White Rose CCS Project

Overview Presentation: March 2014

Use of this Slide-pack

- This slide-pack is developed by Capture Power Limited to act as a basis for presentations/ communications regarding the project at pre-agreed events by CPL or the Top Four Sub-Contractors: Alstom, BOC, Drax or NGCL.
- The slide-pack is amended on a regular basis to reflect updates and new material developed over the course of FEED
- The slide-pack is developed and managed by the CPL Knowledge Manager; **any updates or significant changes must be approved by the CPL General Manager** and DECC notified.
- Any incorrect information should be flagged immediately for correction and any additional slides required should be requested for inclusion to the Knowledge Manager.
- CPL maintains a list of KT Events, which will be located in the Team Sharepoint on KT. Any additional events at which CPL or its Partners are speaking should be added to this register and a notification sent to the Knowledge Manager.

‘Carbon Capture and Storage (CCS) has the potential to be one of the most cost effective technologies for decarbonisation of the UK’s power and industrial sectors, as well as those of economies worldwide’

CCS Roadmap

Department for Energy and Climate Change

Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- Benefits
- Summary

Project Snapshot

- A new modern ultra-supercritical 426MWe (gross) Oxy-Power Plant
- Located at the Drax Power Station Site, Selby, North Yorkshire
- Clean power generated for the equivalent needs of 630,000 homes
- 100% of flue gas treated, 90% CO2 capture rate → 2 million tonnes CO2/year
- Biomass co-firing leading to zero - or negative - CO2 emissions
- Anchor project for National Grid's regional CO2 transport & offshore storage network
- CO2 to be permanently stored in a deep saline formation offshore, beneath the North Sea

Largest Oxy-combustion CCS Commercialisation Project Worldwide

Project Status

- Preferred Bidder in the UK's £1Billion CCS Commercialisation Programme
- FEED Contract awarded - signed by the UK Government on 20th December 2013
- FEED underway: detailed risk reduction and planning programme leading to financial close, FID and construction commencement.
- Continuing work with the UK Government (DECC) towards Project Contract and Contract for Difference (CfD)
- NER 300 application: Sponsored by UK Government; only CCS project in the NER competition with EIB due-diligence on-going
- Re-engaging with funding community after strong interest shown during the pre-FEED phase

White Rose on track for a Final Investment Decision end 2015

Project Objectives

- To demonstrate Oxy-combustion CCS technology as a reliable, flexible, and competitively priced low-carbon technology
- To help reduce CO2 emissions in order to meet future environmental legislation and to combat climate change
- To improve the UK's security of electricity supply by providing a coal-based low-carbon electricity generation option
- To generate enough low carbon electricity to meet the energy needs of more than 630,000 homes
- To act as an anchor project for the development of a CO2 transportation and storage network in the UK's most energy intensive region

Project Timescales:

• FEED/Risk Reduction Phase ~ 2 years	End 2015
• Construction	~4 Years
• Start-Up / Commissioning	~2019
• Commercial Proving and testing	1 – 3 Years
• Full Commercial Operations commencement	~ 2021 - 2023

Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- Benefits
- Summary

The White Rose Developers

Sponsors

Delivery

A Strong Industrial Consortium

CAPTURE POWER

ALSTOM

- A global leader in the world of power generation, power transmission and rail infrastructure
- A pioneer in large-scale and efficient CCS technologies

drax

- Owner & operator of the UK's largest, cleanest, most efficient coal-fired power station; 7% of the UK's electricity needs
- Produces more renewable power than any other UK facility
- Committed to reducing Drax & UK power generation carbon footprint

BOC
A Member of The Linde Group

- The largest provider of industrial gases in UK
- A member of The Linde Group, a world leading gases and engineering company

nationalgrid

- An international electricity and gas company and one of the largest investor-owned energy companies in the world
- Expert in running high pressure natural gas system in a safe, reliable and efficient manner

CAPTURE POWER

Power Station Location

Location: Drax Power Station, North Yorkshire, UK

Partner Roles

OXY-POWER PLANT & CO_2 TRANSPORT & STORAGE

CAPTURE POWER

- Full-Chain Integration

nationalgrid
Carbon Ltd

Alstom

- Development & Delivery of Oxy-Power Plant (excl. ASU)
- Integration of Oxy-Power Plant

Drax

- O&M (Lead Operator) of Oxy-Power Plant (excl. ASU)
- Trading Services
- Site Services
- Fuel Supply
- Electrical Connection

BOC

- Design & Delivery of ASU
- O&M of ASU

- Development & Delivery of Transport & Storage network
- O&M of Transport & Storage network

Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- Benefits
- Summary

Partner Objectives – Oxy-Power Plant

- Alstom having validated Oxy-combustion CCS technology at pilot-scale is seeking to demonstrate technology's efficiency and value on a large scale demonstration project
- Drax is actively looking for possibilities to reduce CO_2 emissions and recognises CCS as an essential medium to long term decarbonising solution for existing and new-build coal-fired power plants
- BOC is seeking to demonstrate efficient large scale air separation units to meet the needs of future Oxy-combustion projects
- With these aligned objectives, Drax, Alstom and BOC joined forces to develop the White Rose Project at the Drax site
- Upon demonstration, Alstom & BOC will be able to commercialise Oxy-combustion technology for full scale applications

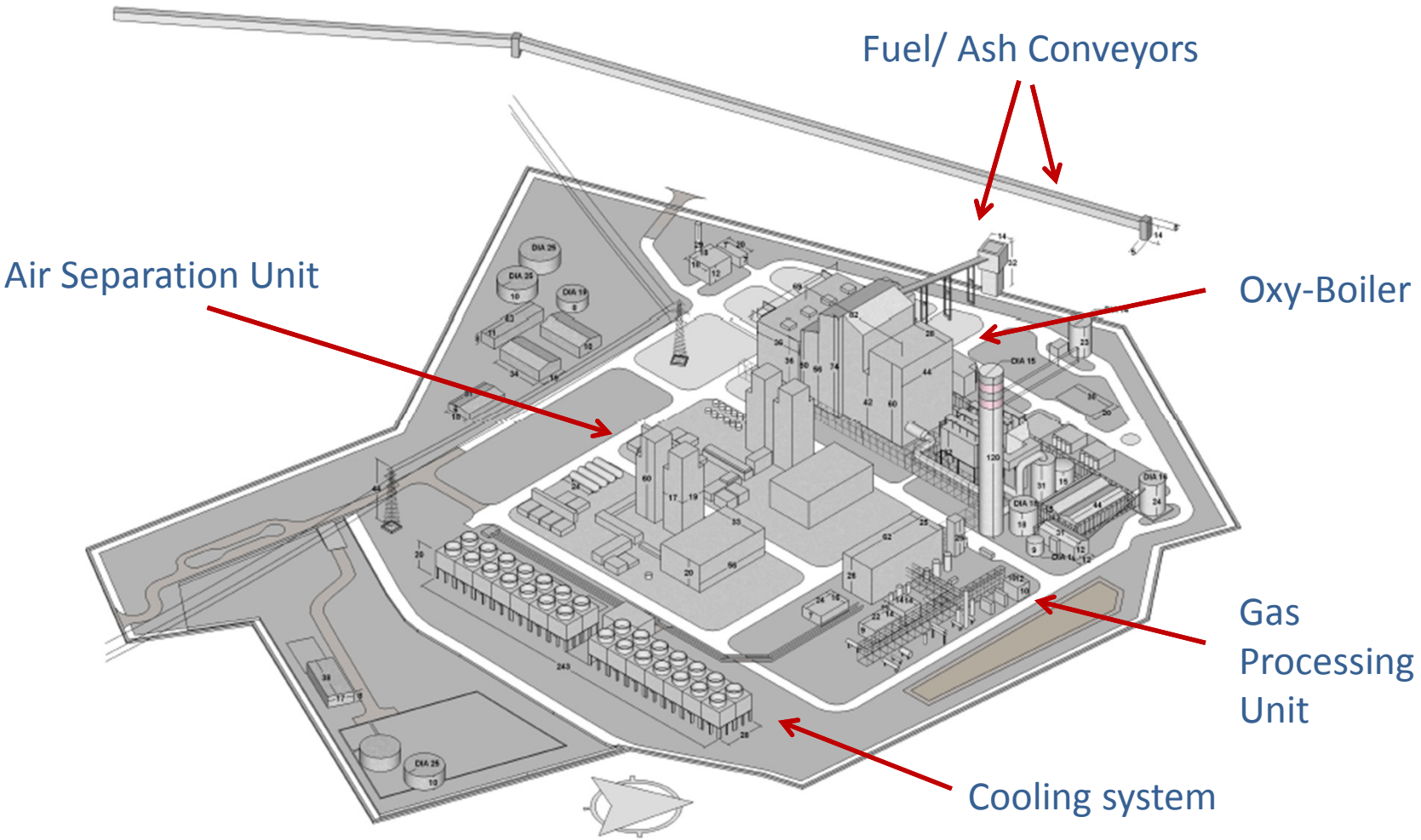
Why Oxy-Combustion?

- Oxy-combustion is very similar to existing air-fired operation and is developed from well-known systems and processes
- The air and gas separation units have already been developed as part of other industrial processes
- Compared to post-combustion technologies, oxy-combustion does not require large quantities of chemicals new to the power plant environment for CO_2 removal
- Quantities of gaseous emissions (NOx and SOx) released into the atmosphere are very low
- Oxy-combustion has the potential to be retrofitted to existing plant if sufficient land is available
- The technology has been proven through pilot projects around the world

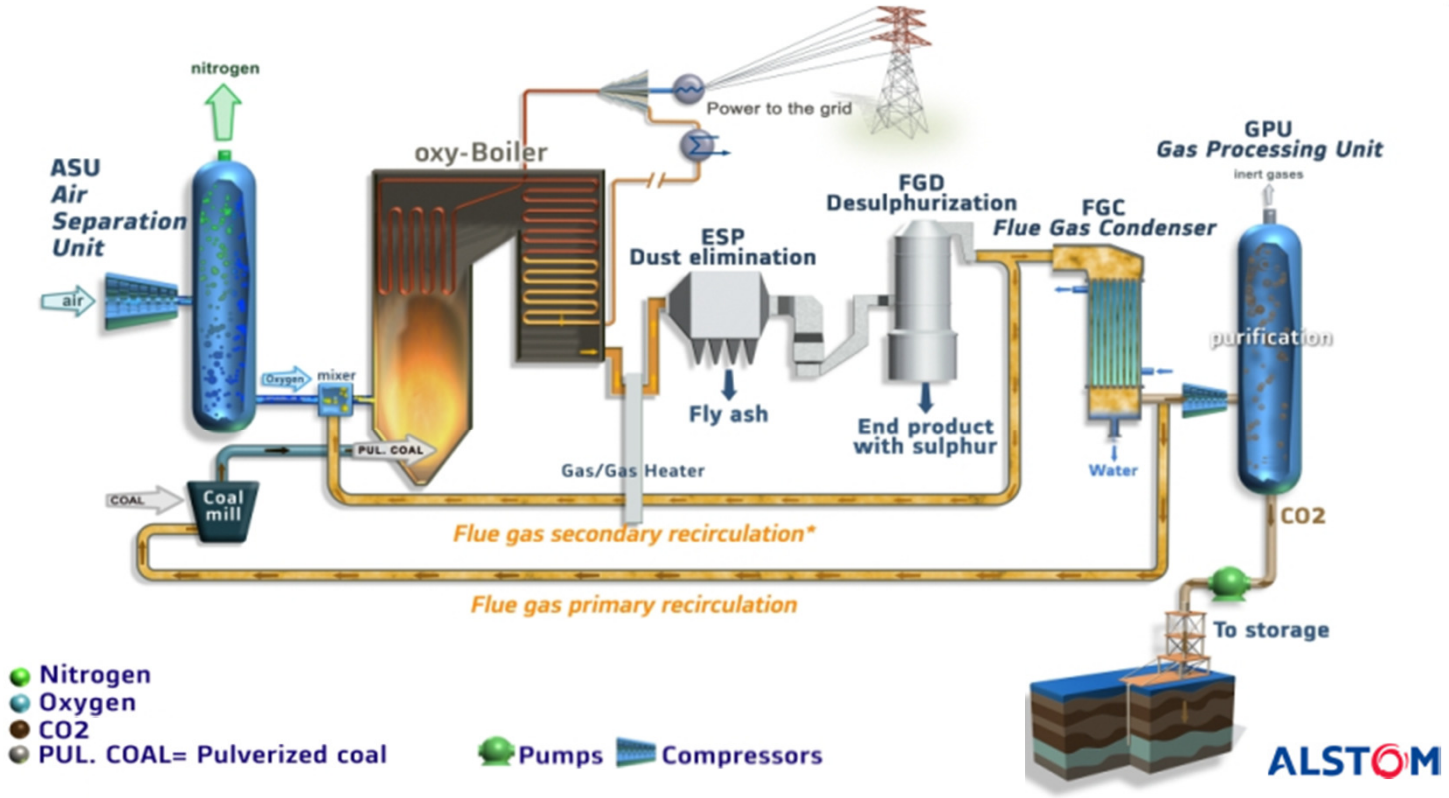
About Oxy-Combustion

- The oxy-combustion system for CCS entails:
  - Using oxygen mixed with recycle CO_2-rich flue gas instead of air for the combustion process
  - Nitrogen is eliminated from the system leading to flue-gas consisting largely of CO_2 and water
  - This flue-gas is further treated and compressed before being transported for storage
- The process requires additional units to conventional coal-fired power stations:
  - An Air Separation Unit (ASU) which produces near pure oxygen from air; and
  - A CO_2 processing unit , the Gas Processing Unit (GPU) to treat and compress the captured CO_2 to meet pipeline specification
- Some modifications to the power plant are also necessary:
  - CO_2 rich flue-gas is partially recycled to maintain the required temperature and heat absorption rates in the boiler
  - Water is removed from the flue-gas before treatment in the GPU
  - Air leakage into the boiler and flue-gas system has to be minimised

Oxy-Power Plant Components



Oxy-Combustion Technology



- Reliable: main components exist; drawing on high degree of conventional technology
- Fuel Flexibility: applicable for all types of boilers, firing systems and fuels
- Scale-up: no constraints anticipated for commercial units based on Schwarzepumpe pilot
- Emissions: No new chemicals introduced to the power plant

Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- Benefits
- Summary

CO_2 Transport & Storage National Grid
Summary

Transport Development

- Onshore route planning
  - public consultation completed
- Offshore route planning on-going

Off-shore pipeline

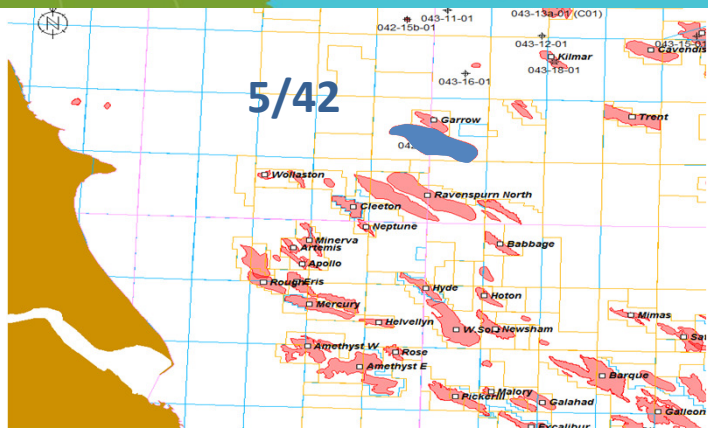
- Route corridor identified
- Surveys complete

Storage Development

- Regional assessment completed
- Block 5/42 identified prime target, 2012 UKs first CCS License

Store Appraisal

- 1st Appraisal well drilling completed (summer 2013) with positive initial results



National Grid – Humber Cluster

CCS Cluster Development

- Clusters allow economy of scale (of pipelines and stores) which are key to CCS cost reduction
- The Humber Cluster connects the largest concentration of CO_2 emissions in Europe with a very large, proximate and available store in a Southern North Sea saline formation
  - The White Rose project is expected to provide the anchor load for the Humber Cluster
  - The Don Valley Project (a follow on user) has helped fund Humber Cluster development

National Grid – CO_2 Pipeline

Transport Development

- R&D programme
  - Dense phase programme underway
  - Using anthropogenic CO_2
  - Designed to satisfy safety and consenting requirements
  - CO_2 specification developed to enable use of multiple capture technologies.
- Onshore route planning
  - public consultation completed
- Offshore route planning on-going

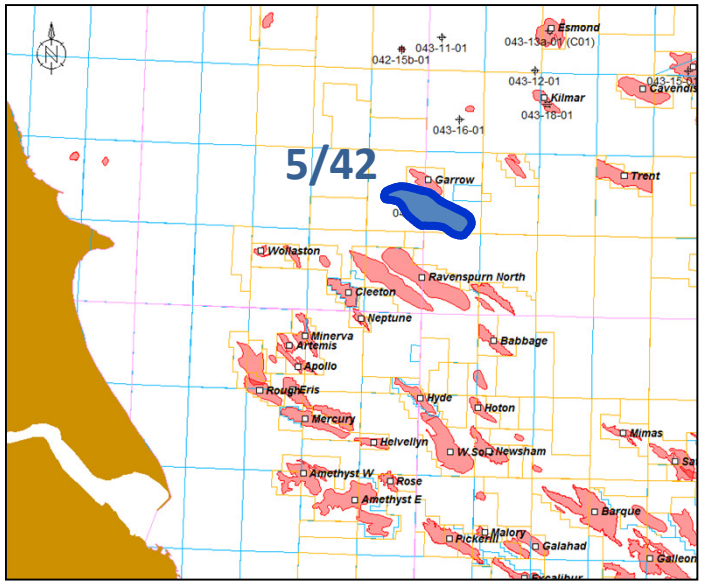
Offshore Pipeline

- Route corridor identified
- Near shore survey completed
- Environmental survey completed
- Geophysical survey completed.

National Grid – Store Identification

Store Selection

- Regional assessment completed
- >250 wells and >23,000 km^2 of seismic data assessed in target area to shortlist key sites
- Technical programme using extensive database identified 5/42 as the prime target
- National Grid secured the UK's first CCS Licence in 2012



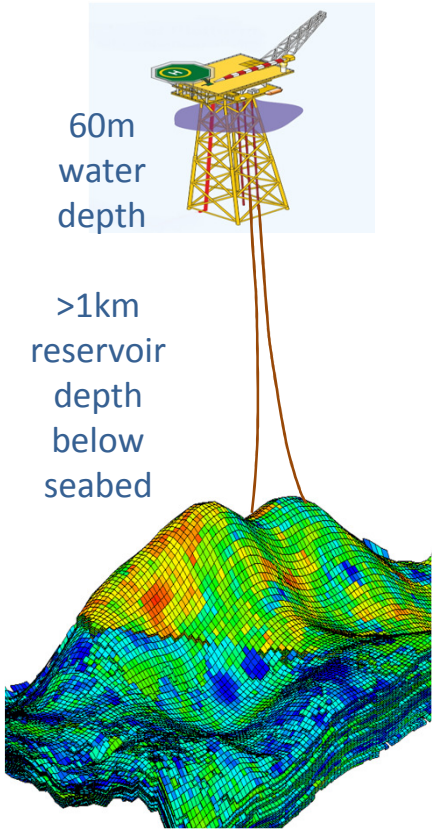
Store Appraisal

- Comprehensive subsurface model used to identify data gaps
- First UK CO_2 specific appraisal well drilled by National Grid in summer 2013 to collect data and samples that confirm the suitability of the 5/42 structure as a CO_2 store

National Grid – Store Development

5/42 Store Development

- 5/42 is estimated to have capacity to permanently store at least 200 Mte CO_2 – well in excess of that captured in the White Rose project
- The initial development is expected be a normally unmanned wellhead tower standing in 60m of water with two CO_2 injection wells
- A detailed store development plan will be agreed with the regulator to secure a storage permit. This will include a monitoring plan to demonstrate permanent storage
- Performance data from the White Rose project will provide valuable information for store expansion to accommodate future Humber Cluster CO_2 volumes



Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- Benefits
- Summary

CCS Commercialisation - Programme

- UK CCS Programme is key to realising the White Rose CCS:
  - A multi-million pound grant funding a portion of the FEED costs
  - A major Capital Grant funding part of the project capex from the £1 billion budget
  - A market support for clean low-carbon electricity generated in the form of a Contract for Difference
- NER 300 via European Commission
  - Would provide supporting revenue during operation

The UK CCS Commercialisation programme and NER funding are essential to take CCS from the demonstration stage to full commercialisation

CCS Commercialisation Objectives

Principle alignment of objectives DECC – White Rose Partners

DECC: "The Government believes that CCS can make an important contribution to the UK's secure, affordable, low carbon future and to global efforts to combat climate change. It is therefore committed to encouraging the development of cost-competitive CCS in the UK and abroad."[1]

- Climate Act 2008: Sets legally binding carbon budgets through 2050 and sees CCS playing an important role.
- CCS Roadmap published in 2012[2]
  - UK CCS Commercialisation Programme £1 bn plus market support
  - EMR supporting all low-carbon with CfD mechanism
  - Removing barriers to deployment of T&S networks etc.
  - CCS as part of the future low-carbon energy mix with at least 10 GW of CCS by 2030

1 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/251005/CCS_CRTF_Govt_Response_and_CCS_Update_15_Oct.pdf
2 https://www.gov.uk/government/publications/the-ccs-roadmap

CCS Commercialisation Objectives

Principle alignment of objectives DECC – White Rose Partners

Capture Power Limited: "Project developers aim to demonstrate the technical and commercial viability and market fit of CCS enabled coal-fired power stations in the future UK electricity market"

- Alstom: White Rose will provide the platform for global deployment of Oxy-CCS.
- Drax: CCS an attractive medium to long term decarbonising solution complementing biomass
- BOC: Deploying efficient large scale ASUs for future Oxy-combustion projects
- National Grid: Developing a regional CO_2 transport and storage infrastructure.

Drax, Alstom and BOC formed Capture Power Limited to develop the White Rose Project teaming up with National Grid for the T&S solution

Delivering CCS Commercialisation

Success is not just realising the White Rose project but seeding an industry. To do this we need:

- Technology that fits the demand dynamics of the future power market
- Competitive LCoE vs. alternatives
- Large scale multi-user CO_2 T&S infrastructure
- Supportive legislation and regulation
- Availability of competitive financing
- Public acceptance

To be successful we need to make the case for CCS in the future power market. One project is not a future.

Index

Overall Benefits

- Investment and Jobs
  - Core Humber Cluster projects will boost UK economy by £1.3bn and generate 4000 skilled jobs to 2020 and 400 permanent long term jobs therafter[1]
  - By 2030 Cluster will increase area's economic output by 0.8% per year, attract up to £11billion foreign investment, support 11,000 jobs' and create 2000 new jobs[1]
  - UK-based CCS industry: between £3 - 6.5bn p.a. nationally by the late 2020s, sustaining between 70,000-100,000 jobs.[2]
- CO_2 reductions
  - Cost of achieving 2050 targets could be £32bn higher by 2050 without CCS[3]
  - CCS could be major contributor to 4th Carbon Budget Period targets (c.a. 119 Mt/a)

CCS bringing investment, jobs and decarbonising UK power

1 CO_2 sense 2012 The national, regional and local economic benefits of the Yorkshire and Humber CCS cluster
2 AEA, 2010, Future Value of Coal Abatement Technologies in Coal and gas power generation to UK Industry
3 ETI The future Role of CCS in UK decarbonisation, G. Day, IMECHE CCS Conference London October 2013

Index

- Project Update
- White Rose Consortium
- Oxy-Combustion
- Transport & Storage
- CCS Commercialisation Programme
- CCS Commercialisation Delivery
- CCS Deployment Timeline
- Benefits
- Summary

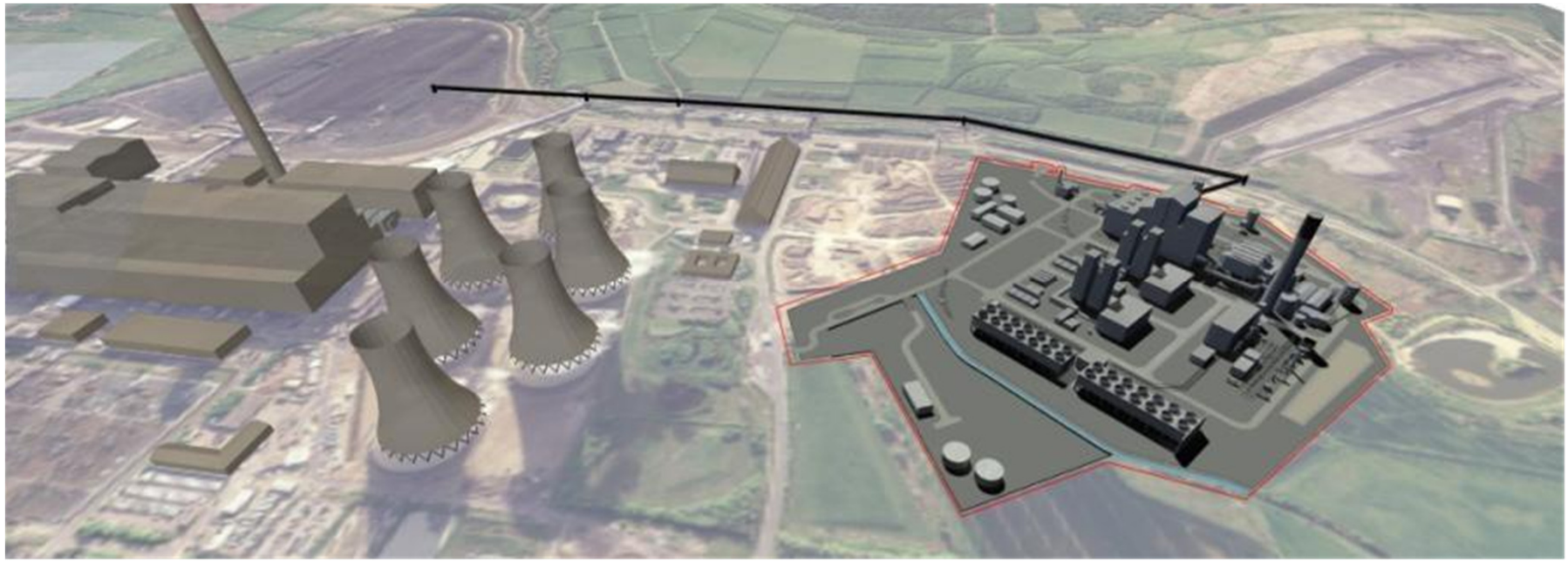
Summary – Delivering the Outcome

The right project at the right time in the right location

- First Class Investors committed to CCS
- Technology – proven needing only full chain demonstration
  - Oxy-fuel capable of flexible power generation (as well as base load)
  - Biomass co-firing to deliver zero or negative CO_2 emissions
- CCS Cluster Development
  - WR is anchor project for National Grid's regional CO_2 transport & offshore storage network
- UK Government enabling through CCS Roadmap and Energy Bill
  - EMR – vital and key to financial viability of WR and long term CCS
- LCOE – Competitive generation
  - CCS can compete with other forms of Low Carbon and compete in real markets

White Rose achieving the Objective: CCS full commercialisation

The Future of Clean Power



White Rose will show that abated fossil-fuel power stations will be able to generate flexible, reliable and affordable power as mid-merit plants, providing security of supply and grid stability complementing base load nuclear generation and intermittent renewables