Programme Area: Carbon Capture and Storage

Project: Scoping New Thermal CCS Power Station

Title: Stage B Identification of potential sites

Abstract:

This project undertook a desk-top selection and review study, to identify potential sites available for the development of a new low carbon thermal power plant that might benefit from the marginal cost of connection to a carbon sink. Stage A of the study, presented in July 2014, identified a ‘long list’ of possible sites for new power stations, and applied qualitative criteria to highlight sixteen high ranking sites, confirming the potential variety of development locations in the target geographical area. The Stage A report included a commentary on each of the 16 sites, outlining the basis of the ranking scores for these sites and an overall site summary. The individual sites were not highly differentiated in the initial desk top review and are dominated by current or previous generating sites. [Ref 1] This Stage B report presents the outputs of the desktop study related to summary outlines for project development for clean fossil. The study has focused on four technology applications to illustrate potential development approaches at sample regional sites but stresses that these locations are representative of a wider number of similar sites. The study also identifies a number of regional power projects that are ‘indevelopment’ that may have merits for clean fossil deployment and through collaboration could reduce the time-scale for route to market of a part chain CCS project.

Context:

The aim of this project was to scope out a potential ETI Project which would establish an investment proposal for a new, GW scale, carbon-abated, thermal power station, which minimised risk and built on infrastructure which was at the time being proposed in response to the DECC CCS Commercialisation Competition. This scoping exercise had two major components: a review of potential sites where such a station might be built, taking into account existing infrastructure and planned CO2 transport and storage infrastructure; and the development of an investment model to identify the key features of an investable CCS power project. The ETI's ultimate objective was to establish a new investment consortium ready to undertake 'front-end engineering design' (FEED) on a major thermal power station development incorporating CCS (£2bn+ capex). This initial scoping project sought to create a clear view of the structure of that future FEED study, the likely shape of the power project and to identify potential partners.

URS

Stage B

Identification of potential sites

7 October 2014

Rev 4.0

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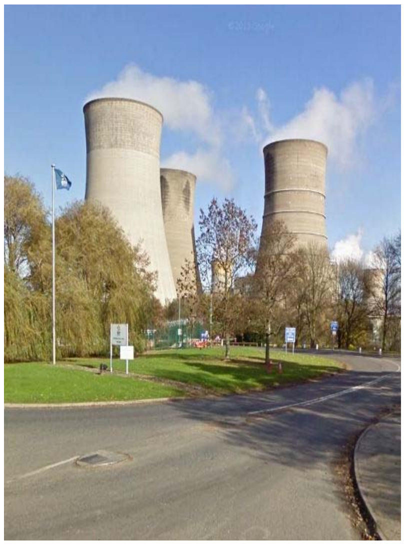
Prepared for:
Energy Technologies Institute

UNITED KINGDOM & IRELAND



REVISION SCHEDULE

Rev	Date	Details	Prepared by	Reviewed by	Approved by
1		First Client Issue for Discussion Only	Emma Bonser EIA Consultant	Richard Lowe Technical Director	Martin Land Business Lines Director, Power
2	27 Aug 2014	Revised Issue for Review			
3	2 Sept 2014	First Formal Issue to ETI	Richard Lowe, Technical Director	Martin Land Business Lines Director, Power	Peter Williams Director, Power
4	7 Oct. 14	Minor Amendments and updated to review comments from ETI (25 Sept)	Richard Lowe, Technical Director	Martin Land Business Lines Director, Power	Peter Williams Director, Power

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1 INTRODUCTION

URS was appointed by the Energy Technologies Institute (ETI) in June 2014 (Consultancy Agreement ref. NHE/CS/URS) to undertake a desk-top selection and review study, to identify potential sites available for the development of a new low carbon thermal power plant that can benefit from the marginal cost of connection to a carbon sink. This scope of works constitutes work package WP1.1 of ETI's 'Incentivisation of Thermal Power with CCS' programme with study output reports at Stage A and Stage B.

Stage A of the study, presented in July 2014, identified a 'long list' of possible sites for new power stations, and applied qualitative criteria to highlight sixteen high ranking sites, confirming the potential variety of development locations in the target geographical area. The Stage A report included a commentary on each of the 16 sites, outlining the basis of the ranking scores for these sites and an overall site summary. The individual sites were not highly differentiated in the initial desk top review and are dominated by current or previous generating sites. [Ref 1]

This Stage B report presents the outputs of the desktop study related to summary outlines for project development for clean fossil. The study has focused on four technology applications to illustrate potential development approaches at sample regional sites but stresses that these locations are representative of a wider number of similar sites. The study also identifies a number of regional power projects that are 'in-development' that may have merits for clean fossil deployment and through collaboration could reduce the time-scale for route to market of a part chain CCS project.

The summary outlines include;

- A reference plot size for four 'standard' technology clean fossil power plant at 1 GW (gross)
- Likely Interface issues related to fuel supply, grid connection and CO_2 transport issues (e.g. routes, key crossings) with a view on their relative significance
- Estimate for the timescales of development and implementation of each 'standard' power station/capture plant
- Outline of CapEx cost models for each technology and development phase costs

  (Note - ETI provided information on nominal cost of fossil power plants with CCS [Ref 2])
- Key risks (to timescale and cost) associated with CCS programme and projects.
- Opportunity, synergies & advantages for fast tracking as alternatives to full new build (desk top assessment only).

The outputs of Stage A and Stage B are designed to inform and assist the ETI in developing the scope and breadth of a 'Project Call' for parties to express interest in advancing a new development and extending the UK programme for low carbon investment.

The report provides a concept summary basis to allow consideration of sensitivity and market testing with potential utility, investment and development parties.

2 STUDY SUMMARY OUTLINE

2.1 Background

In order to consider a Concept case for Clean Fossil development a set of reference parameters has been established for a 1 GW (Gross) power plant and then using the largest footprint 'tested' for spatial and environmental 'fit' at specific locations to illustrate a set of technology/location combination options.

In parallel, a reference development and implementation timeline has been established and tested against the specific combination options including opportunities, synergies and risks.

This is a concept level study and the technical, environmental and project parameters will evolve further in the next phase of feasibility. This study is generic and independent of any specific Owner or vendor. The generic aspect is important to encourage the inclusion and additive proposals during consultation and market testing in advance of a Project Call.

The view of CapEx trends for each technology is based on public domain cost models and is deemed to be appropriate for this initial consideration. In considering progressing development it is important that the data related to development options and investments is generated by the Developer and not by ETI.

The Concept Summary and commentary is based on the following elements;

- Technical Requirement Template
- Location Considerations
- Project Development Aspects

The approach to each of these elements is described in more detail in the sections below.

2.2 Technical Requirement Template

The report identifies a typical template for a 1GW clean fossil power plant for the following four technology solution options;

- Natural Gas fired Combined Cycle Gas Turbines (CCGT) with post combustion capture

- Pulverised Fuel Ultra Super Critical boiler / steam turbine generator (USCPF) with post combustion capture

- Integrated Gasification Combined Cycle (IGCC)

- Pulverised Fuel with Oxy Fuel pre combustion capture

In producing the reference footprint for the four technology solutions, in-house experience, simple comparison with Guidance [Ref 3] and a desktop review of current developments has informed the spatial template. Interface parameters, such as the nominal water demand requirements, grid export and the anticipated mass of carbon captured have been included but this will require further investigation at feasibility stage.

For the consideration of potential sites in the defined region around White Rose, spatial testing was performed using the largest footprint requirement. This is based on 260,000 sq metres (26 Ha) equivalent to a 900 MWe Oxy Fuel power plant. The other technology options generally require less space. It has been assumed that the coal stock areas may be outside this requirement. This is deemed acceptable as the highest ranking sites are adjacent to coal reception and storage facilities.

2.3 Project Development

The report identifies the typical project development parameters with respect to schedule and cost for a new part chain capture plant and seeks to identify any specific opportunities or advantages for a specific technology / location combination.

The overall schedule for development and deployment has been considered as a major new project in accordance with the Consenting and Implementation timescales for a National Significant Infrastructure Project (NSIP). This will require a Development Consent Order (DCO) to be granted by the Secretary of State under the Planning Act 2008.

In the wider context of UK Energy programme, a short commentary on the enabling interfaces has also been included to highlight interactions with broader issues.

The relative costs for technology solutions have been referenced to previous ETI work [Ref 4]. The cost basis is similar to recent DECC UK generation cost models and is deemed to provide an acceptable range of technology costs for the purposes of this desk top study.

The cost impacts of specific technology solutions on individual representative sites is considered at a macro level but in line with a concept study these are indicative drivers and generally remain within the overall band of accuracy of the original work.

A summary risk register has been included to capture a range of current uncertainties at the programme and project level of CCS in UK.

Opportunities for advancing alternative developments, increasing the probability of multiple responses to a call and for further informative study paths have also been identified.

In producing this report we have considered a conservative approach to project development activities, timescales. Opportunities and risks are at a summary level and where necessary assumptions have been recorded.

2.4 Location Considerations

In considering the deployment of technology solutions in the target region, three typical sample locations have been chosen from the ranking list identified in Stage A report. These locations were chosen because they were ranked highest in the Stage A report and/or held specific benefits to the deployment prospects.

The sample locations are intended to test sensitivity of possible development projects **but** must be considered as a representative of a larger group of potential host sites, rather than being specific preferred sites under single ownership. (See Section 2.5)

The specific locations considered for testing technology solution options area as follows;

1. Close coupled to proposed CO_2 network and clean energy power hub. (e.g. Drax)
2. Close vicinity to new CO_2 network with land & redevelopment opportunity (e.g. Eggborough)
3. Proximity to fuel supplies with multiple site locations in an industrialised area. (e.g. Immingham)

NOTE – These are sample sites only, have been subject to desk top study only and do not represent any preference or intent for development. No Utilities or landowners have been approached at this stage.

2.5 Primary and Secondary Geographical Grouping

In the process of developing the Stage A interim and final report, it was increasingly apparent that there is a primary group of potentially viable sites in close proximity to the sink connection at Drax, and then a range of sites with significant potential and similar characteristics within a broader geographical sector that form secondary groups of potential host locations.

The primary group (close proximity) is dominated by existing or planned power station sites, whilst the secondary groups (potential sites) have both power and large industrial sites. We are aware that the secondary groups may include regional or enterprise specific motivation to be involved in a future Project, and therefore are mindful not to exclude them.

For this Stage B report, the characteristics of sample sites at Drax, Eggborough and Immingham are under concept consideration against technical solution options. Immingham acts the 'label' for a range of potential sites in North Lincolnshire that are within the boundary of the original brief, including sites in other secondary sectors. The primary and secondary geographical grouping is illustrated in the Figure 1 below with individual names as example names only.

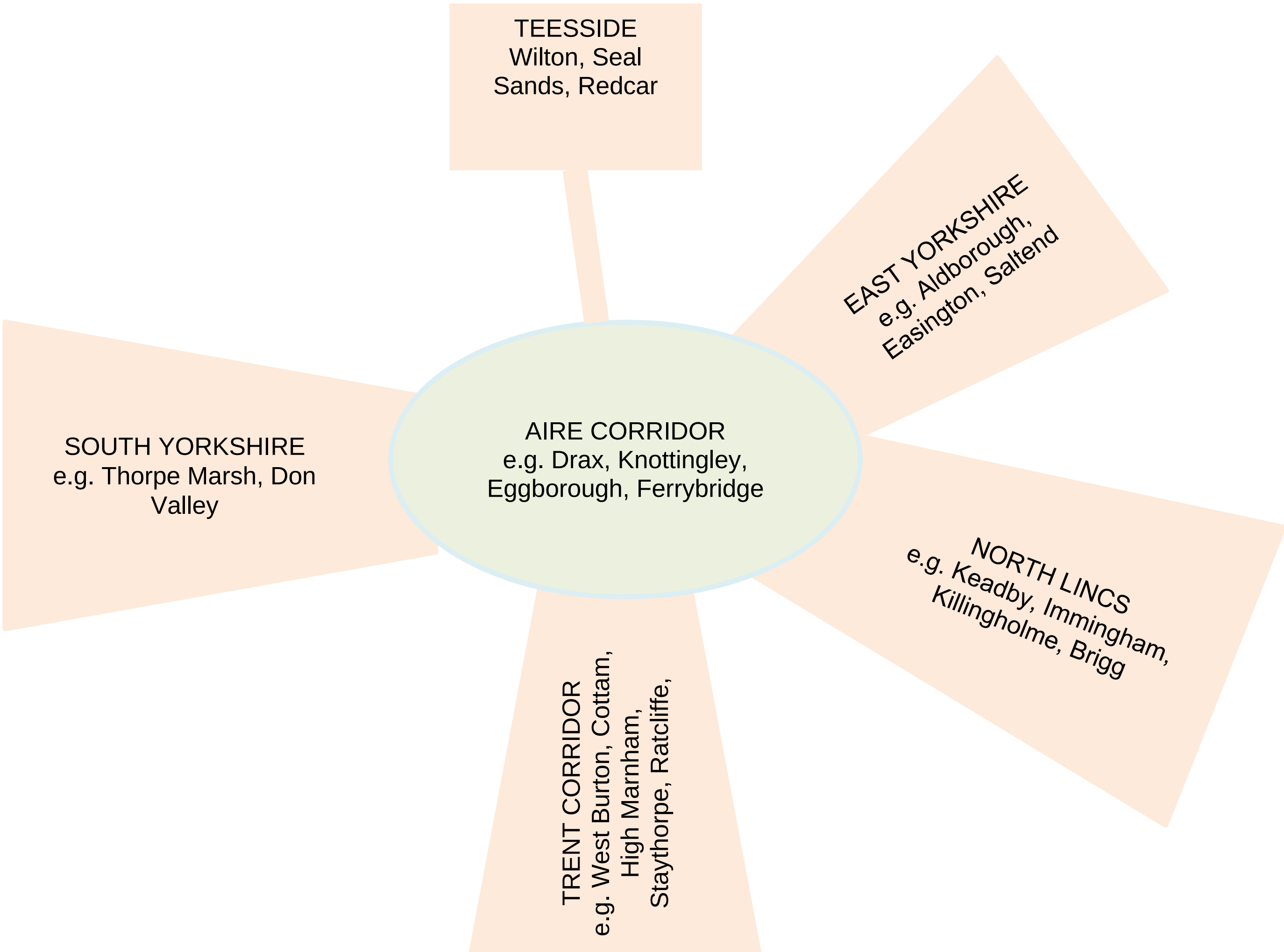

Figure 1 – Primary and Secondary Groupings

2.6 Reference Data for Site and Boundary

The Stage A report reviewed the brief boundary area, with a ‘hot spotting’ approach to identify and geographically capture the ranking criteria. A series of criteria maps were produced and by overlaying these maps the potential development hotspots where identified where interface requirements meet. Not surprisingly there is significant alignment with current and previous major generation sites.

The hot spotting approach is illustrated in the following figures

Figure 2	CO_2 Export
Figure 3	Grid Connection
Figure 4	Potential Availability of Water
Figure 5	Solid Fuel Transportation Corridor
Figure 6	Gas Supply Network
Figure 7	Top ranked screening sites

This generated a desk top ranking list as below with the first, third and fourteenth being chosen for further review;

Stage A Rank	Location	Fuel	Score	Stage A Report Page No
1=	**Drax**	Coal / Gas	24	13
1=	**West Burton**	Coal / Gas	24	17
1=	**Eggborough**	Coal / Gas	24	21
4	**Teesside (sample)**	Gas / (Coal)	23	25
5=	**Thorpe Marsh**	Gas	22	29
5=	**Keadby**	Gas / (Coal)	22	33
5=	**Cottam**	Gas / Coal	22	37
5=	**Ferrybridge**	Coal / (Gas)	22	41
9=	**Scunthorpe**	Coal / Gas	21	45
9=	**Hatfield**	Coal / Gas	21	49
9=	**Brigg**	Gas	21	53
9=	**Stallingborough**	Gas / Coal	21	57
9=	**Kellingley**	Coal / Gas	21	61
14	**Killingholme (sample)**	Gas	20	65
15=	**Novartis (Grimsby)**	Gas	19	69
15=	**Immingham**	Coal / Gas	19	73

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Figure 2 - CO_2 Export

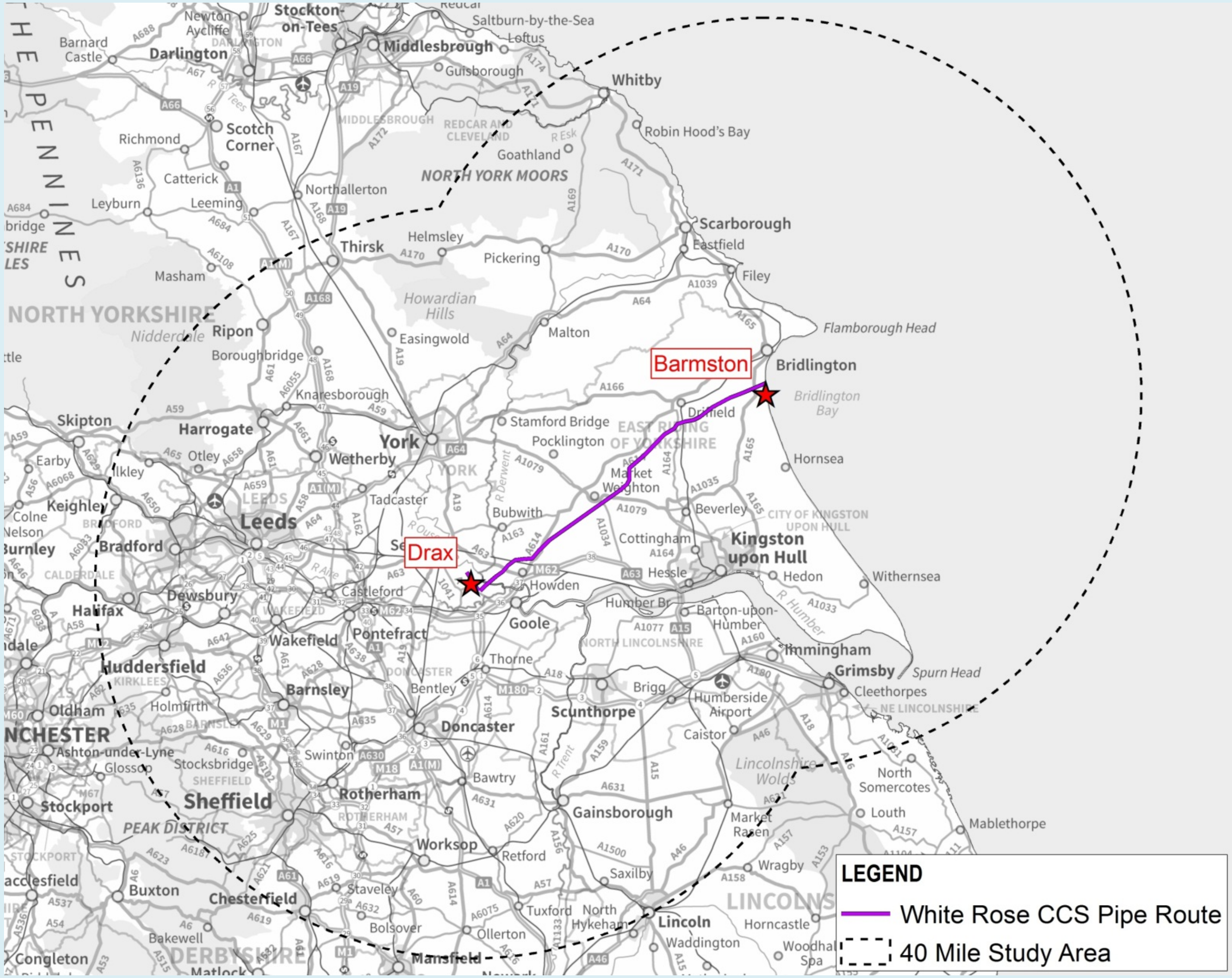


Figure 3 - Grid Connection

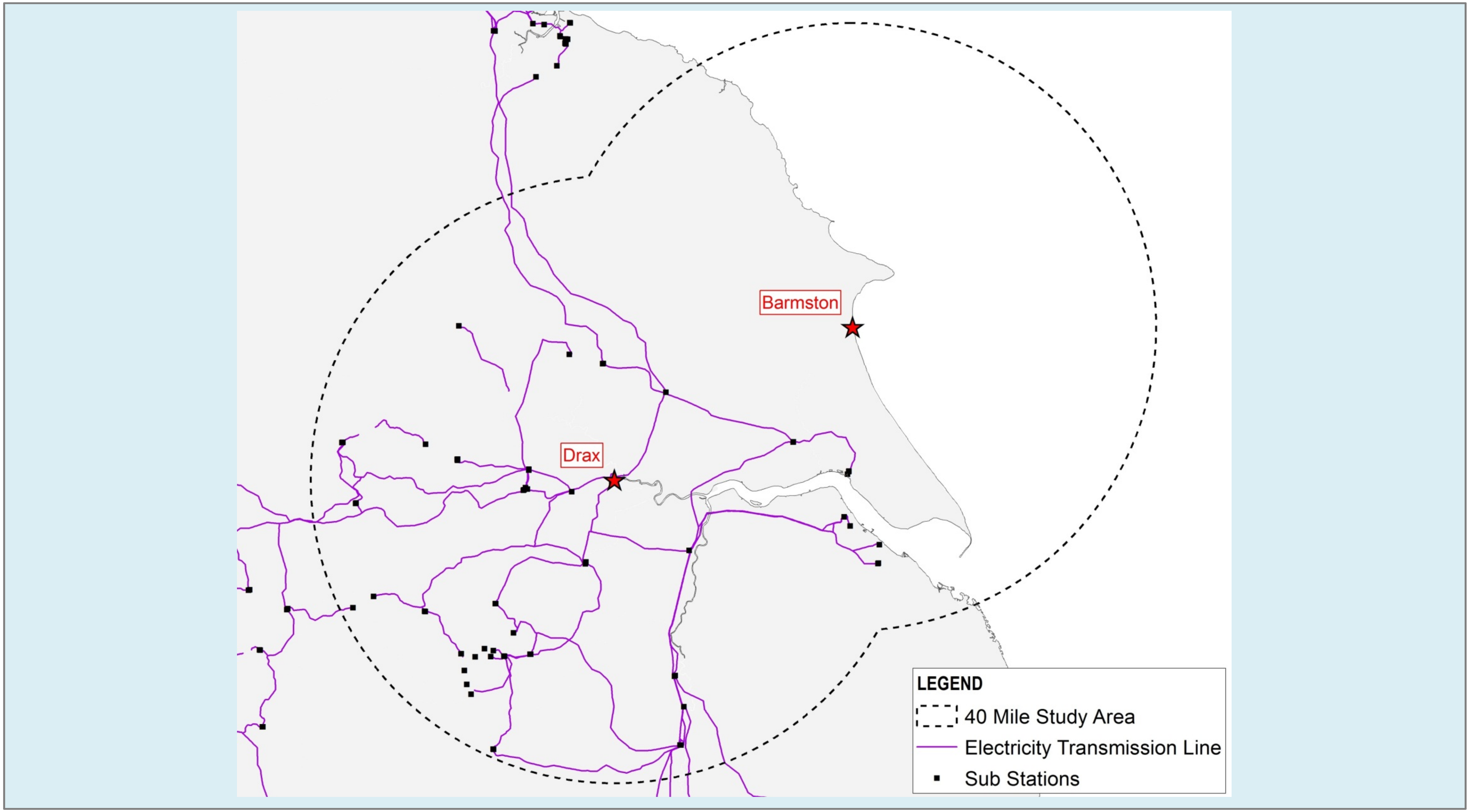


Figure 4 - Potential Availability of Water Supply

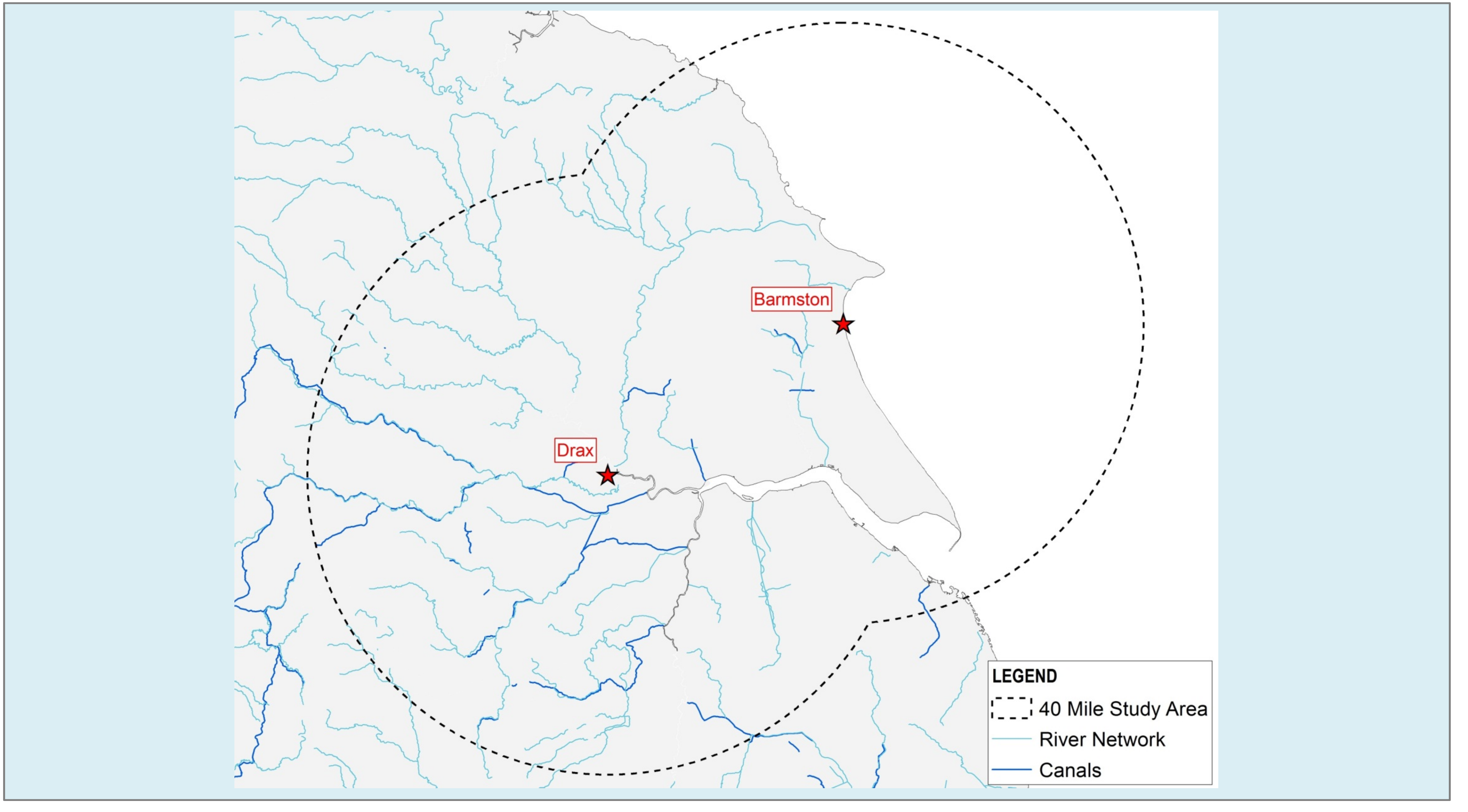


Figure 5 - Solid Fuel Transportation Corridor

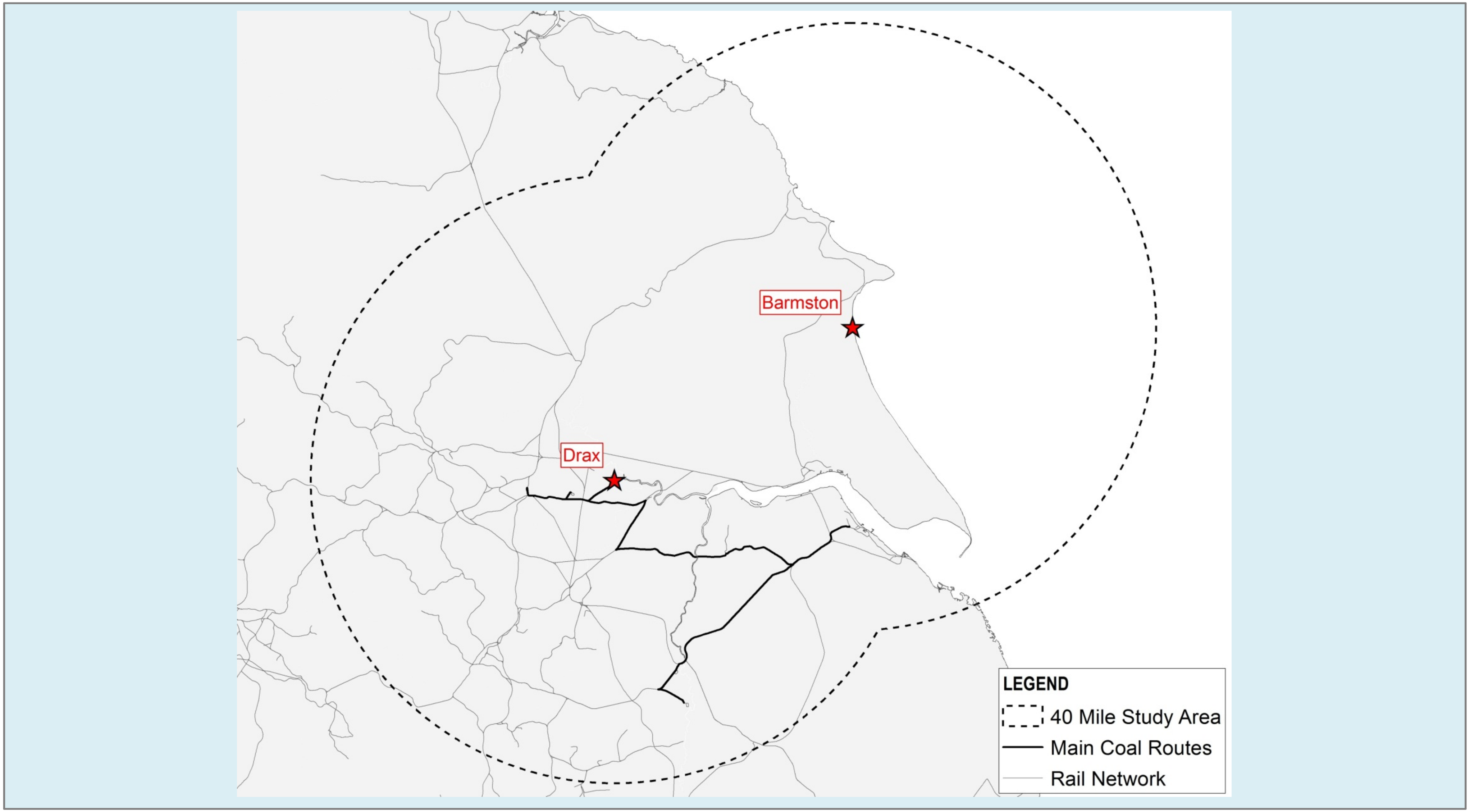
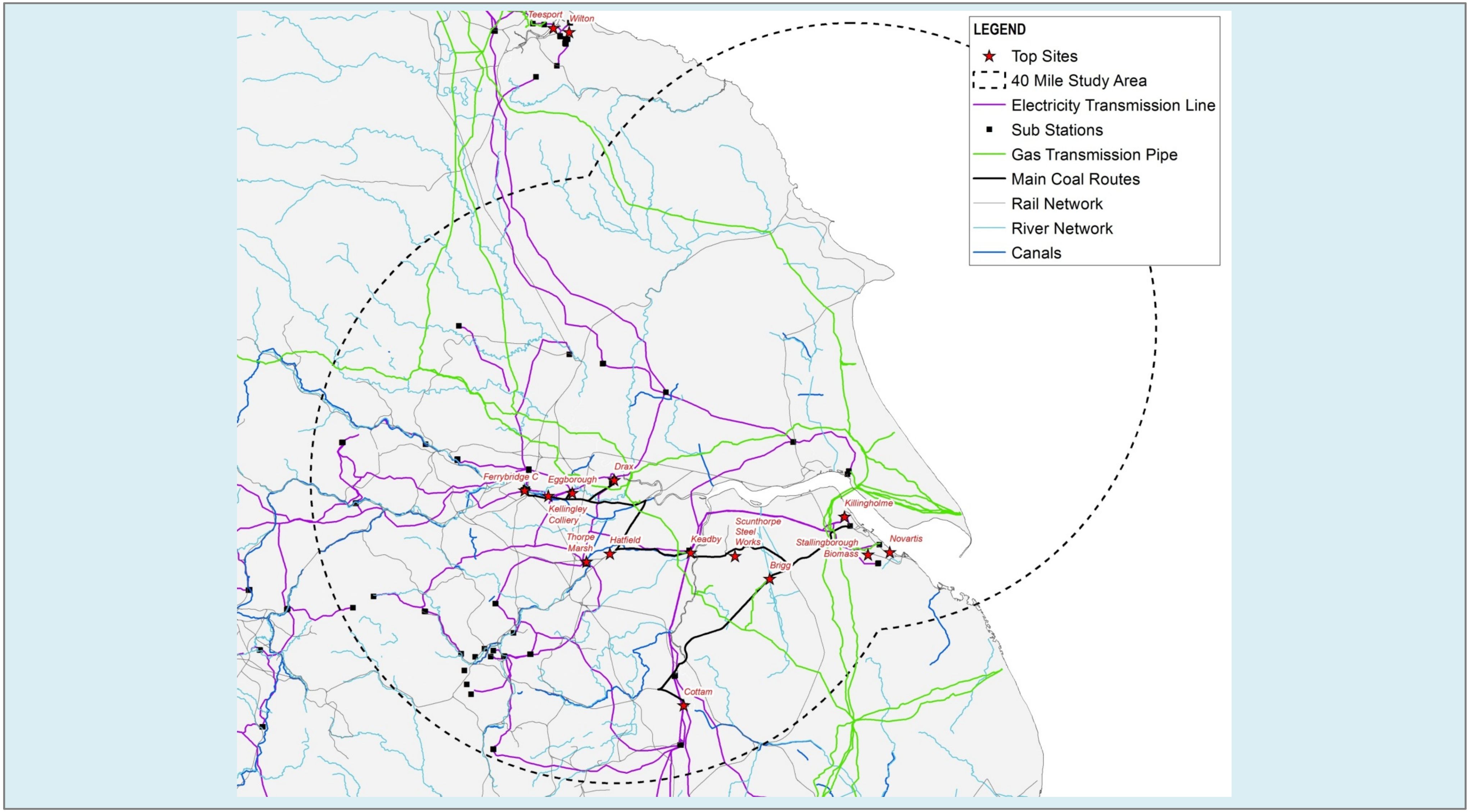


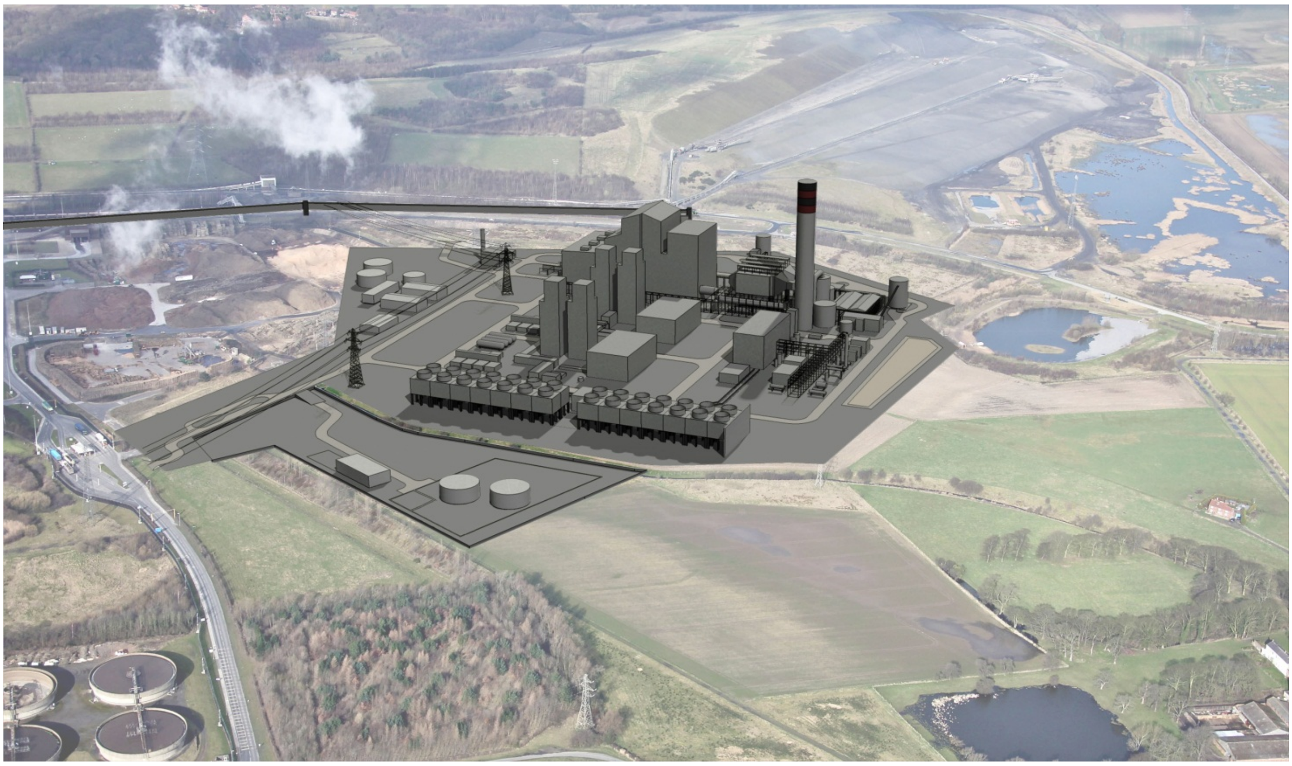
Figure 6 - Gas Supply Network

Figure 7 - Top Ranked Screening Sites



Section 3

Technology options and Development Parameters



Courtesy – White Rose Website

3 TECHNOLOGY OPTIONS AND DEVELOPMENT PARAMETERS

3.1 Introduction

The output of this study is to illustrate the potential sites available for a new low carbon thermal power plant that can significantly benefit from being close to the EU and UK government supported investment support to the CCS programme and in particular White Rose. This is generally referred to as a part chain capture project. Stage A of the report illustrated that there are a large number of possible sites in the Yorkshire and Humber corridor. This is consistent with current and historic power generation and industrial operations. Stage B provides an overview of development considerations for a new facility by 'testing' options against three specific sample locations.

This section considers four carbon capture technology applications at c 1GW scale, with an overview of the development and implementation parameters, and the consideration of their 'fit' to three representative locations. The four technology application templates have been prepared recorded in Section 3.2 for the following plant options;

- Natural Gas fired CCGT with post combustion capture
- Pulverised Fuel Ultra Super Critical boiler / steam turbine generator with post combustion capture (USCPF)
- Integrated Gasification Combined Cycle (IGCC)
- Pulverised Fuel with Oxy Fuel pre combustion capture

In Section 3.3, there is a summary of typical project development and implementation parameters including an overview of how the Development Consent Order (DCO) process could influence the future part chain capture projects. Outline schedules and CapEx trends are included to inform the discussion.

Three site specific reference locations have been considered in Section 3.4, to illustrate the potential considerations for development. The three locations (Drax, Eggborough and Immingham) are considered in the broader context of their attributes for project development and to 'test' and illustrate the technology combinations possible at a range of similar sites.

- The area in the vicinity of **Drax** offers the potential of a development location with the benefits of the adjacent generating station and close coupled interfaces, within the vision of being the lead clean power hub in UK. Development would likely be off-site from the existing generating station, and the proposed White Rose oxy-fuel development, but could use the same technology as White Rose, or an alternative technology. This could be by a new Developer.
- The area in the vicinity of **Eggborough** offers the potential of a development location with either onsite or near site options. The potential to consider onsite space where there are current opted-out units could be attractive as a New Clean Coal option (Site Re-birth). The interfaces for carbon export are in near field range and at <16 km will avoid at DCO application for the pipeline.
- The wider area in the **Immingham** region offers the potential of a development in a number of separate locations in the area. The proximity to fuel imports and heavy industrial operations is attractive. In the base consideration, the Immingham region is at far field boundary range for carbon export but illustrates the considerations related to a longer connection. Advantages may emerge if other Clean Fossil Developments in this vicinity substantially progress.

In Section 3.5, a list of other regional sites, already in the development process, has been included to capture the ongoing regional interest in large central generation in the area. This includes natural gas fired power station proposals at Keadby, Knottingley and Thorpe Marsh and clean coal proposals at Hatfield and Killingholme. A list of current coal stations and their status under LCPD Directives is also included.

Note - The report considers the connection to CO_2 export networks provided by others and there is no consideration of the transportation system, storage location or capacity at this stage.

3.2 Technical Templates

This section identifies typical templates for a clean fossil power plant, in the 1 GW range, for the following four technology solution options;

- Natural Gas fired CCGT with post combustion capture
- Pulverised Fuel Ultra Super Critical boiler / steam turbine generator with post combustion capture (USC PF)
- Integrated Gasification Combined Cycle (IGCC)
- Pulverised Fuel with Oxy Fuel pre combustion capture

In producing the reference footprint for the four technology solutions, in-house experience and simple comparison with Guidance [Ref 4] and other current developments has informed the spatial template in the following way;

DECC guidance updated in a technical memo by Imperial College in collaboration with technical authors provides guidance [Ref 5] for UK CCS readiness for a selection of technology options. These are generally in the 500 - 800 MW range. In reviewing this data, comparing in to current developments and typical power station arrangements, typical 1GW scale reference templates has been established. This is intended to be technology and vendor neutral.

The anticipated carbon captured has been included and this will require further investigation at feasibility stage, depending on the specific choice of process parameters and operating equipment. The estimate is simplistic and uses a 90% capture assumption and assumes an equivalent 8,000 running hours for all plant technologies.

At the time of the study it is anticipated that CO_2 capacity for a new connection will be provided for in any new export bearer system (by others). No spatial allowance has been made for new coal stock areas,

The template information is summarised below;

	NG CCGT	USCPF	IGCC	USCPF OXY
Nominal Gross Capacity (MWe)	1,000	800	1,040	900
Site dimensions for generation equipment (m)	264	360	328	487
	251	294	294	487
Site dimensions for CO_2 capture and compression equipment (m)	205	129	341	132
	171	100	341	157
Total site footprint (m2)	**110,000**	**150,000**	**220,000**	**260,000**
Total site footprint per Approx. net capacity (m2/MWe)	**110**	**188**	**212**	**288**
Estimated Captured CO_2 for Export (tonnes per day)	**8,640**	**13,824**	**16,623**	**12,442**
Estimated Annual CO_2 for Export (8,000 hours running)	***2,880,000***	***4,608,,000***	***5,541,120***	***4,147,200***

Note – The Annual CO_2 Export estimate is nominal and is equivalent to 8,000 running per technology (e.g. 92%). This is purely used to illustrate the overall capacity for infrastructure.

3.2.1 Natural Gas Fired CCGT with post combustion capture

Introduction

The UK has a high concentration of natural gas combined cycle generating units (all unabated), built in four tranches from 1990 with investment encouraged by the relative low capital cost, shorter build times and belief in gas availability.

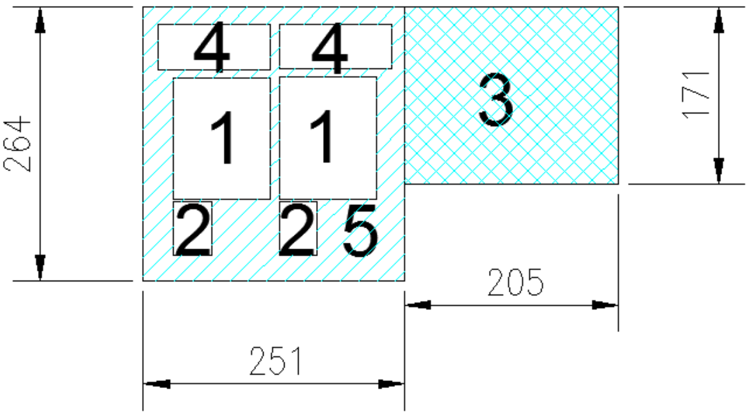
Modern unabated CCGT units achieve a relative low carbon intensity compared to other fossil plant as a result of their higher energy efficiency (fuel to power) and there is potential for further improvement in the overall fleet emissions if H class technology is deployed in the next tranche of UK build. CCGT carbon emissions tend currently to be in 450 – 550 gCO_2/kWh range with potential to attain 370 gCO_2/kWh. The Peterhead CCS project is based on adding capture and compression to one of the existing CCGT units at the site.

Future CCGT build is likely to need fiscal support through capacity payments as a result of challenges from alternative Wind generation (cheaper but intermittent) and the trend for higher gas price (global demand and marginal spark spread). This is provided for in the Electricity Market Reform (EMR) proposals and the first series of new capacity auctions are due in late 2014.

Since the introduction of the EU Directive 2009/31/EC on Geological Storage of carbon dioxide and subsequent publication of UK Carbon Capture Readiness guidance in 2009, all new CCGT project proposals over 300 MW are required to evidence that there is passive provision for future CCS addition (CCS ready or CCR). An abated CCGT would target emissions in the range of 50 – 200 gCO_2/kWh. This will be influenced by policy, technology and fuel source.

Plant Footprint

In this study, the template established is for a natural gas fired CCGT station with post combustion capture and is based on 2 x 500 MW units.



Key

1. Power Island
2. Sulphur Gas Removal
3. CO_2 Capture & Compression
4. Hybrid Cooling Towers
5. Other Equipment

3.2.2 Pulverised Fuel Ultra Super Critical boiler / steam turbine generator with post combustion capture.

Introduction

The contribution and capacity of coal fired units in the UK continues to change as price, policy and regulation impacts the market. Higher gas prices and limited running hours under LCPD directives had encouraged a short term increase in coal generation but with coal plant retirement increasing (Opted out plant) and carbon plant levies the trend is now to a significant decline in the contribution of coal to the generation mix in UK.

No new Coal units have been constructed since Drax and any new applications must now have demonstrate to capture of carbon dioxide from a minimum of 300MW of plant output and achieve 90-95% capture of that carbon. This requirement emerged after the submission of the 2 x 800 MW new build proposals at Kingsnorth, which subsequently progressed through FEED stages of first UK CCS programme before project deferral. Other new pulverised coal projects at Tilbury and Hunterston were under consideration plus conversion of units at Longannet.

Any new pulverised coal plant with CCS is likely to move to supercritical or ultra-super critical steam conditions with their higher temperatures and pressures leading to efficiency gains over the sub critical units from three decades ago.

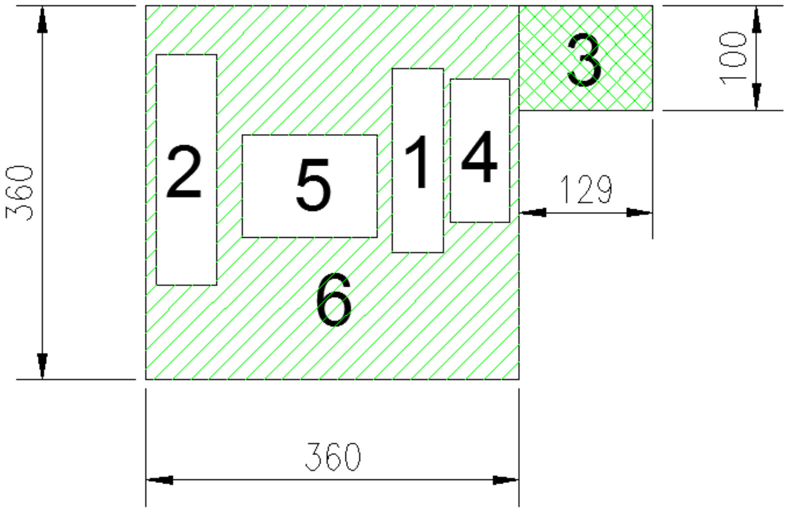
The term "supercritical" refers to main steam operating conditions being above the critical pressure of water (221.5bar).

- Supercritical (SC) is a term used to designate a coal-fired power plant design with the inlet steam temperature to the turbine above 565°C at an approximate pressure of 260bar.
- Ultra-supercritical (USC) is a term used to designate a coal-fired power plant design with the inlet steam temperature to the turbine at 615 to 630°C at an approximate pressure of 260bar.

Future clean coal new build will need fiscal support through Contract for Differences (CfD) as a result of the significant additional cost of carbon plant facilities. The potential for a CCS CfD is provided for in the Electricity Market Reform (EMR) proposals and recognises the potentially important role for coal in security and affordability elements of the energy supply challenge. In essence, coal can be considered as a tactical storage option with potential for significant volumes to be held ‘ready’ for conversion to electricity.

Plant Footprint

In this study, the template established is for an Ultra Super Critical Pulverised coal power station with post combustion capture and based on an 800 MWe unit, similar to those previously developed for Kingsnorth and Tilbury.



Key

1. Power Train
2. Sulphur Gas Removal
3. CO_2 Capture and Compression
4. Hybrid Cooling Towers
5. Boiler Units
6. Other Equipment

3.2.3 Integrated Gasification Combined Cycle (IGCC)

Introduction

There are currently no large scale IGCC power plant in construction or operable in UK. A number of IGCC projects have been proposed and initial development activities commenced.

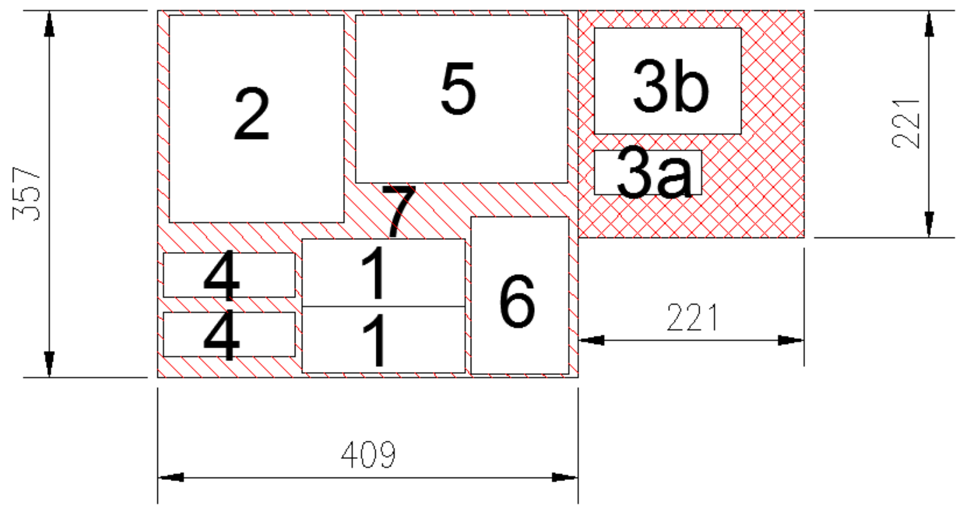
IGCC plants have the potential to be built in two stages with a conventional gas fired combined cycle constructed and put into operation. The coal gasification plant can then be built and commissioned later providing an alternate syngas feedstock. This approach is deemed to reduce technical and investment risk but may also lead to a wider set of non-optimum plant requirements. If the project is approached as a two stage process with the decision gateways four to five years apart, there is a high risk that the second capital investment decision is not forthcoming and hence may result in only the CCGT element being built.

The Hatfield project (aka Don Valley) achieved a two-stage consent and was successful in securing early levels of funding through the ERP and NER programme. However, this project did not receive funding from the recent NER300 competition and is now under review.

Approaching IGCC as a single build project is possible with fiscal support through Contract for Differences (CfD) or other mechanisms. New IGCC projects were or are under consideration by Progressive Energy in Teesside and C-Gen at Killingholme.

Plant Footprint

For the purpose of this study, this template has been established for an IGCC power station based on two units and overall gross output of 1040 MW.



Key

1. Power Train
2. Sulphur Gas Removal
3. CO_2 Capture and Compression
    a. Compression Equipment
    b. Separation equipment / Regeneration
4. Hybrid Cooling Towers
5. Gasification Units
6. Air Separation Units
7. Other Equipment

3.2.4 Pulverised Fuel with Oxy Fuel pre combustion capture

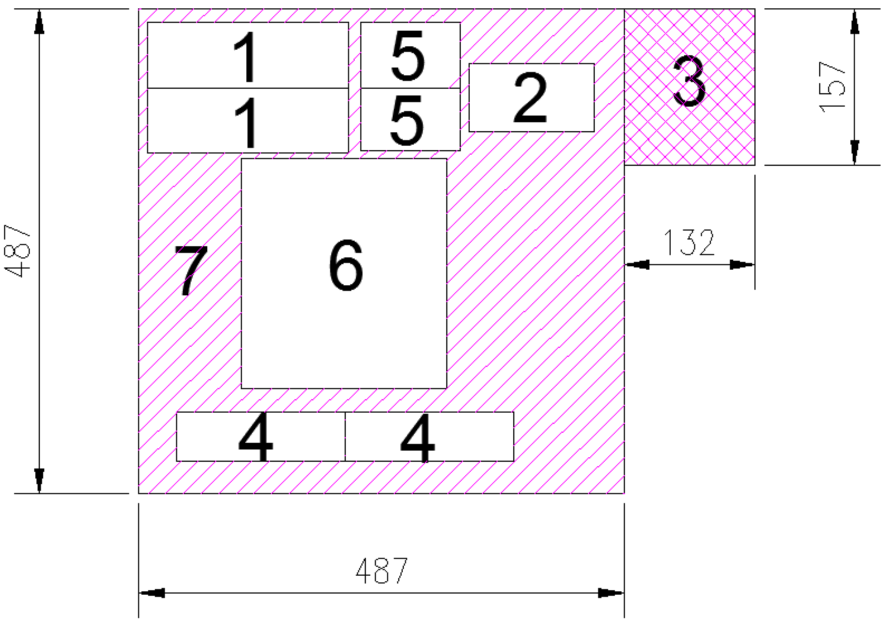
Introduction

There are currently no large scale Oxy Fuel pre combustion power plant in construction or operable in UK.

The White Rose project (adjacent to Drax) is the leading UK project as Oxy fuel project and is currently in the late stages of preparation of its DCO submission to the Planning Inspectorate. The project is ranked in the current stage of UK CCS programme and was recently successful in securing early levels of funding through the ERP and NER programme. The project will target fiscal support through Contract for Differences (CfD) or other mechanisms. Other new Oxy Fuel projects are only likely to be developed in response to evidence from White Rose.

Plant Footprint

For the purpose of this study, this template has been established for an oxy fuel pre combustion power station and is largely based on deploying two 450 MW units similar to the White Rose proposal to achieve 900 MW gross output.



Key

1. Power Block
2. Sulphur Gas Removal
3. CO_2 Capture and Compression
4. Hybrid Cooling Towers
5. Boilers
6. Air Separation Units
7. Other Equipment

3.3 Project Development

This section identifies the typical development parameters with respect to schedule and cost for a new part chain capture project. This summary is consistent with a concept level desk top study and acts only as a commentary on the typical range of development, implementation and investment considerations.

3.3.1 Typical Development timelines

A new clean fossil power plant is considered to be a National Significant Infrastructure Project (NSIP) and will require a Development Consent Order (DCO) under the requirements of the Planning Act 2008; the consent needs to be consistent with the National Policy Statements for Energy and for Fossil Fuel Electricity Generating Infrastructure (EN-1 & EN-2). This is considered in Section 3.3.2 to 3.3.7.

Modifications to add CCS equipment to a power station already exists or where a Consent has already been granted may avoid the need for a DCO, and be possible under Town and Country Planning Act. (TCPA). This is considered in Section 3.3.8.

3.3.2 Development Consent Order

The DCO process, administered by Planning Inspectorate (PINS), centralises the decision making on major projects with a view to assured timescales for Determination. The initial obligation is on the Proposer to draft, consult and lodge a comprehensive submission related to the project and its impact and submission occurs after a process of stakeholder consultation.

The summary time line for a DCO has been captured below;

Associated Development

Any additional facilities that are required for the project such as CO_2 export connection, transmission connections, marine works, etc. should be included in the project submission so a single determination can be reached. In planning reform, this was deemed a benefit to an infrastructure project such as a new power plant with CCS, where essential scope is outside the traditional site boundary, by providing Consents in a single determination.

In general, the DCO will include the permissions related to Section 37 Overhead lines, Pipelines Act, Marine Licencing, Section 106 and Section 275 works associated with the project.

3.3.3 Timescale Variability

Consenting timelines have been notoriously difficult to predict but have traditionally taken in the region of 48 months for a new thermal power plant The DCO process has formalised a 16 month approval timescale but places the emphasis on the Proposer to have completed wide and meaningful consultation over a necessary period in advance of submission on all elements of the wider project.

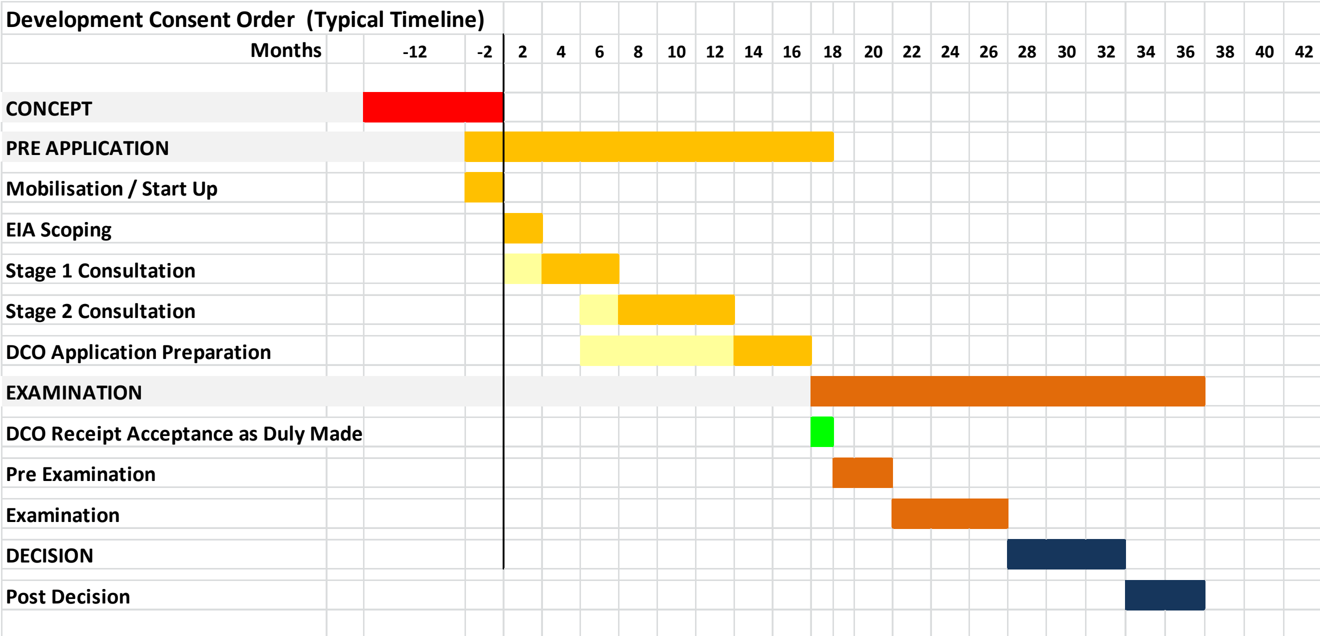
Our assumption is that an Entity can progress the Scoping, Environmental Impact Assessment (EIA), Project Environment Information Review (PEIR) and their final Environmental Statement (ES) to achieve submission in 16 months (min 12 – max 24 months) resulting in a 32 month schedule to Consent. This extends to 36 months with a 2 month start-up and 2 months post decision period. The Environmental

(PPC) Permit required from the EA (SEPA) is typically applied for and granted in parallel or shortly after Consent and therefore not typically on the critical path to development.

This assumption is based on a part chain capture project, without the complexity of offshore assets.

3.3.4 Typical Development timelines

A typical Development Consent Order timescales, for the pre-application, examination and decision process, has been expanded from previous page to show the typical stages in the Pre Application process and is summarised below;



The typical approach in the Pre-application phase is for a progressive development of scoping and consultation where the applicant will communicate plans, engage with stakeholders and perform the studies to collate the evidence that the intended development has been progressed with adequate consultation with stakeholders and appropriate regard to the National Policy Statements and Planning policies. The application has to include details of associated development such as transmission lines, pipelines and utilities connections. In the Gantt chart above, the concept stage is a series of enabling activities before the DCO process commences. The DCO process then has Pre Application, Examination (which includes pre-examination and then the examination period) and Post Decision phases.

3.3.5 Concept

The four phases of activities shown in Pre Application will be preceded by a range of feasibility and concept studies that will have developed a positive business case for a new project, either as a business imperative or as a strategic option. The activities in this phase would include site identification and selection, engineering concept and economic assessment and would generally take between 6 to 12 months. The output of these studies will inform the project definition for the formal development process.

3.3.6 Pre Application

Start Up

In the initial start-up for a DCO application, and before any public declaration of intent, there will be a period of alignment between the Project, Technical and Planning team members to review concept and feasibility information and to align to the scope, boundaries and limits. It is important that the functionality and requirements of the new power plant and the extent of interfaces are agreed and base-lined during this start-up period. This will allow the team to consider and reflect on their strategy, and the opportunities and potential risks that may arise in the planning phase, to create a broad but reasonable envelope for the project on the specific site location.

Environmental Impact Assessment (EIA) Scoping

On commencement of the formal development process, the applicant will notify the Planning Inspectorate (PINS) of the intent to develop a project and look to hold an introductory meeting. The project team will then consider the wider aspects of the project and produce an Environmental Impact Assessment (EIA) Scoping Report which forms the basis of information for PINS and stakeholders to consider and review the project and impacts. The submission of the EIA scoping report to PINS is a formal requirement and triggers a review and response as a 'Scoping Opinion' to the breadth and extent that the applicant should prepare their application.

The EIA Scoping Report has the specific purpose to;

- outline the study area and providing a brief description of the proposed scheme;
- describe the site, the surrounding land use and key environmental features;
- present the proposed EIA scope, including discussion of which environmental issues can be omitted or 'scoped out' of the EIA;
- outline the proposed structure of the Environmental Statement (ES), with the proposed methodologies for all technical studies; and in particular outline and justify those areas where we propose to scope out or limit the degree of work to be undertaken.

A response from PINS, on the scoping report, is required to be issued within 42 days after submission, and forms the basis of the agreement for the activities to be undertaken and considerations to be included in the Application, to comply with the requirements of the Planning Act.

Stage 1 Consultation – 3 to 4 months

Typically (although not exclusively) a 2 stage consultation process tends to be adopted by Applicants. In the initial stage of consultation, the team will create a detailed plan for the full range of consultation activities envisaged to meet the expectation of the Scoping Opinion. This will include publishing public notices and agreeing communication routes (e.g. Website, mailbox). In this phase, the applicant or their representative would normally instigate a series of initial discussions with statutory consultees and the wider group of stakeholders. Discussions in this period will help inform the project team of potential issues or concerns that can then be considered in the proposal. This will inevitably lead to adjustment of particular aspects of the project scope, interfaces and potential connection routes as a result of specific feedback or observations, which is an essential part of the DCO process.

The basis for consultation will be captured and agreed in the Statement of Community Consultation (SOCC), consistent with section 42 and 47 of the Planning Act, that will cover the following area;

- Sufficient detail of the project, including the technical combustion, capture and compression process, the likely scale and both positive benefits and potential negative effects.
- A clear explanation of what is being consulted on, what is settled and why, and what remains to be decided.
- A description of how consultation will be undertaken, both within the vicinity and beyond the vicinity of the scheme.
- A framework for the community consultation generally, stating where and when events will be taking place.
- Acknowledgement that the project falls within the scope of the EIA Directive and how the preliminary environmental information will be publicised and consulted upon.
- Contextual information on the Planning Inspectorate's role as examining authority, the status of National Policy Statements (NPSs) (which define issues that are of national significance and therefore not to be debated for specific individual applications of that type) and on the consultation timetable, DCO submission, examination and decision making process.

The Stage 1 Consultation activities provide the basis for the more formal and detailed exchanges and interactions in Stage 2.

Stage 2 Consultation and Studies – 5 to 6 months

Assuming 2 stage consultation is undertaken, in the second stage of consultation, the team will formally consult with stakeholders including the statutory consultees and community stakeholders. Consultation is for a minimum of 8 weeks.

One approach to Stage 2 consultation is to undertake it around the publication of the Preliminary Environmental Information Report (PEIR), which is a formal requirement of the DCO process. The PEIR will typically take the form of a preliminary Environmental Statement (ES) containing interim information that will be developed and confirmed in the final preparation of the ES. In this way, meaningful consultation can be undertaken prior to finalising the scheme, so stakeholders have a credible opportunity to influence the scheme.

In support of the DCO application, a series of technical studies and descriptions will also be prepared to summarise significant aspects of the project and associated developments. The study reports will include the technical requirements, construction methods, land ownership issues and environmental constraints of specific areas. They will also outline the status of contractual negotiations and acquisition of land and rights and define the responsibilities for design in the next stage of development.

The Preliminary Environmental Information Report (PEIR) and the Environmental Statement will typically cover the following areas at interim and final stages of information;

- Non-Technical summary
- Introductory Sections
- Air Quality Assessment
- Noise Assessment
- Landscape Assessment
- Traffic and Transport Assessment
- Surface Water Assessment
- Hydrogeology, Geology and Soils Assessment and Flood Risk Assessment
- Socio-economic Assessment
- Cultural Heritage Assessment
- Ecology Assessment
- Waste Assessment
- Sustainability Assessment
- Health Impact Assessment

All the above chapters are required to be considered for the main development site and any Associated Development such as new transmission lines or gas pipelines.

The studies and reports will include a arrange of areas and topics at a summary level, including;

- Design and Access Statements - outline parameters and influences
- Grid Connection Statements - identifying connections and route
- Gas Pipeline Statements - identifying connections and routes
- CO_2 export Statement - identifying system and corridor routes
- CHP Assessments - consideration of loads and CHP ready
- Land Plan - showing Ownerships and interests
- Works Plan - showing sections of work and timescales
- Utilities Plan - showing main interfaces to utilities
- Constraint Plans - showing areas of sensitivity
- Landscaping Plans - temporary and final scheme

Additional technical studies will be required on the design of the generating station, building sizes, utility demand, emissions, and choice of technology to inform the EIA process and justify the application of Best Available Techniques (BAT) to the EA.

Application Preparation – at least 4 months from end of Stage 2 consultation

The final stage in the pre Application process is the collation and review of all the study information related to the project and a full review and consideration of the responses from the consultation. This review may lead to modifications in approach or design based on feedback and observations although it is intended that much of these changes are captured through early consultation

The activities to support the drafting and completion of required reports and studies can commence in parallel to Stage 1 and Stage 2 consultation activities but can only be completed after Stage 2 consultation has ended.

Soon after the end of Stage 2 consultation, the applicant will meet again with the PINS team to provide an update on the project development activities and confirm the timescale for the DCO application to be submitted. The compilation and legal review in advance of submission is expected to take at least 4 months.

In this final phase of activity, the project team will apply a design freeze to the project and concentrate on producing the final versions of all studies and reports to support the DCO application. This will include the Environmental Statement (ES) and a Statement of Common Ground (SoCG) with Local Planning Authority (LPA) and technical consultees.

During this period the draft Development Consent Order itself is drafted, with associated Requirements to mitigate the environmental effects of the proposed development. Other documents prepared in this phase include the Explanatory memorandum, Consultation Report, Book of Reference and Statement of Reasons (the latter required for any compulsory purchase of land or rights).

3.3.7 Examination

On receipt of an application there are four phases of the determination before a decision is confirmed. This is then followed by a post decision period, where challenges may occur.

Acceptance Period – 1 month

On receipt of a DCO application, PINS have 28 days to review and confirm that the submission is duly made and 'fit' to be taken to pre-examination.

Pre Examination – 3 months

The initial Pre Examination period includes the opportunity for 'Interested Parties' to express their desire to contribute to the decisions. This may include parties over above the original stakeholders that have already been consulted. Additional information and clarifications may be requested from the Applicant.

Examination – 6 months

The Examination period is set for 6 months and may result in the call for additional evidence or studies in respect of certain aspects. A number of meetings and submission of supplementary information will be required during the detail examination period.

Decision – 6 months

On receiving the Recommendation from PINS the Secretary of State has a period of 6 months to review and confirm the Decision.

Post Decision

There is the potential for challenges to the any Decision, and these will give rise to Judicial Review, for which a period of 6 weeks has been provided in PINS guidance.

3.3.8 Alternative Planning Scenario – Non DCO Timelines

Whilst a DCO is the appropriate pathway for a new facility, there may be an alternative scenario for progressing planning for adding the additional elements of part chain capture where a Power Station already exists or a Consent has already been granted for a non-abated fossil unit.

For modification to existing consented infrastructure (e.g. an existing section 36 consented power station), it would be possible to retrofit abatement technology (a post combustion CCS plant) under a modification to the section 36 consent, which would be supported by a Town and Country Planning Application (TCPA) and associated EIA but would not necessitate a full DCO application. This route should also be open to a replanted power station provided that the electrical output of the power station is not increased.

Note - Interestingly, UK experience is inconsistent in the precedence of this approach and there are case studies of FGD and SCR retrofit applications being treated as permitted development and in certain cases as full new applications. The approach would need to be reviewed further against a specific project proposal.

If the need for DCO can be avoided, this could shorten the consenting time-scale for the retrofit of any CCS plant. While an EIA would still be required there would be a reduction in the consultation and determination time-scales for the application. A 9-12 month application period would be realistic for a non-DCO application subject to timing of or access to seasonal surveys. Post application, the determination process would be of the order of 6 months rather than 15 months.

The alternative planning scenario considered above is for the part chain capture elements of additional equipment added to an existing consented site and would probably be limited to the short distance connections of a CO_2 pipeline. (less than 10 miles) and can be progressed under Town and Country Planning. Over 10 miles, a Pipeline Construction Authorisation is required under the Pipelines Act and applications would require a supporting EIA.

It should be noted that the consenting of any associated development infrastructure (notably any CO_2 pipeline) may be considered a separate application and could itself become a Nationally Significant Infrastructure Project (NSIP). If this happens then there is a requirement for its own DCO, similar to the case for the White Rose pipeline. The advantage of the DCO pathway is the ability to secure CPO provisions for the pipeline, should they be required, with the disadvantage of the increased consenting timescale over a standard consent under the Pipelines Act.

Summary of potential Planning Approaches

Project Scope	**Most Likely Pathway**
New power plant (with CCS or CCS ready)	DCO
Modified power plant	Non-DCO if not increasing capacity
Re-birth of existing power plant	DCO if increased capacity
Retrofit of CCS on existing	Non-DCO
New CO_2 pipeline < 10 miles	TCPA, could be DCO unless CPO needed
New CO_2 pipeline > 10 miles	Under Pipeline Act and likely to be DCO if significant

3.4 Typical Engineering and Construction Implementation timelines

3.4.1 Implementation Assumptions

The typical implementation timescales for the four carbon capture technologies considered in this study have been summarised below. The timelines are independent of Vendor or detailed technology but are consistent with empirical views of CCS programmes.

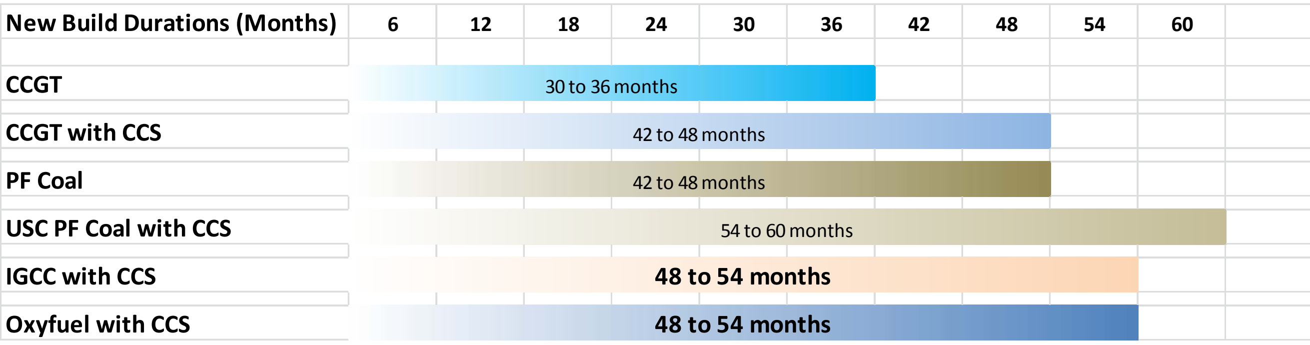
To ensure a consistent view of implementation timelines we have assumed that the scope of detail engineering, interface engineering and construction timescales within the period is consistent with the concept of the power plant and capture plant and local interface connections only (say max. 40km).

There is normally a requirement for an engineering development period (or FEED) in advance of the implementation timescales. These are considered in the overall project timelines in Section 3.4.2. This may be performed in parallel with the Consenting exercise or after Consent is determined.

Outline Timelines for 1,000 MW plant with CCS (months)

Phase	CCGT	USCPF	IGCC	USCPF OXY
Development	18 - 24 months for FEED			
Implementation (*CCS)	42 – 48	54 - 60	48 - 54	54 – 60

*CCS - Note. The forecast durations are reference timelines for a UK power plant site with good construction access and adequate laydown area. In general, the deployment period for a part chain capture Project is likely to be 6 to 12 months longer than a conventional unabated plant in UK.



Note – Durations are for part chain Capture plant only. No consideration of the CO_2 transportation or offshore works is included in the above timescales.

The deployment period may be extended due to the complexities of a First of a Kind (FOAK) full scale capture plant design and build project in the UK and will also depend on the volume of engineering progressed in the development phase in advance of consent decision.

There may be potential for accelerated schedules as Second of a Kind (SOAK) and Nth of a kind (NOAK) part capture plants but there is insufficient evidence to include in this desk top study.

3.4.2 Overall New Project Timelines

The summary timelines for development and implementation have been represented in Section 3.3.5 and 3.4.1 respectively. In this section, there is consideration of overall generic timeline, specific deployment opportunities and critical interfaces to other infrastructure. The Development timelines in Section 3.3.5 represented a realistic 36 month DCO planning timeline which was deemed to be similar for each technology

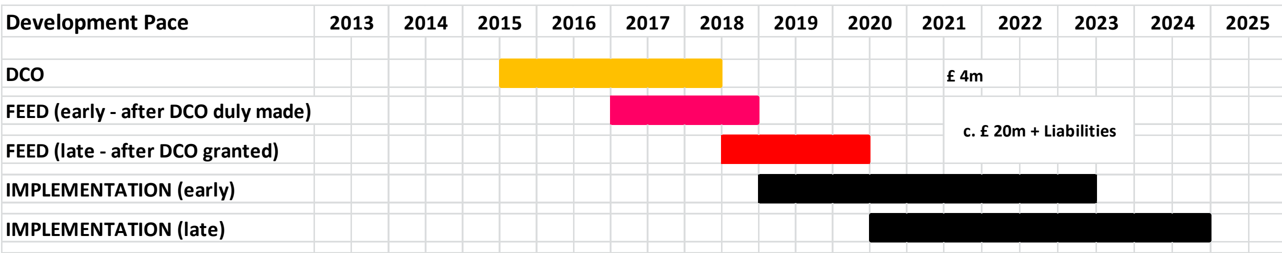
To represent a new build clean fossil project, a 3 year development period and 4.5 years for implementation has been used as the generic baseline with 6 months allowed between Consent and FID. This timescales of 8 years accommodates three of the four clean fossil technology choices (not new PF coal). This may be extended depending on the approach to FEED engineering timing and expenditure.

The need for FEED activities to cover the development engineering and unique combination of functional equipment for a CCS plant has become a normal feature of recent clean power projects. The FEED activities have the aim to progress development to attain better definition, increased consideration of integration elements and to improve cost certainty as the project moves to Financial Investment Decision (FID). This is certainly a necessary feature of full chain projects. In the case of part chain projects, it is thought that 24 months for FEED would be a generous allowance for development engineering, given the interface assumption that the project will connect to a CO_2 system (by others). The typical implementation schedule below shows an early schedule with FEED developed in parallel to consenting, and a late schedule with FEED starting after Consent determination.

It is always tempting to think development decisions can be made more quickly and projects can be constructed in shorted periods but realistically conventional power projects will take at least 8 years from the point a project emerges as a 'named opportunity' until commercial operation. There is no evidence that a CCS project will progress any faster, and indeed 8 years may be too optimistic!

3.4.3 Typical 'New Part Chain Capture Project' Timeline

The typical project timeline for a new part chain capture project is shown below. Overall durations range from 96 months to 114 months, depending on the approach to FEED engineering.



It is generally assumed that the development phase engineering to FEED output would be performed concurrently within the latter half of the typical 36 month period for DCO application. This would require a substantial investment in engineering expenditure typically c £ 15 to 25 million to reach procurement grade documentation necessary for a capital investment decision. The alternate situation is to achieve Consent and then progress the FEED engineering in advance of Final Investment Decision (FID).

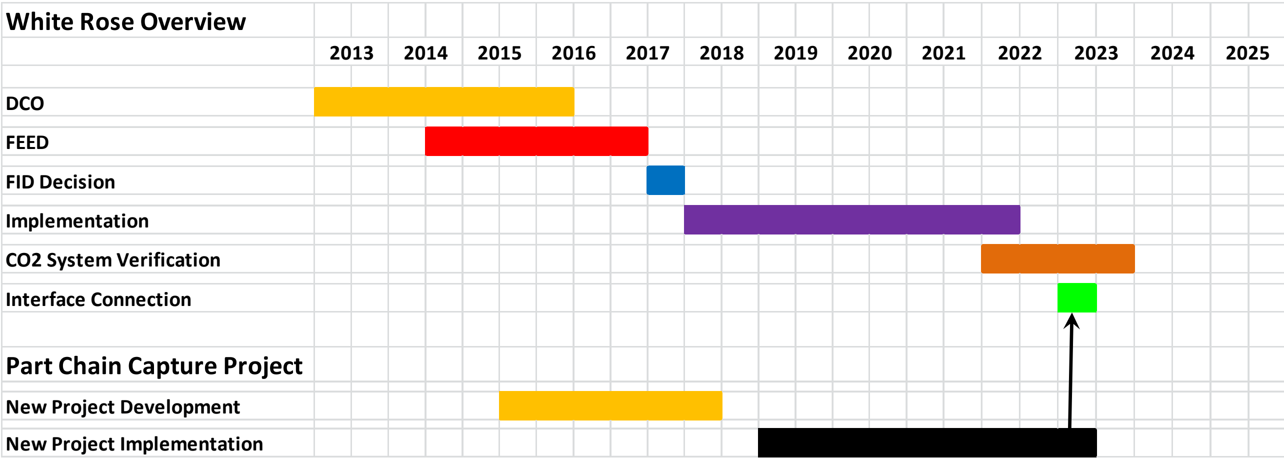
Note - The FEED engineering expenditure is in excess of the £ 3 to 4 million development cost for planning and consenting activities in 3.3.5. (i.e. Owner, Consultant and any Land option costs).

3.4.4 White Rose Full Chain CCS Project - Generic Interface Timeline

To assess the relative development place of a new part chain capture plant as a next phase project in the UK CCS programme, it is important to review the current progress and likely completion of White Rose full chain capture and storage project. White Rose is one of the two UK CCS first phase programme projects.

White Rose is the anticipated anchor project, being planned on the site adjacent to Drax, and as such holds the critical interface for providing the connection to downstream CO_2 transportation and storage facilities.

The current schedule for White Rose suggests Operations in early 2020's with an obligatory period of 'no leak' proofing and a representation of this is included at a summary level below;



The critical interconnection interface to the CO_2 transportation and storage would typically be available and proven by the mid-2022, consistent with a 54 month implementation period and subject to full Financial Investment Decision (FID) for White Rose being achieved by mid-2017 latest.

The decision to run the FEED programme virtually in parallel with the DCO consent represents a potential risk as the consent may not be fit for purpose if substantial design changes are progressed during the FEED. This risk may be somewhat tempered by the fact that DECC are keen to see the FOAK CCS anchor project be developed, but a theoretical stakeholder or public objection remains.

The key decision related to a new project call would therefore be the pace of development phase activities and the corresponding scale of expenditure in advance of the White Rose full FID decision. From the position today, it is expected that any new part chain project, progressed as a result of the ETI project call could commence the DCO process in mid-2015 and with a 36 month duration would secure DCO decision in mid-2018. This is subject to the Planning Inspectorate accepting a CCS part chain project that is dependent on others to deliver the transportation and storage. This may become a high risk interface dependency that manifests itself as a conditional restriction in the DCO decision although effectively the parallel separate DCO applications of the White Rose oxy-fired plant and the National Grid Carbon pipeline (when they are in fact parts of the same full chain CCS scheme) again may provide precedence with PINS and mitigate this risk.

The earliest completion date of a brand new part chain capture project is estimated to be c. mid 2023. This would fit with the expected availability of White Rose. A more likely delivery assessment is end 2024. Against this schedule CfD mechanism agreement would be required in late 2017.

3.4.5 Peterhead CCS Project

Peterhead is the other UK CCS first phase programme project, and given its north east Scotland location is outside the study brief for consideration of connection to the CO_2 transportation and storage system. The project is in public consultation stage and is expected to progress towards a consent application submission in early 2015.

Peterhead will retrofit carbon capture equipment to one of the three existing 385MW combined cycle-gas turbines of the SSE Peterhead power station. The flue gas from the turbine will be diverted to an absorber where about 90% of CO_2 will be extracted using amine capture technology. The captured CO_2 will be treated, dried and compressed at the power station site and piped for long-term storage at Shell's depleted Goldeneye gas reservoir, which is located 100km offshore in the North Sea. A short, new pipeline connecting an existing subsea pipeline will be installed for transporting the CO_2.

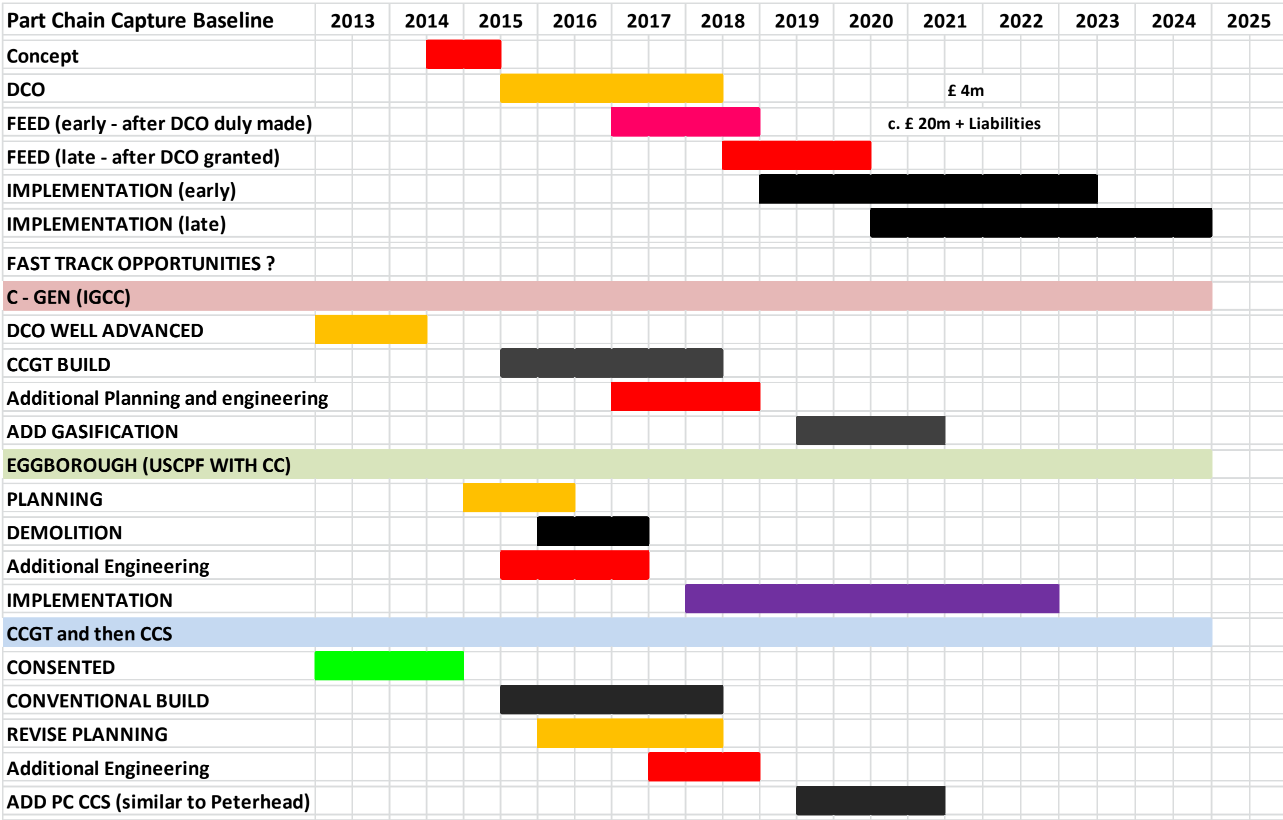
3.4.6 Fast Track Opportunities

In contrast to a completely new developed part chain capture project in the target region, it is also appropriate to consider alternative opportunities to accelerate another capture project. An alternative could encourage a' faster' and less expensive solution and may encourage more respondents to a call.

As an example, there may be potential to encourage earlier deployment of the carbon capture element of an existing development project by advancing the pre-combustion capture works on a new project (similar to C-Gen) or encouraging earlier post combustion on a new CCGT project (like Knottingley or Thorpe Marsh). It is therefore important that any market testing or project call encourages 'in-development' projects to consider participation.

Alternatively, there is also the potential to examine the re-use of critical assets and benefit from considerable savings at an existing coal site. This could involve the introduction of an ASC PF solution in the footprint of a demolished unit where specific units that do not have FGD scrubbers. The ability to progress a project without the need for a new DCO will need to be reviewed on a case by case basis; new ways to modify an existing DCO without the need for full re-application are also being finalised by Government in a similar way to the recent modifications allowed under the Growth and Infrastructure Bill.

A beneficial case for alternatives, different to the 'vanilla' new part chain project build should be considered, and potential timelines (early completion) have been summarised shown below;



There may be the need for a complex FEED engineering element for an alternative build scenario, given the need to work within pre-defined and emerging interface conditions, but it is anticipated that this can be accommodated in advance of any specific investment decision whilst still enabling each of the 'fast track 'projects to be ready before a complete new part chain build or the critical interface date to White Rose. FEED activities are shown in red in the above Gantt chart.

3.5 Technology Development and Deployment Cost Assessments

In considering the potential investment levels for the four technology options then this report has used the reference work, provided by ETI, as the initial basis and then reviewed observations on first of a kind (FOAK) and second of a kind (SOAK) deployment for part chain projects from recent UK Generation CapEx cost model reports. This approach to the potential CapEx investment costs is deemed to be a 'relative' representation of the different technologies and presents an overview of trends rather than a view on the actual current CapEx costs.

The study does not offer a new view on accuracy of current costs but seeks to highlight the potential drivers or benefits of specific approaches based on the nominal costs of new plant, as stated below.

CapEx rates for Each Technology EPC £ per kW gross – First of a Kind (FOAK)				
Technology	**NG CCGT**	**USCPF**	**IGCC**	**USCPF OXY**
Foster Wheeler [Ref 6]	1,216	2,565	2,223	3,132
PB [Ref 7]	1,576	3,530	4,844	*4,000*
MM [Ref 8]	1,250	2,891	3,006	*3,500*
Assumption for this report	**1,250**	**2,890**	**3,006**	**3,500**

Note - The rates produced in previous ETI studies were shown to have good correlation to studies by EPRI, IEA and US DOE for the similar technology options.

More recently the relationship between coal plants has changed with IGCC estimates changing significantly. This is to be reviewed.

On the nominal rates above the overall capital cost for a new part capture power plant, on a spot basis, would be as follows;

Total CapEx Estimate for Each Technology Estimated CapEx for a part chain capture project – First of a Kind (FOAK)				
Technology	**NG CCGT**	**ASC PF**	**IGCC**	**ASC PF OXY**
Gross Output Nominal (MW)	**1,000**	**800**	**1,040**	**900**
Implied Total CapEx (£m)	**£1,250 m**	**£ 2,543 m**	**£ 3,126 m**	**£ 2,835 m**

Note - The cost estimates above are **indicative only,** based on previous cost reports and have not been subject to a detail commercial estimating review. These prices must not be used as the basis for any investment considerations or to support CfD assessments. The prices represent a base guestimate on which to base observations on scope and maturity. All these estimates are +/- 40%.

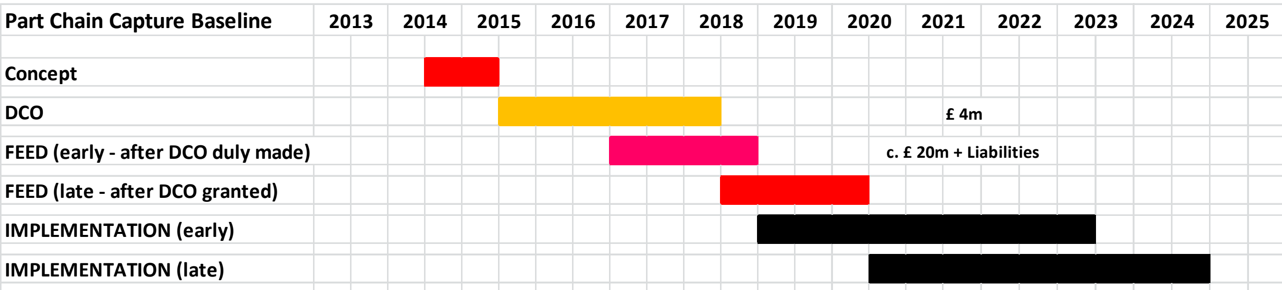
3.5.1 Project Development – Planning and Cost Progression

The approach to development of a new project will have to consider the balance between pace and risk exposure. In the initial development period, up to securing a DCO Consent, engineering activity will be necessary to inform the application but can be minimal and contained in a total feasibility cost of c £4m.

The desire to develop the project, increase engineering definition to reduce risk at interfaces and commence procurement activities to inform an accurate capital cost estimated, backed by tenders and to secure the land for development and routes can be significant and typically in the range of 3 – 5 % of the overall cost. In this study it is assumed that the development cost will be to the lower end of the range at 3% due to the battery limits of the technology options (part chain capture - generation, capture and local transmission only).

It is possible that contract liabilities and land options for grid connection, fuel and carbon may equate to a similar level too, and that liabilities will continue to grow with time in the case that development is pro-longed unless modifications to enabling contracts are effected. The liabilities would be a combination of options and liabilities that would only become payable if the project did not proceed.

The key decision for ETI in a project call will be the anticipated pace of development and whether funding to planning and DCO with minimum engineering is enough to start a 'next phase' UK CCS programme project.



The activity breakdown for a new power project would typically be based around the following elements of effort to progress activities to risk reduction milestones. The outline costs, for a part chain CCGT with CCS project would typically be in the region of;

	Effort	**Cost**
Concept	0.03%	£ 0.375 m
Planning and Feasibility (to DCO)	0.3 %	£ 3.75 m
Development (including FEED)	3 %	£ 37.5 m
Implementation	94 %	£ 1,210 m

NOTE – this is for part capture project (no transportation and storage),

The potential development costs for each of the other technologies are shown in section 3.5.7.

3.5.2 Deployment Costs

In this section we have summarised the trends for capital expenditure (CapEx) investment costs that will help inform the strategy for project call options for ETI. CCS remains an immature technology in terms of full chain deployment however in this study we are considering the part chain elements of generation, capture and local transmission with the interface connections to the CO_2 network (provided by others). This allows more scope for traditional commercial trends to be valid.

The first deployment of a technology is always deemed to have a cost premium, representing the novelty, time, risk and contingency elements of developing, manufacturing, constructing, commissioning and correcting a very new plant. This premium can be in the region of 20% for the First of a kind application (FOAK). [Ref 9]

The subsequent deployment of the same technology is deemed to benefit from the design and experience from previous projects and the resulting confidence in decision making based on this experience. This is often referred to as Nth of a kind (NOAK).

In this study, and on the basis of the relative immaturity of CCS, we are considering that, at best, the ETI will encourage deployment of a technology that has been used once before and therefore can benefit from aspects of the first project but does not have the full benefit expected with a NOAK. We have called this 'second' project deployment Second of a Kind (SOAK). This should not be confused with a second phase project under UK CCS programme.

The potential cost for projects in each technology group are summarised is this section, with the trends for cost reduction as technology matures. The typical elements of plant equipment costs for a FOAK part chain capture plant are summarised below [Ref 10]

CapEx ESTIMATES Equipment Cost element (In line with FW breakout elements)		CCGT	USCPF	IGCC	Oxyfuel
ASU	GB£M	0%	0%	9%	18%
Gasification / Boiler	GB£M	0%	48%	21%	41%
Power Island	GB£M	44%	13%	31%	12%
Sulphur Gas Removal	GB£M	33%	23%	11%	0%
CO_2 compression	GB£M	10%	8%	6%	11%
Others	GB£M	14%	8%	22%	17%
Total CapEx	GB£M	100%	100%	100%	100%

Concept of Deployment Costs

First of a Kind (FOAK) - The costs and premiums for novel deployment of a first unit configuration

Nth of a Kind (NOAK) - The costs associated with the deployment of mature technology

Second of a Kind (SOAK) - The costs associated with a second deployment using FOAK experience

Scale - General assumption that multiple units achieve savings compared to one unit

NOTE - The FOAK and NOAK costs summarised in 3.5.3, 3.5.4, 3.5.5 and 3.5.6 are developed from recent UK Electricity Generation Cost Models. The SOAK and CCS indications are by analysis of the scope and technology maturity required for a second UK CCS project.

3.5.3 CCGT with CSS cost trends

CCGT plant is typically accepted as the 'cheapest to buy' and 'fastest to build' of conventional large generating plant options and benefits from a scalar plant capacity deployed in multiples of standard unit configurations, typically in multiples of 400 to 500 MW (F and H Class).

The price history of conventional (unabated) CCGT projects has been cyclic over the thirty years of large projects build, with price fluctuating between £300 / Kw and £600 / Kw. The additional cost of CCS elements for a CCGT power plant equate to a 75% increase in CapEx.

The current price level for a FOAK CCGT with CCS project is estimated at £1250 /Kw, resulting in a CapEx estimate of £1,250m for a 1000 MW plant.

The improvements for Second of a Kind (SOAK) or Nth of a Kind (NOAK) could be considerable but currently there are no new CCGT with post combustion CCS near to implementation in UK.

The fitment of post combustion capture to a new CCGT (intent to build with CCS) is a possible 'fast-track' alternative and this may deploy similar technology to that being developed for Peterhead CCS project, but would have the advantage of being deployed to latest F or new H class gas turbines. (Peterhead units date from early 2000).

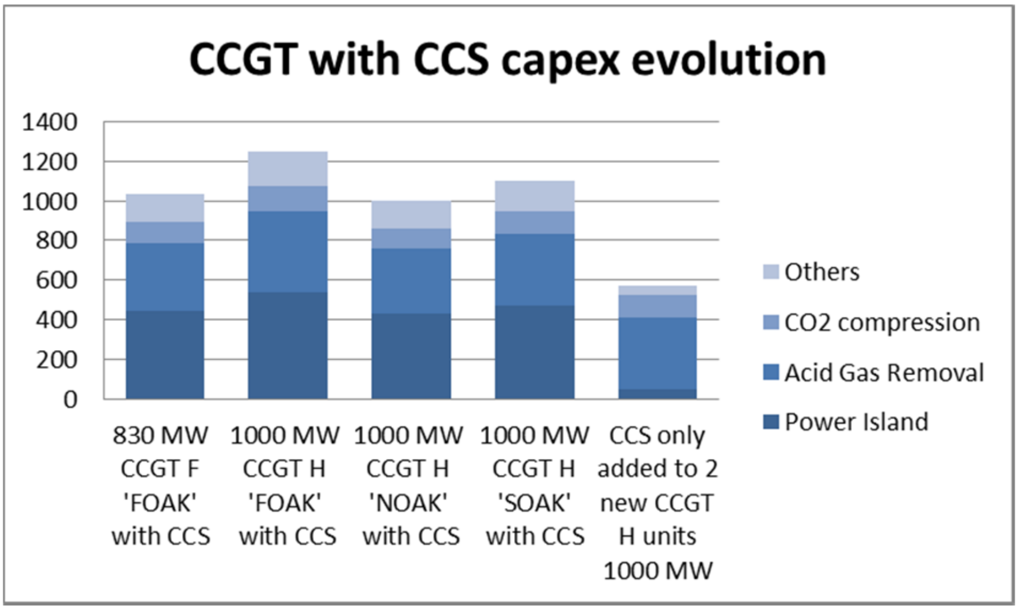


Chart 1 - this chart shows the potential trends as technology matures showing the typical relationship between FOAK (F and H class) in the first two columns and NOAK costs in the third column. This is based on costs in Electricity generation Cost Models [Ref 8]

For the purpose of illustrating the potential costs for a UK CCS programme project, the cost of a SOAK project has been considered in Column 4. This option will benefit from the learning of Peterhead or other similar projects but will not have attained the deployment maturity consistent with lower NOAK cost levels.

The fifth column identifies the estimated cost of the introduction of CCS equipment only to a new modern CCGT (already in plan for deployment).

Note – The price levels are based on a desk top review of £/Kw with improvements for repeat examples, and have not been market tested. The approach is consistent with EPC cost levels in previous reports [ref 8, P78]

3.5.4 Ultra super critical (USC) with CSS cost trends

There have been no new pulverised fuel (PF) new coal power plants built in the UK since completion of Drax. The technology move to Ultra Super Critical steam conditions, from sub-critical steam, missing out the super critical conditions, means that the core technology is still immature in UK although new build projects in Europe have continued. (Asia tended to avoid the higher conditions of USC)

A new USC PF plant in the UK would need to deploy FGD, SCR and CCS in the base configuration to be compliant with DECC guidance with capture equipment functional in initial operation to attain a PPC operating permit.

The price indications for a new USC PF plant in the UK are therefore not underpinned by UK experience and must be considered as an early estimate and cannot be considered reliable. The additional cost of CCS elements for the plant equate to a 45% increase in CapEx required.

The current price level for a FOAK USC plant with CCS project is estimated at £2,890 /Kw, resulting in a CapEx estimate of £4,624 m for a 1600 MW plant similar to Kingsnorth, with a lower estimate of £2,543 m for a FOAK 800 MW plant. A single unit will cost more than 50% of two units. The improvements for Second of a Kind (SOAK) or nth of a Kind (NOAK) could be considerable but currently there are no new USC with post combustion CCS in planning or near to implementation in UK so benefit would need to be derived from the wider European experience at Maasvlakte 3 in Netherlands

The deployment of a new USC with CCS on a site where there are existing coal units, that will be ‘turned off’ as a result of not having FGD is a possible ‘fast-track’ alternative but will require the demolition of existing units before new equipment is installed. This ‘Re-birth’ option for deployment, within a coal supply enabled site, offers marginal cost advantage.

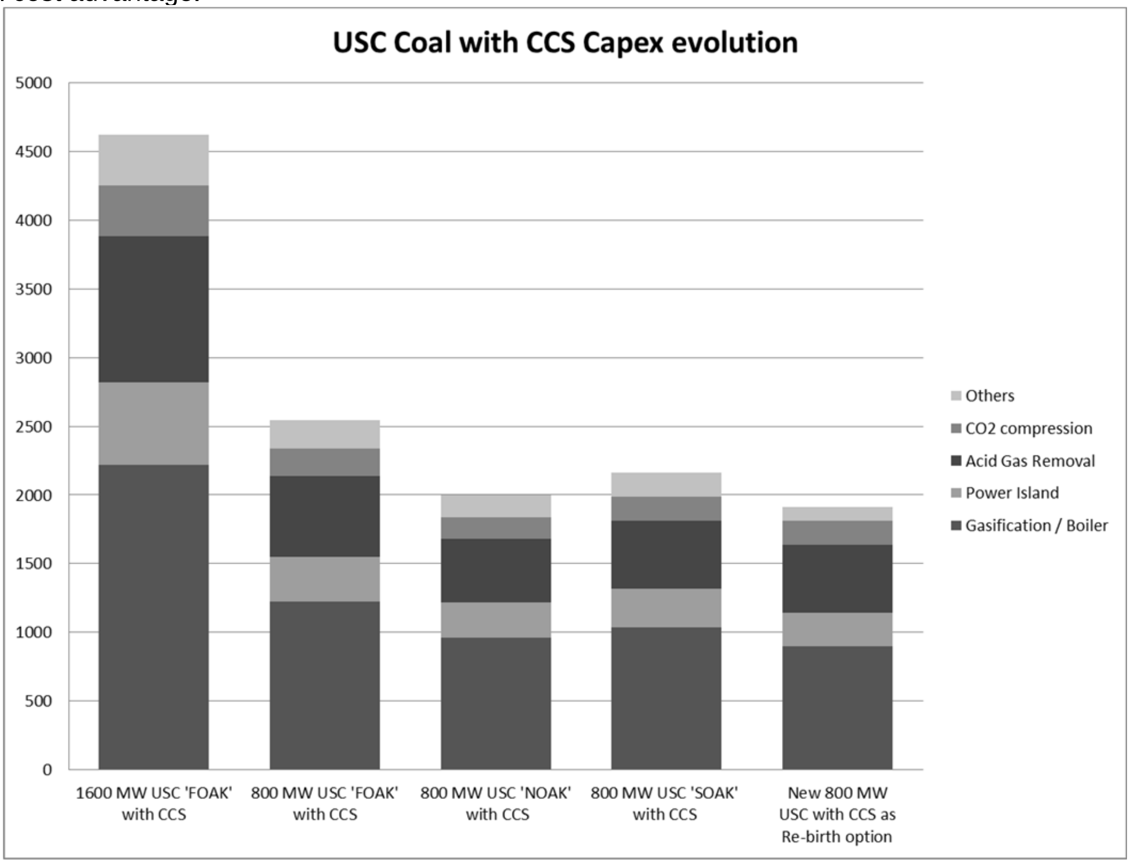


Chart 2 - this chart shows the potential trends as experience of USC with CCS matures together with the marginal cost advantage of a re-birth option within an existing coal plant location.

3.5.5 IGCC with CSS cost trends

There have been no IGCC power plants built in the UK although a number of developers have commenced projects that could deploy the technology.

A new IGCC plant in the UK with both Gasification and Generation in the base configuration would need to add capture to be compliant with DECC guidance with full functionality in initial operation to attain a PPC operating permit.

The price indications for a new IGCC plant in the UK are not underpinned by UK experience and must be considered as an early guestimate and cannot be considered reliable for investment purposes of CfD calculation.

The current price level for a FOAK IGCC plant with CCS project is estimated at £3,006 /Kw, resulting in a CapEx estimate of £3,126 m for a 1040 MW plant with two power train units. [Note - Much higher prices were presented by Poyry in a recent risk workshop]

The improvements for Second of a Kind (SOAK) or nth of a Kind (NOAK) could be considerable. It is not clear whether a new IGCC plant will be deployed by C-Gen, under their broad planning application, or alternatively by other developers in the near future but this could offer the basis for learning and feedback.

The deployment of the gasification and capture elements onto a CCGT project (subject to Fuel supply and Turbine model) could see a significant reduction in the overall CapEx required.

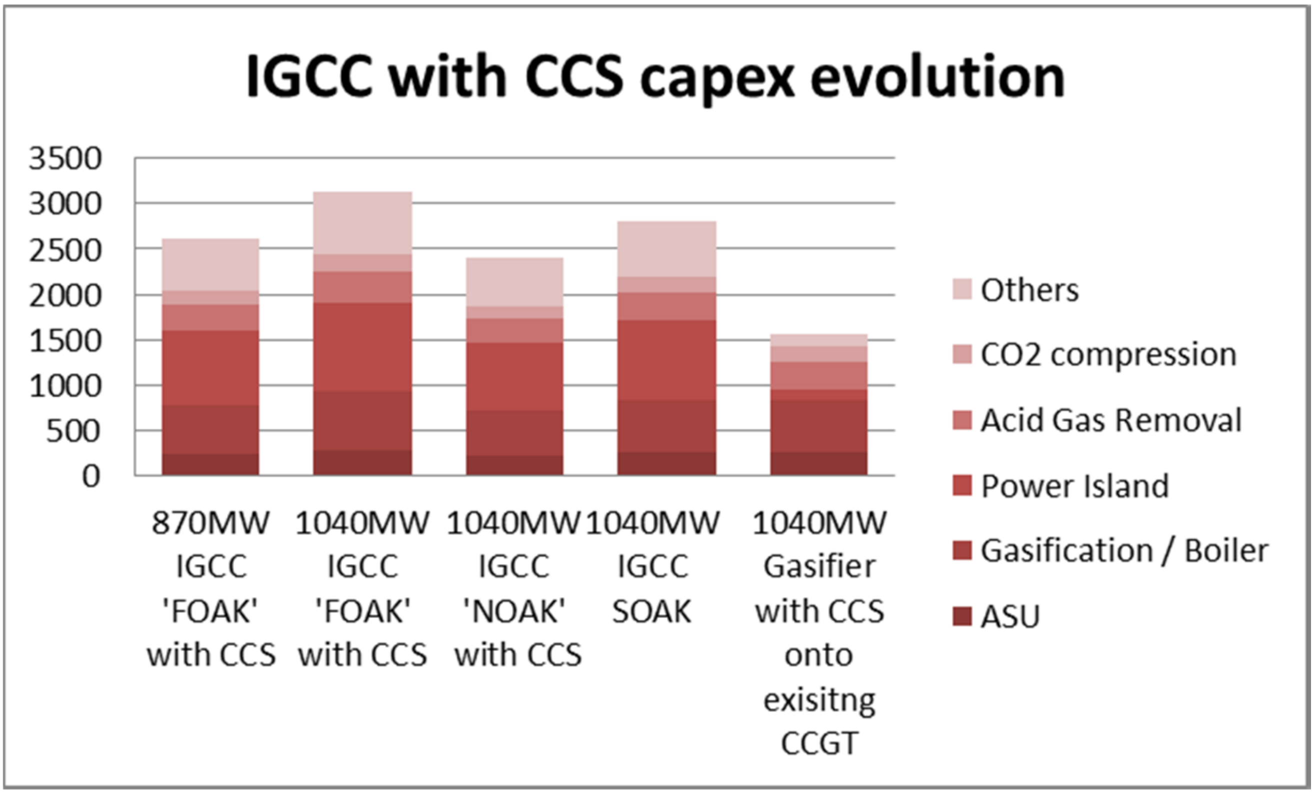


Chart 3 - this chart shows the potential trends as experience of IGCC with CCS matures together with the overall cost level of supporting additional equipment added to a modern CCGT plant.

3.5.6 Oxy Fuel Coal with CSS cost trends

The development of Oxy Fuel coal with CCS at White Rose will be the first deployment in the UK and will be the primary source of engineering and capital cost information.

As a new coal plant, carbon capture must be present in initial operation to be compliant with DECC guidance with full functionality in initial operation to attain a PPC operating permit.

The price indications for a new Oxy Fuel plant in the UK is not underpinned by UK experience and therefore must be considered as an early estimate and cannot be considered reliable.

The current price level for a FOAK Oxy Fuel plant with CCS project is estimated at £3,500 /Kw, resulting in a CapEx estimate of £2,835 m for a 900 MW plant with two power train units.

The improvements for Second of a Kind (SOAK) or nth of a Kind (NOAK) could be considerable but will be informed by the completion cost of White Rose. The concept of ETI supporting a new two unit development site appears to have significant merits in contributing to understanding the reality of SOAK developments. The consideration of two units being near the first demonstrator (White Rose) is likely to benefit from both learning effects and the synergies from close coupling to coal reception facilities and other associated services.

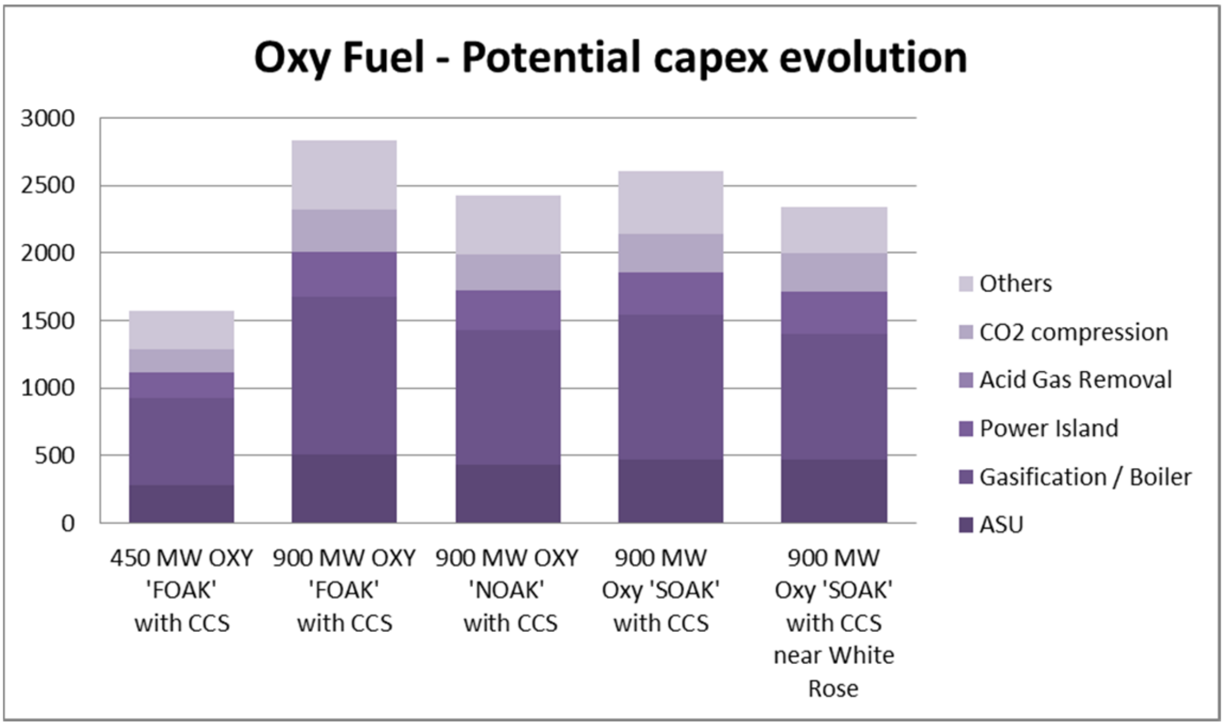


Chart 4 - this chart shows the potential trends as experience of Oxy Fuel with CCS matures together with the beneficial scalar costs of deploying two units with further improvements with experience in deployment.

The development of two units based on the White Rose final specification and configuration is considered to offer opportunity to deliver less than the NOAK costs. This would assume maximum learning and experience transfer to the new project.

3.5.7 Major Development Costs in advance of FID

In Section 3.5.1, reference was made to the direct development costs related to the specialist services engaged on the progression of the planning application and outline engineering with respect to the minimum budget commitment to Development. There are a range of other costs that may become relevant during Development and in advance of FID to enable the project and to protect the overall timescales. These are considered in summary below;

Full Chain Development v Part Chain Development

This study is focused on the options for a part chain capture project focused on the generation, capture and compression elements and **not** the transportation and storage elements. Recent studies have suggested that for a CCGT with CCS the total development costs for a FOAK deployment could be as high as £91 m [Ref 8] compared with £ 27m a year earlier [Ref 7]. This higher recent estimate would undoubtedly include some consideration of the development of transportation and storage. Similarly the costs related to the development of Coal with CCS have been quoted to £250m, not dissimilar to the Euro 300m FEED support announced to assist White Rose. Generally these costs are outside of the minimum development costs to support a DCO planning process. The absolute need to spend such high sums to improve certainty on a part chain project development is not fully evidenced.

Basic Development Costs and FEED – CCGT with CCS example

The minimum development costs for a part chain capture were estimated at c. £ 4m for the commencement of a DCO planning process. This is relatively insignificant, at c 0.3% of the overall costs of a 1000MW CCGT with CCS, estimated at c £ 1250m.

The commitment to FEED engineering for the same plant may be in the region of 3%, say £37.5m, to progress the plant design and interface definition to a point where requirements and specifications support the recommendation for an Investment Decision. The aim of the FEED should be to allow an investment decision to be made with confidence that engineering and contracts are developed sufficiently to indicate that the project can be completed can be achieved for c £1250m.

Further commitments and liabilities may occur as applications for connections, land options and supply agreements that are progressed within a development phase. These costs would contribute to the overall estimate of £91m in the recent cost model reports.

The total development phase cost estimates for each technology are summarised below, with the contrast between recent cost models and the part chain development costs;

Total Development Costs (in advance of FID)	**CCGT with CCS £ m**	**ASC with CCS £m**	**IGCC with CCS £m**	**Oxy with CCS £m**
Pre-licencing costs, Technical & Design	50	128	71	
Regulatory & Licencing	41	128	71	
Total	**91**	**256**	**142**	
Note - Based on data from UK Electricity Generation Costs Update [Ref 8] – uncorrected				
<u>Study Report Development Cost Summary</u>				
DCO Development Costs	**4**	**4**	**4**	**4**
Part Chain Development Costs @3% of EPC	**37.5**	**76**	**93**	**84**

3.5.8 Other Development Phase Cost Considerations

In considering elements that contribute to cost or liabilities for the development phase of a power station then the following three areas are highlighted for information.

Land Options

For a new development site, the overall purchase cost of 260,000 square metres (65 acres). Construction Laydown areas may add another 200 acres giving a total of 265 acres.

At a typical cost of £5,000 to £25,000 per acre, this would suggest a maximum price in the region of £6.625 million as a purchase price.

In a development period, an option fee of 15% may become payable, and this would be just less than £1m. This 'option to purchase' would be sufficient to satisfy the outline requirements of land rights to support the DCO application and examination.

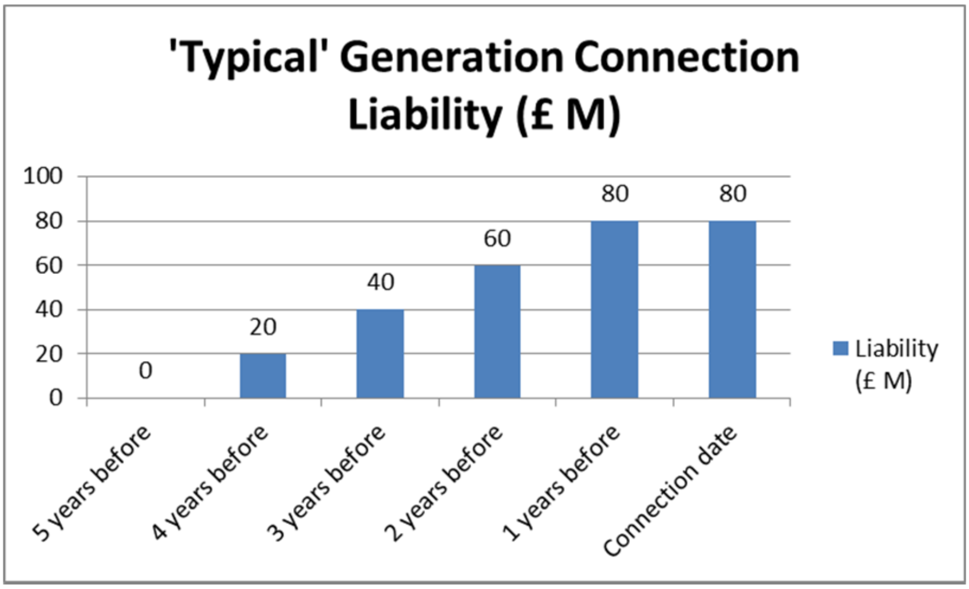
If a site is wholly owned by a developer then there is unlikely to be any requirement to provide for land costs during the development period.

Electricity Connections

For a 1000 MW development a direct application to National Grid for electrical connection would normally be expected. Under current methodologies then the connection application fee is relatively modest but the Connection Cancellation fee can become crippling.

The application for connection would attract a fee of £400,000 in line with Connection and use of Systems Code (CUSC) charging statements. [Ref 12]

In making an application to National Grid, a response Offer will be provided in 12 weeks. If the applicant then opts to accept the Connection Offer, they will become liable for cancellation costs if the project is not progressed and does not connect to the Grid. The User commitment element in section 15 of the CUSC agreements [Ref 13] exposes the applicant to 100% of cancellation charges if termination is within one year of agreed connection date, and 75% within two years, 50% within 3 years, 25% within 4 years. If the cancellation charge was calculated at £80m, then this would mean the charge would be start at £20m at four years from connection date. For part chain capture this should be after FID but liabilities would normally require Board level authority.



The project development conundrum is to balance securing the schedule and confidence of the essential export connection requirement with the pace of development and related exposure to liabilities. An application would normally look for a connection to be available some 5 to 6 years later. As we expect Implementation to take more than four years, then avoiding the first year of liabilities (25% at 4 years before) should be possible. One common technique is to secure a Connection Agreement, and then to modify the application as the project development schedule progresses, and slips!

If a site already has an export connection, and there is likely to be the retirement of part of the current generating capacity, the opportunity to secure that connection and capacity for new units could be possible. This would be on the basis of maintaining the existing Transmission Entry Capacity (TEC) agreement.

Gas Connections

A new gas connection would connect to the National Transmission System operated by National Grid.

The initial application for connection will costs £14,000 and will receive a response in 2 months. A full connection offer including concept design of the offtake arrangement costs £62,000 and will take 6 months.

The capital cost of the new minimum connection will normally be between £1 and £2 M. [Ref 14]

CO_2 Export Connection Costs

The ability to connect a new part chain capture project to the CO_2 infrastructure adjacent to White Rose is a key beneficial attribute for a further CCS project in the region. The costs of three typical Carbon export pipeline connections have been included to provide an indicative estimate of the onshore transportation system. These costs are for the pipe line connection only and are additional to the EPC CapEx which includes the cost of Carbon Capture and compression equipment.

The potential connections distance for possible regional development sites are all in the 2 to 40 mile range. The onshore pipe line specification will typically be in line with ISO 3183 L450M or API 5L X65. Construction would typically be by cut and cover but the pipeline route will include under road and under rail crossings and water course crossings and a typical cost for overcoming these features has been indicated.

The following parameters have been used to generate a typical construction cost for the options.

Parameters for typical connections

Capacity (Additional to White Rose)	2 to 5.5 M/tonnes per year
Connection distance (to White Rose)	2 miles, 10 miles or 40 miles.
Lower/Upper Size for Dense Phase Transmission	12 / 18 inch pipeline
Typical Construction Cost	£ 1m to 2 m per Mile.
Typical Under road / under rail crossing	£ 400k
Typical Water course crossing	£ 1,000k

Indicative Costs for Connections

The indicative costs for three connection combinations have been summarised below. The costs obviously increase with distance and number of obstacles to overcome or avoid. At 40 miles, the typical cost of the pipeline infrastructure would add c £70m to the project costs.

A site adjacent to White Rose (c 2 miles max)	£ 3 million
A typical site 10 miles from White Rose	£ 18 million
A typical site 40 miles from White Rose	£ 70 million

Note – The emerging data from the White Rose pipeline FEED will provide an updated view of pipeline constructions costs in the region. Alternatively this can be market tested.

3.5.9 Sample Site Development Cost Consideration

In considering the development costs of specific technologies on sample sites there is the potential to examine synergies and benefits of existing infrastructure. At this stage the drivers are captured in terms of a potential CapEx reduction consistent with the broad approach to costing in the desk top study.

The specific considerations of potential sites serves to inform the issues to be considered in the next stage of concept development work and an expanded commentary on the planning aspects of the sample sites is included in the section. This commentary is indicative only and is not intended to inform any decision by a Developer.

Major Coal Site with close coupling to CO_2 network – Sample site Drax

In considering the location of the onshore transportation network at Drax, then a further coal based development adjacent to the operational Drax site and adjacent to the White Rose development could benefit from the existing coal reception facilities, water extraction and wider national grid electrical infrastructure.

E.g. the development of two further oxy coal units adjacent to Drax may benefit up to 20% cost saving based on a First of a Kind single unit deployment. The saving contributions would result from;

- sharing portions of existing coal reception and storage
- sharing other utility services
- technology developed and deployed identical with minor modifications to that at White Rose
- move to two units on new site

Major Coal Locations – with pipeline connection to CO_2 export station – Sample Site Eggborough

An onsite development at Eggborough in close proximity major interfaces and replacing two of the existing unabated coal units could realise up to 15% reduction in capital cost but would be offset by demolition costs and poor access during construction, reducing savings to c 10%.

A development on the land adjacent to the Eggborough power station could realise a 5% saving in overall CapEx and this could rise to c.12% if the utility connections from a retired unabated units were diverted to serve the new abated units.

Industrial Location – multiple sites, near to coast and close to fuel import facilities

A project near or close to the C-GEN development at Killingholme or in the wider Immingham area would likely need new investment in full scope but may be able to benefit from direct cooling, short transfer distance of coal. The addition of a 40 mile long distance carbon pipeline, with a significant crossing under the River Trent, would add circa £70m to the project cost, equivalent to c 7% increase in cost to a 1000 MW CCGT with CCS and only 4% cost increase to a coal technology project.

The further assessment of the likely cost for the development and deployment of a site at Immingham would require an initial concept development and choice of technology.

Note - Interface information for the CO_2 export connections away from the power station site were not in the original study and have been estimated at £1m / km for on land routes, equivalent to £50 -70m. [Ref 15]

3.6 Programme and Project Risks

In considering the development of a low carbon thermal power project then the following summary of potential risks is offered at programme and project level. Further work on risk identification and capture is recommended.

3.6.1 Programme Level risks

Issue	Description	Impact	Potential Risk	Mitigation	Mitigated Risk
INVESTMENT GRADE POLICY AND MECHANISMS FOR CCS PROJECTS	The additional cost of CCS abatement equipment is significant and is not rewarded under traditional market support will compete with Nuclear for CfD (Horizon and/or NuGen).	Investment Case for CCS enabled fossil project will fail.	HIGH	Energy Bill in UK must provide for adequate and protected CfD provision for CCS projects. May need to have allocations of projects confirmed or re-assessed.	MED
SUPPORT MECHANISMS FOR CCS GENERATION PROJECTS with THIRD PARTY TRANSPORTATION ASSETS	The support mechanism for CCS projects fails to recognize the structure of a project that relies on third party transportation or fails to provide cover for the third party assets if their Owner defaults.	Investment and / or risk profile will not be possible.	MED	Lobby for the structure of CCS projects to be flexible. Encourage the provision of CCS networks as a regulated business or as a third party venture (e.g. like OFTO regime)	LOW
ANCHOR PROJECT SUPPORT	The UK or EU support of White Rose does not continue after next Election in 2015 due to reasons outside control of Owner Group.	Development work funding may be withdrawn preventing FEED work.	MED	Review and understand the current funding mechanism Include specific interface works scoping in the Anchor project.	LOW
ANCHOR PROJECT PROGRESS	The White Rose Project fails to progress in line with expectation in technical or commercial activities due to Owner Group decisions.	Delay or suspension of project prevents the timely development and deployment of the anchor project assets, and creates reasonable doubt of critical interface being available and causes abandonment.	HIGH	Consider alternate sinks in conjunction with other projects. Control expenditure in development phase within tight boundaries in relation to White rose progress through milestones.	LOW
GLOBAL INCIDNENT ON CARBON NETWORK	A significant incident undermines confidence in sector.	Public Opinion and support for new CCS projects in region declines.	MED	Consider Safety Case and consultation activities to ensure a balanced view of risk that can be maintained.	MED

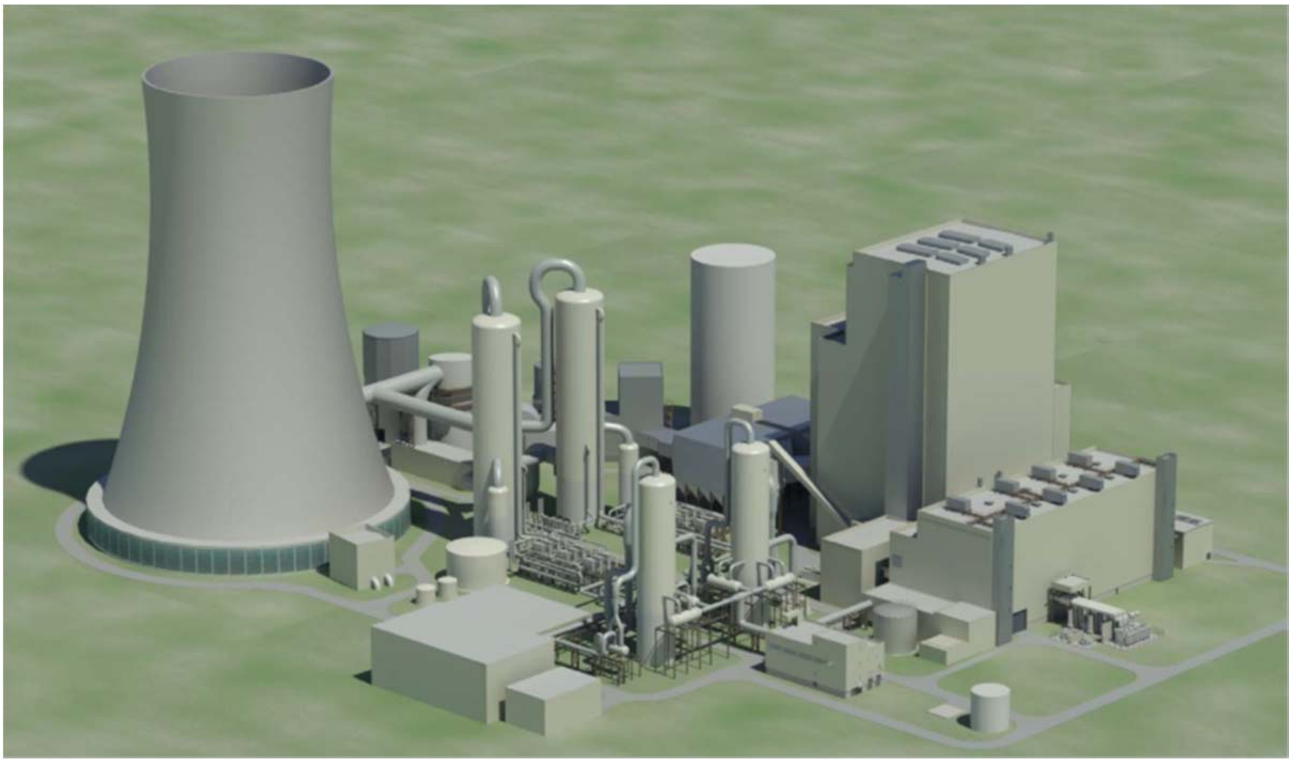
3.6.2 Project Level Risks

For this summary, the project is defined as the development activities of a CCS plant

Issue	Description	Impact	Potential Risk	Mitigation	Mitigated Risk
INTERESTED PARTIES	There is no sensible response to a Project Call.	Hard to progress project and embarrassing to all involved.	MED	Market Test the call before a formal decision to launch.	LOW
INTERESTED PARTIES	Failure to agree Contracts for funding	Causes project to stop and re-tender	MED	Develop requirements to enable ETI to be the Developer, with land options	LOW
PROJECT PROGRESS	Project fails to progress at agreed pace or struggles to secure skilled resource in UK market context	CCS project does not progress at desired pace.	MED	Insist on named resources and examine before Award. Agree resources and milestones for payment	LOW
PERMIT APPLICATION	Failure to collate full, consistent and compliant documents for DCO submission.	Authority do not accept submission and cause re-work with corresponding cost increase and delay	MED	Agree full scope of Requirement, and appoint competent planning leader.	LOW
FUEL SWITCH	Significant change in fuel commodity prices destroy project economics	Causes project to stop or be abandoned		Review conditions where project would fail under Coal / Gas or CO_2 price change.	LOW
TECHNICAL SCOPE	The technical scope of the project changes significantly	Causes significant change to Consenting and schedule	MED	Establish a disciplined configuration control system for the project	LOW
STATE AID	The Project does not meet the State Aid criteria	Causes project to stop or be abandoned	MED	Seek early advice	LOW
CHALLENGE	The process for project call and award results in a ‘disappointed’ bidder who challenges project selection	Causes project to stop or be abandoned	MED	Review process for contract development and award and include no right to object	LOW
OWNER CHANGE	Project Developer withdraws from market	Causes project to stop or be abandoned	MED	Consider step in rights and assignment	LOW

Section 4

Locations



800 MW PF with CCS. Courtesy – Siemens

4 LOCATION REVIEWS

4.1 Sample Locations

In this section, three site specific reference locations have been considered to illustrate the potential considerations for development of a low carbon thermal power station. The three sample locations (Drax, Eggborough and Immingham) are considered in the broader context of their attributes for project development and to 'test' and illustrate the technology combinations possible at a range of similar sites.

The sites were representative of other locations in the area and were chosen due to the following basic attributes;

- The area in the vicinity of **Drax** offers the potential of a development location with the benefits of the adjacent station and close coupled interfaces, within the vision of being the lead clean power hub in UK. Development would be off-site from existing station, probably use an alternate technology to White Rose and could be by a new Developer.

- The area in the vicinity of **Eggborough** offers the potential of a development location with either onsite or near site options. The potential to consider onsite space where there are current opted-out units (ref) could be attractive as a New Clean Coal option (Site Re-birth). The interfaces for carbon export are in near field range.

- The wider area in the **Immingham** region offers the potential of a development in a number of separate locations in the area. The proximity to fuel imports and heavy industrial operations is attractive. In the base consideration, the Immingham region is at far field boundary range for carbon export but illustrates the considerations related to a longer connection. Advantages may emerge if other Clean Fossil Developments in this vicinity substantially progress.

Each location has been considered with respect to the outline spatial capacity of the site and surroundings to accommodate specific technology (see below) and then the environmental and planning aspects of further development have been considered.

	Technology Option			
SITE	**NG CCGT**	**ASC PF**	**IGCC**	**OXY Fuel**
Drax	Yes	Yes	Yes	Yes
Eggborough	[Yes]	Yes	Yes	Yes
Immingham	Yes	Yes	Yes	Yes

In section 4.5, a further six locations have been identified as other regional sites, already named and 'in development'. These are Don Valley, Keadby, Killingholme, Knottingley, Thorpe Marsh and of course White Rose.

For completeness, a summary of the regional operational coal sites is listed in section 4.6 showing the opted in and opted out sites under LCPD.

4.2 Major Coal Locations – e.g. Drax

As a sample location, Drax has been used as the potential location of further part chain projects connecting to the new CO_2 export facilities created by White Rose. This is representative of a coal based site with **close** proximity to the CO_2 network.

Drax is already the largest generation site in UK, with a combination of coal and biomass firing on six large 660 MW units contributing to 4,000 MW capacity. The additional 450 MW White Rose oxyfuel power plant to the north of the site will add to the capacity connected at the transmission point.

All 6 units at Drax are opted in under LCPD 1 and each unit has been fitted with Flue Gas Desulphurisation (FGD) and will remain in operation past 2015. Recently Drax has constructed large storage silos for Biomass and is looking at converting up to 3 units to full biomass firing.

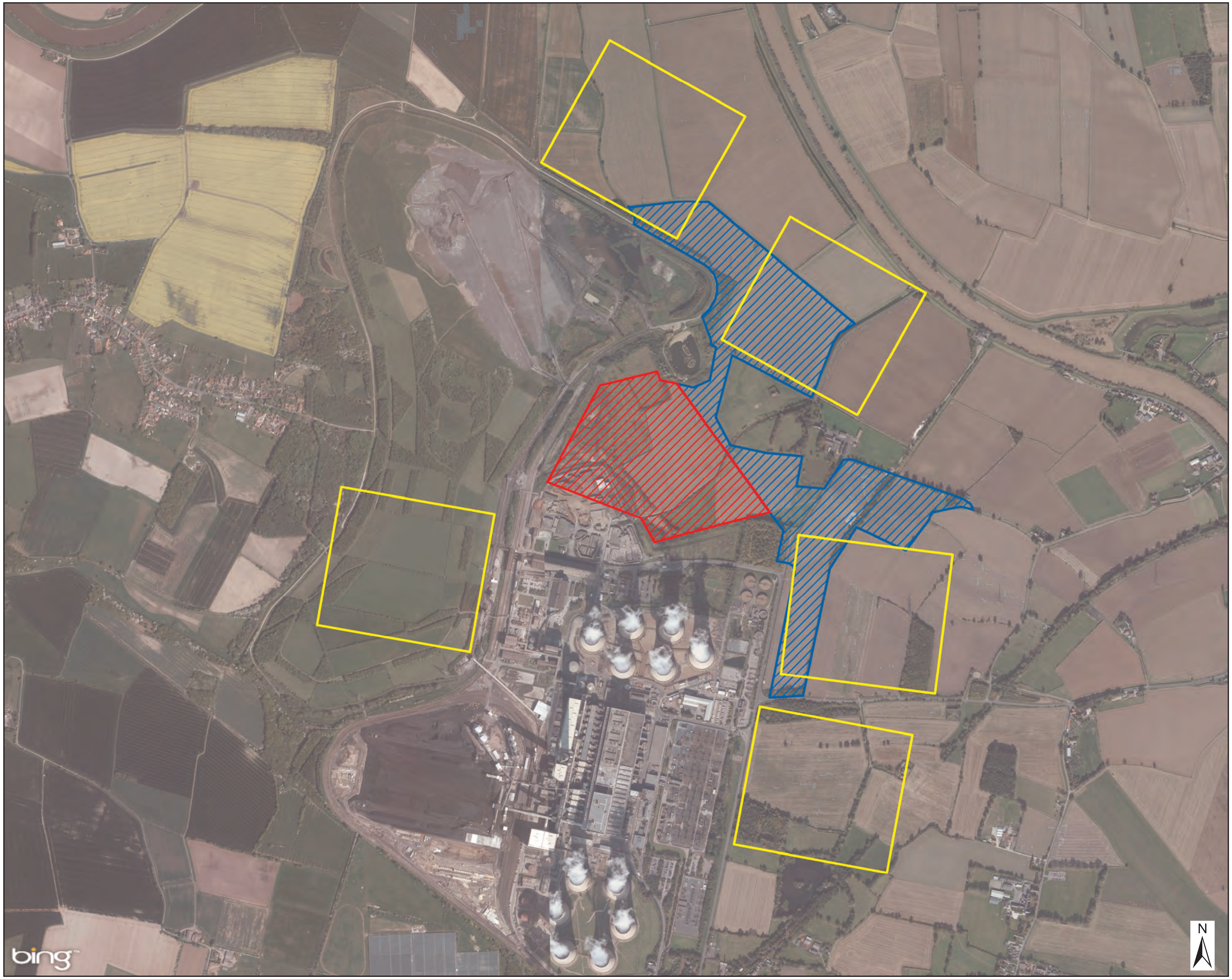
The summary commentary for the Drax site based on the desk top assessment, and ignoring the option for a second oxy fuel power plant is as follows.

Development Sites

There are potential development sites to the West, North and East of the current Drax coal power station, although sites to the immediate North and East would only be available after the construction activities for White Rose have been completed . These are captured on the map images 1a and 1b. The largest plot plan (Oxy Fuel) has been taken to represent the technologies as the worst case scenario for land requirements.

It is possible that either a coal based IGCC or PF with post combustion capture could be deployed and subject to installing a connection a gas fired CCGT with post combustion capture.

Image 1 – Overview of DRAX



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Legend

- Potential Plot Locations
- WRCCS Operation Area
- Construction Laydown Area

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Revision Details	By / Check	Check Date	Suffix

Purpose of Issue: FINAL

Client: ENERGY TECHNOLOGIES INSTITUTE

Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title: MAP 1A DRAX AREA

Drawn	Checked	Approved	Date
PB	EB	EB	08/08/2014

URS Internal Project No.	Scale @ A3
47071043	1:12,500

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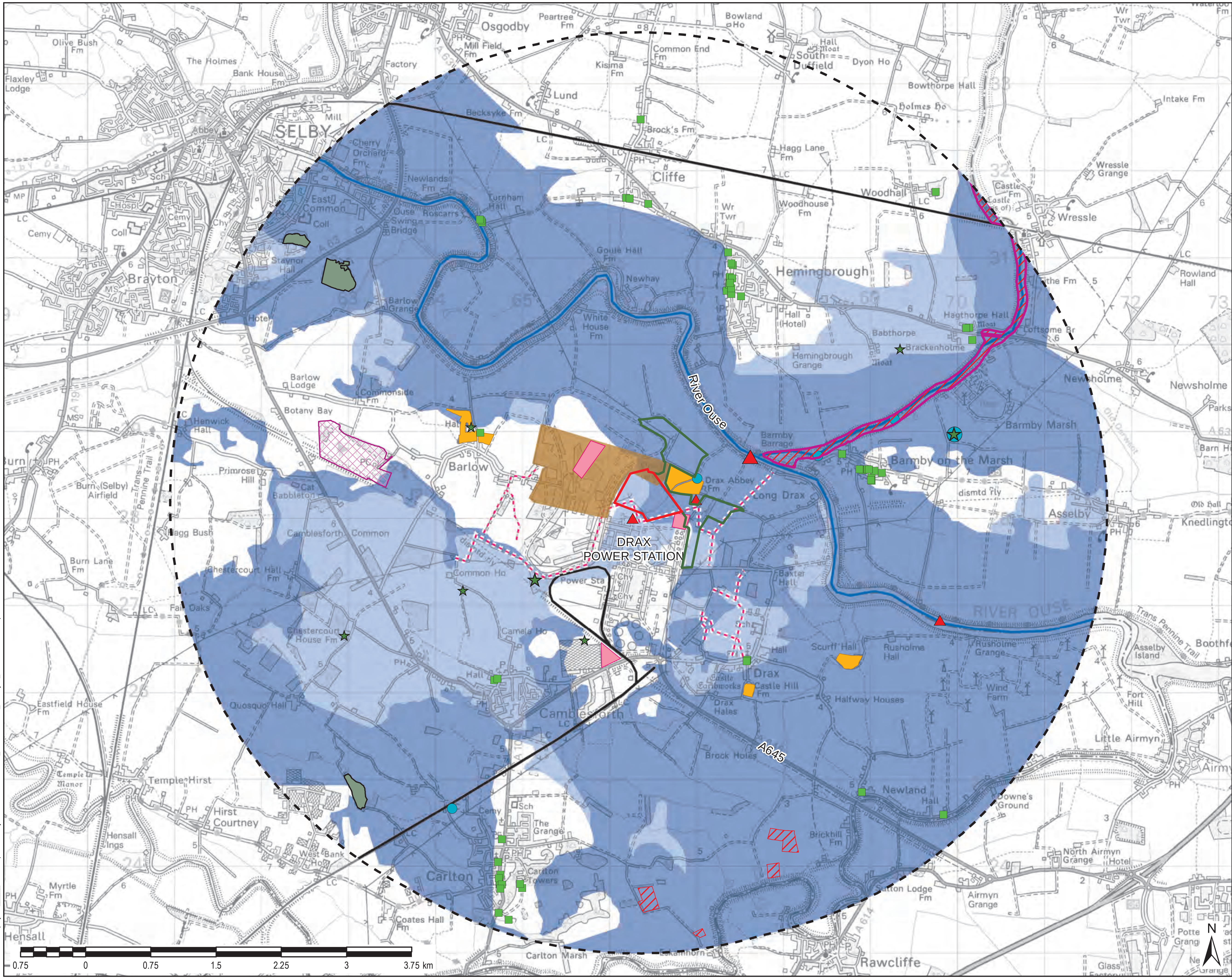
Drawing Number	Rev
47071043/MAP 1A	0

File Name:K:\Newproje\47______ - UK Blueprint CC Project\GRAPHICS-Data\GIS_Data\01-WIP\01_03-Project_Files\MXDs\Final\Map 1a Drax Area.mxd



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KEY

- 5Km Study Area
- WRCCS Operation Area
- Construction Laydown Area
- Public Right Of Way
- Rail
- Scheduled Monument
- Listed Buildings
- Ancient Woodland
- Local Nature Reserve
- Special Area of Conservation
- Sites of Special Scientific Interest
- Historic Landfill
- Authorised Landfill
- Flood Zone 2
- Flood Zone 3
- Surface Watercourses

Water abstraction from ground water source
- Large size of abstraction
- Medium size of abstraction

Water abstraction from surface water source
- Large size of abstraction
- Medium size of abstraction

Water abstraction from Tidal water source
- Large
- Medium

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue: FINAL

Client: ENERGY TECHNOLOGIES INSTITUTE

Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title:

MAP 1B DRAX AREA CONSTRAINTS

Drawn	Checked	Approved	Date
PB	EB	NS	07/08/2014

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47071043	1:40,000

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Drawing Number	Rev
47071043/MAP 1B	-

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Environmental and Planning Considerations

Drax, as allocation has a strong heritage of coal-fired power generation and therefore the environmental constraints are largely not significant as a result of that context. In particular, there are no on-site internationally or nationally designated sites of ecological interest, although there is a Special Area of Conservation (the river Derwent) 1.2 km to the north east.

There are no heritage sites at risk from any development and the site is not in or adjacent to any Air Quality Management Areas.

The site lies on good rail (Hull and Barnsley railway line) and road (M62 and A645) transport routes.

Parts of the site lie in Flood zone 3 which would necessitate further justification of use in the event that development was in those areas.

At this stage, the main potential constraint is considered likely to be associated with water abstraction. With the existing power station and biomass conversion, coupled with the White Rose development, further river abstraction is likely to be challenging, although groundwater abstraction may be possible, either through new licences or transfer of rights from existing consents.

From a planning perspective, the site has benefitted from several power related consents in the last few years, and the overall site area of 750 hectares provides sufficient development area, although workforce planning and sufficient construction laydown space in the short term may be challenging issue. The heritage and scale of the existing assets means that current public attitudes to the future development of a CCS enabled generating station is likely to be neutral or positive, rather than hostile.

Advantages

Positive public engagement

Lower consenting risk

Limited environmental constraints

Close coupling to the CO_2 network

Disadvantages

Limited water supply

Timing issues related to workforce access and limited construction laydown space

Further development in an intense area of generation

Summary

A site with good potential that may be compromised in time or impact by the other ongoing existing and proposed developments.

4.3 Major Coal Locations with pipeline connections to CO_2 export network – Sample site Eggborough

There are a number of coal stations in the region with established facilities and surrounding land that may be appropriate for consideration of a complete new build, or for the build of new units in place of existing units due for retirement (Re-birth). In this broad category we have sites at Eggborough, Ferrybridge, West Burton and Cottam. Eggborough is the closest to the CO_2 network at Drax.

The power station at Eggborough has four 500 MW units contributing to 2,000 MW capacity. The Owner has planned to convert one or two units to Biomass firing and has publicly sought planning permission under permitted development but actual work has not yet commenced.

All four units at Eggborough are opted in under LCPD 1 but only two, Unit 3 and 4, currently have FGD fitted. This is due to the definition of a combustion unit via a common stack within the Industrial Emissions Directive although in practice the Emission Limit Values that need to be achieved would be expected to prohibit the operation of the non-FGD units post 2016.

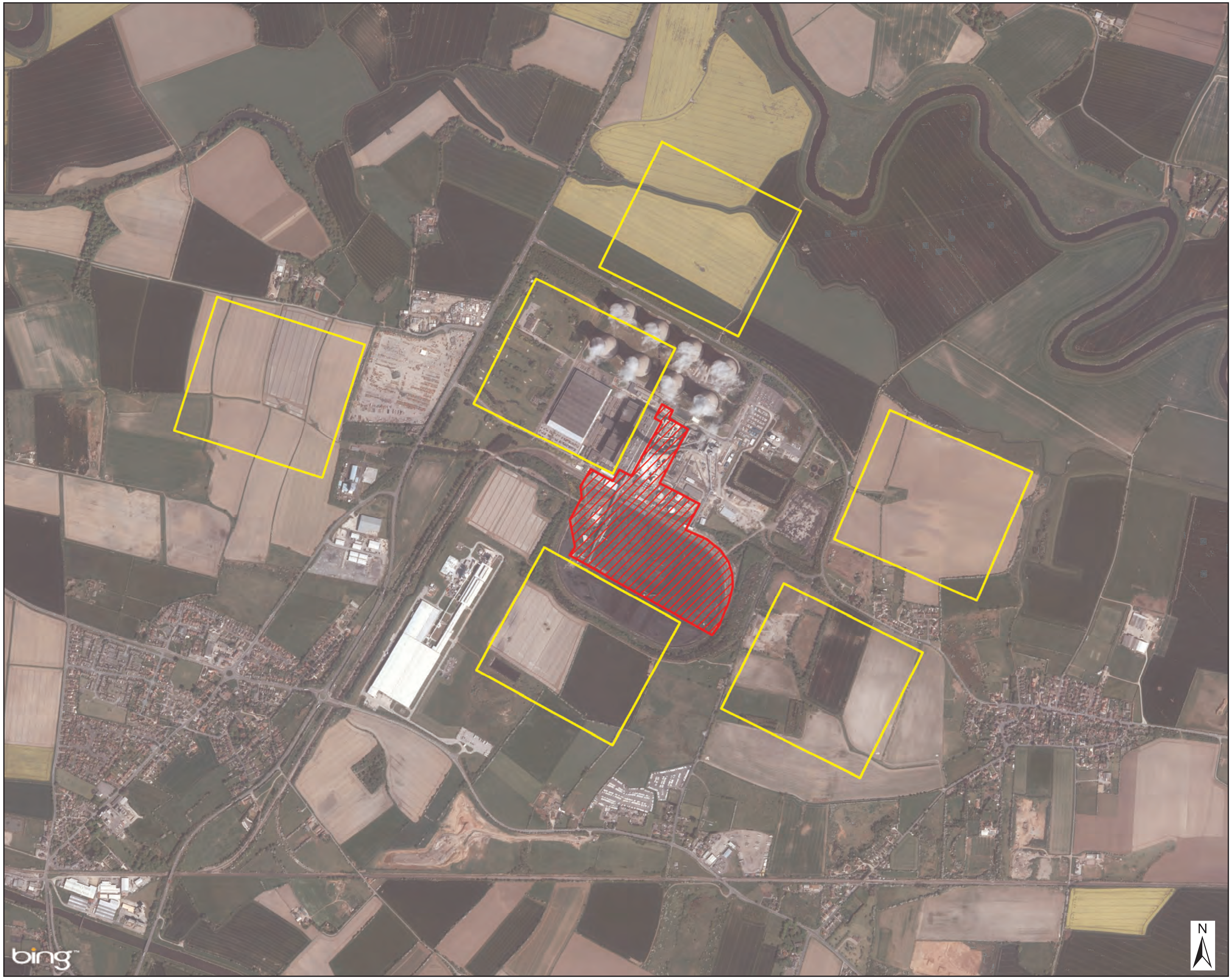
The summary commentary for the Eggborough site and immediate surrounding area based on the desk top assessment is below. Locations are captured on the map images 2a and 2b.

Development Sites

There are potential development sites to the West, North and East of the current Eggborough coal power station with the site to the south previously identified for new biomass storage and conveyor transfer facilities.

It is possible that any one of the four technology option could be deployed in the Eggborough Area. There is spatial capacity for either a coal based Oxyfuel, IGCC or PF with post combustion capture and subject to installing a high pressure connection a gas fired CCGT with post combustion capture. Development could be progressed within the site boundary to replace 2 units.

Image 2 – Overview of Eggborough Area



Legend

- Eggborough Power Station Biomass Project
- Potential Plot Locations

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Purpose of Issue: FINAL

Client: ENERGY TECHNOLOGIES INSTITUTE

Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title: MAP 2A EGGBOROUGH AREA

Drawn	Checked	Approved	Date
PB	EB	EB	08/08/2014

URS Internal Project No.	Scale @ A3
47071043	1:12,500

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47071043/MAP 2A	0

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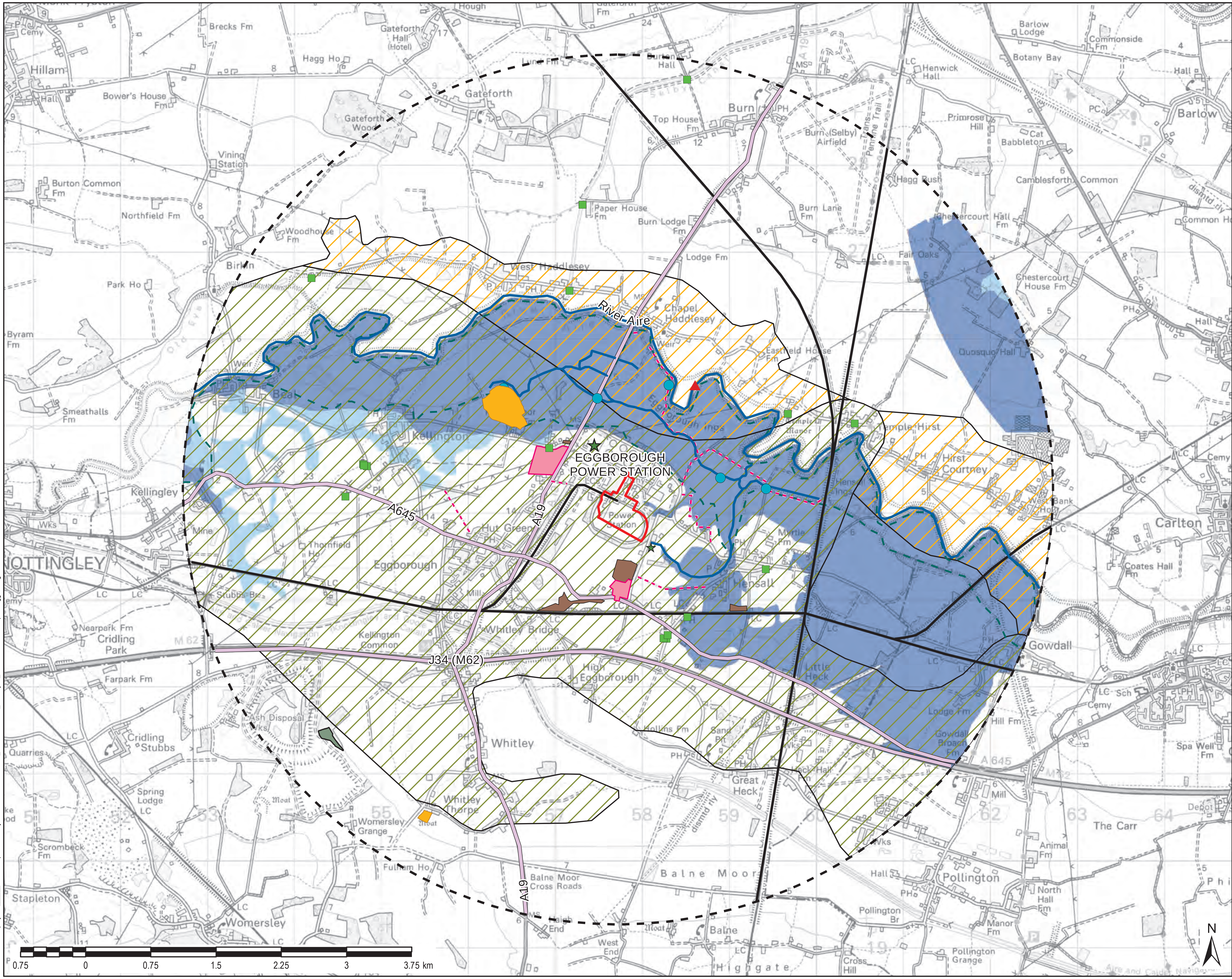

File Name:K:\Newproje\47_____ - UK Blueprint CC Project\GRAPHICS-Data\GIS_Data\01-WIP\01_03-Project_Files\MXDs\Final\Map 2b Eggborough Area Constraints.mxd

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KEY

- 5km Study
- Eggborough Power Station Biomass Project
- Public Right Of Way
- Roads
- Rail
- Scheduled Monument
- Listed Buildings
- Ancient Woodland
- Local Nature Reserve
- Historic Landfill
- Authorised Landfill
- Surface Watercourse
- Major Aquifer
- Minor Aquifer
- Flood Defence
- Flood Zone 2
- Flood Zone 3

Water Absraction from Tidal
- Medium Size of

Water Abstraction from Surface Water
- Medium Size of

Water Abstraction from Groundwater
- Large Size of
- Medium Size of

Revision Details	By Check	Check Date	Suffix

Purpose of Issue: FINAL

Client: ENERGY TECHNOLOGIES INSTITUTE

Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title: MAP 2B EGGBOROUGH AREA CONSTRAINTS

Drawn	Checked	Approved	Date
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Environmental and Planning Considerations

The Eggborough site has a strong heritage of coal-fired power generation and therefore the environmental constraints are largely not significant as a result of that context. In particular, there are no on-site internationally or nationally designated sites of ecological interest, and none within 5km of the site. The site lies on good rail (Knottingley to Goole railway line) and road (A19) transport routes.

There are no heritage sites at risk from any development and the site is not in or adjacent to any Air Quality Management Areas.

To the north of the site is designated Flood zone 3 which would necessitate further justification of use in the event that development was in that area.

Assuming that the CCS enabled project replaced the existing generating station, there would be sufficient consented water abstraction to support the proposed development, potentially with retention of the natural draught cooling towers, although replacement with hybrid towers would be more realistic. However, a biomass conversion project has been proposed for the generating station and impact would need to assessed.

Groundwater vulnerability is high although that is true of other power stations in the area and has not prevented ongoing development provided that adequate protection is designed into the generating station; this is regulated and enforced through the Environmental Permit.

There are a number of recorded landfills in and around the site – again not uncommon for existing coal-fired power stations and these should not pose significant risk to any new development although may affect the location of specific plant within the footprint.

From a planning perspective, the site has benefitted from several power related consents in the last few years, including the biomass conversion and the overall site area of greater than 300 hectares provides sufficient development area, with sufficient construction laydown space. The heritage and scale of the existing assets means that current public attitudes to the future development of a CCS enabled generating station is likely to be neutral or positive, rather than hostile.

Any carbon pipeline from the site to Drax is around 10 km – less than the 10 mile threshold discussed above although any such pipeline would be progress as Associated Development to any DCO for the new generating station.

Advantages

Positive public engagement and Lower consenting risk.

Limited environmental constraints and Limited constraints on carbon pipeline.

Good developable area including laydown and access.

Availability of water supply.

Disadvantages

Biomass development may add additional constraints on area with assessments necessary.

Summary

A site with excellent potential subject to proposed developments.

4.4 Industrial Development Area – Sample site Immingham

The general area from Killingholme, Immingham and Stallingborough has a number of gas fired combined cycle units together with the country's largest CHP plant at the Phillips 66 Humber Oil refinery.

Immingham is also the location of Humber International Terminal (HIT) which can handle the unloading of 10 million tonnes of coal a year, equivalent to a fifth of UKs current total imported coal volume. The UK used c. 60 million tonnes in 2013 of which 50 million tonnes was used in power generation. Only 10 million tonnes was from UK production.

The summary commentary for the Immingham and immediate surrounding area based on the desk top assessment is below.

Development Sites

There are potential development sites along the Humber coastline with the wider area in Map 3 and the Kilingholme areas in Map 4a and 4b.

Note: The area shown for CGEN Killingholme is the total area for the application site including the Electrical Grid Connection Land, the Gas Connection Land, the Cooling Water Connection Land, the Construction Laydown Area, and the Operations Area and totals over 2,000,000 sq. m. The area shown for nominal 1GW proposed template is only based on the operational area, at 220,000 sq. m.

It is possible that any one of the four technology option could be deployed in the Immingham Area. There is spatial capacity for either a coal based Oxyfuel, IGCC or PF with post combustion capture and there is also space for a gas fired CCGT with post combustion capture.

Image 3 – Overview of Killingholme

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Legend

- Potential Plot Locations
- C.Gen North Killingholme Power Project

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Project Title
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Drawing Title
MAP 3
OVERVIEW OF IMMINGHAM

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Legend

- Potential Plot Locations
- C.Gen North Killingholme Power Project

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Client: ENERGY TECHNOLOGIES INSTITUTE

Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title: MAP 4A KILLINGHOLME AREA

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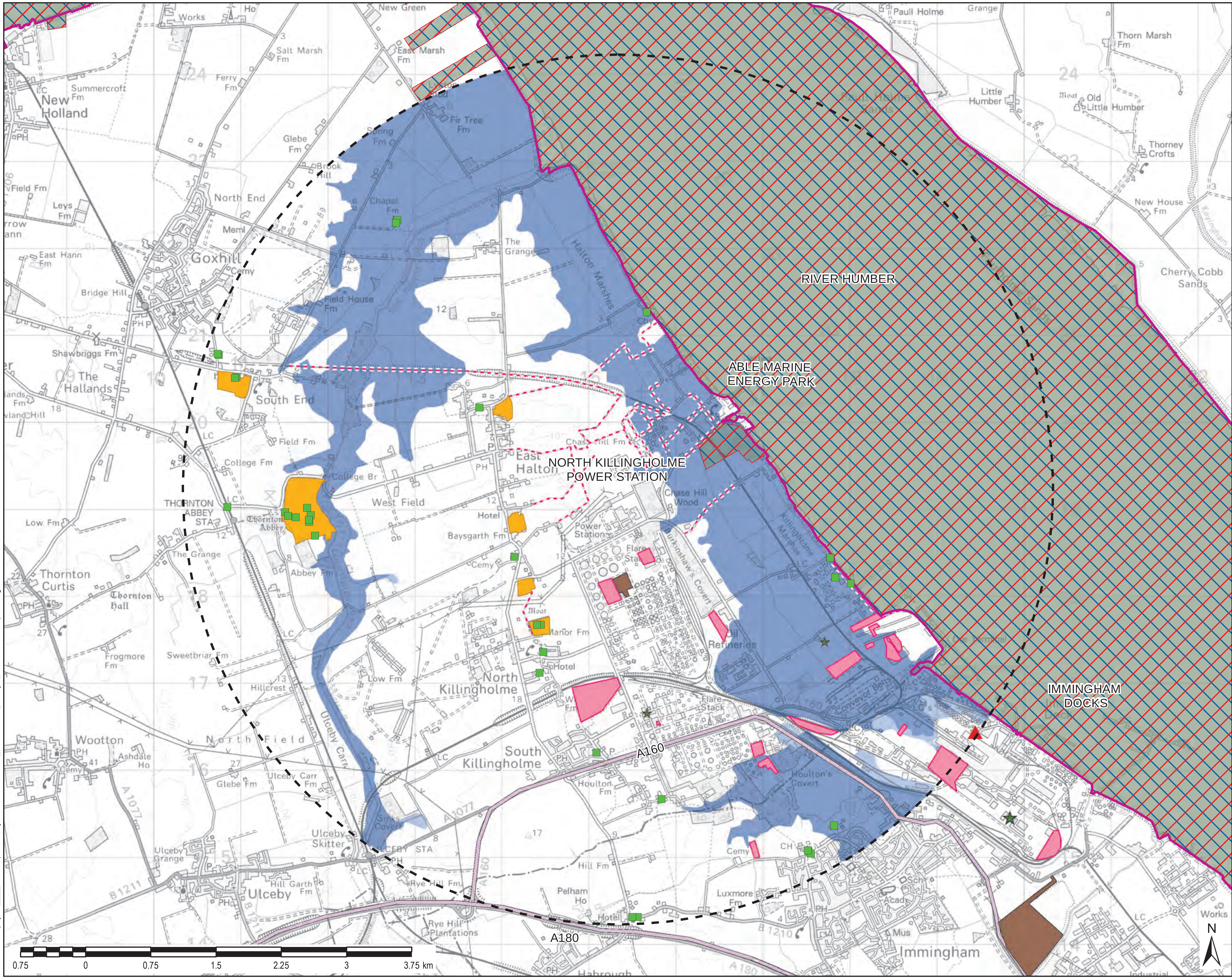

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KEY

- 5km Study Area
- Public Right Of Way
- Roads
- Scheduled Monument
- Listed Buildings
- Historic Landfill
- Authorised Landfill
- Flood Zone 2
- Flood Zone 3
- Special Area of Conservation
- Sites of Special Scientific Interest
- Special Protection Area
- RAMSAR

Water Absraction from Tidal Water

- Large Size of Abstraction

Water Abstraction from Groundwater

- Large Size of Abstraction
- Medium Size of Abstraction

Revision Details	By / Check	Check / Date	Suffix

Purpose of Issue: FINAL

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Project Title: UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title: MAP 4B KILLINGHOLME AREA CONSTRAINTS

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Environmental and Planning Considerations

The site has a strong industrial heritage and therefore the environmental constraints need to be put into that context. Nevertheless, the adjacent river Humber is an internationally designated ecological site and therefore needs careful consideration and protection, particularly if any coastal works or jetties are proposed. This may affect the technology choice unless existing coal offloading assets can be utilised.

There are no heritage sites at risk on any potential sites although there are several within the vicinity and the site is not in or adjacent to any Air Quality Management Areas.

The site lies on good rail and road (M180 and A180) transport routes.

Most identified sites are designated as Flood zone 3 which would necessitate further justification of use in the event that development was on those sites.

There should be sufficient consented water abstraction to support the proposed development, either directly from the estuary (notwithstanding the ecological risks and challenges that would create, based on the sensitivity of the area) or from further up the river.

Groundwater vulnerability is high in places although that is true of power stations in the wider area and has not prevented ongoing development provided that adequate protection is designed into the generating station; this is regulated and enforced through the Environmental Permit.

There are a number of recorded landfills in and around the site – again not uncommon for existing coal-fired power stations and these should not pose significant risk to any new development although may affect the location of specific plant within the footprint.

From a planning perspective, the area has benefitted from a range of industrial consents in the last few years and there should be sufficient development area, with sufficient construction laydown space in the vicinity. The heritage and scale of the existing industry and bulk material offloading and handling operations means that current public attitudes to the future development of a CCS enabled generating station is likely to be neutral, rather than hostile.

Any carbon pipeline from the site to Drax or Barmston is of significant length - around 40 km – and would necessitate either several major crossings (motorways, rail lines, rivers) to Drax or the Humber and a railway line to Barmston. The latter may be a more feasible route, particularly if access across the Humber could be realised through existing crossings.

Advantages

Neutral to positive public engagement with relatively low consenting risk.

Good developable area including laydown and Availability of water supply.

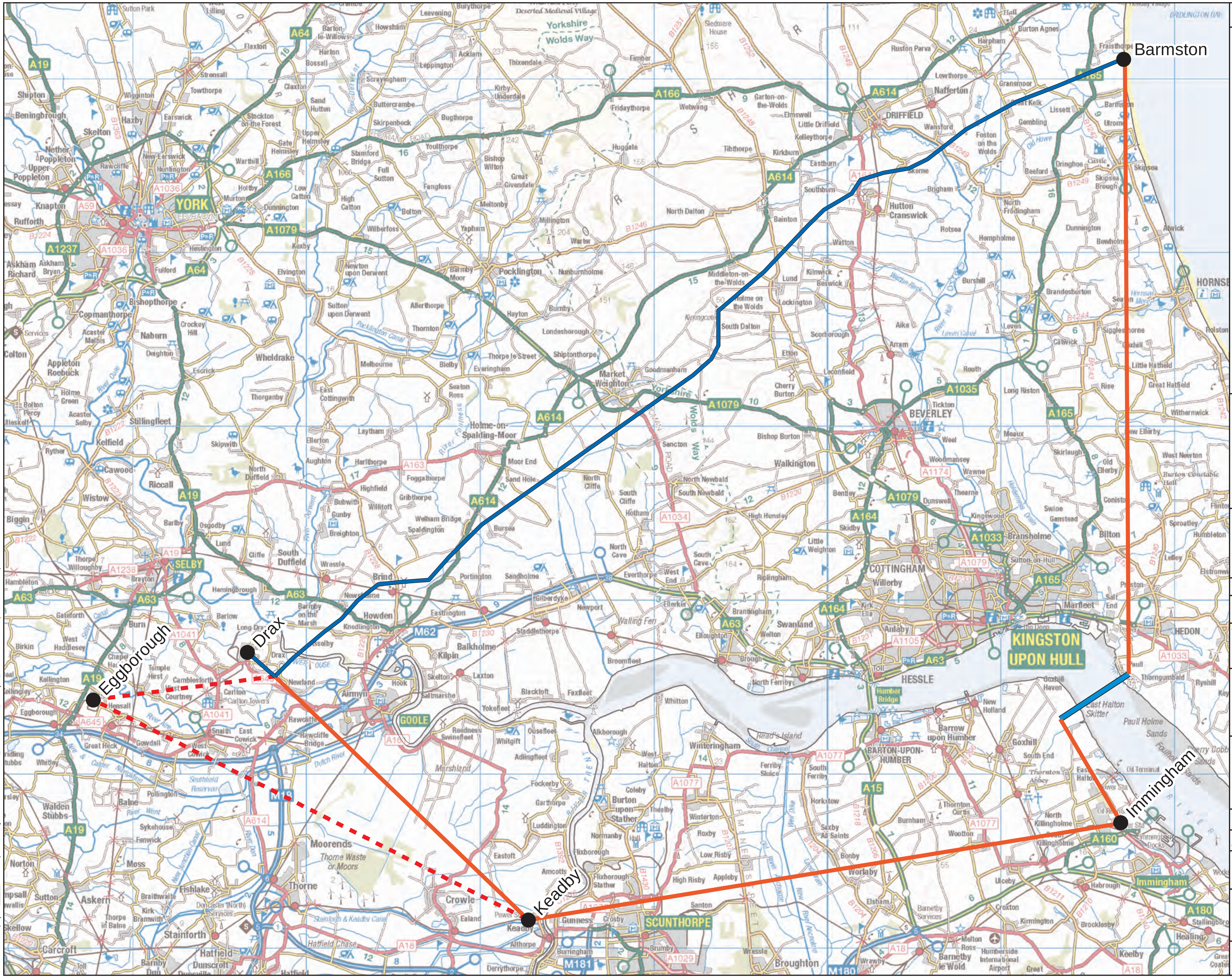
Disadvantages

Sensitivity of Humber estuary and Development in Flood Zone 3.

Length and complexity of carbon pipeline (unless linked to C-Gen or similar).

Summary

A site with good potential provided the ecological sensitivities are adequately managed and a suitable route for the carbon pipeline can be realised.



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Legend

- White Rose CCS Pipe Route
- South Humber Pipeline Option
- Eggborough Connection Options
- Humber Crossing Tunnel (Preferred Route)

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue

FINAL

Client

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Project Title

UK BLUE PRINT CARBON CAPTURE PROJECT

Drawing Title

MAP 5
OVERVIEW OF
PIPELINE CORRIDORS

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4.5 In Development Locations

This section identifies a selection of current thermal development proposals, in addition to the sample locations in Section 3.4 above.

The existence of other development project locations expands the commercial and environmental considerations before a progressing a further new development, but also serves to emphasise the general attractiveness of the region and the high potential of a cluster for low carbon thermal projects.

The information summarised in relation to each project has been obtained from early planning documents and the respective public information available and is offered for information only. Two of the projects have been progressed through the Planning Inspectorate under the DCO process and therefore status should be reviewed as projects progress through phases of planning and funding.

The following projects are illustrative of current options that are in development (alphabetical);

4.5.1 Don Valley (Hatfield)

A proposed 920 MW IGCC has been under development at the Hatfield Colliery site, near to Stainforth in South Yorkshire, for the last decade, and is now known as Don Valley Power Project.

The development was progressed under Section 36, and consented as a two stage deployment in February 2009.

The site is largely contained within the site of the former coal mine operations but will require connections to the national gas and electricity networks some 15 to 20 km away. The Section 37 Consent for the Overhead line connection was granted in May 2014.

4.5.2 Keadby

A proposal for a second 720 MW CCGT station exists on a site adjacent to the existing 360 MW power station. The Consent was granted in 1993 and has since been extended.

The development was submitted under the previous Section 36 Consenting regime and the application pre-dates the need for CCS ready considerations. No requirement to comply on CCS ready when making a time extension application currently exists.

The site is adjacent to the Keadby and Stainforth canal and very close to the River Trent and is at a nominal midpoint between Drax and Immingham.

4.5.3 Knottingley

A proposal for a new CCGT power station rated up to 1500 MW CCGT is being progressed on a site at Knottingley in West Yorkshire.

The development is being progressed under DCO regime and examination closed on 13th September with the Planning Inspectorate due to submit their recommendation by 13 December 2014 for a decision by June 2015.

The site is near to Calder Canal and close to River Aire, and between the major power station at Ferrybridge and Kellingley Colliery (Due for closure by 2017).

4.5.4 Killingholme

A proposal is being progressed for a new 470 MW IGCC on the south bank of the Humber estuary near North Killingholme in Lincolnshire.

The power station development has been approved on 11th September under DCO regime after the Planning Inspectorate issued a report of recommendation to the Secretary of State on 11th June 2014. Approval does not include Consents for necessary gas or electricity Works. These will be subject to further approvals.

This is an area that already has three other CCGT power stations but also benefits from close connection to Coal importation and Petro-chemical facilities.

4.5.5 Thorpe Marsh

A proposal for a new CCGT power station rated up at between 1000 and 1500 MW CCGT is being progressed on a site at Thorpe Marsh in South Yorkshire.

The development was progressed under Section 36 regime and granted in October 2011. The Barque Field was identified as the potential carbon sink (not binding).

The site was previously a coal fired power plant. Connections for electricity export are local to the site and gas connections are c. 30 km.

4.5.6 White Rose

A proposed 450 MW oxy fuel coal project adjacent to the Drax power station taking benefit from the existing coal reception facilities.

The White Rose Project has completed public consultation and is aiming for a submission to the Planning inspectorate in Quarter 4, 2014. If the application is submitted in October 2014, and accepted as duly made, then a decision would be expected in early 2016.

4.5.7 Further Planning Information

Further information on planning decisions and projects under consideration is available via the following sources of information.

DECC decisions under Section 36 & Section 37 and Areas for CCR

See link to S36 / S37 website - https://www.og.decc.gov.uk/EIP/pages/recent.htm

See link to CCR decision website - https://www.og.decc.gov.uk/EIP/pages/c02.htm

Planning Inspectorate projects

Infrastructure Projects -http://infrastructure.planningportal.gov.uk/

Killingholme - http://infrastructure.planningportal.gov.uk/projects/yorkshire-and-the-humber/north-killingholme-power-project/?ipcsection=overview

Knottingley - http://infrastructure.planningportal.gov.uk/projects/yorkshire-and-the-humber/knottingley-power-project/

White Rose - http://infrastructure.planningportal.gov.uk/projects/yorkshire-and-the-humber/white-rose-carbon-capture-and-storage-project/?ipcsection=overview

4.6 Existing Coal Stations in UK

Coal, as a generation fuel, continues to be in transition in UK with no new coal build since Drax and the legacy impact of LCPD and SCR decisions. Closures of 'opted out' plant has commenced (e.g. Kingsnorth, Didcot, Cockenzie, etc.) across UK, and the challenge of SCR will lead to plants investing in low emission equipment to reduce NOx emissions or entering the National Transition Plan (IED) with limited running of less 17,500 hours and closure by 2023.

The major coal plants in the target region are listed below as information only;

Station	Owner	Capacity (MW)	Observation
Cottam	**EdF**	**1948**	**FGD fitted**
Drax	**Drax Power**	**3960**	**FGD on 6 units** **2 or 3 units to convert to biomass.**
Eggborough	**Eggborough Power Ltd**	**2000**	**FGD on 2 units**
Ferrybridge 1 & 2	**SSE**	**980**	**No FGD - Closed**
Ferrybridge 3 &4	**SSE**	**980**	**FGD fitted.** **Fire damage on 1 unit**
Ratcliffe on Soar	**EON**	**2000**	**FGD fitted.** **Has already undertaken SCR work**
West Burton	**EDF**	**1924**	**FGD fitted**

5 SUMMARY

The Stage A report identified a wide range of locations where power plant development may be possible. A long list of sites were reviewed with 16 locations emerging as high ranking sites, and these are listed in Section 2.6.

This Stage B report has progressed the desk top study and considered technology, location and project deployment options to inform ETI on the potential approaches to encouraging through a project call the mobilisation of development for a next phase project in the UK CCS programme.

There is significant potential for development of new part capture chain power plants in the target area. This is generally driven by the availability of sites, capacity at interface connections and a balanced view to planning and consenting in the region.

The location of the White Rose CCS project will benefit from the major infrastructure available at the adjacent Drax power station and in particular will share common coal reception and handling facilities. White Rose will establish a transportation and storage solution that has capacity to accept other emitters. White Rose is considered the anchor project for further part chain capture projects.

A typical power plant footprint, representing the largest of the technology options, has been tested against a sample set of sites. The consideration of these typical sites has helped develop an approach to a Project Call but it is essential that the call accommodates any party who may be interested and therefore repeated use of the reference site names is not helpful.

The opportunity for pure new build option will require a combined development and implementation period of not less than 8 years.

The development and deployment costs of large scale low carbon fossil power plants is not underpinned by a large experience base and hence has low maturity. Any new project will need strong leadership and the time to further develop configuration as part of the UK programme. The corresponding investment will need substantial fiscal support or be driven by enforcing low carbon legislation.

Costs for deployment are uncertain and Developers must be responsible for the detail cost estimation and projections consistent with their need to reach a compelling investment case. The ETI role is to encourage enablers, sponsor cost reduction and learning whilst maintaining the vision for low carbon.

The potential to deploy a Second of a Kind (SOAK) technology in a new part chain capture plant may serve to demonstrate the beliefs and anticipation of cost reduction after first implementation. This can therefore contribute to the viability of subsequent CCS deployment in UK.

There may be alternative part chain capture schemes that can be deployed on existing or newly intended development that could contribute a second major demonstration plant and be a major contributor to the carbon transport system in advance of a complete new build plant development.

Programme and project risks for any CCS project in the UK will need to be developed further to recognise the learning from previous CCS initiatives, evolving EMR policy and regulation and the ability of a Developer or a new project to piggy back on the Anchor project.

The ETI should reflect on the intervention strategy and possible outcomes of a project call.

6 CONCLUSIONS AND RECOMMENDATIONS

This Stage B report identifies a range of considerations with respect to the development of a new part chain capture project in the target region in Yorkshire in readiness for the scoping of a Project Call.

There is potential for a new low carbon project to benefit from the infrastructure created by the UK CCS programme and specifically the White Rose project.

There is a risk that failure to progress White Rose would leave any further new project stranded unless step in rights are provided and underwritten.

The development, preferred technology and site options should be considered further through market testing.

The level of attainment, and exit strategy, at the end of any ETI funding should be a successful DCO, with the opportunity for ETI to retain a minority stake in a project as it progresses.

Alternatively, there may be the opportunity for ETI to recover 100% funding if site is sold to others. (Consented). This may result in a repeat cycle of funding and recovery for further enabled development sites.

If a fast track demonstration project is an attractive option then there is the potential to encourage CCS functionality onto ‘in-development’ projects but ETI would have to consider whether this is their role. (CfD clarity for CCS programme) and whether the intended level of funding would make the difference?

The option to extend the life of an existing site by encouraging the introduction of latest USC technology could be attractive and cost competitive even given the complexities of site ownership and managing interface.

In all cases ETI have to be comfortable and confident that CCS programme in UK would be advanced by their intervention.

It is recommended that;

- Further consideration of the drivers and enablers for project development are progressed through a concept study.
- Market testing of the Sector stakeholders around drivers and enablers is undertaken to encourage contributions in advance of any project call.
- The opportunity to take two separate sites into development should be considered as a credible pathway to create the next phase demonstrators, enabling technology and fuel flexibility
- Any project call is formulated to encourage multiple bidders, and could be on the following basis;
    - A brand new project with part chain capture technology using Oxy Fuel Coal with CCS for the purpose of demonstrating Second of a Kind benefits
    - CCS deployment on an existing or intended new build project (CCGT or IGCC)
    - New ASC PF coal units deployed on an existing coal site. The ‘Re-Birth’ option.
- ETI consider their involvement carefully to ensure that value of their intervention is positive and encourages attainment of new enablers.

7 REFERENCES AND GENERAL READING

The specific references and general guidance used in producing this desk top study are listed below for information;

1. URS Stage A Report for ETI, July 2014
2. ETI provided cost information from FW WP1
3. DECC Carbon Capture Readiness Report, 2008
4. ETI provided cost information from FW WP1 (as reference 2)
5. Imperial College Guidance Note for CCR including URS input
6. ETI provided cost information from FW WP1 (as reference 2 and 4)
7. PB UK Electricity Generation Cost Model 2011 Revision 1
8. Mott McDonald UK Electricity Generation Cost Updates 2010
9. Mott McDonald Presentation on Cost Premiums, Guy Doyle, November 2010
10. ETI provided cost information from FW WP1
11. Mott McDonald UK Electricity Generation Cost Updates 2010 (as reference 8)
12. National Grid - The statement of Use of System Charges – April 2013
13. National Grid – CUSC Section 15 Rev1.3
14. National Grid – Gas Charging Statement August 2013
15. AMEC Engineering Design and Capture Study for One North East, September 2010.

    General review

16. CIVITAS, Electricity Costs – The Folly Wind Power, Ruth Lea, January 2012,
17. AECOM, White Rose Preferred Pipeline Corridor Report, April 2013
18. UK APGTF CCS Strategic Report, January 2014
19. CoalPro, Budget 2014 Representation, February 2014
20. Yorkshire Forward, A Carbon Capture and Storage Network for Yorkshire and Humber, June 2008

Appendix A – Technology Footprints for 1 GW power plant

LEGEND

Site dimensions for generation equipment (m)

Site dimensions for CO2 capture and compression equipment (m)

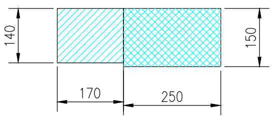
CCR Land Footprint Review

Case studies Review

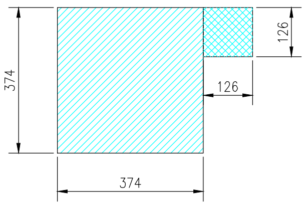
Nominal figures for in development projects

CCGT with post-combustion capture

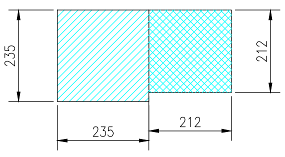
785 MW
79m2/MW



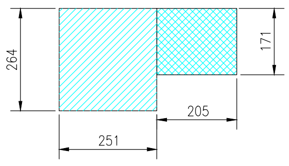
Knottingley
1,500 MW
104m2/MW



Thorpe Marsh
960 MW
104m2/MW

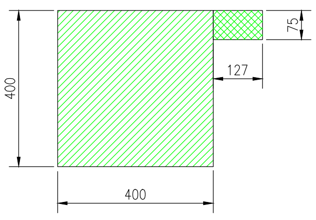


1000 MW
110m2/MW

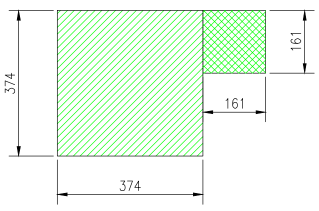


USCPF with post-combustion capture

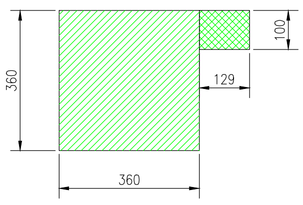
785 MW
340m2/MW



Kingsnorth
1,600 MW
104m2/MW

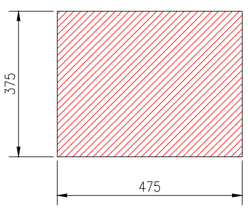


800 MW
188m2/MW

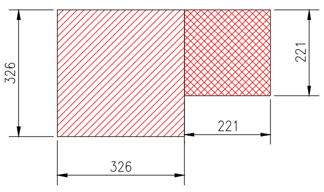


IGCC with capture

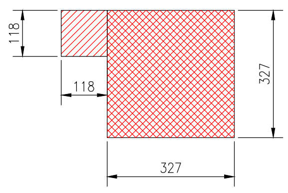
785 MW
229m2/MW



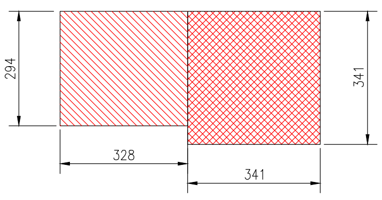
Don Valley
920 MW
168m2/MW



Killingholme
470 MW
257m2/MW

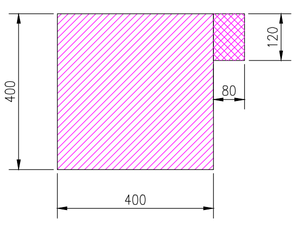


1040 MW
212m2/MW

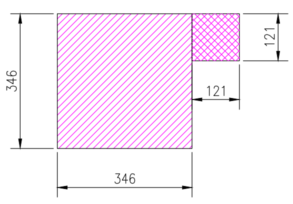


USCPF with oxy-combustion capture

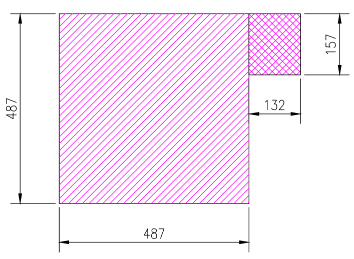
500 MW
340m2/MW



White Rose
450 MW
299m2/MW



1000 MW
260m2/MW



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Revision Details	By / Check	Date	Suffix

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

IT IS ASSUMED THAT ALL WORKS ON THIS DRAWING WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROPRIATE METHOD STATEMENT.

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

Project Title: UK BLUEPRINT CARBON CAPTURE

Client: ENERGY TECHNOLOGIES INSTITUTE

Drawing Title: REFERENCE PLOT PLANS FOR FOUR REFERENCE 1000MW CLEAN FOSSIL POWER PLANTS

Purpose of issue: DRAFT

Designed	Drawn	Checked	Approved	Date
NA	NA	ML		Aug 14

URS Internal Project No.: 47071043

Suitability:

Scale @ A2: 1:10,000

Zone / Mileage:

Drawing Number: UBCC-URS-P2-XX-DR-ZZ-00001

Rev: P1

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Appendix B –
CapEx Evolutions for CCS part chain capture power plants

Appendix B - CapEx Summary to support Charts in Section 3.5

CCGT with CCS evolution to extended fit		830 MW CCGT F 'FOAK' with CCS		1000 MW CCGT H 'FOAK' with CCS		1000 MW CCGT H 'NOAK' with CCS		1000 MW CCGT H 'SOAK' with CCS		CCS only added to 2 new CCGT H units 1000 MW	
ASU	GB£M	0	0%	0	0%	0	0%	0	0%	0	
Gasification / Boiler	GB£M	0	0%	0	0%	0	0%	0	0%	0	
Power Island	GB£M	446	43%	538	43%	430	43%	473	43%	50	
Acid Gas Removal	GB£M	342	33%	413	33%	330	33%	363	33%	363	
CO2 compression	GB£M	104	10%	125	10%	100	10%	110	10%	110	
Others	GB£M	145	14%	175	14%	140	14%	154	14%	50	
Total CAPEX	GB£M	1038	100%	1250	100%	1000	100%	1100	100%	573	
CAPEX efficiency	GB£/kWh	1250		1250		1000		1100		573	

USC with CCS evolution		1600 MW USC 'FOAK' with CCS		800 MW USC 'FOAK' with CCS		1000 MW USC 'FOAK' with CCS		800 MW USC 'NOAK' with CCS		800 MW USC 'SOAK' with CCS		New 800 MW USC with CCS as Re-birth option	
ASU	GB£M	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Gasification / Boiler	GB£M	2220	48%	1221	48%	1526	48%	960	48%	1037	48%	900	48%
Power Island	GB£M	601	13%	331	13%	413	13%	260	13%	281	13%	240	13%
Acid Gas Removal	GB£M	1064	23%	585	23%	731	23%	460	23%	497	23%	497	23%
CO2 compression	GB£M	370	8%	203	8%	254	8%	160	8%	173	8%	173	8%
Others	GB£M	370	8%	203	8%	254	8%	160	8%	173	8%	100	8%
Total CAPEX	GB£M	4624	100%	2543	100%	3179	100%	2000	100%	2160	100%	1910	100%
CAPEX efficiency	GB£/kWh	2890		3179		3179		2500		2700		2387	

IGCC with CCS		870 MW IGCC 'FOAK' with CCS		1040 MW IGCC 'FOAK' with CCS		1040 MW IGCC 'NOAK' with CCS		1040 MW IGCC SOAK		1040 MW Gasifier with CCS onto exisitng CCGT	
ASU	GB£M	235	9%	281	9%	216	9%	253	9%	253	
Gasification / Boiler	GB£M	549	21%	657	21%	505	21%	590	21%	590	
Power Island	GB£M	811	31%	969	31%	745	31%	870	31%	100	
Acid Gas Removal	GB£M	288	11%	344	11%	264	11%	309	11%	309	
CO2 compression	GB£M	157	6%	188	6%	144	6%	168	6%	168	
Others	GB£M	575	22%	688	22%	529	22%	618	22%	150	
Total CAPEX	GB£M	2615	100%	3126	100%	2404	100%	2808	100%	1570	
CAPEX efficiency	GB£/kWh	3006		3006		2312		2700		1509	

Oxy Fuel with CCS		*450 MW OXY 'FOAK' with CCS*		*900 MW OXY 'FOAK' with CCS*		*900 MW OXY 'NOAK' with CCS*		900 MW Oxy 'SOAK' with CCS		900 MW Oxy 'SOAK' with CCS near White Rose	
ASU	GB£M	284	18%	510	18%	437	18%	470	18%	470	18%
Gasification / Boiler	GB£M	646	41%	1162	41%	996	41%	1070	41%	930	41%
Power Island	GB£M	189	12%	340	12%	292	12%	313	12%	313	12%
Acid Gas Removal	GB£M	0	0%	0	0%	0	0%	0	0%	0	0%
CO2 compression	GB£M	173	11%	312	11%	267	11%	287	11%	287	11%
Others	GB£M	284	18%	510	18%	437	18%	470	18%	340	18%
Total CAPEX	GB£M	1575	100%	2835	100%	2430	100%	2610	100%	2340	100%
CAPEX efficiency	GB£/kWh	3500		3150		2700		2900		2600	

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