenging emissions

Network

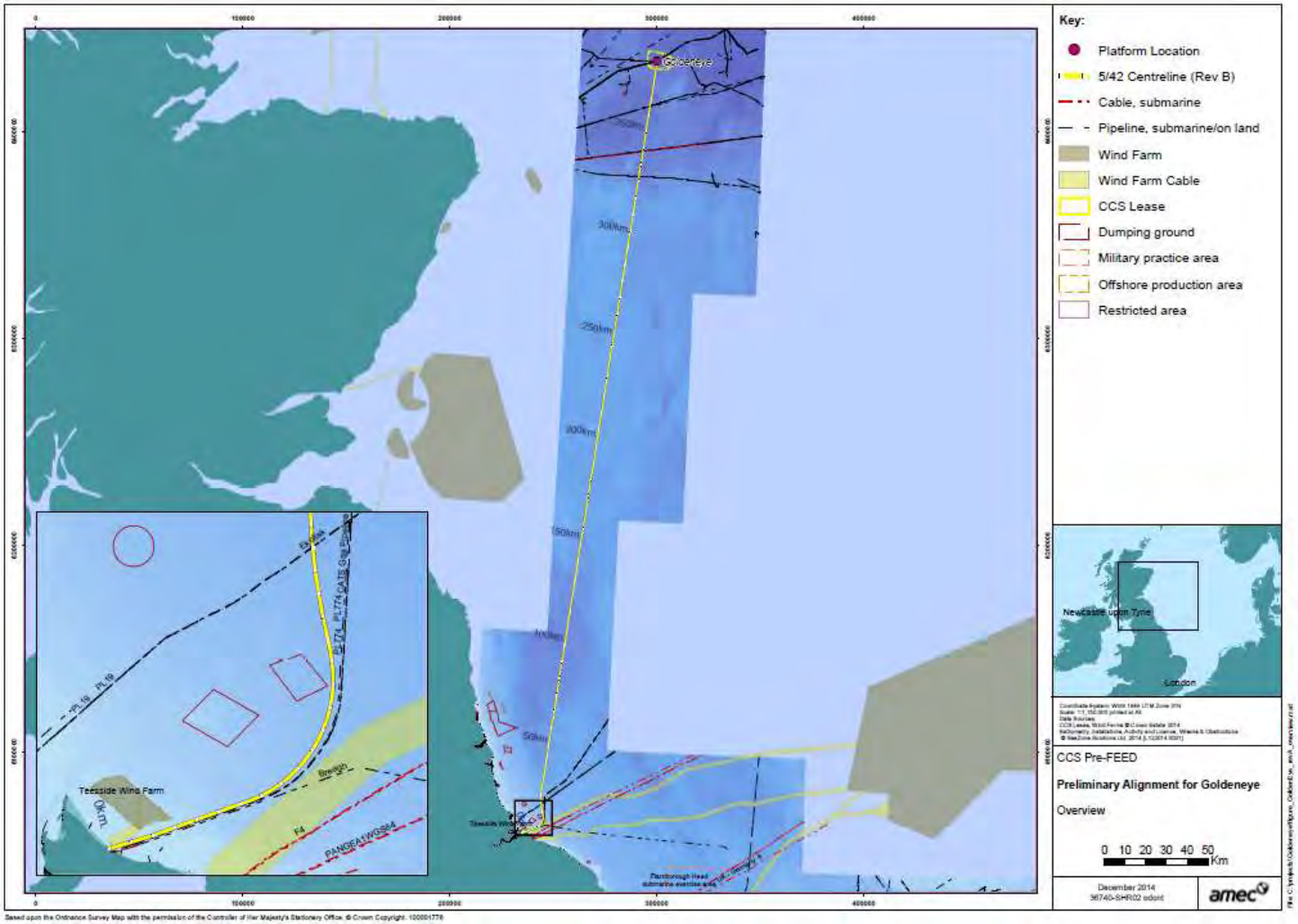
What we did

- Two cases
  - 5 million tonnes/year CO2
    - Consider 4 core sites
  - 15 million tonnes/year CO2
    - Consider all sites
    - Scenario modelling on what could happen.
    - Right sized for end use of 15mmtpa
- Defined pressure regime and entry specification
- Area definition, route determination using in house framework
- Offshore options
  - 5/42 SNS Nation Grid Carbon White Rose
  - Shell Goldeneye
  - Selected landing area, orientated onshore network to offshore entry point
- Other key points
  - Minor design concepts – booster, line connection
  - Costs for both, most detailed undertaken so far

Onshore


SSI MAIN SITE
BOC NORTH TEES
GROWHOW
SSI COKE OVENS (SOUTH)
SSI BOS PLANT
LOTTE

Offshore


Key:
Platform Location
5/42 Centreline (Rev B)
Cable, submarine
Pipeline, submarine/on land
Wind Farm
Wind Farm Cable
CCS Lease
Dumping ground
Military practice area
Offshore production area
Restricted area
Goldeneye
300km
250km
200km
150km
100km
50km
Teesside Wind Farm
0km
Bruigh
F4
PANDORA/WGS84
Pembroke Head submarine exercise area
Newcastle upon Tyne
London
CCS Pre-FEED
Preliminary Alignment for Goldeneye
Overview
0 10 20 30 40 50
Km
December 2014
amec

Key issues

Things to consider

- Access on Teesside is excellent
  - Considered 5 clear route options
  - Still some areas of difficulty
    - Congestion
    - Urban issues on Teesside aren't a problem
    - Potential impact on other users (low temp release)
  - Targeted re-use of existing service corridors
- Detailed route assessment
- No major obstacles – area designed for inter-site connection to common services
- Focused on accurate costs
- In network terms
  - Future challenges – portfolio of emitters
  - Steel works to plasma gasifiers to biofuels and combustion EfW plant
  - How as a network to do you optimise that?

Key Issues

Things to think about

- Network
  - Deployment
    - Rate
    - Size
    - How do you cost vs. right size without a driver for people to join
- Offshore
  - Considered existing sites only – better options?
    - Access to information
    - Access to risk issues
  - Impact of storage on upstream emitters
- Flexibility
  - Concerns raised on composition in network
  - Impact of downstream on network
  - No info provided on storage performance
    - impacts on operations
    - impacts on economics for emitters
  - Deployment limitations
    - storage composition requirements defining capture plant

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Industrial CCS Project

CCS for the chemical industry

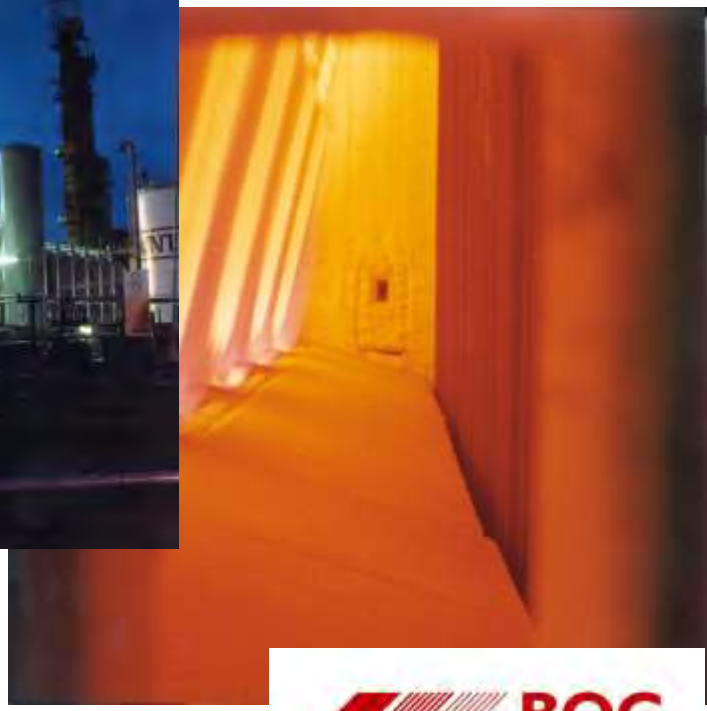
Jay Brooks BOC

7th September 2015 – Strathclyde workshop

BOC

Member of The Linde Group

BOC Teesside Hydrogen



Member of The Linde Group

ICCS Teesside

- Progressive Energy 8 year relationship
- Teesside Collective TVUL leadership
  - North East Business links (NEPIC)
  - Pale Blue Dot
  - AMEC FW
  - Voluntary steering group

BOC
Member of The Linde Group

Teesside Collective 2030

https://www.youtube.com/watch?v=Aa71J9Rnw1w

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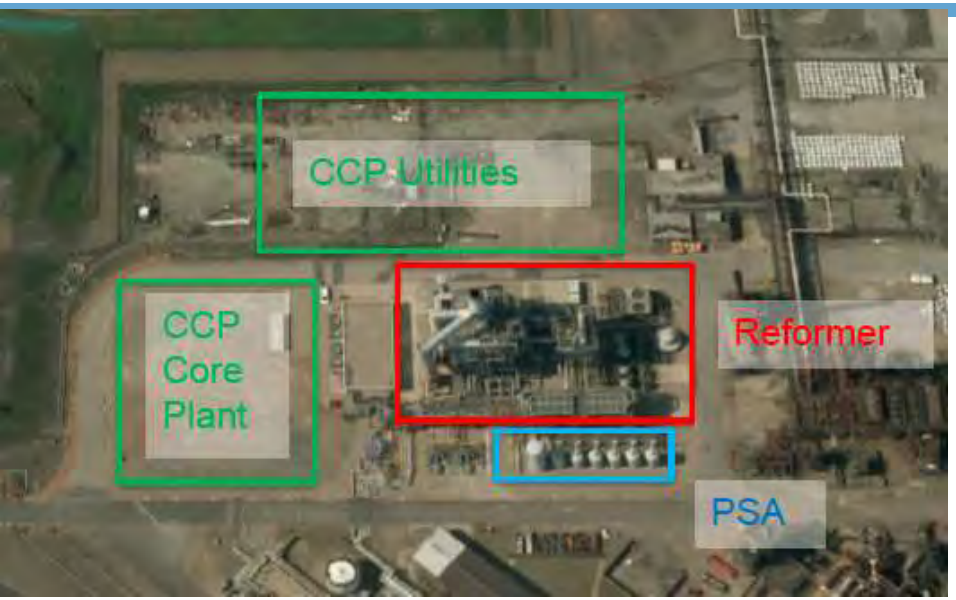
Research Challenges

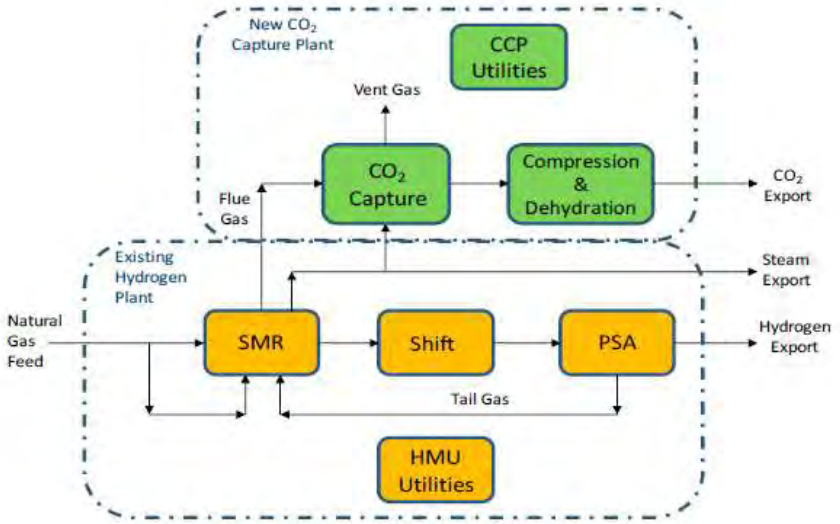
Technology choice
Pilot plant or full scale
Links with key industries or companies

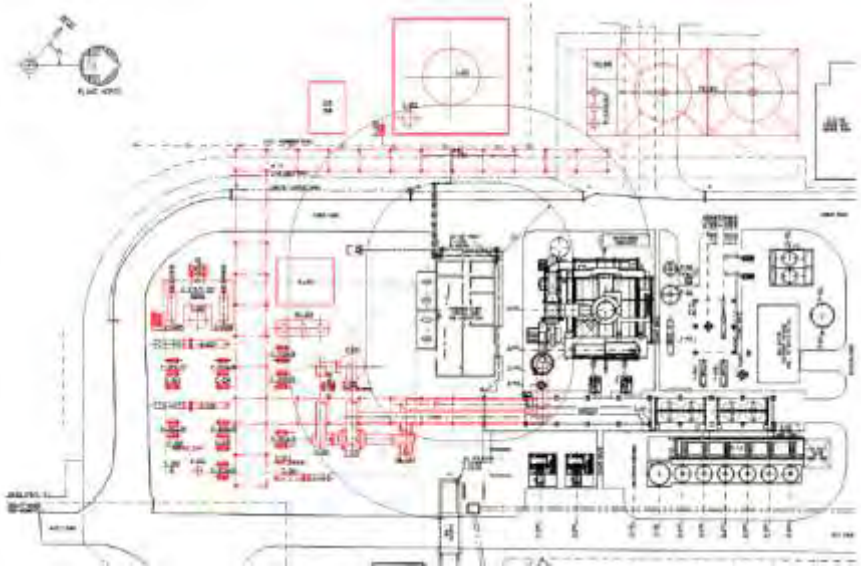
Support business to reach cost effective solutions in required timescales

Drive down the cost curve

BOC Teesside Hydrogen research challenge







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BOC Teesside Hydrogen research challenge

- CCP Design : Conventional Amine Process (MEA)
- No significant impact on the Hydrogen Plant
- Reforming CO_2 : 21.5 te/h
- Combustion CO_2 : 17.8 te/h
- CO_2 Capture Rate : 305 ktpa
- Total power consumption of the CCP : 5.9 MW
- Specific power consumption : 0.166 MWh/te CO2
  0.61 MWh/te Carbon
- Estimated TIC £55.1m
- OPEX (fixed + variable) : £4.66m/year (estimated) plus power & utility
- Overall Schedule : ~58 months from start of pre-FEED to RFSU.

Summary - Beat that

In a constructive collaborative and timely manner

Back up slide

- TH2 PFD
- List optional tech choices

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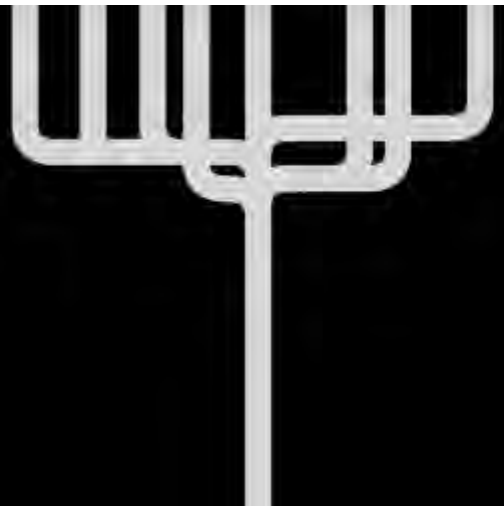

BOC

Member of The Linde Group

Pale Blue Dot.

Overview of the Teesside Collective Industrial CCS Project and respective insights on overall network issues

Tim Dumenil

UKCCSRC Workshop – Research Challenges in Industrial CCS
7th September 2015

Agenda

- Introduction
- Project Objectives and Overview
- Infrastructure Requirements
- ICCS Value Chain & Support Mechanism
- ICCS Business Case Output
- Next Steps for Teesside
- Key Insights for Industry and Research Challenges

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Delivering advice in three key areas

We help organisations of all sizes to **create opportunities** and **mitigate risks** arising from major changes in the energy markets.

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TVU Objectives

Tees Valley unlimited → TEESSIDE CO2LLECTIVE
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Initiate 2014

- 4 companies from process industry
- Collaboration with DECC/BIS
- Experienced advisors
- Concept studies complete

Influence 2015+

- Targeted engagements in 2015 and beyond
- Re-branding
- Commercial mechanism
- Business case

Implement 2015+

- Developing *Next Steps* plan

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Teesside Overview

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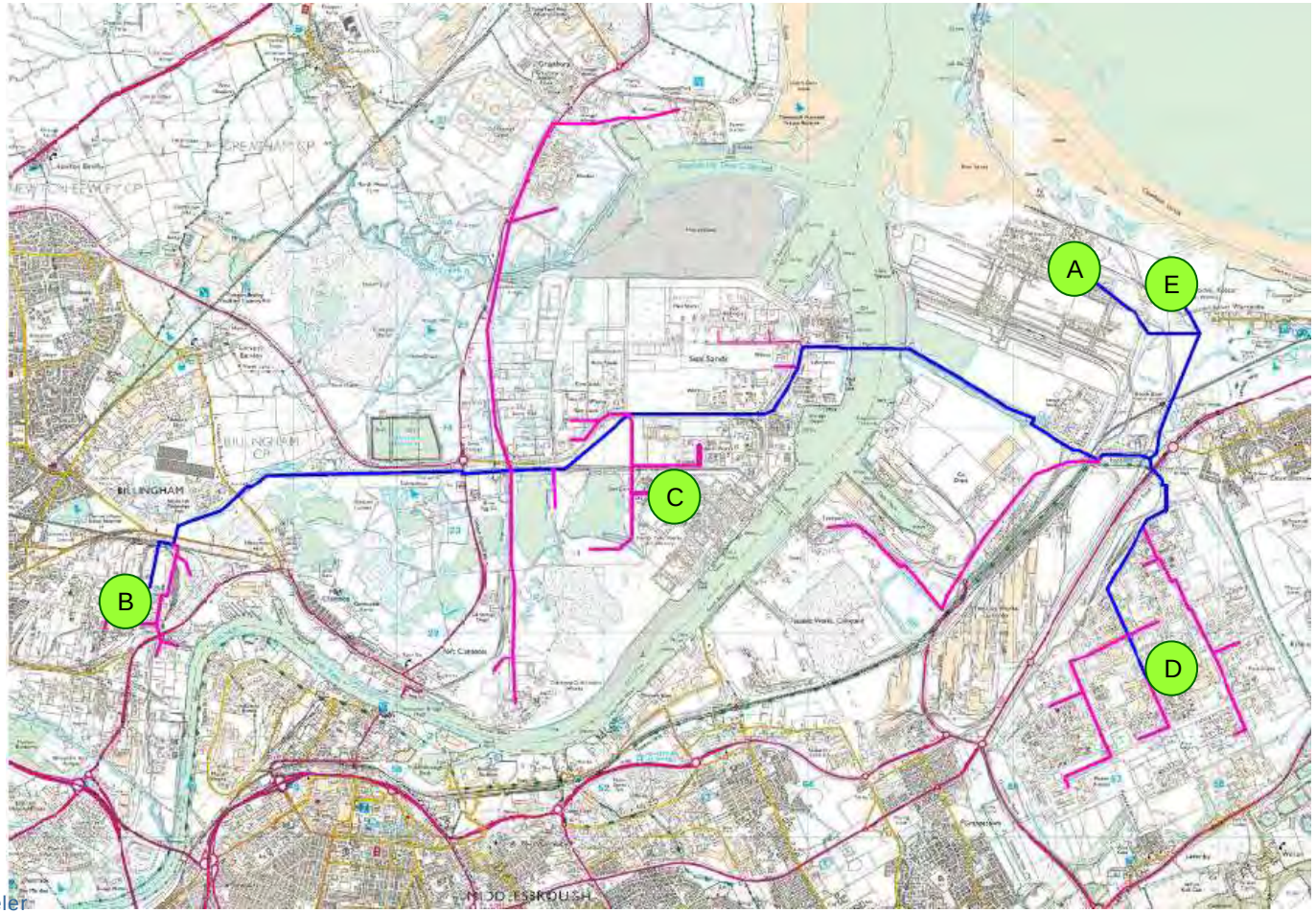
5 major elements to capture, transportation & storage of 2.8 mTpa of CO2
1) Capture, 2) Gathering, 3) Boosting, 4) Offshore Transport, 5) Storage



System Capacity

- 5 mTpa or
- 15 mTpa

Storage Solution

- Bunter 154km
- Captain 433km

Image Source:
Amec Foster Wheeler

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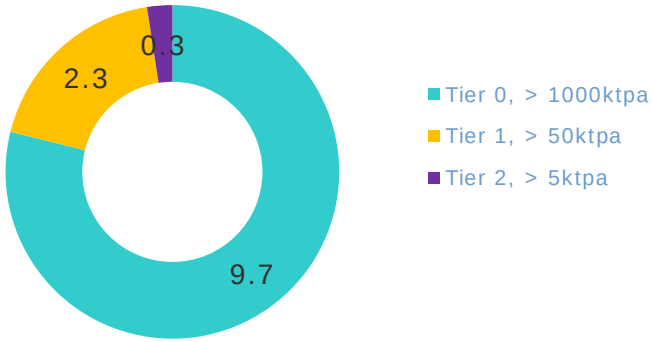
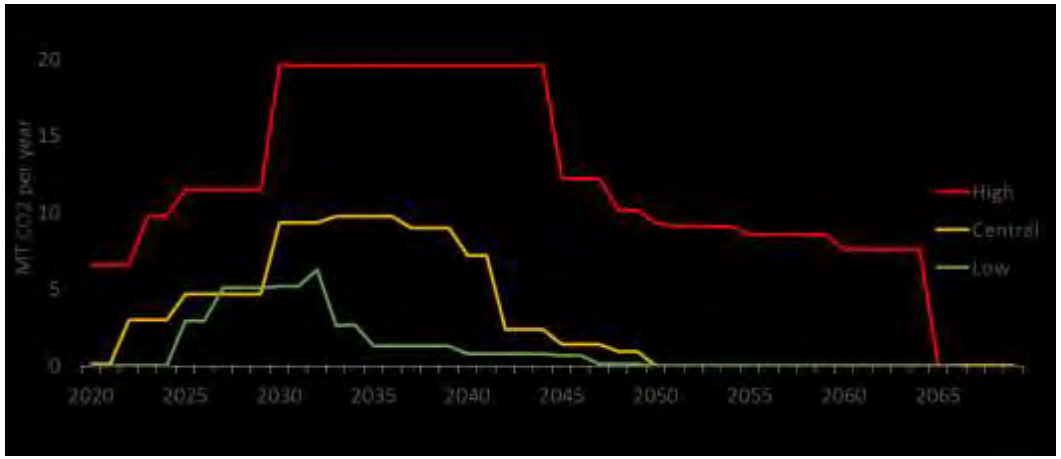
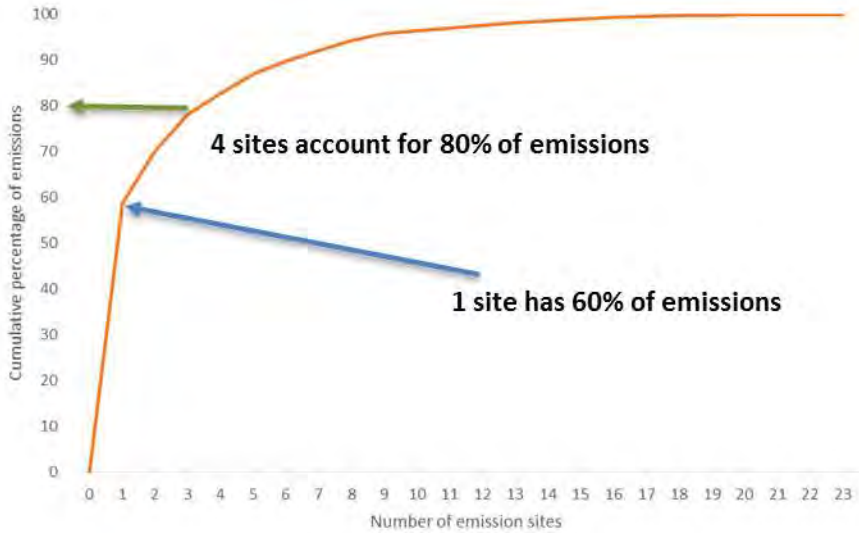
Estimating Infrastructure needs

12Mt CO2 currently emitted







- Multiple sources of CO2 supply
- CO2 volumes variable
- Longevity of the businesses
- Importance of timing of an acceptable ICCS investment mechanism

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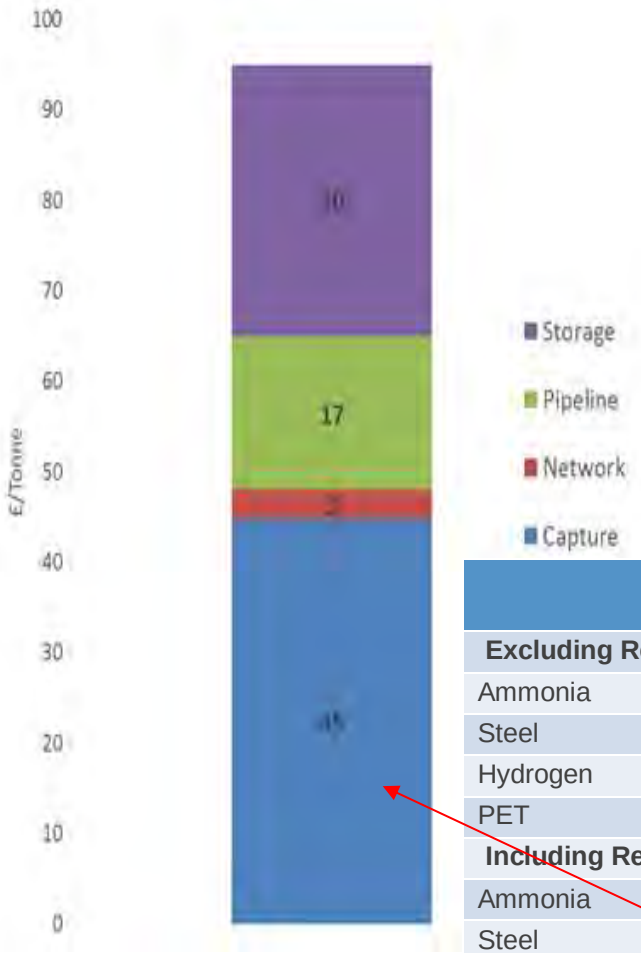
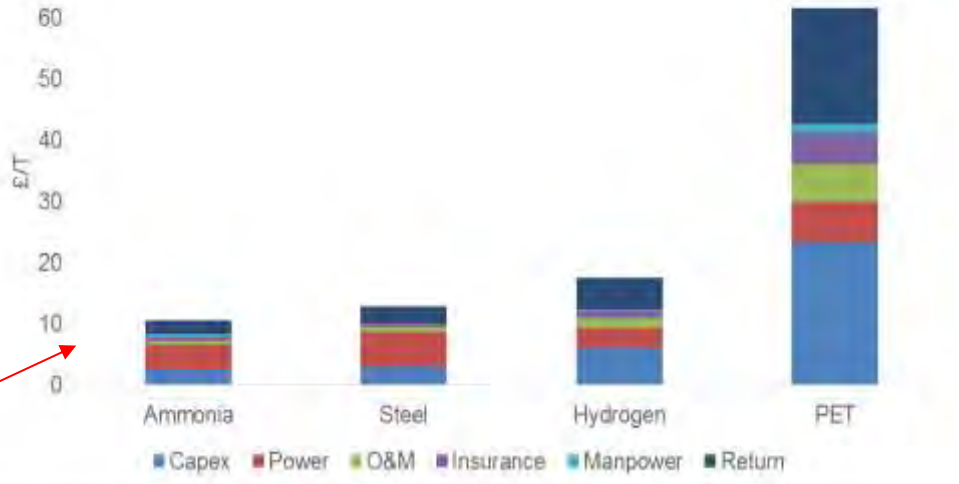
Business Case Output



Teesside ICCS is technically & economically viable:

- Scenario discounted capex cost ranges £0.8-£2.1bn
- Over 20 years the entire ICCS Chain for the Reference Scenario requires undiscounted financial support of £5.4bn (£1.5bn PV_7) equating to **£95/T** for 56.5mT CO_2 stored. (13% IRR. 7% Discount Rate)
- Capture 47%, Gathering 3%, Offshore 50%
- Trebling the infrastructure only requires an additional 8% of support (£104m)

	Financial Support (£/T over 20 years)	
Excluding Return	Undiscounted	PV7
Ammonia	25.5	8.4
Steel	30.5	10.1
Hydrogen	34.8	12.4
PET	116.7	42.8
Including Return	Undiscounted	PV7
Ammonia	37.4	10.5
Steel	45.3	12.7
Hydrogen	61.6	17.5
PET	214.9	61.6



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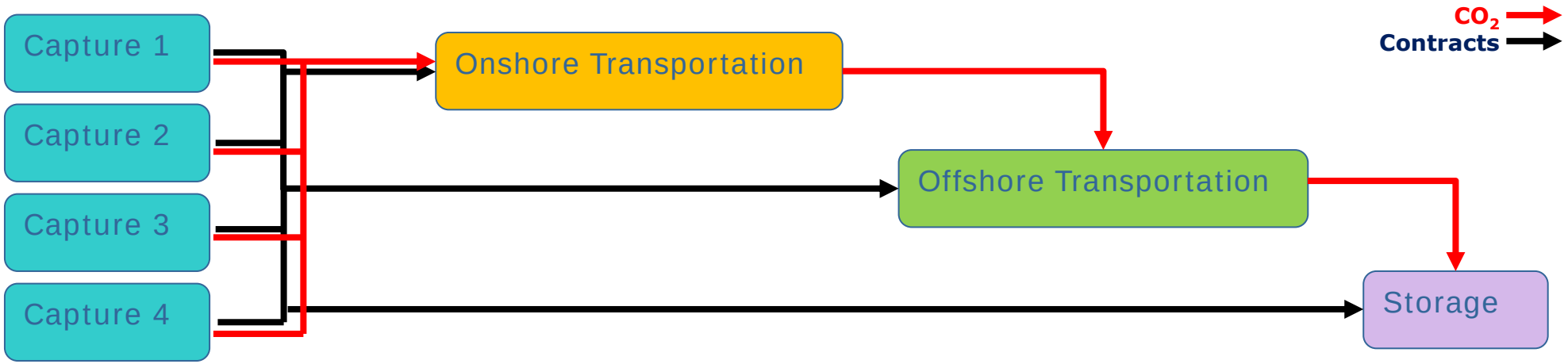
ICCS Value Chain – initial thoughts

- Disaggregated model
  - Each emission site will require a capture facility, which may be operated by the process company, or someone else
  - Onshore transportation of gases is commonplace & many interested players
  - Offshore transportation of gases is also commonplace but fewer players
  - Very few players in storage domain
  - Several variations all with multiple players, which adds commercial complexity



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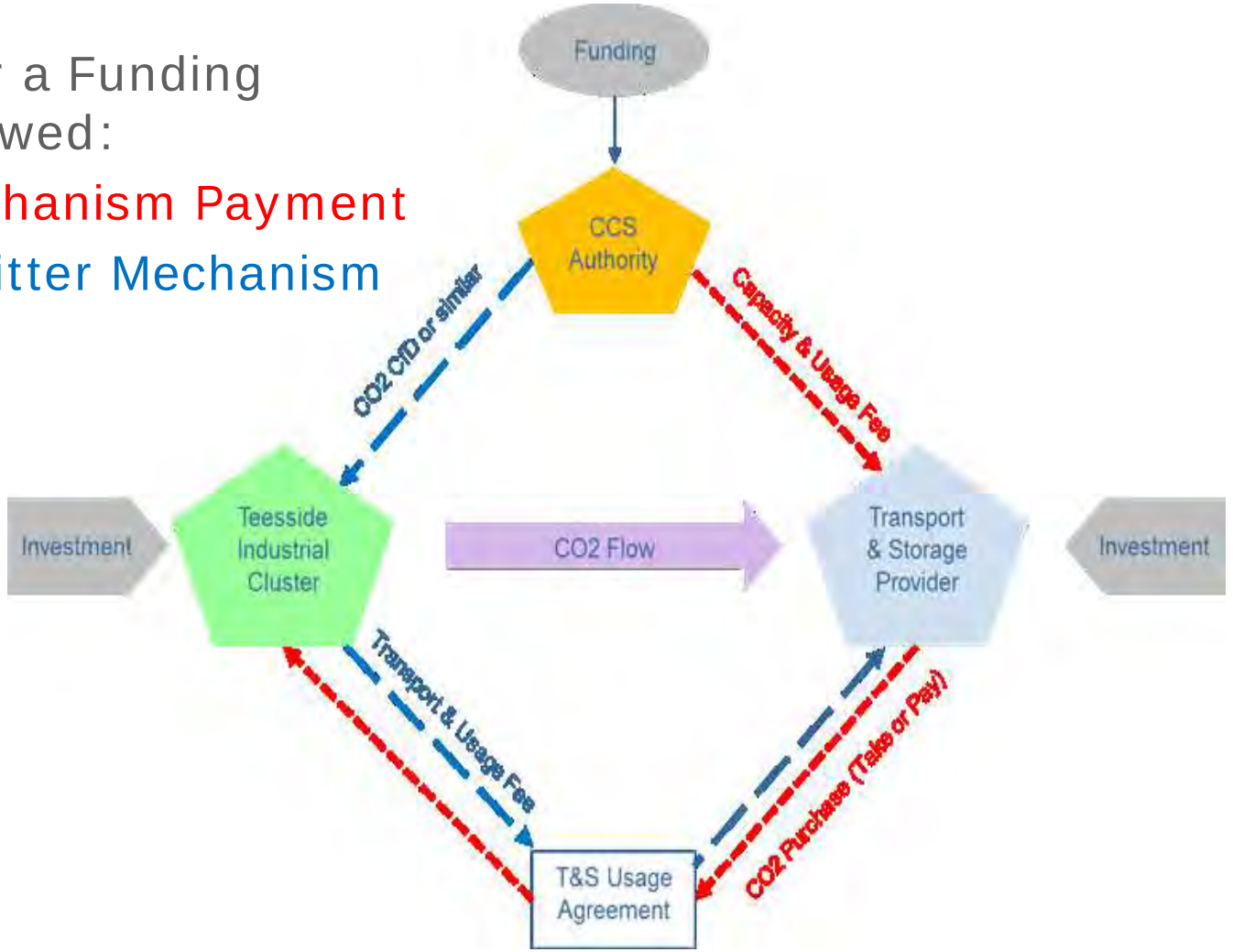
Commercial Support Mechanism

Three options for a Funding Mechanism reviewed:

- a Storage Mechanism Payment
- a CO_2 CfD Emitter Mechanism
- a hybrid



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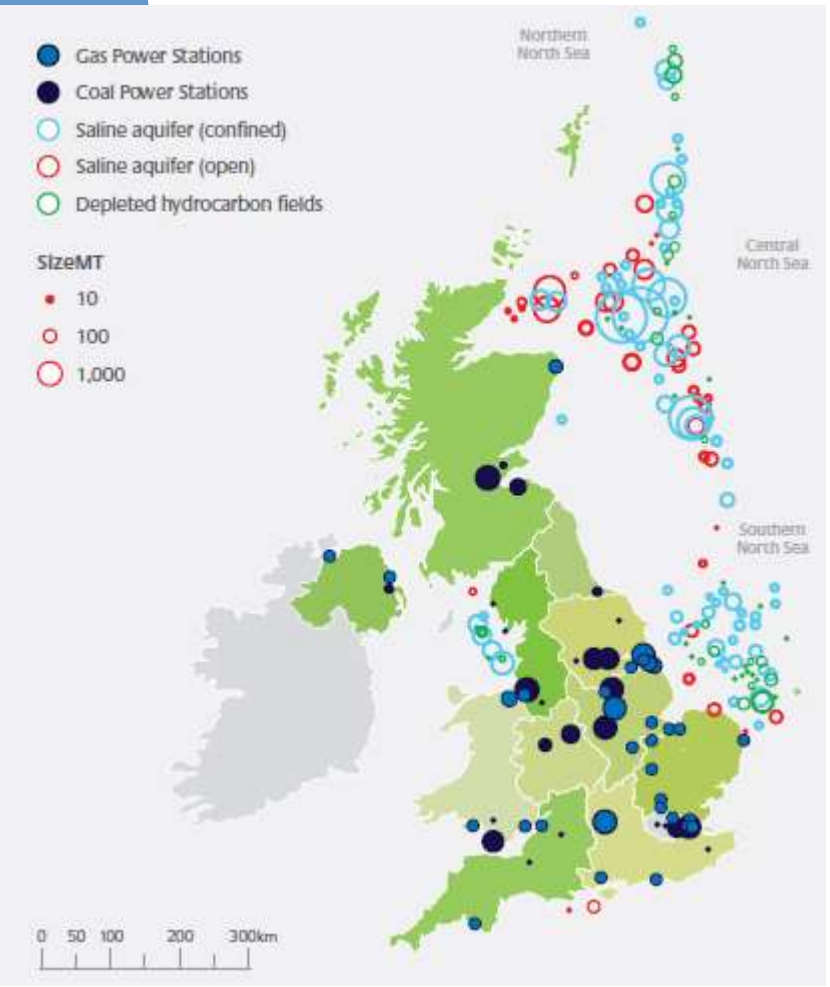
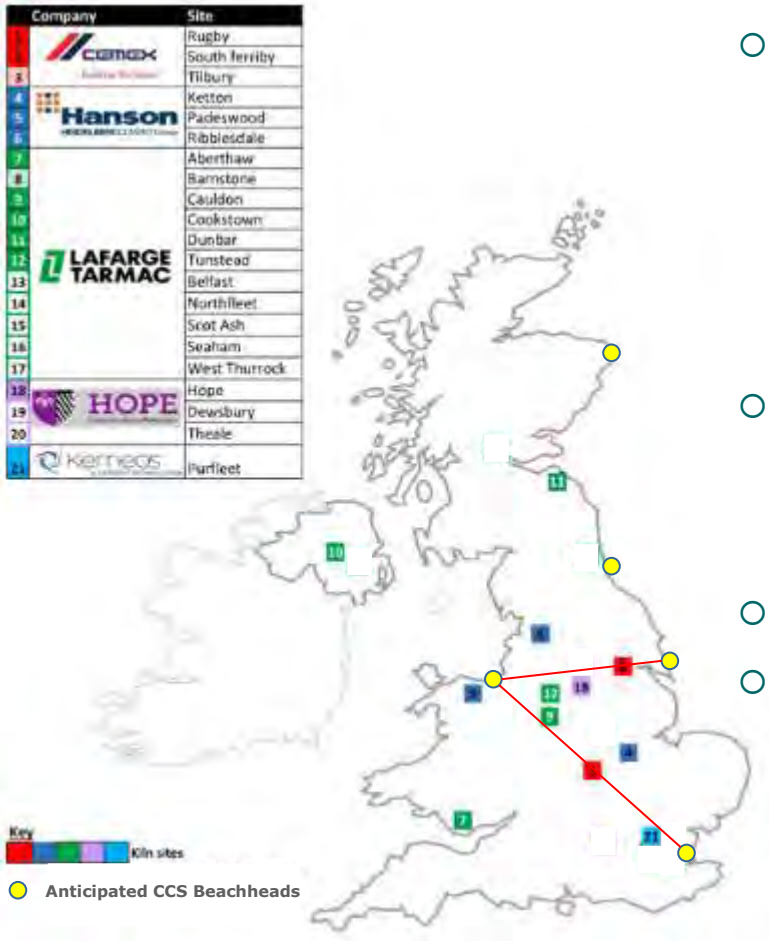
Cement Industry: CCS is core to Carbon Strategy





- CCS Progress
  - Capture via 2 options √
  - Oxyfuel at €50/T CO_2
  - Storage??
- Scale of Factory
  - 1-2 mT
  - 10 mT
- Regional Solutions
- CCS Cost in relation to Cement Cost

Image Source:
ETI and MPA

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Summary of Key Network Issues

- TC, structure and contracted partners worked very well
- Perceptions for Risk & Return (0 to 25+% range)
- Ownership
- Full Chain Costs: 50% Capture, 50% Transport & Storage
  - Lots done and known on capture. Cost reduction??
  - Transport & Storage??
    - Appraisals, Risk reduction, Cost reduction
- Commercially more complex versus a single full chain power station project
  - Multiple sources, vastly differing scales, cross-chain liabilities
  - Increased risk of commercial carbon leakage
  - Multiple players add complexity to risk allocation & financing
- Financial support needs are significant. Commercial mechanism attractive to global corporations
- Getting started

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Summary of Research Challenges

- Is a cement kiln operation viable on Teesside and if so at what capacity?
- Where else can collaboration across the high emitter sectors of Cement, Power, Refineries and Steel deliver gathering network solutions?
- Will consumer accept CCS? What is societal thinking about the risks and cost/value of carbon. How much will Governments & Public be prepared to pay for Low Carbon Solutions?
- What IRR will be acceptable for each element of the chain?
- What will make Transportation and Storage less risky?
- Can further significant cost reduction be achieved on Capture?
- Can further storage appraisal lead to major cost reduction?
- What funding mechanism will be politically acceptable?

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