White Rose Carbon Capture and Storage Project

January 21st 2014

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‘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

Project Snapshot

- A new modern ultra-supercritical up to 450MWe Gross Oxy Power Plant
- Clean power generation with the entire flue gas treated to capture 2 Million t/y CO_2
- CO_2 to be stored in a saline formation in the southern North Sea
- Biomass co-firing leading to zero (or negative!) CO_2 emissions
- Located at the Drax Power Station Site, Selby, North Yorkshire
- An anchor project for National Grid's regional CO_2 transport & offshore storage network
- Project development activities on-going
- UK CCS Commercialisation Programme (DECC)
  - Project is preferred bidder, and FEED Contract has been signed
  - FEED phase includes negotiation of funding support for the construction (grant) and operation phases (CfD)
- European NER funding application – project nominated for support by UK Government

Largest Oxy-combustion CCS Demonstration Project Worldwide

Our Objectives

- To demonstrate Oxy-combustion CCS technology as a reliable, flexible, and competitively priced low-carbon technology
- To help reduce CO_2 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 CO_2 transportation and storage network in the UK's most energy intensive region

Project Promoters – A Strong 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, reliably and efficient manner

CAPTURE POWER

Partner Roles

Location: Drax Power Station, Selby, North Yorkshire, UK

Project Promoters

Oxy-combustion Power Plant & CO_2 Capture

CO_2 Transportation & Storage

- Alstom
- Drax
- BOC
- National Grid

Why Oxy-combustion?

There are a number of different methods of accomplishing carbon capture and storage on a power station, with Oxy-combustion having a number of advantages:

- 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
- Quantities of additional 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 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

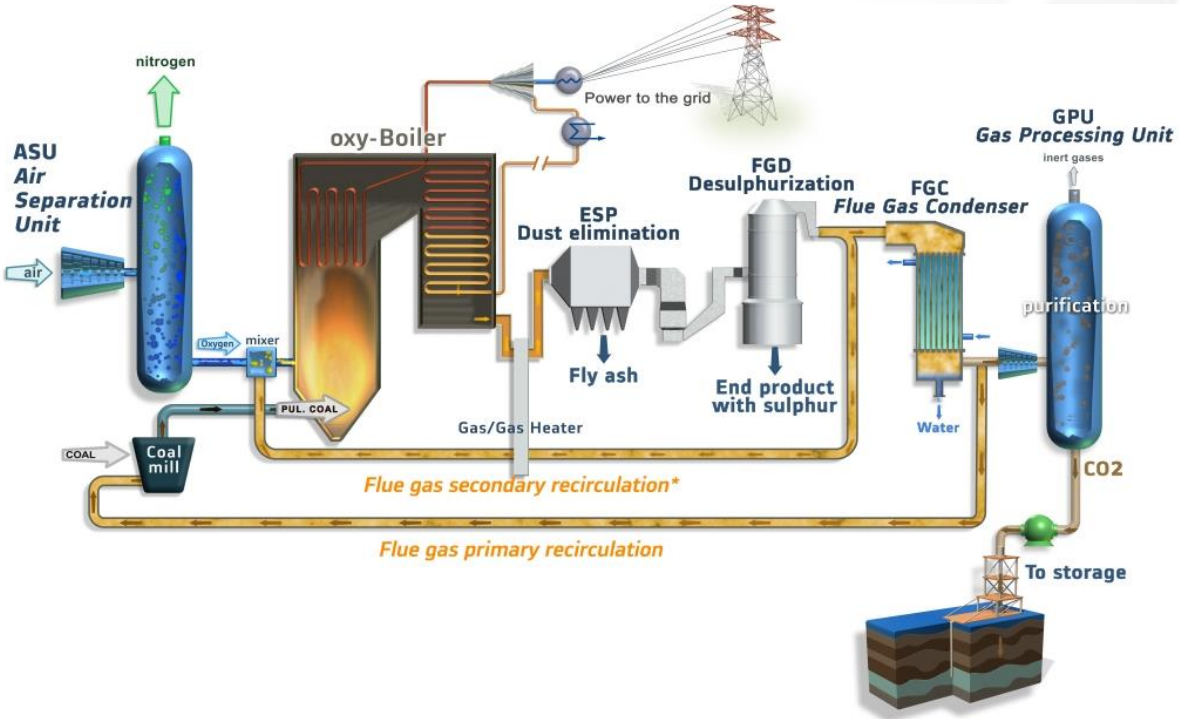
The process requires additional units to conventional coal-fired power stations:

- 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-combustion Technology



Oxy-combustion technology already validated at pilot scale

White Rose Project aims to demonstrate commercial viability at full scale

- Reliable: Main components already exist, requiring adaptation to power and scale-up
- Flexibility: Applicable for all types of boilers, firing systems and fuels
- Scale-up: No constraints anticipated for larger commercial units
- Emissions: No new chemicals introduced to the power plant

National Grid - CO_2 Pipeline Project Status

Transport Development

- R&D programme
  - Vapour phase programme completed
  - Dense phase programme underway
- Onshore route planning
  - public consultation underway
- Offshore route planning on-going

Storage Development

- Regional assessment completed
- 257 wells assessed in target area
- Key sites shortlisted
- Technical programme to identify prime target (two front runners) developed
- 1st Appraisal well drilling completed (summer 2013)

Project Development Status

- DECC public funding and EU - NER submissions under evaluation and negotiation
  - **DECC**
    - White Rose CCS Project selected as one of two preferred bidders
    - Contract signed to support a 2 year risk reduction phase (Dec 2013)
    - Objective is to complete engineering, procurement, commercial framework leading to financial close in late 2015/early 2016
  - **NER** - evaluation will be completed by June 2014
- FEED activities now underway
- Permitting process for the Oxy Power Plant in progress
- Engaged with National Grid Carbon on the project CO_2 Transport & Storage solution development and on the wider Humber cluster
- Demo project Cost of Electricity calculations confirm expected commercial competitiveness of CCS versus other low-carbon alternatives

Outlook

• FEED/Risk Reduction Phase ~ 2 years	End 2015/Early 2016
• Construction	~4 Years
• Start-Up / Commissioning	~2019/20
• Commercial Proving and testing	1 – 3 Years
• Full Commercial Operations commencement	~ 2021 - 2023

End

Why Yorkshire?

A report by CO2Sense highlighted a number of economic advantages to a CCS cluster in Yorkshire and Humberside, including:

- Delivering £1.3bn of investment to the UK and 4,000 skilled jobs
- Increasing Yorkshire and Humberside's economic output by an estimated 0.8%
- Attracting as much as £11bn in foreign investment and a further 11,000 jobs
- A Yorkshire and Humberside CCS cluster has the potential to cut UK carbon emissions by up to 19% and to transform one of the UK's highest emitting regions into one of the cleanest

"This report gives conclusive evidence for the business case for investing in CCS in Yorkshire and Humber. The opportunities for the supply chain – valued at up to £251m – are enormous, as are the potential for inward investment in the area. We want to see the Government back these plans, which will bring so many opportunities for the UK's

CO2sense™ carbon sense 2 commercial sense